March 14, 1950

P. HAAS

2,500,355

ELECTRON DISCHARGE TUBE

Filed Nov. 14, 1944

3 Sheets-Sheet 1

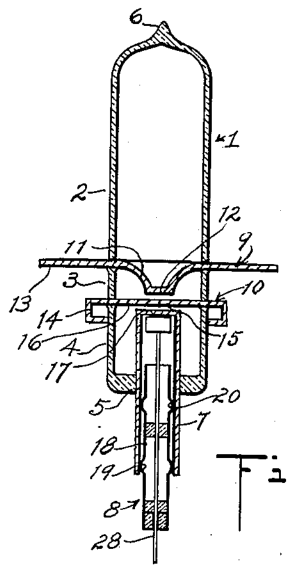


Fig. 1.

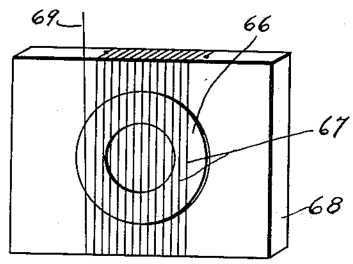


Fig. 3.

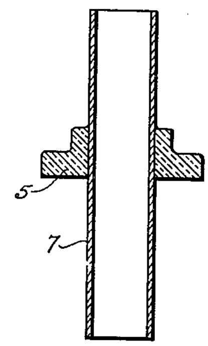


Fig. 4.

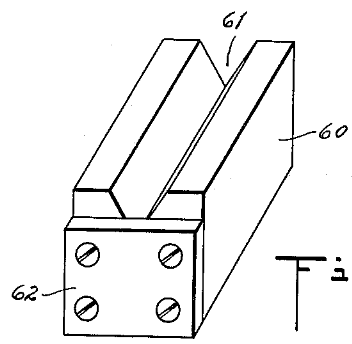
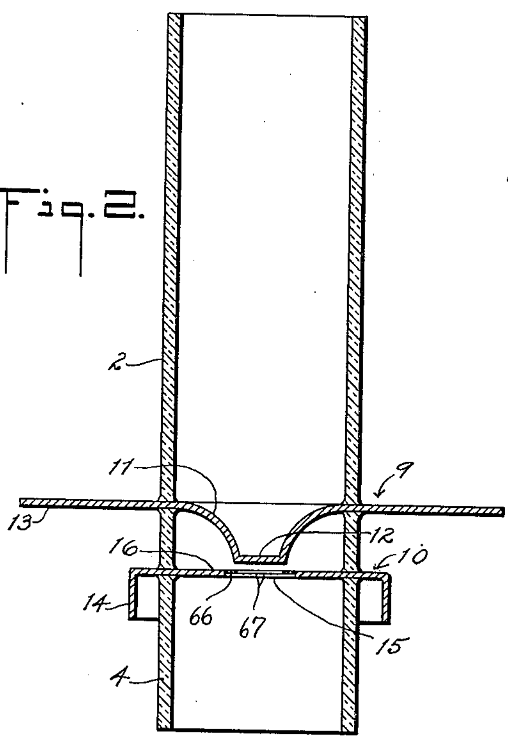


Fig. 8A

Fig. 2.



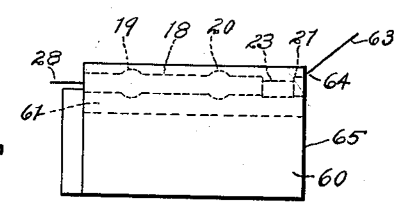


Fig. 8B

PAUL HAAS
INVENTOR

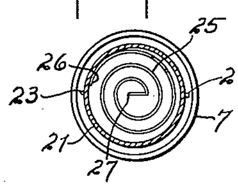
BY John J. Rogan
ATTORNEY

March 14, 1950 P. HAAS 2,500,355

ELECTRON DISCHARGE TUBE

Filed Nov. 14, 1944 3 Sheets-Sheet 2

Fig. 5A



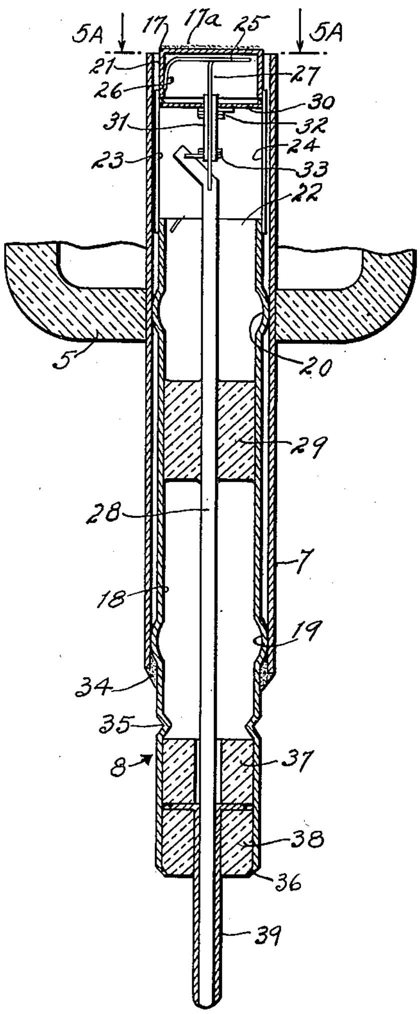
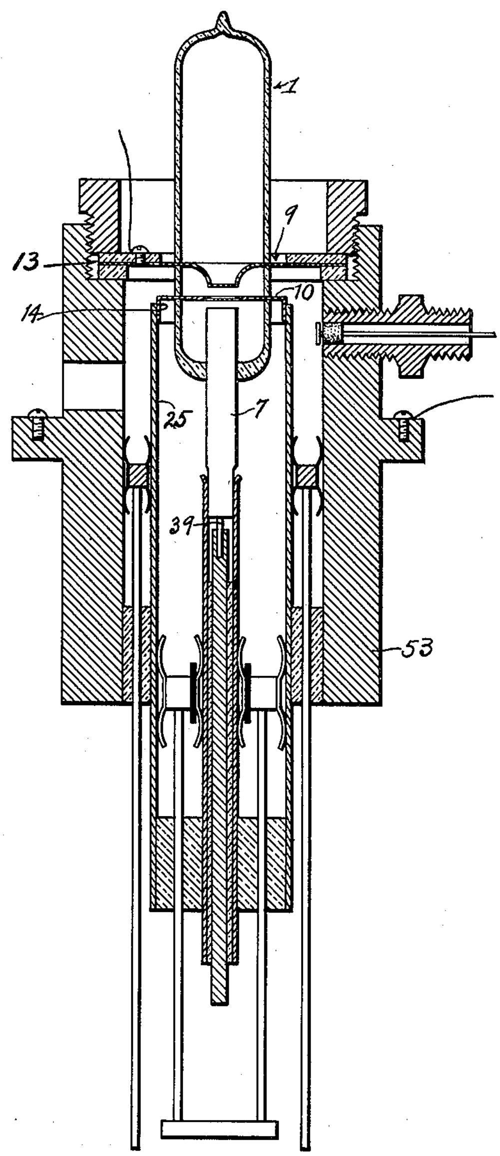


Fig. 5.

Fig. 9.



PAUL HAAS
INVENTOR

BY John J. Rogan
ATTORNEY

March 14, 1950 P. HAAS 2,500,355

ELECTRON DISCHARGE TUBE

Filed Nov. 14, 1944 3 Sheets-Sheet 3

Fig. 6.

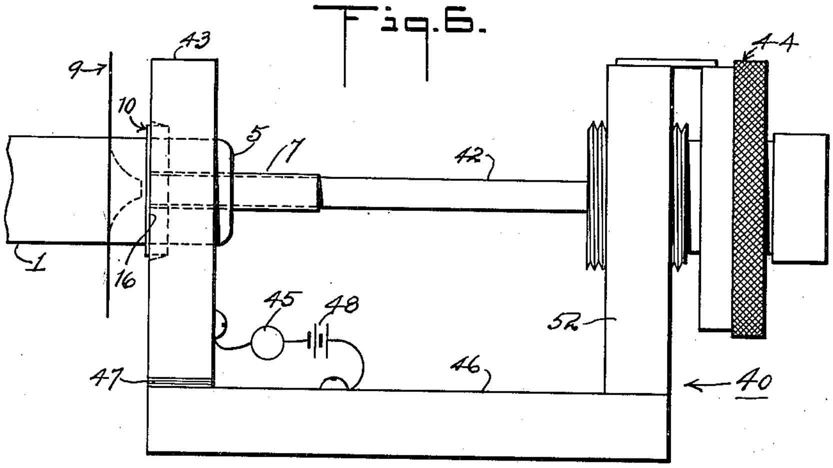
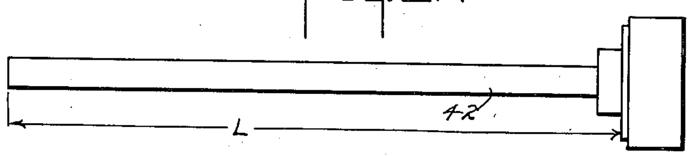


Fig. 6A



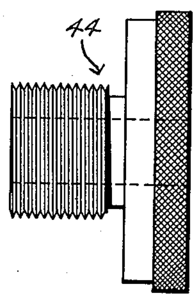


Fig. 6B

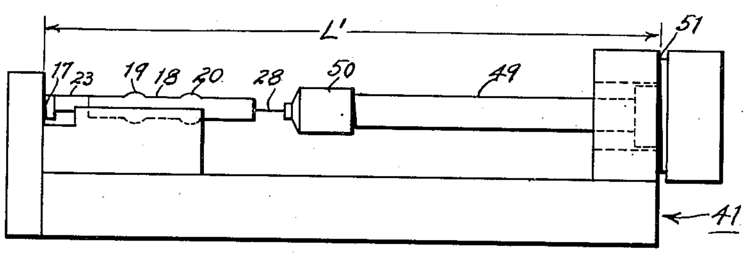


Fig. 2.

PAUL HAAS
INVENTOR

BY John J. Logan
ATTORNEY

Patented Mar. 14, 1950

2,500,355

UNITED STATES PATENT OFFICE

2,500,355

ELECTRON DISCHARGE TUBE

Paul Haas, Emporium, Pa., assignor to Sylvania Electric Products Inc., Emporium, Pa., a corporation of Massachusetts

Application November 14, 1944, Serial No. 563,348

16 Claims. (Cl. 250—27.5)

This invention relates to electron discharge tubes and more particularly to discharge tubes with substantially planar parallel electrodes.

It is a principal object of the invention to provide an electron discharge tube for ultra high frequency use in which the electron transit time is reduced to a minimum by extremely close spacing of the tube electrodes.

It is another object of the invention to provide an electron discharge tube of the planar triode type, all electrodes and lead-in conductors of which are adapted to form parts of co-axial cavity resonators to be externally disposed and used as input and output circuits of the tube.

According to one object of the invention, means are provided for establishing separate parallel channels for the high frequency components on one hand, and for the low frequency and direct current components on the other hand of the return paths of anode and grid currents in close proximity to the emitting surface of the cathode.

According to another object of the invention, means are provided whereby the cathode-to-grid spacing in a planar parallel electrode mount is carried out subsequent to all glass and metal-to-glass sealing operations.

A feature of the invention relates to the completion of the vacuum-tight connection between the cathode and the rest of the tube assembly at a location remote from the active cathode surface, whereby any danger of oxidation or deterioration of the active cathode surface due to the heat required for obtaining the vacuum-tight connection is completely eliminated.

While the invention is particularly useful for triodes with planar parallel electrodes of rotational symmetry, which during operation utilize an axial electron stream either as negative grid or grounded grid triodes in conventional circuits, it may also be used in connection with velocity modulated tubes or for any type of electron gun, wherever an extremely close spacing between a flat cathode and a cooperating electrode is desirable.

For purposes of illustration, the invention will be described in connection with a planar triode. In the drawing,

Fig. 1 is a schematic view of a tube mount having axial symmetry, with planar parallel electrodes according to the invention.

Fig. 2 is an enlarged longitudinal section of the grid-anode assembly of the tube shown schematically in Fig. 1.

Fig. 3 illustrates the method of winding the grid electrode.

Fig. 4 is a sectional view of the header of the tube.

Fig. 5 is a sectional view of the heater-cathode assembly according to the invention, which is inserted as a unit into the completed grid-anode assembly of the tube.

Fig. 5A is a sectional view of Fig. 5 taken along line 5A—5A.

Figs. 6, 6A, 6B and 7, show jigs used for achieving the cathode-grid spacing.

Figs. 8A and 8B are views of the cathode coating trimming jigs.

Fig. 9 is a sectionalized view of a coaxial transmission line connector arrangement for the various electrodes of the tube.

The tube shown in Fig. 1 comprises a tubular glass envelope 1 consisting of cylindrical sections 2, 3 and 4, header 5 and tip 6. Into header 5 is centrally sealed a tubular metal sheath 7, containing the heater-cathode assembly 8 which will be described hereinbelow. Anode 9 is sealed between envelope sections 2 and 3, and grid disk 10 is sealed between sections 3 and 4 of the envelope 1. Anode 9 is in the form of a substantially disk-shaped metal piece with a tray-like curved inner portion 11 surrounding the central flat anode portion 12. The peripheral part 13 of anode 9 is located externally with respect to the tube envelope, forming a ring-shaped lead-in seal, to constitute the end surface of an external tubular conductor of a co-axial resonance cavity. Grid disk 10 has an external ring-shaped portion provided with a skirt 14, adapted to be fitted into the cylindrical end of a metal pipe forming another part of the external cavity. A central aperture 15 is provided in the flat portion 16 of grid disk 10 in which aperture may be an annular frame 66 by which the grid wires are supported.

Cathode disk 17 which carries on its exposed face the electron-emitting coating 17a is held in close proximity to grid-disk 10 and is carried by heater-cathode assembly 8. The unit consisting of anode 9, grid 10, envelope 1 and header 5 carrying tubular metal sheath 7 will be referred to herein as the "envelope mount." Unit 8 will be referred to as the "heater-cathode assembly."

The spacing between grid and anode obtainable by sealing the parts together in a glass lathe can be kept within the desired tolerances. Experience has, however, shown that it is very difficult to obtain uniformity of the extremely close cathode-grid-spacing needed for eliminating electron transit time effects at several thousand megacycles. This spacing must be of the order of a few thousandths of an inch, and it has been found that such spacings cannot be kept within the desired tolerances by known glass sealing methods.

In particular, it is difficult to combine this critical grid-cathode spacing with the further requirement, that the cathode lead-in should form a part of a co-axial cavity comprising the input circuit of the tube, and to obtain minimum high-frequency losses in this lead-in conductor.

This is accomplished according to the invention by designing the cathode-heater assembly unit 8 as a substantially rigid insert, encased in metal sheath 7. Metal sheath 7 forms, according to the invention, a part of the envelope mount. The lower part of this envelope mount, comprising header 5 with sealed-in metal sheath 7 is shown in enlarged form in Fig. 5. Heater-cathode assembly 8 is here shown inserted into metal sheath 7. It consists of an elongated angularly bulged metal tubing 18, of an outside diameter slightly smaller than the inside diameter of sheath tube 7. It is provided near its ends with two annular swellings or bulges 19 and 20, which act as guide rings for unit 8 within sheath 7. Cathode disk 17 is provided with a skirt portion 21, and is held in spaced relation from, and attached to, the upper rim 22 of bulged tube 18 by a plurality of cathode support wires, two of which 23 and 24 are shown in Fig. 5. Skirt 21 is thus supported coaxially with respect to metal sheath 7, and separated by a very narrow annular space from it, which forms a capacity high enough to conduct the ultra high frequency currents passing through the cathode and to metal sheath 7 with no appreciable impedance.

This arrangement has various advantages. In the first place, it establishes metal sheath 7 as a perfectly cylindrical lead-in conductor for cathode disk 17. Sheath 7 is therefore adapted to form part of an internal conductor of a co-axial input cavity resonator for operation of the tube in an ultra high frequency circuit, whose outer conductor may consist of a metal pipe 25 (Fig. 9) attached to the skirt 14 of grid disk 10, for which cathode disk 17 and grid disk 10 form the capacity gap between the end surfaces of this concentric line resonator cavity. No wires of small diameter are thus involved in making the electric connection between cathode disk 17 and the external and inner conductors of the input resonator cavity.

On the other hand, only a minimum of heat conduction from cathode skirt 21 to tubular sheath 7 takes place, because the annular space between them excludes a direct metallic contact. Metallic heat conduction from cathode skirt 21 to the bulged metal tube 22 is also minimized, by supporting the skirt 21 by a plurality of thin metal wires, of which 23 and 24 are shown in Figs. 5 and 5A.

Flat helical or spiral metal filament 25, which serves as heater for the cathode, is attached at its outer end 26 to cathode skirt 21, and at its inner end 27 to filament lead 28. Filament lead 28 is held axially and concentrically with respect to bulged tube 18 by glass bead 29, which is sealed to both, tube 18 and lead 28, in a vacuum-tight manner.

To provide further heat conservation, a heat reflector 30 is provided at the lower end of cathode skirt 21, and the axial end portion of filament 25 is threaded through a central hole in the heat reflector by means of ceramic bushing 31, attached to the heat reflector and to filament lead 28 by means of wire springs 32, 33.

Fig. 5 shows the heater-cathode unit 8 soldered into metal sheath 7 at its lower end by an annular solder ring 34. It also shows crimpings 35, 36, at the lower end of bulged tubing 18, with inserted bakelite spacers 37, 38 and metal base pin 39, forming a lower plug-in connection for the heater current supply.

This plug-in contact pin for the heater current supply is formed after the tube 1 has been exhausted. The lower portion of bulged tubing 18, below bulge 19, is at that stage uncrimped, and does not contain the Bakelite spacers 37, 38, and metal base pin 39, when the heater-cathode unit 8 is being telescoped into metal sheath 7.

After the heater-cathode assembly is completed in the form ready for being telescoped into metal sheath 7, the accurate cathode-grid spacing operation must be carried out. This is accomplished by gauges comprising two jigs 40 and 41 as will now be described in connection with Figs. 6, 6A, 6B, and Fig. 7.

Calibrating rod 42, with calibrated length L between its end surfaces (as shown in Fig. 6A), serves as one of two auxiliary gauge means for adjusting the cathode grid spacing. The envelope mount above described is inserted and clamped horizontally in the left-hand end piece 43 of jig 40 as indicated in Fig. 6, in which the outlines of part of the envelope 1, anode 9, grid ring 10 and metal sheath 7 are indicated. Calibrating rod 42 of length L is slid into micrometer screw arrangement 44 (shown in Fig. 6B), telescoping the straight end of rod 42 into metal sheath 7 on the jig. Micrometer screw 44 is now turned, the rod moving with it axially to the left, until its left-hand end touches the flat portion 16 of the grid inside the mount assembly. This contact is preferably indicated by a contact indicating lamp 45 as shown schematically in Fig. 6. The michrometer screw is now locked, and rod 42 removed from the jig. It will be understood that part 43 is insulated from base 46, and part 44 by insulation 47, this insulation being bridged by lamp 45 and battery 48 in series.

Heater-cathode assembly 8 is now placed into a second jig 41, whose length L′ is shorter than length L of calibrating rod 42 by the desired cathode-grid spacing. Assembly 8, being much shorter than either L or L′, must be supplemented by a second, shorter calibrating rod 49, provided with a pin vise 50, into which the end portion of filament lead 28 is clamped, so as to obtain the correct length L′ from cathode disk 17 to the calibrating shoulder 51 of rod 49.

The entire unit of Length L′, consisting of heater-cathode assembly plus the vised-on supplementing calibrator rod 49 is now removed from jig 41, and slid into jig 40, telescoping the heater-cathode assembly through block 52 and metal sheath 7, until shoulder 51 contacts the locked micrometer surface. The grid-cathode distance obtained in this manner is obviously L minus L′, viz., the specified spacing.

In this position, the heater-cathode assembly 8 is soldered or brazed at 34 (Fig. 5) to metal sleeve 7, and the tube is ready for exhaust and processing. After termination of this step, the external parts of the tube are cleaned and silver-plated, the metal base pin 39 and Bakelite spacers 37, 38, are introduced, and the end of bulged tubing 18 is crimped at 35 and 36, as previously described in the finished mount of Fig. 5.

The tube is now ready for use, and can be mounted into an appropriate ensemble of metal pipes 25 and 53 (Fig. 9) completing the co-axial cavity resonators to be connected to the external rings of anode 9, grid 10 and metal sheath 7. The heater voltage can be supplied conveniently by the base pin 39 of the cathode-heater assembly.

The various conductors and tube elements particularly those which are sealed into the glass, should preferably be made of an alloy such as "Sylvania #4 alloy" consisting of from 38 to 44% nickel, 4 to 8% chromium, the balance substantially iron, plus the addition of a small percent of another metal such as aluminum, zirconium, calcium, beryllium and the outer surface of the conductors should be coated with a low resistance metal such as copper. I have also found that in view of the critical and precise dimensioning that is required for tubes of the type disclosed, the thickness of the cathode electron-emissive coating 17*a* must be accurately gauged. For this purpose, the heater-cathode unit 8 may be supported in a V-shaped jig block 60 (Figs. 8A and 8B). This block has a V-shaped groove 61 to receive the heater-cathode assembly and is provided with a stop plate 62 against which at one end the heater-cathode unit 8 abuts as indicated in Fig. 8B. The cathode coating 17*a* then projects slightly beyond the opposite end of the groove 61. If desired, the groove 61 in block 60 may be provided with recesses to receive the bulged portions 19 and 20. In coating the cathode, the initial coating is preferably overcoated so that a certain thickness of this cathode coating projects beyond the flat right-hand end of block 60. This overcoating can then be removed by shaving as indicated by the blade 63, the shaving edge 64 of which abuts against the end 65 of the jig, and by moving the blade 63 vertically upward and downward the excess emission coating is accuratey removed. This shaving operation not only eliminates the ever-present problem of an uneven coating of uncertain thickness, but in addition it insures a smooth even surface which will be absolutely parallel to the grid 10 even though the disk 17 itself is out of alignment and not perpendicular to the longitudinal axis of the cathode assembly.

Likewise, since the grid electrode must be perfectly planar and parallel to the plate and cathode surface, it should be manufactured in the manner illustrated in Fig. 3. Each grid consists of a flat molybdenum disc 66 resembling a washer and with parallel tungsten wires 67 extending across the central opening. Fig. 3 shows the disc during the process of manufacture. The grids are made two at a time by sandwiching two bolybdenum washers 66 on opposite faces of a gauge block 68, the washers 66 being suitably clamped to the said opposite faces of the block. The fine grid wire 69 is then wound around the block with appropriate spacing between turns and then the wires are welded or gold-brazed to the flat face of each washer preferably in a non-oxidizing atmosphere. The wound wire may then be severed around the periphery of each washer thus leaving each grid in the form of a flat annular frame across one face of which the grid wires 67 extend in spaced parallel relation. If desired, each of the washers 66 may be split and held in contracted position during the winding and grid-forming operation, so that when the finished grid is removed from the winding block 68, the washer 66 tends to expand and increase its circumferential size and thereby maintain the grid wires completely taut. The finished grid electrode can then be centrally

fastened to the grid disc 10 by means of a series of eyelets. By thus making the grid ring as a separate element, there is achieved a simplification in assembly in that it eliminates relatively complicated and less reliable supports for mounting the grid. Furthermore, by this arrangement, it is possible to make the disc assembly as a sub-assembly such as shown in Fig. 2, the three sections of glass and the two metal discs being assembled in a suitable ceramic jig and the sealing of the discs to the glass being effected by induction heating at high frequency.

In preparing the heater-cathode assembly (Fig. 5), the disk 17 with its cylindrical wall 21 can be of nickel and its outer diameter should be slightly less than the inside diameter of the tube 7. This therefore leaves a small annular gap between the members 7 and 18 which serve as a capacity coupling means between the cathode 17*a* and the cathode metal sheath 7. This provides a sufficiently low impedance return path for any high frequency currents which would otherwise tend to flow through the support wires 23 and 24. These latter wires may therefore, in accordance with the invention, be made of extremely small diameter, thus conducting a minimum of heat away from the cathode. In order further to confine the heat within the cathode cap, the heat reflector 30 is of course supported by the ceramic insulator tube 31, so as to insulate it from the end 27 of the heater-cathode and the periphery of the said reflector 30 may be provided with three embossed points so that it contacts the lower edge of the rim 21 in only three very restricted areas.

What is claimed is:

1. An electronic control comprising an enclosing envelope, a plurality of metal electrodes having opposed surface areas in planar parallel relation, said electrodes having their peripheral margins sealed into and extending through the wall of said envelope, a tubular metal member sealed through one end wall of said envelope, said tubular member having its inner end open and in spaced relation to one of said electrodes, a heater-cathode unit including a metal sleeve carrying a cathode and telescoped into said tubular member, and means sealing the external end of said tubular member to said sleeve.

2. A device according to claim 1 in which one of said plurality of electrodes has a dish-shaped central portion with a flat bottom, and another electrode is a grid electrode having a central window in which is fastened a substantially planar wire grid.

3. An electronic control device comprising a glass envelope formed of three tubular sections; a first metal disc electrode having its marginal area sealed between the first and second sections; a second metal disc electrode having its marginal area sealed between the second and third sections, a glass header extending transversely across the end of said third section, a tubular metal member sealed centrally through said header, a cathode-heater unit including a metal sleeve carrying a cathode cap and telescoped through said member, said cap carrying electron-emissive material, said cap being located with its flat face in closely spaced parallel planar relation to the center of said second electrode, and means sealing the external end of said member to said sleeve.

4. A device according to claim 3 in which the said first electrode has a central portion offset towards said second electrode, the offset portion having a planar surface extending parallel to the plane of the said second electrode, and said sec-

ond electrode has a central window in which is rigidly mounted a grid unit comprising an annular metal member having a flat face and having a plurality of spaced grid wires integrally united into the flat face.

5. A device according to claim 3 in which said cathode-heater unit comprises an inverted metal cup having its flat surface coated exteriorly with electron-emissive material, a heater filament mounted within said cup, a heat confining closure plate closing the open end of said cup, a tubular metal member telescoped into said metal sleeve, and a plurality of fine wires supporting said cup in spaced relation longitudinally from the end of said tubular metal member, the external diameter of said cup being slightly less than the internal diameter of the adjacent end of said tubular metal member providing a capacity between said cup and said tubular member which is of much lower impedance to ultra high frequency currents than the impedance of said fine wires.

6. An assembly unit for tubes comprising a glass header having an elongated tubular metal sleeve sealed centrally and transversely therethrough, another tubular metal sleeve of slightly smaller diameter than the first sleeve and telescoped therein, means maintaining said sleeves in fixed spaced relation, a cathode cap having a downwardly depending skirt telescoped into one end of the first-mentioned sleeve, and a plurality of thin support wires extending between the end of said second sleeve and said skirt supporting said cap in longitudinal spaced relation to the end of said second sleeve while maintaining said skirt in circumferential spaced relation within said end of said first sleeve.

7. An assembly unit according to claim 6 in which said cathode cap has its open end substantially entirely closed by a separate heat reflector disc, and a coiled heater wire is mounted within said cap, said heater wire having one end fastened to the inner periphery of said skirt, and the other end extending centrally through said reflector disc but insulated therefrom, and a current supply conductor extending axially through said second sleeve and fastened to said other end of the heater wire.

8. An indirectly heated cathode for electron tubes comprising an inverted metal cup having its flat surface coated exteriorly with electron-emissive material, a heater wire having a substantial planar spiral shape mounted in close spaced relation to the internal face of said flat surface, a heat reflector disc over the open end of said cup, and means to support said disc so that it substantially entirely closes said cup.

9. An electronic control device comprising an enclosing envelope having a planar cathode surface, a planar grid electrode, and a planar anode, said grid and anode having integral flat peripheral disc portions sealed into and through the wall of said envelope and providing integral external annular flanges, and a flat grid unit including a metal annulus carrying spaced grid wires with the annulus rigidly fastened to the margin of a central window in said grid electrode.

10. Apparatus for assembling the parts of a tube of the type having planar cathode grid and anode; comprising means to hold a preformed assembly unit consisting of a tubular glass envelope containing planar anode, planar grid and a header with a central tubular metal sleeve extending exteriorly therethrough; means to support a mandrel of fixed known length in axial alignment with said sleeve and extending through said sleeve into abutting relation with the planar grid; an adjustable stop cooperating with said mandrel for determining a fixed length between said grid and said stop; means to hold another preformed assembly unit consisting of a cathode cap and an elongated tubular metal member attached thereto and with a central rigid conductor; means to hold another mandrel in axial alignment with said central conductor, said other mandrel having an adjustable gripping member and a gauging stop whereby the overall length of said other assembly unit to said stop can be adjusted to a fixed length slightly less than the first-mentioned fixed length; said first-mentioned mandrel being removable and replaceable by the second-mentioned mandrel with its attached second assembly unit whereby a predetermined fixed gauged spaced relation is obtained between said planar grid and the end of the cathode.

11. An elongated unitary heater-cathode assembly adapted to be slipped into a tubular metal sheath, comprising a piece of metal tubing having two narrow annular bulged portions whose diameters are slightly larger than that of the unbulged length of the metal tubing, a skirted cathode disc, means supporting the cathode disc in axially spaced and coaxial relation on one end of the metal tubing, said means including a plurality of stiff metal wires, a straight filament lead disposed axially within the metal tubing, means supporting and spacing the filament lead in its axial position within and by the inner wall of said metal tubing, said means including an annular glass bead, heating means for the cathode disc including a flat spiral filament whose outer terminal is welded to the skirt of the cathode disc, and whose inner terminal is welded to the axially disposed filament lead.

12. An envelope mount comprising a plurality of axially aligned disc-shaped electrodes sealed through and supported by the cylindrical wall of a tubular glass envelope closed on one end by a glass header through which is centrally sealed a tubular metal sheath axially aligned with said disc-shaped electrodes, said tubular metal sheath having a portion extending axially in the glass envelope into close proximity of one of said disc-shaped electrodes and an external portion extending outwardly from the glass header in axial direction; and a unitary tubular heater-cathode assembly, telescoped into the tubular metal sheath, and comprising a disc-shaped thermionic cathode provided with a cylindrical flange, positioned at the end of the tubular sheath adjacent to one of the disc-shaped electrodes, means supporting and radially spacing said cathode coaxially within the tubular sheath, said means including a second metal tubing to which the cathode is attached by wires and which is provided with a plurality of axially spaced peripheral annular bulges engaging the inner surface of the tubular metal sheath, a flat spiral filament in close proximity to the cathode, a filament lead extending along the axis of the second metal tubing supported by and spaced from the inner surface of the second metal tubing by a glass bead forming vacuum-tight metal-to-glass seals with the axial filament lead and the inner surface of the second metal tubing, and a vacuum-tight annular metal joint between the external end of the tubular metal sheath, removed from the glass header, and a ring-shaped portion near one of the peripheral bulges of the second metal tubing.

13. The method of assembling a triode with planar parallel electrodes which comprises the steps of preparing an envelope mount comprising a tubular glass envelope, a disc-shaped anode, a disc-shaped grid electrode and a header carrying a tubular metal sheath, part of which extends into the envelope and having an end near the grid electrode, and another part of which extends outward from the envelope, having an external end, the two disc-shaped electrodes and the metal sheath being axially aligned; making a tubular heater-cathode assembly adapted to be telescoped into the metal sheath, and having a disc-shaped cathode on one end; telescoping the tubular heater-cathode assembly into the metal sheath; adjusting the desired cathode-to-grid spacing; and forming a vacuum-tight annular metal joint between the external end of the tubular sheath and a short peripheral section of the tubular heater-cathode assembly.

14. The method according to claim 13 in which the adjusting of the desired cathode-to-grid spacing is carried out by establishing externally to the envelope mount a fixed reference plane at a known axial distance from the grid on a calibrating fixture to which the envelope mount is rigidly clamped, supplementing, in a second, separate calibrating fixture, the axial length of the heater-cathode assembly by an adjustably connectable and lockable auxiliary calibrating rod, calibrating the overall axial extension of the heater-cathode assembly and the auxiliary calibrating rod to a length less than the known axial distance from the grid to the fixed reference plane by the desired cathode-to-grid spacing, locking the heater-cathode assembly to the auxiliary calibrating rod forming a rigid unit with it, telescoping this rigid unit into the tubular metal sheath with the cathode pointing toward the grid and terminating the telescoping motion when the free end of the auxilary calibrating rod coincides with the fixed reference plane.

15. An electron discharge tube comprising an envelope containing a plurality of cold electrodes and closed by a glass header through which a

tubular cathode lead-in conductor is sealed, a disc-shaped thermionic cathode provided with a cylindrical peripheral flange of a diameter smaller than the inside diameter of the tubular cathode lead-in conductor, means adjacent said cathode for heating the cathode, and means coaxially supporting the flange of the disc-shaped cathode within the tubular lead-in conductor in radially spaced relation thereto.

16. An electron discharge tube comprising an annular condenser, constituting a low impedance for ultra high frequency currents, formed by the cylindrical flange of a disc-shaped cathode and the inner surface of a tubular cathode lead-in conductor axially aligned and radially spaced with respect to and around said cylindrical cathode flange, means supporting said cathode from the inner surface of the tubular cathode lead-in conductor, means connected to said cathode for conducting direct current from the cathode to the lead-in conductor, a flat resistance heater spiral near the cathode, and coaxially disposed means within said conductor for supplying heater current to the flat heater spiral.

PAUL HAAS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,805,626	Jordan	May 19, 1931
1,930,219	Zimber	Oct. 10, 1933
2,091,443	Heintz	Aug. 31, 1937
2,218,254	Wengel	Oct. 15, 1940
2,225,853	Baker et al.	Dec. 24, 1940
2,280,980	Samuel	Apr. 28, 1942
2,310,811	Schantl et al.	Feb. 9, 1943
2,335,818	Trumbull et al.	Nov. 30, 1943
2,353,742	McArthur	July 18, 1944
2,353,743	McArthur	July 18, 1944
2,367,331	Bondley	Jan. 16, 1945
2,421,039	Segerstrom, Jr.	May 27, 1947