Oct. 30, 1934. L. A. GEBHARD 1,978,424

HIGH POWER DEMOUNTABLE ELECTRON TUBE

Filed March 14, 1933 2 Sheets-Sheet 1

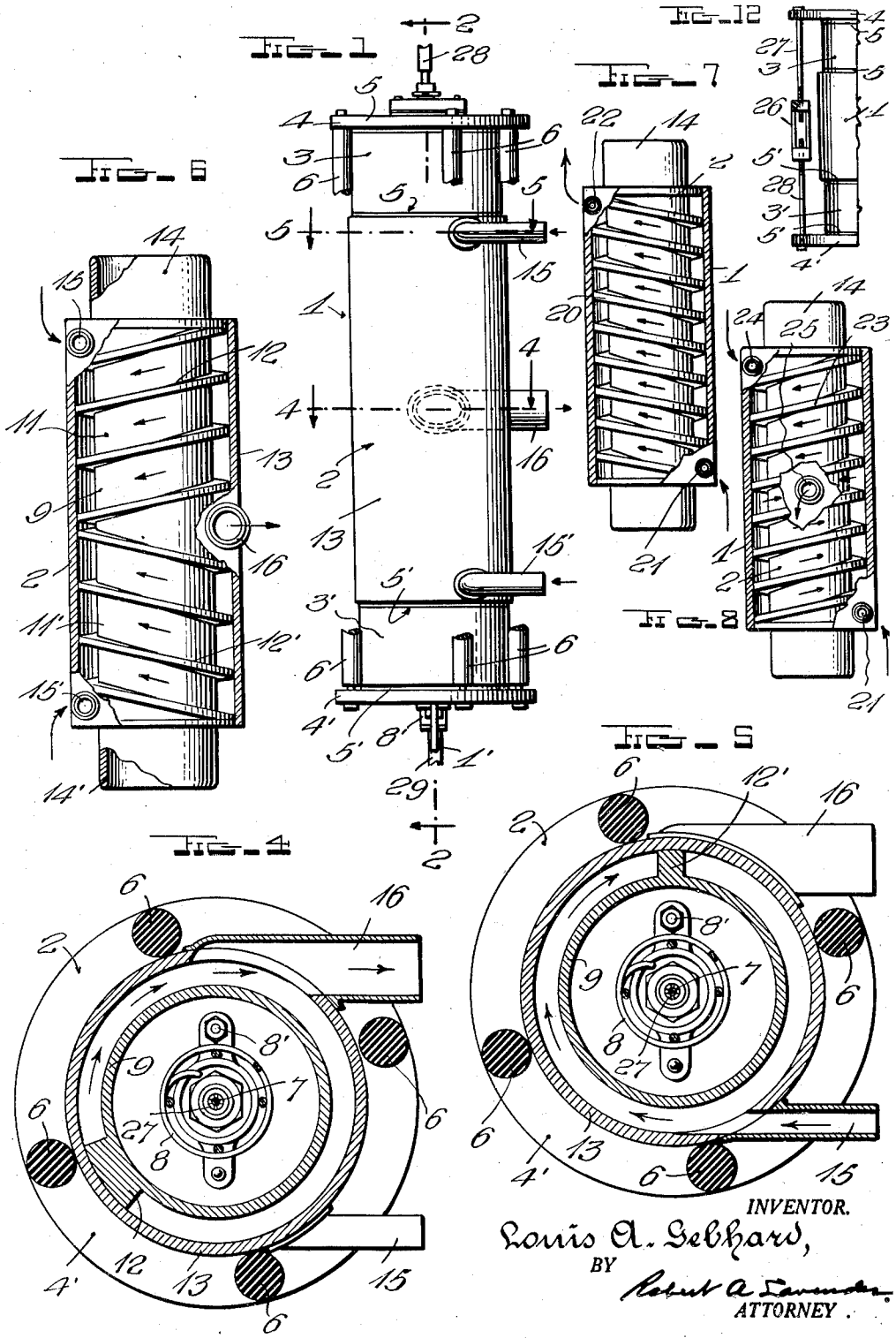

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FIG. 2

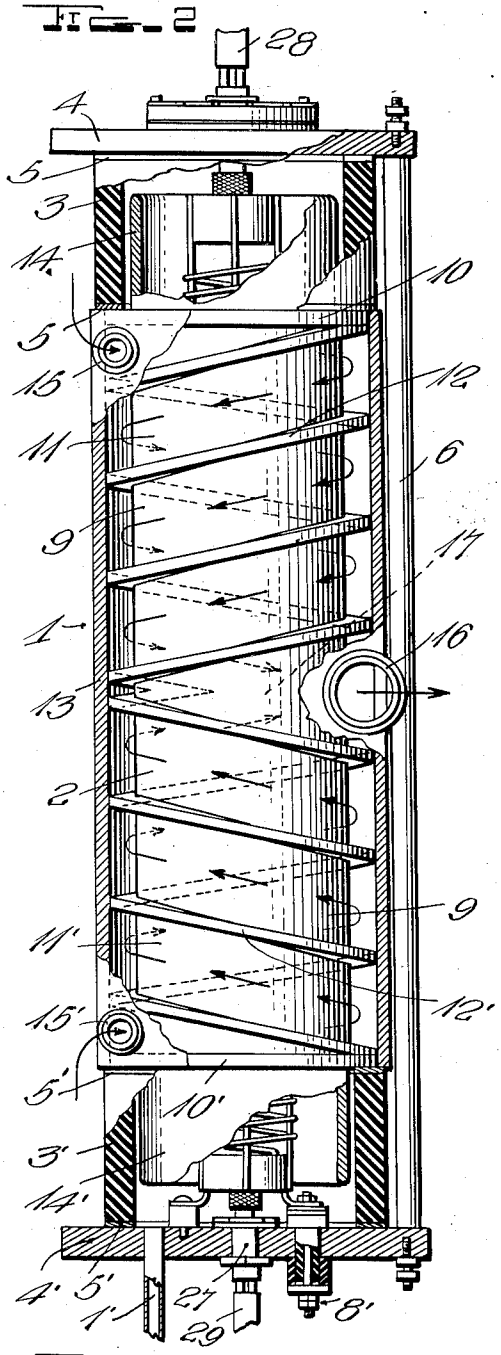


FIG. 3

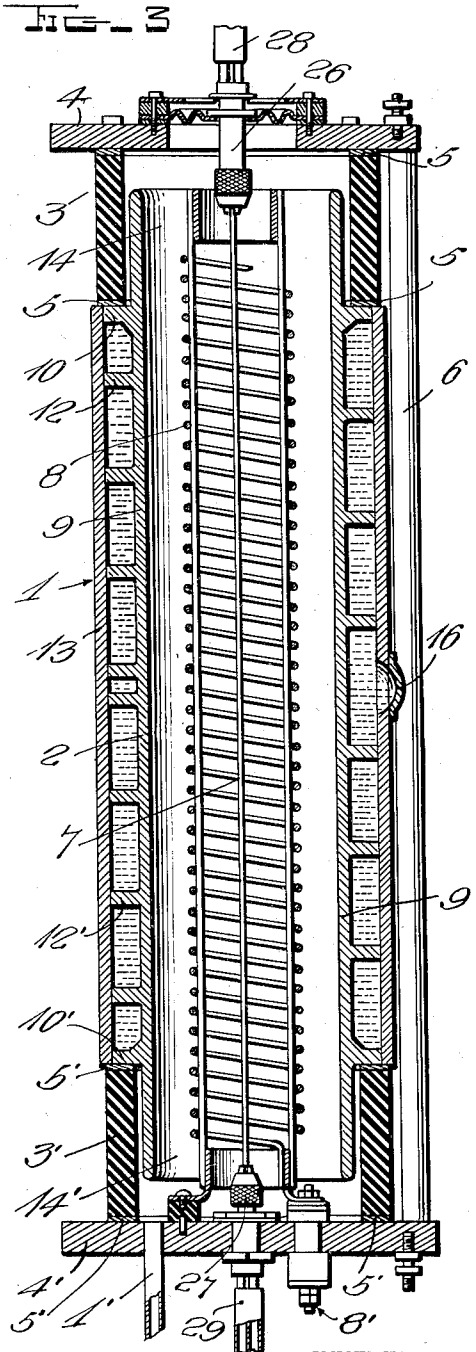


FIG. 9

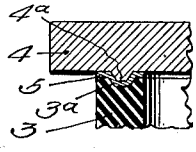


FIG. 10

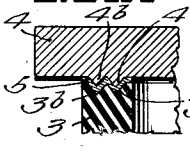
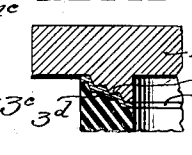


FIG. 11



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Patented Oct. 30, 1934

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UNITED STATES PATENT OFFICE

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HIGH POWER DEMOUNTABLE ELECTRON TUBE

Louis A. Gebhard, Washington, D. C.

Application March 14, 1933, Serial No. 660,708

10 Claims. (Cl. 250—27.5)

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

My invention relates broadly to high power demountable electron tubes and more particularly to an anode cooling system for demountable electron tubes.

One of the objects of my invention is to provide a construction of high power fluid cooled demountable electron tube in which the elements of the tube may be replaced when such elements have deteriorated, without discarding the entire tube.

Another object of my invention is to provide a construction of high power tube having a cylindrical anode provided with means for insuring the continued cooling of the tube during operation, the coolng means being of such construction that the demountable characteristics of the tube are not impaired.

Still another object of my invention is to provide a simplified construction of high power demountable electron tube having an anode which forms the envelope of the tube and wherein the anode is provided with a fluid cooling jacket constructed to provide maximum surface contact between a cooling medium and the exterior surface of the anode for maintaining the temperature of the anode relatively low under conditions of continuous operation.

A further object of my invention is to provide a construction of demountable electron tube including a fluid cooled anode structure wherein the exterior surface of the anode structure is provided with a spirally formed heat radiating fin which provides, with a coacting jacket, a spiral path around the anode for the passage of cooling fluid operating to dissipate heat due to electronic bombardment of the anode in the demountable tube.

A still further object of my invention is to provide a construction of high power electron tube which includes a tubular anode serving as the evacuated envelope for the tube, and wherein the exterior surface of the tubular anode is provided with a spirally disposed fin extending between flanges formed on the anode and coacting with a surrounding jacket for providing a spiral path for the passage of cooling fluid in surface contact with the exterior of the anode for insuring continuous cooling of the anode under conditions of electronic bombardment.

Another object of my invention is to provide a compact construction of high power demountable electron tube in which the envelope for the tube is constituted by an anode having fluid cooling passages formed adjacent the exterior surface of the anode for continuously dissipating heat generated under conditions of electronic bombardment.

Still another object of my invention is to provide a construction of cylindrical anode for an electron tube in which the exterior surface of the anode is provided with fluid cooled passages which are spiralled from opposite ends of the anode to the center thereof for the introduction of cooling fluid adjacent opposite ends of the anode and the discharge of the cooling fluid adjacent the center of the anode for effecting maximum heat dissipation from the anode.

A further object of my invention is to provide a construction of fluid cooled high power demountable tube in which the distribution of cooling fluid in contact with parts of the tube is such that uniform cooling over the entire area of the tube may be obtained for avoiding unequal expansion of parts with the resulting tendency for loss of vacuum in the demountable tube.

Other and further objects of my invention reside in the construction of the fluid cooled demountable electron tube as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a side elevation of the high power tube of my invention with the tension members, which maintain the parts of the tube in assembled relation, broken away to more clearly illustrate the tube structure; Fig. 2 is a central vertical longitudinal section through the tube taken on line 2—2 of Fig. 1 with certain of the parts illustrated in side elevation; Fig. 3 is a central vertical longitudinal section through the assembled tube structure taken on line 2—2 of Fig. 1; Fig. 4 is a horizontal sectional view through the tube structure taken on line 4—4 of Fig. 1 and illustrating the discharge port for the cooling fluid; Fig. 5 is a transverse sectional view taken on line 5—5 of Fig. 1 and showing the arrangement of ports for the introduction of cooling fluid into the anode structure; Fig. 6 is a side elevational view of the anode structure with parts broken away and illustrated in section; Fig. 7 is a side elevational view of a modified form of anode structure with parts shown in cross section;

Fig. 8 is a side elevational view of a further modified form of anode structure for a fluid cooled electron tube constructed in accordance with my invention; Figs. 9, 10 and 11 illustrate modified forms of gas tight joints which may be used for insuring a gas tight closure within the tube of my invention; and Fig. 12 illustrates a schematic form of insulated turn-buckle device which may be used in compressing the end plates upon the ends of the insulated sleeves which are secured over the tubular anode structure.

The demountable electron tube of my invention employs a replaceable filament structure where the filament is normally supported in expansible and contractible screw chucks carried in opposite ends of the tube which enable a new filament to be introduced in the tube upon disassembly of the tube after the destruction of the filament. The details of the structure by which the filament may be replaced have been set forth more fully in my

copending application Serial No. 660,707, filed March 14, 1933, entitled Demountable electron tube. The closure for the tube is formed by a cylindrical anode having removable end portions which are normally secured over opposite ends of the anode under compression and the closure maintained air tight and evacuated from time to time as may be required by any suitable vacuum pump. The demountable parts of the tube are provided with suitable gaskets at the joints therebetween by which vacuum may be more readily maintained within the chamber formed by the tubular anode. The anode employed in the tube structure of my invention is tubular in form and has a spirally disposed fin on the surface thereof extending between flange members adjacent opposite ends of the anode. A cylindrical sleeve is disposed over the spirally formed fin and coacts therewith to form a fluid cooling passage for the circulation of cooling fluid around the anode. The fluid may be introduced at the end of the passage adjacent one end of the anode and discharged at a point opposite the other end of the anode, or the spirals may be oppositely directed toward each other and the fluids introduced at points adjacent the ends of the spiral passages formed on the anode and directed toward the center of the anode where it is discharged.

The structure of tube of my invention is highly compact, which is very desirable in an electron tube system used on high frequencies since distributed capacities are thus reduced to a minimum and operation improved. Good cooling must be present in a demountable vacuum tube otherwise the temperature of the parts will rise and impair the tightness of the air tight joints.

Referring more particularly to the drawings, the closure for the tube is formed by a tubular anode 2 having a jacket 1 concentrically disposed about a portion of the anode as will be more fully understood by reference to the drawings. The anode 2 is supported between insulators 3 and 3' and end plates 4 and 4'. Gaskets are provided at 5 and 5'. The whole is held together by longitudinal insulating tension members 6. The filament is shown at 7, the grid at 8, grid terminal at 8' and outlet to the vacuum pump at 1'. The anode of the tube consists of an inner cylindrical member 9 having shoulders 10 and 10' which engage with gaskets 5 and 5'. Cut into the surface of 9 are two spiral grooves 11 and 11' starting at the shoulders 10 and 10' respectively and meeting at the center. The raised portion or walls 12 and 12' are part of the anode structure 2. The structure between the shoulders 10 and 10' is enclosed in an outer cylinder 13. A liquid tight joint is made between the ends of 13 and shoulders 10 and 10' by soldering, brazing or welding. The ends 14 and 14' of the anode 2 extend beyond shoulders 10 and 10' respectively as described in my copending application. Inlets for the cooling liquid are provided at 15 and 15' at the outer ends of the spiral grooves. An outlet is provided at 16. The spiral grooves are arranged so that the cooling liquid as it enters the structure passes around the anode in the same direction, meeting at the center still in the same direction. The two paths of the liquid combine and pass through the outlet 16 except for a small portion which passes around the center of the anode and through a gap 17, as shown in Fig. 2, between the central ends of the walls 12 and 12'. The arrows of Fig. 2 show the path of the cooling liquid. Inlets 15 and 15' and outlet 16 are fastened to the outer cylinder 13 by soldering, brazing or welding so as to make a liquid tight joint. These inlets and outlets are arranged so that the cooling liquid connections come from the same direction. This makes for greater compactness and ease of connection to the insulating hose coil. The area of the outlet 16 is equal to the sum of the areas of 15 and 15' so as to provide uniform liquid flow.

The cooling of the anode in this arrangement is very efficient due to the large surface area in contact with the cooling liquid. In addition there is substantial radiating surface provided by walls 12 and 12'. These walls are part of cylindrical member 9 and the heat is readily conducted through the metal. The water being a less efficient conductor is allowed a great area of contact. Thus the amount of heat which can be conducted away with a safe operating temperature of the cooling liquid and of the anode per inch length of tubes having the same diameter, is greater in this construction than it is in tubes using just a simple inner cylinder for a cooling surface. By arranging the cooling liquid to enter the structure at a point near the air tight joints the tightness of these joints is assured. Passing the cooling liquid around the anode in the same direction prevents excessive turbulence at the outlet 16. This permits greater flow of the cooling liquid for the same pressure drop in the system or the less pressure drop for the same flow. Improved cooling also ensues due to the reduction of turbulence.

While a preferred form of the arrangement has been described, obviously certain modifications are possible. For instance, a single spiral covering the full length of the cooling surface of the anode may be used with cooling fluid entering at one end and discharging at the other end as shown in Fig. 7. This modification is not as desirable as the one described, in that the air tight joint adjacent to the outlet is subjected to a much higher temperature than that adjacent to the inlet, the cooling liquid being heated in its passage through the tube. The spiral element which forms the fluid cooling passage in the structure of tube shown in Fig. 7 has been designated by reference character 20. The inlet for the cooling fluid in this arrangement is shown at 21 while the outlet is represented at 22. The direction of flow has been represented upwardly. A single continuous spiral with inlets at both ends and an outlet at the center may be used as shown in Fig. 8, but increased turbulence will result reducing cooling efficiency. The structure of Fig. 8 has been shown as including the spiral element 23 connected with the outer surface of anode 14 and coacting with jacket 1 to form a spiral passage for the cooling fluid which is uniform throughout the length of the passage. The inlet port 21 provides means for introducing cooling fluid at one end of the spiral passage. The inlet port 24 provides means for introducing cooling fluid adjacent the other end of the passage. The center discharge port 25 is disposed midway of the spiral passage and provides a discharge means for the cooling fluid without a reduction in the cross sectional area of the cooling fluid passage and accordingly without increased turbulence which normally results in the reduction of the cooling efficiency of the tube. This constitutes a substantial improvement over the spiral arrangement of passages illustrated in Fig. 7. Instead of making walls 12 and 12' integral with 9, they may be made separate and soldered, brazed or welded to cylindrical member 9. Unless a good joint results, however, the

thermal conductivity at the joint will be poorer and cooling efficiency of the arrangement will be less.

The filament 7 which is removably mounted within the tube is supported between screw chucks 26 and 27, each of which are fluid cooled by fluid inlet and discharge connections illustrated at 28 for chuck 26 and at 29 for chuck 27.

Throughout the several assembly views of the tube of my invention I have illustrated gaskets at each of the joints which are placed under compression for preventing the leakage of gas. To simplify the illustration of the invention, these gaskets have been illustrated schematically in the assembly views. However, I desire that it be understood that in practice the joints are formed with coacting faces establishing a serpentine course through the joint which substantially prevents undesirable leakage and provides a gas tight seal. Fig. 9 shows end plate 4 provided with an annular projection 4*a* which fits into a coacting annular recess 3*a* in the insulator 3. The gasket 5 which is disposed therebetween provides a substantial seal against the leakage of gas. Fig. 10 shows a modified construction in which end plate 4 is provided with a pair of concentric ribs depending from end plate 4 as illustrated at 4*b* and 4*c*. These ribs fit into coacting annular recesses 3*b* and 3*c* in insulator 3. A gasket 5 which is disposed between the ribs and the coacting recesses is deformed out of plane for establishing a gas tight seal. Fig. 11 shows a further modified form of seal in which end plate 4 has an annular projection 4*d* thereon having an echelon or offset annular face. The insulator 3 is provided with a coacting face which is offset in steps or echelon formation as represented at 3*d*. The gasket 5 disposed between the echelon faces 4*d* and 3*d* serves to prevent seepage of gas between the joints. As I have pointed out any one of the types of joint illustrated, or any other form of joint may be used for insuring a gas tight closure within the anode structure.

It will also be understood that the tension members 6 have been illustrated schematically for the purpose of simplifying the illustration and that in practice I employ any suitable arrangement of tension adjusting means for compressing the end plates 4 and 4′ against the gaskets 5, insulator 3, gaskets 5′ and insulator 3′, and against the ends of the anode 1. One form of tension adjusting means has been illustrated in Fig. 12 where a turn-buckle of suitable insulation material 26 engages the screw threaded members 27 and 28, extending through the end plates 4 and 4′. Adjustment of turn-buckle 26 permits the required tension to be placed upon the assembled parts of the tube for insuring a gas tight closure. A suitable tool engaging surface may be provided on the insulated turn-buckle to enable the turn-buckle to be properly adjusted. Other forms of tension means may be employed and by the illustration in Fig. 12, I do not intend my invention to be limited to the particular form of tensioning means shown.

The arrangement of cooling system for the anode by which fluid at low temperature is introduced at each end of the anode and the discharge fluid which has absorbed heat generated by electronic bombardment and is subsequently discharged at the center of the anode, insures uniform expansion of parts adjacent opposite ends of the tube and thereby enables a vacuum to be maintained in the tube without excessive loss.

While I have described my invention in one of its preferred embodiments I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalty thereon or therefor.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A demountable electron tube comprising a cylindrical anode, cover members for said anode insulatingly mounted at each end thereof, means for removably mounting electrodes within said anode and between said cover members, a spirally disposed continuous strip carried by said anode, a cylindrical jacket coaxial with said anode with the inner wall thereof connected with the outer periphery of said strip for forming a spiral passage for cooling fluid connected with the surface of said anode.

2. A high power demountable electron tube comprising a tubular anode having an annular flange adjacent each end thereof, an insulated sleeve disposed over each end of said anode adjacent the flanges thereon, end plates extending across said insulated sleeves, tension members interconnecting said end plates for binding said end plates, sleeves and anode under pressure for forming a substantially gas tight chamber, electrodes removably mounted within said chamber, a spirally disposed strip formed on the exterior wall of said anode intermediate said flanges, a jacket concentrically disposed about said anode and extending over said spirally disposed strip and defining a spiral passage for cooling fluid around said anode, and fluid inlet and discharge connections for said jacket.

3. A high power demountable electron tube comprising a tubular anode having an annular flange adjacent each end thereof, an insulated sleeve disposed over each end of said anode adjacent the flanges thereon, end plates extending across said insulated sleeves, tension members interconnecting said end plates for binding said end plates, sleeves and anode under pressure for forming a substantially gas tight chamber, electrodes removably mounted within said chamber, a wall member extending between the flanges on the exterior wall of said anode and defining a spiral passage along the length of said anode, a jacket secured over said flanges and extending over said wall member and connected with the peripheral edges thereof, and fluid inlet and discharge connections at opposite ends of said jacket for insuring a continuous circulation of cooling fluid over the exterior surface of said anode directly adjacent the interior surface thereof which is subjected to electronic bombardment.

4. A high power demountable electron tube comprising a tubular anode having an annular flange adjacent each end thereof, an insulated sleeve disposed over each end of said anode adjacent the flanges thereon, end plates extending across said insulated sleeves, tension members interconnecting said end plates for binding said end plates, sleeves and anode under pressure for forming a substantially gas tight chamber, electrodes removably mounted within said chamber, a strip disposed edgewise on the exterior surface of said anode and extending in a spiral path between the said flanges on said anode, a cylindrical

jacket extending coaxial with said anode, the inner wall of said jacket being connected with the periphery of said strip and defining a spiral passage for cooling fluid along the length of said anode, a fluid inlet connection adjacent the flange at one end of said jacket and a fluid discharge connection adjacent the flange at the opposite end of said jacket.

5. A high power demountable electron tube comprising a tubular anode having an annular flange adjacent each end thereof, an insulated sleeve disposed over each end of said anode adjacent the flanges thereon, end plates extending across said insulated sleeves, tension members interconnecting said end plates for binding said end plates, sleeves and anode under pressure for forming a substantially gas tight chamber, electrodes removably mounted within said chamber, a strip integrally connected with the outer wall of said anode and disposed in a spiral path between the flanges on said anode, a jacket disposed over said flanges and over said spiral strip therebetween, fluid inlet connections extending into said jacket at opposite ends thereof and adjacent the flanges thereon, and a fluid discharge connection disposed substantially central of said jacket for discharging cooling fluid passing toward the center of said jacket from the inlet connections on opposite ends thereof.

6. A demountable electron tube, a tubular anode, end plates for said tubular anode, means insulatingly connecting said end plates with the ends of asid tubular anode, compression means for maintaining said end plates in assembled relation with said tubular anode, electrodes removably mounted concentrically within said tubular anode and between said end plates, an annular flange adjacent each end of said anode, a strip member thermally connected with the exterior wall of said anode and extending spirally in a clock-wise direction from the flange at one end of said anode to the center of said anode, a strip member thermally connected with the exterior wall of said anode and extending in a counterclock-wise direction from the other of said flanges toward the center of said anode and interconnected with the end of the aforesaid strip, a jacket extending between said flanges and surrounding said spirally arranged strips, a fluid inlet connection extending through said jacket adjacent each end thereof for delivering cooling fluid to the spiral passages surrounding said anode, and a fluid discharge connection adjacent the center of said jacket in a position at which said spiral strips meet for discharging cooling fluid from said jacket.

7. A high power demountable tube comprising a tubular anode, a closure for each end of said anode, electrodes removably mounted within said closure concentrically within said anode, a flange connected with the exterior wall of said anode adjacent each end thereof, a jacket extending between said flanges, a member disposed between the inner wall of said jacket and the outer wall of said anode for defining a passageway for cooling fluid around said anode, fluid inlet connections for said jacket adjacent opposite ends of said passageway and a fluid discharge connection for said jacket disposed centrally of said passageway.

8. A high power demountable electron tube comprising a cylindrical anode, an annular flange formed on said anode adjacent opposite ends thereof, an insulated sleeve concentrically disposed over each end of said anode and abutting with the annular flange thereon, end plates extending across the ends of said insulated sleeves, means for maintaining said end plates, said sleeves and said anode under longitudinal compression for providing a substantially gastight chamber within said anode, a multiplicity of removable electrodes mounted within said chamber, a jacket disposed concentrically about said anode and connected with the flanges adjacent the opposite ends thereof, a strip member thermally united with the exterior surface of said anode and extending in a spiral path between said flanges and connected at its exterior periphery with said jacket for defining a spiral path around said anode, fluid inlet connections adjacent each end of said jacket for delivering cooling fluid to the spiral path formed about said jacket, and a fluid discharge connection intermediate the length of said jacket for discharging fluid which circulates through said spiral path from each end of said jacket.

9. A high power demountable electron tube comprising a cylindrical anode, an annular flange formed on said anode adjacent opposite ends thereof, an insulated sleeve concentrically disposed over each end of said anode and abutting with the annular flange thereon, end plates extending across the ends of said insulated sleeves, means for maintaining said end plates, said sleeves and said anode under longitudinal compression for providing a substantially gastight chamber within said anode, a multiplicity of removable electrodes mounted within said chamber, a jacket disposed concentrically about said anode and connected with the flanges adjacent the opposite ends thereof, a strip member extending in a spiral path from one of said flanges toward the center of the tube, a strip member extending from another of said flanges in a direction opposite to said first mentioned spiral path to a position intermediate said anode and connected with the other of said strip members, a jacket surrounding said strip members and extending between the flanges on said anode, fluid inlet connections at opposite ends of said jacket and a fluid inlet discharge connection centrally of said anode at a point adjacent the juncture of said strip members.

10. A high power demountable electron tube comprising a tubular anode, a flange adjacent each end of said anode, an insulated sleeve concentrically disposed about each end of said anode and abutting with the flange thereon, end plates extending across the ends of said sleeves, tension means interconnecting said end plates for maintaining said end plates, said sleeves and said anode under compression for providing a substantially gastight closure, a multiplicity of electrodes removably mounted within said closure, and fluid circulating passages symmetrically disposed about said anode for insuring equal cooling of the opposite ends of said anode for equalizing the expansion thereof under conditions of temperature change due to electronic bombardment.

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