

Aug. 22, 1950

V. L. RONCI ET AL
MOUNTING OF ELECTRODES IN ELECTRON DISCHARGE
DEVICES AND METHOD OF FABRICATION

2,520,016

Filed Oct. 15, 1946

2 Sheets-Sheet 1

FIG. 2

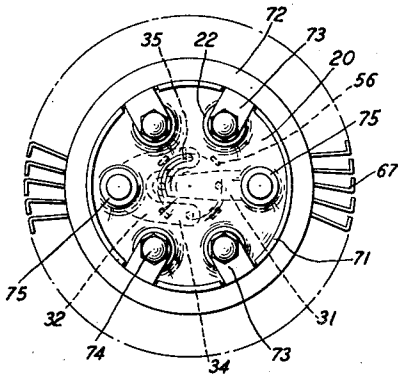


FIG. 1

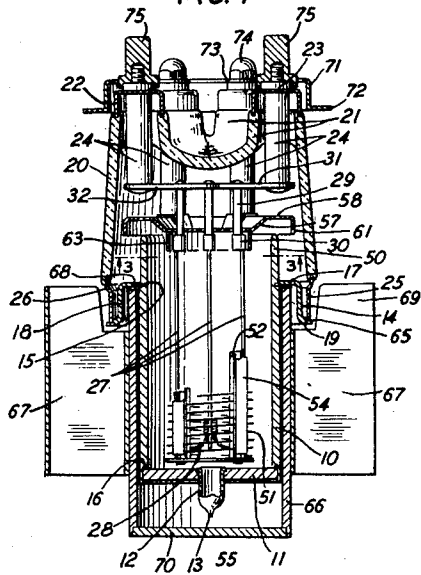


FIG. 4

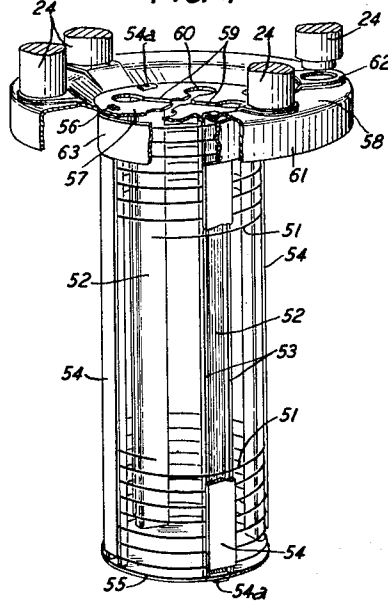


FIG. 3

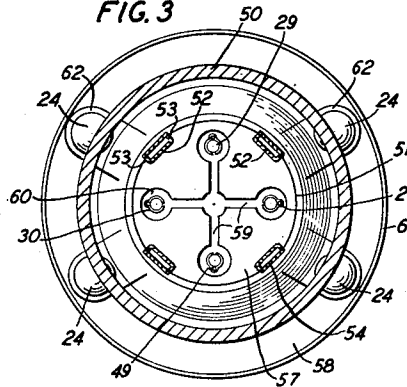
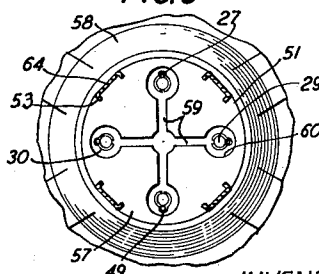


FIG. 5



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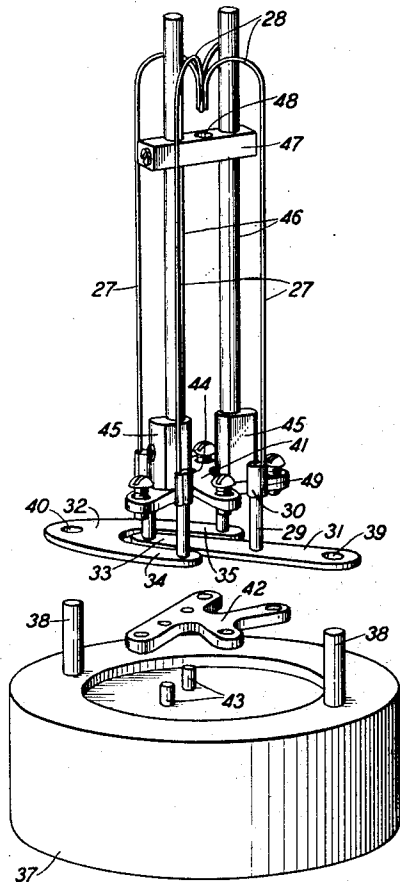


FIG. 8

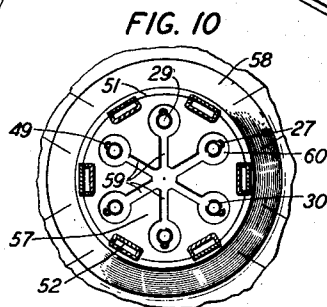
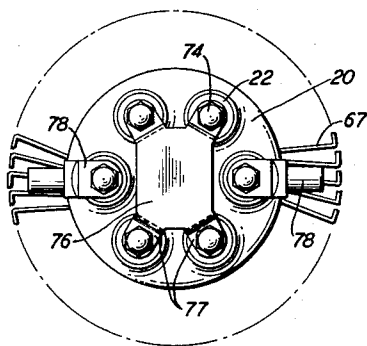


FIG. 10

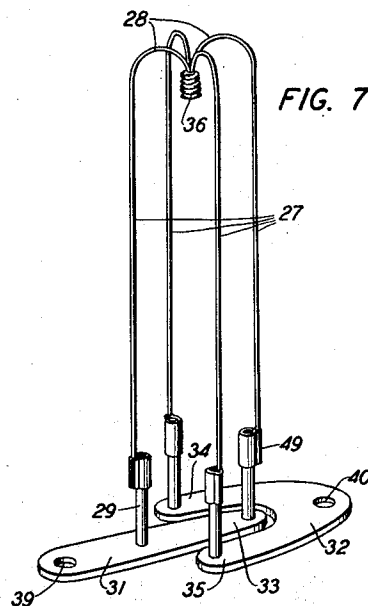


FIG. 7

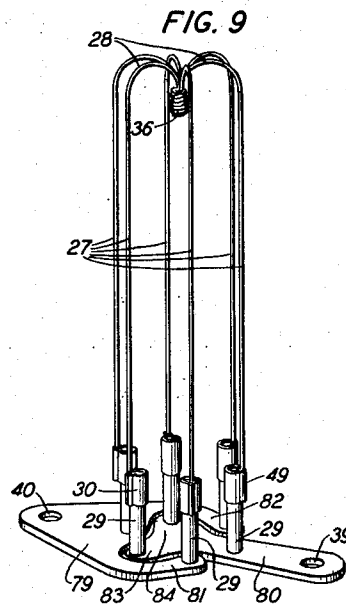


FIG. 9

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UNITED STATES PATENT OFFICE

2,520,016

MOUNTING OF ELECTRODES IN ELECTRON DISCHARGE DEVICES AND METHOD OF FABRICATION

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14 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices of the high power type for generating energy at relatively high frequency levels.

In high voltage communication transmitting systems employing electronic devices, considerable turbulent energy is dissipated as heat loss in the course of generation of the useful energy output of the devices. During operation, the heat energy imposes severe temperature strains on the internal electrodes so that mechanical stresses in the electrode assemblies are accentuated to such a degree that the electrical characteristics of the device may be materially altered or irreparable distortion occurs so that the device must be removed from service.

An object of the invention is to substantially eliminate mechanical stresses in the fabrication of the electrodes in electron discharge devices.

Another object of the invention is to prealign the components of the several electrode assemblies in the construction of the device.

A further object of the invention is to improve the mounting of fragile internal electrodes in high power discharge devices.

A still further object of the invention is to fabricate the filamentary cathode assembly so that deleterious temperature stresses are avoided during operation of the device.

Another object of the invention is to insure substantially absolute concentricity in the relationship of the internal electrodes with respect to the receptive surface of the anode of the device.

These objects are attained in accordance with features of this invention, in a particular embodiment, in an external anode type device or tube in which a hollow anode of large surface area forms a portion of the enclosing vessel and is joined to an insulating portion of the vessel supporting the internal electrodes, such as a filament and a control electrode, which are mounted on terminals extending from the insulating portion. Several of the main aspects of the invention are concerned with the mounting of these internal electrodes although certain refinements in the complete assembly are incorporated in the fabrication of the anode and insulating portions of the enclosing vessel.

The filament structure forms one feature of the invention whereby a strain-free mounting is realized and turbulent heat energy cannot alter the relationship of the filament with respect to the other electrodes. This is accomplished by mounting a plurality of filament strands in self-

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supporting relation from a pair of support arms which are premounted and held in accurate positions by clamping means during the fixing of the strands to the arms. During the pre-mounting, the strands are adjustably held in position and any misplacement or distortion of the strands can be easily detected and rectified before the assembly is completed. This method of fabrication eliminates mechanical stresses in the combined structure and, accordingly, the temperature changes encountered during operation will not exaggerate the initial strain effect and thereby change the symmetry of the strands with respect to the other electrodes. The pre-mounted assembly is secured rigidly on the assigned terminals of the device prior to removing the clamping means from the structure. The elimination of mechanical stresses either of the torsional or radial type prior to mounting the filament assembly in the device and, further, preventing strains from being set up in the fixation of the assembly of the terminals virtually inhibits the establishment of subsequent strains or stresses in the combined structure of the filament strands when heated to emission temperature during operation.

Another feature of the invention relates to the assembly of the control electrode or grid mounting in the device. This electrode, in the form of a wire helix of numerous turns, is mounted on a plurality of channel uprights secured to a metallic shield member having bent integral portions which may be readily adjusted during assembly of the grid on the mount and prior to attachment thereto, whereby accurate concentricity of the grid is assured and mechanical strains therein are eliminated. When the bent portions are adjusted to relieve strain and secure coaxial relation with respect to the cathode and anode, the grid is rigidly affixed to the mount.

A further feature involves the substantial shielding of the terminal extensions in the base of the vessel to protect the vitreous seals of the terminals from high temperature effects extant within the active portion of the device. This result is produced by forming restricted slots in the shield of the grid which clear the shield from contact with the filament assembly, while the shield forms a substantial barrier between the high temperature zone of the incandescent filament strands and the terminals in the glass portion of the vessel.

Another feature of the invention relates to the external terminal assembly of the grid for supplying the operating potentials thereto dur-

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ing operation. The internal grid structure is mounted on a plurality of spaced terminals extending from the glass stem of the vessel and these terminals are associated by an external terminal connector on the terminal end of the vessel and secured to the corresponding terminals of the grid structure, to provide a high efficiency connection for supplying high frequency voltage to the control electrode of the device.

Another feature of the invention relates to the fabrication of the metal and glass enclosing vessel portions to reduce the over-all length of the device and to provide a hermetically sealed joint between these portions. This is accomplished by securing a concentric flanged ring to the anode portion adjacent the inner rim thereof, the ring extending in a direction toward the outer end of the anode, and sealing a metallic sleeve on the glass portion or terminal base of the device to the ring to enclose the inner rim of the anode. This construction materially shortens the length of the device and increases the useful length of the cathode and grid electrodes in spatial relation to the anode surface. The metal ring seal also provides a construction in which the annealed glass stem is protected from intense heating effects during the final sealing operation so that strains are avoided in the glass stem. Furthermore, this construction permits the mounting of a heat radiator casing about the anode which efficiently dissipates heat energy losses in the anode and provides cooling of the ring seal and the terminals on the glass stem.

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

Fig. 1 is an elevational view in section, on a reduced scale, of one illustrative embodiment of this invention, showing the assembly of the internal electrodes in the device.

Fig. 2 is an end plan view of the device, on the same scale as Fig. 1, showing the terminal mounting of the internal electrodes and the configuration of the filament supports.

Fig. 3 is a sectional view, taken on the line 3-3 of Fig. 1, showing the grid mounting shield assembly and its relation to the multi-strand filament assembly.

Fig. 4 is a perspective view of the grid assembly with the shield support at the top.

Fig. 5 is a plan view of a modified arrangement for supporting the helical grid on the channel frame.

Fig. 6 illustrates in perspective the premounting assembly for the cathode structure to assure the distortionless character of the cathode, in accordance with a feature of this invention.

Fig. 7 is a perspective view of the filamentary cathode structure after completion of the assembly.

Fig. 8 shows in plan view a modified arrangement of the terminal end of the device.

Fig. 9 is a perspective view of a different filament supporting structure involving six strands, and

Fig. 10 illustrates in plan view the relationship between the six-strand filament structure and a modified shield arrangement for the grid associated therewith.

Referring to the drawing and particularly to Fig. 1, the invention is illustrated as embodied in an air-cooled high power electronic discharge device or vacuum tube having a current capacity

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rating in the range from 3 to 10 kilowatts and which may be utilized in generating high frequency energy in radio transmitter systems. The device, in the embodiment shown, is a triode having an anode, a control electrode and a filamentary cathode, all coaxially related, with the cathode and control electrode extending within the anode and being supported by a glass base portion sealed to the anode.

The anode is preferably formed of a copper sleeve or cylinder 10 with a copper closure plate or disc 11 sealed across one end. The disc is provided with an outwardly extending metal tubulation 12, which is sealed off at 13 after the device is completely assembled and evacuated to a low pressure, so that the discharge is of the pure electron type. The outer surface of the other end of the copper sleeve anode is reduced in diameter to provide a close fitting joint to a copper-plated steel ring 14. The base of the undercut portion and the recessed end of the sleeve are provided with internal grooves 15 and 16, respectively, to form pockets for preformed solder rings of high melting point, for example 37 per cent gold and 63 per cent copper. Smaller rings of solder are located around the inner and outer joints of the tubulation 12 on the closure. The assembly is placed in an oven supplied with hydrogen and heated to 1050° C., to braze the joints at the solder locations, thereby hermetically sealing the respective components together as a rigid unit. The ring 14 has an annular portion 17 projecting radially outward from the surface of the anode intermediate the ends thereof, an integral cylindrical portion 18 coaxially surrounding the anode and turned in a direction towards the closed end of the anode and a continuing terminating flange rim 19 extending outwardly parallel to the annular portion but of larger diameter. This assembly completes the anode portion of the device.

The internal electrodes, namely, the cathode and control electrode or grid, are insulatingly mounted in relation to the anode by being supported from a vitreous base portion or stem. This portion includes a molded "hard" glass cup member 20, preferably formed of borosilicate glass, of tapered configuration having a plurality, for example six, of integral tubular extensions 21 projecting from the closed end of the cup, these extensions being equally spaced in a circle around the base of the cup. The extensions are hermetically sealed to metallic cup terminals 22, preferably of "Kovar" alloy, which has about the same thermal coefficient as the glass to which the terminals are joined. The edge of each terminal is embedded in the outer rim of its respective tubular extension, to form large hollow terminals completely closing the base of the glass cup stem of the enclosing vessel of the device. A threaded button 23, of steel, preferably copper-plated, is brazed to the outer flat surface of each terminal and a similarly plated nickel post 24 is anchored concentrically within each cup by gold-copper solder brazing on the inner surface to extend parallel to the axis of the stem. Two oppositely disposed posts are slightly shorter than the remaining posts and all of them are provided with a reduced shoulder on the free end for mounting the electrodes rigidly within the stem. The outer surface of the cup terminals and the threaded buttons are silver-plated, by electrodeposition, to prevent corrosive oxidation of the metal surfaces of the terminals. A large diameter "Kovar" sleeve 25 is hermetical-

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ly sealed to the open end of the glass cup portion 20. This sleeve is formed with two concentric diameters to provide an annular curved shoulder 25 intermediate the ends of the sleeve, to strengthen the sleeve against warping under high temperature treatment during the sealing of the embedded or larger diameter end in the glass and the subsequent brazing seal of the smaller diameter end to the rim of the mounting ring 14. The completed glass stem is not sealed to the ring until the internal electrodes are mounted on the terminal posts.

One of the principal factors determining the efficiency of operation of the device with respect to power output is the spacial relation of the internal electrodes with the inner surface of the anode. Any variation in concentric symmetry between the surfaces of the multiple electrodes will materially affect the operating characteristics of the device. If distortion occurs in the internal electrodes, the symmetry of the respective electrodes is destroyed and the efficiency suffers. Since the anode is of large mass, the surface thereof will be concentric with the axis of the device provided the sealing operations to the stem or other portion of the enclosing vessel are performed in accordance with recognized manufacturing practice. However, the fragile character of the cathode assembly extending within the anode from the stem and the fine wire construction of the control electrode which concentrically surrounds the cathode and is equally spaced from the anode surface present problems of fabrication and assembly the solution of which generally determines the superiority of the device for consistent performance under high voltage operation in the high frequency field.

The effects of distortion most likely arise from temperature changes incident to operation since the device is primarily intended to generate large amounts of power at high voltages. Accordingly, the heat generated in the discharge space between the electrodes and the consequent thermal conditions of the internal electrodes as a result of this heating effect due to expansion and contraction necessarily will create warping or unequal strain in the electrode assemblies and this result is materially accentuated or aggravated if the electrode assemblies are inherently in a stressed condition due to mechanical forces. However, such forces may not be readily apparent during fabrication but are clearly exposed under high temperature operation.

One of the objects of this invention is to eliminate such distortion or stress in the internal electrodes of the device and this may be realized from the mounting methods and structural assembly of the cathode and grid electrode enclosed in the device, as hereinafter described. The cathode structure, in accordance with this invention, constitutes a departure from general practice in the method of mounting. By following the novel methods as set forth below, mechanical strains and stresses are avoided in the mounting in the device with the result that temperature changes will not alter the normal position of the cathode components and, due to the absence of mechanical distortion effects, the thermal changes inherent in the operation of the cathode will be incident and uniform in all the sections to the linear form of the cathode assembly. Similarly, the control electrode or grid assembly is constructed as a rigid cylindrical

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structure sufficiently braced to withstand necessary handling and mounted in a novel manner to avoid mechanical strains which would be aggravated by temperature changes to create unbalance in the symmetry of the electrodes. Since mechanical and thermal distortion are precluded in the fabrication of the internal electrodes, the symmetry thereof with respect to the anode surface will remain constant throughout the operating life of the device provided external shock does not alter the relationship. However, the effects of such shock also are substantially guarded against by the constructions of this invention.

The cathode structure involves a plurality of rigid filamentary strands 27, of heavy gauge tungsten or thoriated tungsten wire, and these strands are heated to emission temperature to supply copious electron flow toward the anode surface. These strands are formed with a long straight portion parallel to the anode surface and a bowed or curved end portion 28 for coupling all the strands together into a self-supporting skeleton framework. The strands, for example four in number, are equally spaced at 90-degree angles to form a box-shaped frame, thereby distributing the emission of electrons uniformly toward the anode surface. The straight ends are attached to metallic studs 29 of molybdenum by sleeves or clips 30 also of molybdenum, the studs projecting perpendicularly in spaced relation from a pair of oppositely disposed flat metallic supports or straps 31 and 32, shown in Fig. 2 of molybdenum, mounted on the short posts 24 in oppositely disposed relation in the stem. Strap 31 is a single arm member having the arm 33 projecting radially toward the axis while strap 32 is a double arm member having the arms 34 and 35 disposed on opposite sides of but spaced from arm 33 and lying in the same transverse plane. The bowed ends of the strands are joined in converging relation by a coiled tungsten wire sleeve 36 to rigidly hold the bowed ends together.

The method of mounting the cathode structure in the device so that mechanical strains and stresses are eliminated is illustrated in the pre-mounting assembly of Fig. 6. In accordance with a specific arrangement of this invention, the support straps 31 and 32 with the studs 29 brazed in the arms with the aid of a 63 per cent molybdenum—37 per cent cobalt solder having a melting point of 1365° C. are set in their interlaced relation on a circular jig or fixture 37 having oppositely disposed pins 38, to slidably fit the holes 39 and 40 in the mounting ends of the straps, the distance of the pins 38 in the fixture being accurately determined to correspond with the diametrical centers of the short posts 24 in the glass stem 20. A pair of multi-fingered clamps 41 and 42 are secured on opposite sides of the arms of the straps, in the position shown in Fig. 6, to lock the straps together while clearing the studs projecting from the arms. The bottom clamp portion 42 also engages a pair of spaced pins 43 in the recessed center of the fixture to correctly line up the mounting straps and prevent movement of the clamped assembly with respect to the pins 38. The recess in the jig also provides clearance for the bottom portion of the clamp which is below the plane of the straps extending across the fixture. The location of the studs 29 in the arms is determined by their relation to the radii of the clamps between the fingers, the studs on the arms 34 and 35 of strap 32 being centered between

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the pairs of fingers on opposite ends of the clamps and the studs on the strap 31 being centered between the mid fingers and a semi-circular cut-out portion 44 at the center of the straight edges of the upper clamp portion 41. The studs are then positioned at the corners of a rectangle in equal spaced relation and perpendicular to the clamps and holding fixture. The upper clamp portion is provided with a pair of integral sockets 45 which accommodate parallel rods 46 extending vertically from the jig and parallel to the axis of the assembly. A spacer bridging block 47 is adjustably mounted on the rods 46 in slidable relation thereto and is provided with a central aperture 48.

When the above assembly is completed, the molybdenum sleeves 30 are mounted on the studs, these sleeves being formed with an offset channel or socket 49 which is positioned on the outer circumference of the studs with respect to the rectangular location of the studs. The four filament strands 27, which have been accurately formed with their bowed ends, are mounted with their straight ends seated in the sockets 49 and the bowed ends converging in the aperture 48 in the bridging block 47. It is essential to determine exact lateral relation of the filament strands and unrestrained convergence of the bowed end in the preliminary mounting to be sure that mechanical deformation strains are not imposed on the strands in the mounting. This condition may be checked by sliding the bridging block 47 downwardly on the rods. If no deforming defects are present in the assembly the converging ends of the strands will be normally in contact at the apex of the structure. However, if strain is imposed on the strands due to irregular space relation, or improper alignment of the strands in the sleeves 30, such strains will be readily apparent when the block is displaced from the converging ends. After rectification of the faulty strand or strands, the block is restored to its engaging position with the bowed ends of the strands seated in the aperture 48.

Mechanical stress in the strands can also arise after the above procedure is followed, since the strands must be rigidly secured to the studs. The pressure force exerted during the fixation of the strands in the mounting may cause torsional or radial strain to be set up in the strands, but these effects are avoided, in accordance with a feature of the method of assembly of this invention. After the preliminary location of the filament strands in their arbor-like combination, each strand is separately welded or otherwise rigidly affixed to its respective stud and embracing sleeve, for example, by spot-welding the strands between the sleeves and studs. However, during this step of the method the bridging block 47 is lowered on the rods after each strand is welded in place, to determine whether the pressure force exerted by the welding electrodes has introduced any misalignment in the strand during welding. This is accomplished by releasing the block 47 from the convergent ends of the filaments and visually detecting whether the contact of the converging end of the specified strand has changed its position from normal relation to the other strands. It is evident that a slight variation in the collateral junction of the strand in the sleeve socket or channel 49 on the support strap of the mounting will be aggravated at the bowed end of the strand and this condition is readily apparent when the fixed strand is released from the spacer block at the top of the filament structure. When all the

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strands are welded to the studs on the straps and consecutive checking of the bowed ends shows that all the strands are in their assigned positions, the block 47 is removed along with the rods and the coiled sleeve 36 is welded around the converging ends of the strands at the apex of the assembly, to complete the fixation of the strands on the mounting straps.

The complete filament structure is removed from the jig 37 with the clamps intact and the whole unit is transferred to the glass stem 29 with the holes 39 and 43 in the straps aligned with the reduced shoulder ends of the oppositely disposed short posts 24 in the stem. When the straps are fitted on the posts, the reduced ends thereof are welded over the straps to rigidly affix the filament structure to the glass stem. After this operation is completed, the clamps are removed from the arms of the mounting straps 31 and 32.

Since the cathode structure is coaxially supported on the glass stem portion in relation to the axis and the periphery of the stem, the cathode strands will be uniformly spaced in collateral relation to the internal cylindrical surface of the anode portion of the vessel when the final seal is completed between the vessel portions. The relationship of the parallel strands of the filament assembly to the anode, as shown in Fig. 1, provides a structure in which the complete length of the strands is utilized in the operation of the device since the internal anode portion 50 extends into the glass stem portion to be in parallel relation to the anchored filament sections and thereby increases the useful receptive surface of the anode disposed opposite the electron emitting strands of the filament assembly. In order to achieve the highest efficiency in operation, the space relation between the cathode strands and anode must be constant and the mechanical strain-free assembly of the cathode structure in the device assures such constant spacial relation in view of the fact that thermal changes in the fabricated strands under high temperature conditions of operation will not affect the concentricity of the strands by torsional stresses or other forces. This is a result of eliminating mechanical stresses in the strands during assembly.

If the device is to operate as an amplifier or modulator, a control electrode is interposed between the emission source or cathode and the anode, to regulate the flow of electrons to the anode. Since the control electrode or grid is generally constructed of fine wire in the form of a helix, it is necessary to adequately support the grid in the device in relation to the other electrodes and at the same time to eliminate as much as possible any strains or stresses in the construction which might adversely affect the relationship of the grid with respect to the cathode and anode surfaces. In accordance with a feature of this invention the grid, in the form of the cylindrical wire cage 54, is wound in helical form of spaced lateral turns of wire, preferably of tantalum or molybdenum, since these metals have high tensile strength and are highly refractory so that the grid will withstand the high temperatures encountered in the operation of the device. The helical wire is wound on a mandrel of suitable diameter around four channel supports 52 equally spaced on the mandrel, the channels being mounted in position with their bent portions 53 level with the surface of the mandrel. After the winding is completed, overlying metallic strips 54 are superimposed on the helix in parallel relation to the

channel supports and the turns of the helix are rigidly secured between the channels and strips by welding along the edges of the strips disposed opposite the bent edges 53 of the support. The mandrel is removed and the cylindrical configuration of the grid is sufficiently strong to retain its shape as fabricated on the mandrel.

The channel supports are provided with linear extensions 54a on opposite ends which are integral continuations of the flat portions of the supports and form locking ears projecting into slots in the shields at opposite ends of the grid. One of these shields is a tantalum disc 55 which is provided with spaced slots in a circular boundary corresponding to the location of the ears 54a on the inner end of the grid structure, the ears fitting into the slots and being brazed by the molybdenum-cobalt high melting point solder. The ears 54a on the opposite end of the grid channels are fitted into similar slots 56, shown in Fig. 2, which are formed in a beveled platform portion 57 in a large diameter circular shield 58, shown in Fig. 3, formed of sheet molybdenum. The channel support ears 54a are brazed in the slots in the same manner as described above. The central platform portion of the grid shield is provided with diametrical intersecting slots 59 in the form of a cross with the upright supports 52 of the grid equidistantly spaced in a circle between the arms of the cross-shaped slot and outside the extension of the slot. The slots are terminated by circular openings 60 to correspond to and form clearance gaps around the studs 29 of the filament assembly. The rim 61 of the shield is turned at right angles to the surface and coaxially surrounds the platform 57. The annular valley portion of the shield between the rim and the platform is provided with oppositely disposed pairs of integral curved tabs 62 produced by punching the tabs from the sheet metal, the tabs being bent in offset relation on the reverse surface of the shield to lie parallel thereto. The positions of these tabs correspond to the location of the long posts 24 in the glass stem of the vessel.

The disc shield 55 forms a barrier between the anode and the bowed ends of the cathode assembly to protect the cathode from corona arcing in the high potential field within the closed end of the anode. The large diameter grid shield 58 forms a barrier between the high temperature zone of the active portion of the device and the hermetic seals of the terminals in the stem, to prevent fracture of the seals at the terminal joints. This protective function of the shield is enhanced by the substantially complete heat baffle extending across the diameter of the tube adjacent the terminals, the only direct path for the heat energy being through the restricted slots in the shield 58. The flanged rim 61 extends beyond the diameter of the anode portion 50 projecting into the stem and forms an electrostatic barrier across the gap between the high potential rim of the anode and the low potential cathode terminals, whereby arcing across this path is avoided. The anchoring clips 30 and studs 29 on the filament structure are also shielded from the high potential field of the anode by a short cylindrical shield 63 surrounding the grid supports adjacent the platform 57 and is welded to the grid cylinder.

Since the grid structure may be slightly eccentric with respect to the supporting shield 58 due to the soldering connections and may be similarly disposed with respect to the four an-

choring posts 24 in the stem, it is evident that direct connection of the grid structure to the posts would not be practicable if accurate concentricity is desired in the location of the grid between the cathode and anode. This problem is overcome by a method of assembly, in accordance with a feature of this invention, which rectifies minute eccentricity of the grid structure with respect to the rigid anchoring of the grid on the support posts in the stem.

The completed grid structure is assembled on the stem supporting portion in relation to the anchored central filament structure by adjusting the grid over the filament structure and by coordinating the slots 59 with the bowed filament strands so that the shield 58 can be lowered into the cup stem 20 when the shield has passed the strands. The enlarged openings 60 provide clearances for the anchoring studs 27, and the bent tabs 62 are in aligned relation to the posts 24 in the stem. The grid structure is held in this relation by a yielding clamp fixture, not shown, and concentricity of the cylindrical grid may be determined with respect to the filament structure and the axis of the stem. In the event that unbalance is found, the tabs 62 are bent to compensate for inequalities in the combined structure. After the various adjustments are made to accurately space the cylindrical grid around the filament structure, the reduced ends of the posts 24 are welded over the apertured tabs 62 to rigidly secure the grid structure in position on the stem. No further adjustment can be made after the shield is secured to the posts so that the grid is inflexibly mounted on the stem due to the rigid bracing anchorage of the tabs to the posts at the four points in the stem. Because the tabs are located in a relatively cool portion of the stem, and are equally distributed over the large area of the disc shield, any slight tensional strain in the rigid bent tabs cannot be aggravated to torsional stress by thermal effects and, accordingly, the concentricity of the grid structure remains constant throughout the operating life of the device.

The channel supports produce positive strength in the assembly of the grid so that thermal effects in the high temperature zone of the device will not adversely affect the configuration of the grid. The laterals of the helix are anchored to the supports only at the edges of the channels, to reduce the tensional strains on the individual laterals. The reinforcing strips 54 further provide an enclosed passageway longitudinally along the supports of the grid for dissipating the heat energy in the lateral exposed to the thermal effects of the incandescent cathode strands. Since the supports are intermediate the filament strands, they do not interfere with the emission of electrons to the anode surface.

In one form the grid may be constructed as shown in Fig. 5, in which the channel supports 52 are reversed so that the helix is secured to the flat portion 64 of the supports. The turns of the grid helix may be affixed to the portions 64 by brazing with the molybdenum-cobalt solder or these portions may be slotted and the winding applied in the slots after which the slots are swedged to lock the laterals to the supports.

The completion of the internal electrode assemblies on the cup stem prepares the combined unit for mounting within the cylindrical anode assembly. With the anode inverted, the grid and cathode assemblies are introduced into the cavity of the anode and the small diameter portion of

the sealing metal ring 25 is seated on an annular shelf 65 of the anode mounting ring 18 and co-axially surrounds the latter ring so that the inner end 50 of the anode is centrally spaced from the periphery of the rim 61 of the grid shield within the cup stem 20. The joint is hermetically sealed by brazing the ring 25 to the shelf 65 with a solder having the composition of 72 per cent silver and 28 per cent copper. The solder seal is protected from direct exposure to the high temperature zone within the anode by the cylindrical baffle wall 50 of the anode extending beyond the external joint and by the annular cooling gaps on opposite sides of the anode ring 14. This construction also reduces the over-all length of the device by the telescopic relation of the anode and stem mounting and results in utilization to the full extent of the inner anode surface and the length of the active portions of the internal electrodes. The sealing of the metal sleeve 25 to the flanged ring of the anode, which may be performed by high frequency is a hydrogen atmosphere, eliminates temperature strains in the completely annealed glass stem and also prevents intense heating of the internal electrodes and particularly the thoriated filament due to the purifying gas entrapped within the vessel during the high temperature sealing operation. Since the glass stem is rigidly mounted in relation to the anode, the internal electrodes will not vary in their spacial relation to the anode either co-axially or longitudinally so that the electrical characteristics of the device will be constant throughout the operating life of the device.

The intense heat generated in the device is dissipated by cooling air projected against a large radiator affixed to the anode. This radiator includes a cylindrical shell or casing 66 which fits over the anode 10 and is provided with large area fins 67 radiating out from the shell around the circumference. The shell is brazed to the anode, as by cadmium fusible metal, and the inner end extends into the annular space between the anode wall and the ring 14 where it is sealed to the annular portion 17 by a pre-formed solder ring 68. The fins 67 are formed to extend beyond the ring seal by portions 69 which provide physical protection of the seal and increase the radiation capacity of the cooling surface so that forced air flowing through the spaces between the fins is directed in a low impedance path toward the metal seal to maintain this seal relatively cool. The sleeve 66 extends beyond the sealed tubulation 12 on the end of the anode to form a cavity or housing which is closed by a cover member 70. The radiator and casing may be silver-plated to prevent oxidation.

The multiple terminals of the grid on the stem of the device are connected together by a silver-plated terminal ring conductor 71 which surrounds the outer periphery of the stem to enclose the "Kovar" seals 22, the conductor being provided with a flange seat 72 extending outwardly from the ring to surround the glass stem. A plurality of integral bent extensions 73 project inwardly from the opposite rim of the conductor and are attached to the four terminals of the grid by crown nuts 74. The cathode terminals are capped by solid metal contacts 75 which are also silver-plated. The ring conductor 71 provides a high frequency coaxial conductor connection for the grid which may be readily associated with a grounded shield casing or platform on which the device is supported with the flange 72

in contact with the casing to provide a large diameter connection for the high frequency energy. The configuration of the ring conductor also traps the forced air flowing upwardly from the radiator to pass around the terminals of the grid and cathode to absorb the heat dissipated in these components of the structure.

The association of the device in a different circuit set-up may be accomplished by the modification of the terminal connections, as shown in Fig. 8. In this arrangement, a terminal plate 76 is mounted over the central portion of the glass stem 20 and is provided with angular bent legs 77 which fit over the threaded buttons on the grid terminals and the plate is secured thereto by the crown nuts 74. In combination with this grid conductor the filament terminals are provided with transversely mounted terminal lugs 78. The operating voltage for the grid is supplied by a bus-bar clamp, not shown, connected to the plate 76.

The power output of the discharge device can be increased by enlarging the dimensions of the anode and increasing the number of filament sections in the cathode assembly. A modification of the cathode assembly and the support shield of the corresponding grid structure is shown in Figs. 9 and 10. The mounting for the six-strand filament assembly comprises two multi-armed plates or members 79 and 80. The plate 79 is substantially heart-shaped with a pair of inwardly curved arms 81 and 82 extending from the large dimension end of the member, each arm being provided with an upright stud 29 which is equally spaced 120 degrees from another stud in the solid portion of the plate, the latter stud being in line with the mounting opening 40 in the plate. The other strap 80 has an elongated arm portion provided with a mounting aperture 39 in one end and a pair of short divergent arms 83 and 84 projecting from the opposite end, the studs 29 in this strap extending from the short arms and being spaced 120 degrees from a similar stud at a central point of the long arm. The short arms 83 and 84 are located within the arms 81 and 82 of the heart-shaped strap with the studs 29 equally spaced in a circle so that the studs on one strap alternate with the studs on the other strap. These straps may be applied to the premounting fixture with the multi-fingered clamps, as shown in Fig. 6, to assemble the six-filament strands to the studs and produce the strain-free assembly, as heretofore described.

The grid shield 58, as shown in Fig. 10, associated with the six-strand filament structure, is provided with six slots 59 to clear the strands and the channel supports 52 of the grid helix 51 are also increased so that the supports are equally spaced between the strands of the filament structure.

While specific detailed constructions in accordance with this invention have been set forth above, it is, of course, understood that various modifications may be incorporated in the device and the manner of assembly without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a vessel having an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said vessel and having posts projecting within said glass portion, a multi-strand filament assembly having the strands converging toward the axis at one end.

and a pair of arm members supporting the other ends of said strands in coaxial spaced relation to said anode, said arms extending in coplanar relation between said strands and said posts and one of said arm members having portions encompassing a portion of the other of said arm members.

2. An electron discharge device comprising a vessel having an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said vessel and having posts projecting within said glass portion, a multi-strand filament assembly having portions of the strands at one end bowed toward the axis, a pair of arm members supporting the other ends of said strands in coaxial relation to said anode, said arm members extending perpendicularly in a single plane between said strands and a pair of oppositely disposed posts, one of said arm members having portions encompassing a portion of the other of said arm members, a grid electrode interposed between said strands and the inner surface of said anode, and a disc shield supporting said grid electrode having a central portion closely surrounding one end of said strands and an outer portion secured to the remaining posts in said glass portion.

3. An electron discharge device comprising an envelope including an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said envelope and having posts projecting within said glass portion, a multi-strand filament assembly having parallel portions and bowed end portions, a pair of supporting arms secured to a pair of oppositely disposed posts in said glass portion and connected to said parallel portions, said bowed portions being joined together, a grid interposed between said strands and the inner surface of said anode, a disc shield supporting said grid electrode and having a central portion closely surrounding one end of said strands, and integral projections offset from the surface of said shield attached to a plurality of said posts in said glass portion.

4. An electron discharge device comprising an external anode portion and a glass portion sealed thereto, a plurality of terminals extending from one end of said glass portion, a multi-strand filament assembly including parallel portions and converging bowed portions tied together, a pair of arms connected to a pair of oppositely disposed terminals, said parallel portions being joined to said arms in groups, a grid electrode interposed between said strands and the inner surface of said anode, a disc shield supporting said grid electrode having integral projections secured to the remaining terminals in said glass portion, and an external metallic connector adjacent the terminal end of said device and having portions attached to the terminals corresponding to the grid shield connections.

5. An electron discharge device comprising an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said glass portion and having support posts projecting within said glass portion, a multi-strand filamentary assembly including parallel portions and curved portions at one end commonly joined together, a pair of arms supporting said parallel portions from a pair of oppositely disposed posts on each arm, a cylindrical grid within said anode, and a disc shield supporting said grid having bent portions secured to the remaining posts in said glass stem, said shield having centrally disposed cross-shaped slots forming clearance paths equally spacing said

shield about the individual strands of said filamentary assembly adjacent said support posts.

6. The method of mounting a grid electrode concentrically about a filament structure in a discharge device, comprising winding a helical wire on spaced supports, attaching said supports to a disc shield at one end having a central slotted portion and bent portions adjacent the periphery thereof, threading said slotted portion over said filament structure to surround said structure by the grid electrode, adjusting said bent portions in relation to terminal posts in said device to concentrically locate said grid electrode with respect to the filament structure, and attaching said bent portions to said posts.

7. The method of mounting a grid electrode concentrically about a filament structure in a discharge device having terminal posts, comprising winding a helical wire on channel supports disposed on a mandrel, securing metallic strips to said wire parallel to said supports with the turns of wire between said strips and the edges of said supports, removing the assembly from the mandrel, affixing said supports to a metallic disc having integral ears bent parallel to the surface of said disc, mounting said grid electrode around the filament assembly with said ears in contact with a plurality of spaced terminals in said device, adjusting said ears with respect to said terminals to center said grid electrode coaxially about said filament structure, and securing said ears to said terminals.

8. An electron discharge device comprising an enclosing vessel including a cup-shaped anode portion and a glass cup portion having terminals for a plurality of internal electrodes extending into said anode portion, a flanged metallic ring secured to said anode portion adjacent the open end thereof, the flange portion of said ring extending coaxially in a direction toward the closed end of said anode, and a metallic sleeve sealed to the rim of said glass cup portion, said sleeve concentrically surrounding the open end of said anode portion and the major portion of said ring, and the free edge of said sleeve being sealed to the outer rim of said flange portion.

9. An electron discharge device comprising an enclosing vessel including a cup-shaped anode portion and a glass cup portion having terminals for a plurality of internal electrodes extending into said anode portion, a metallic ring having an inner annular portion joined adjacent to the open end of said anode portion, a cylindrical continuing portion spaced from the outer surface of said anode portion and extending in a direction away from the open end of said anode portion and an outwardly turned flange rim substantially parallel to the annular portion but of larger diameter, a metallic sleeve sealed to the rim of said glass cup portion, said sleeve concentrically surrounding the open end of said anode portion and the major portion of said ring, and means sealing said sleeve to said flange rim.

10. An electron discharge device comprising an enclosing vessel including a cup-shaped anode and a glass cup portion having terminals for a plurality of internal electrodes extending into said anode, a flanged metallic ring secured to said anode adjacent the open end, the flange portion extending coaxially in a direction towards the closed end of said anode, a metallic sleeve sealed to the rim of said glass cup portion, said sleeve concentrically surrounding the open end of said anode and the major portion of said ring, means sealing said sleeve to said flange ring, a radiator

casing enclosing said anode having a portion extending between said anode and said flange ring, and radial fins secured to said casing, said fins having portions surrounding said flange ring.

11. An electron discharge device comprising an enclosing vessel having a stem portion at one end, a plurality of conducting terminals extending from said stem, a multistrand filament assembly within said vessel having parallel portions and bowed end portions, a pair of coplanar metallic arms, one of said arms having portions encompassing a portion of the other of said arms, said parallel portions being connected to said arms in alternate order, each of said connections on one arm being equidistant from the neighboring connections on the other arm, said bowed portions being joined together at a central point, and an anode coaxially surrounding said filament assembly.

12. An electron discharge device comprising an enclosing vessel having a stem portion, a plurality of rigid terminals extending from said stem, a filament assembly within said vessel having four parallel strands terminating in inwardly bowed portions tied together at the axis of said assembly, a pair of coplanar metallic arms projecting transversely from said terminals toward said strands and supporting said parallel strands in pairs, the joints of said strands at said arms and the common junction being collaterally preadjusted to eliminate mechanical stresses due to mounting whereby temperature strains are avoided, and an anode mounted in surrounding relation to said filament assembly.

13. An electron discharge device comprising a vessel having an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said vessel and having posts projecting within said glass portion, a multistrand filament assembly having ends converging toward the axis, and a pair of nested arm members supporting the other ends

of said strands in coaxial space relation to said anode portion, said arm members extending in a single plane between said strands and said posts.

14. An electron discharge device comprising a vessel having an external anode portion and a glass portion sealed thereto, a plurality of rigid terminals extending from one end of said vessel and having posts projecting within said glass portion, a multistrand filament assembly having portions at one end bowed toward the axis, a pair of arm members supporting the other ends of said strands in coaxial relation to said anode, said arm members extending perpendicularly in a single plane between said strands and a pair of oppositely disposed posts and a portion of one of said arm members being positioned within portions of the other of said arm members, a grid electrode interposed between said strands and the inner surface of said anode, and a disc shield supporting said grid electrode having a central portion closely surrounding one end of said strand and an outer portion secured to the remaining posts in said glass portion.

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