Oct. 19, 1948. D. H. SLOAN 2,451,987

ELECTRONIC TUBE FOR ULTRA HIGH FREQUENCIES

Filed March 17, 1944 3 Sheets-Sheet 1

Fig. 1.

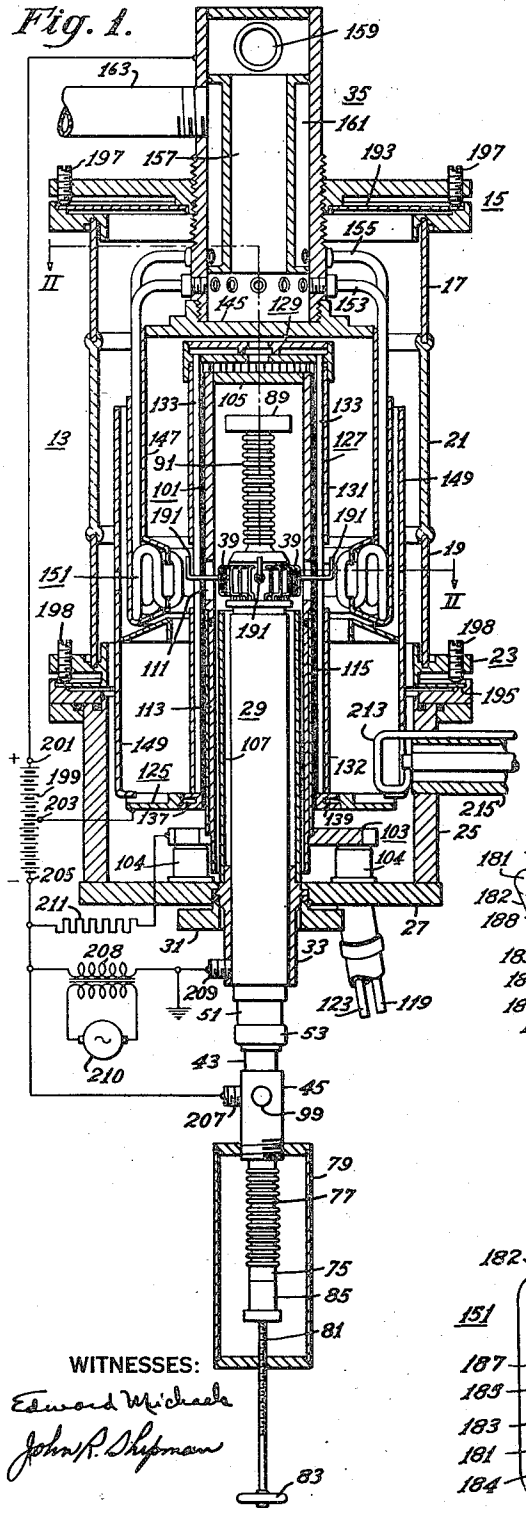
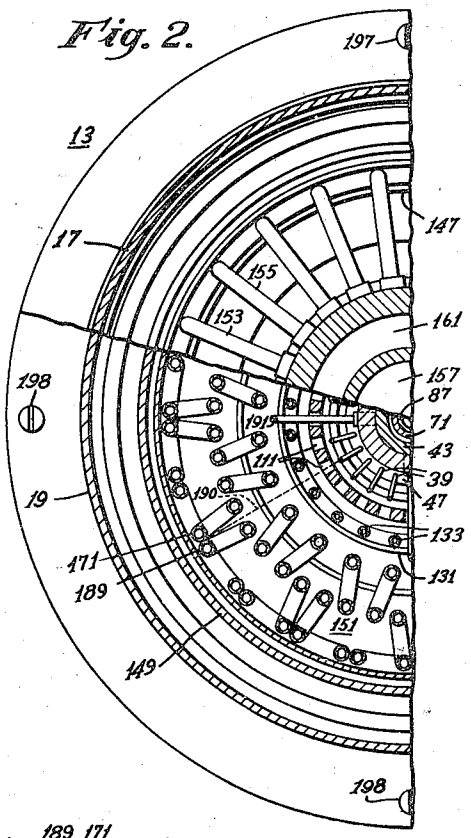


Fig. 2.



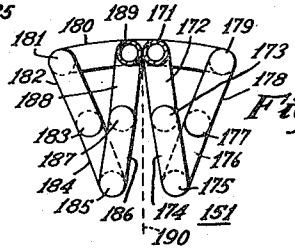
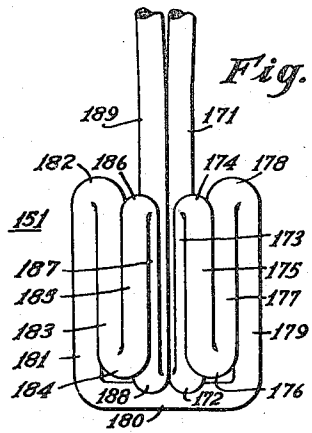


Fig. 4.

Fig. 3.



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Fig. 5.

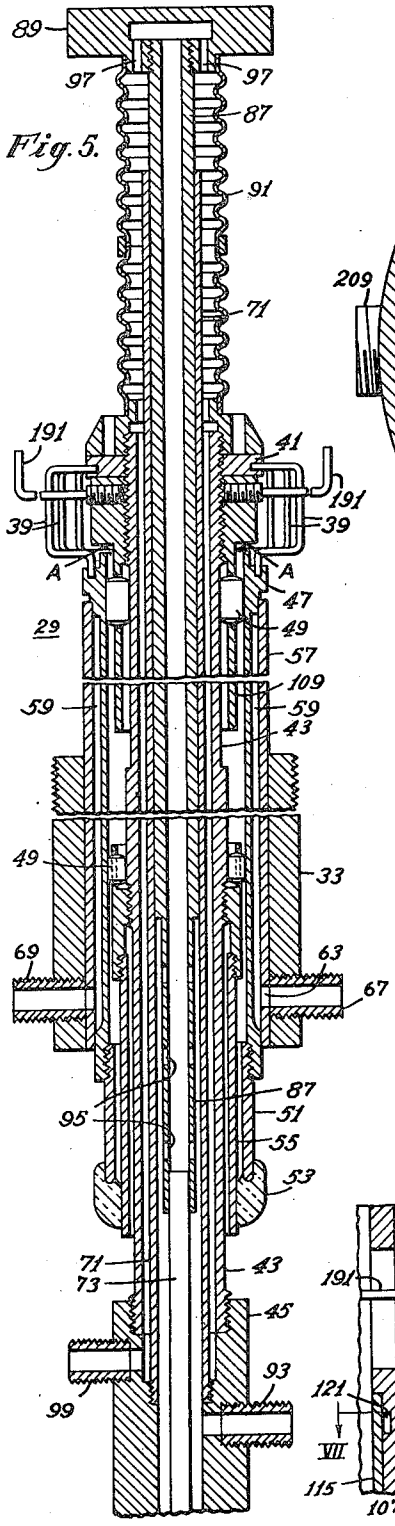


Fig. 7.

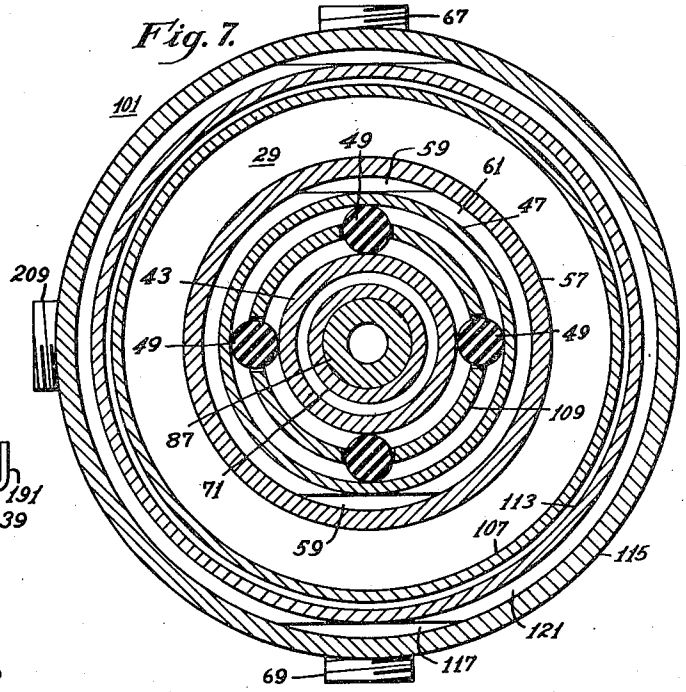


Fig. 8.

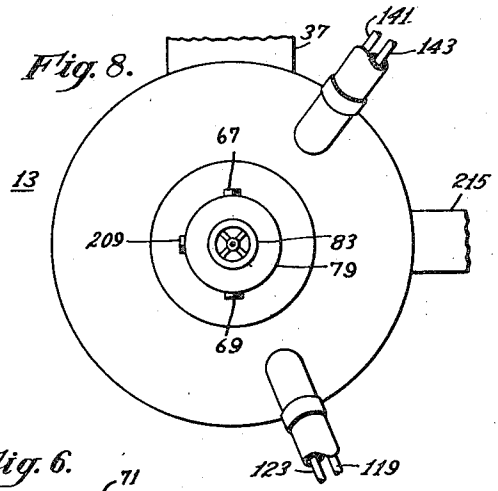
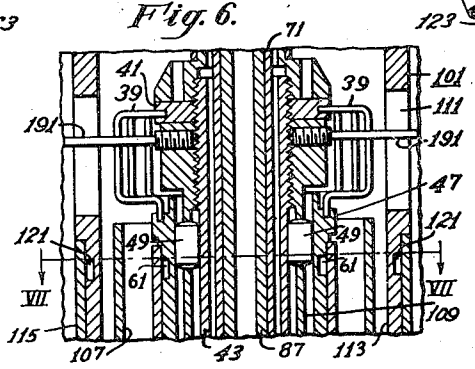


Fig. 6.



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Fig. 9.

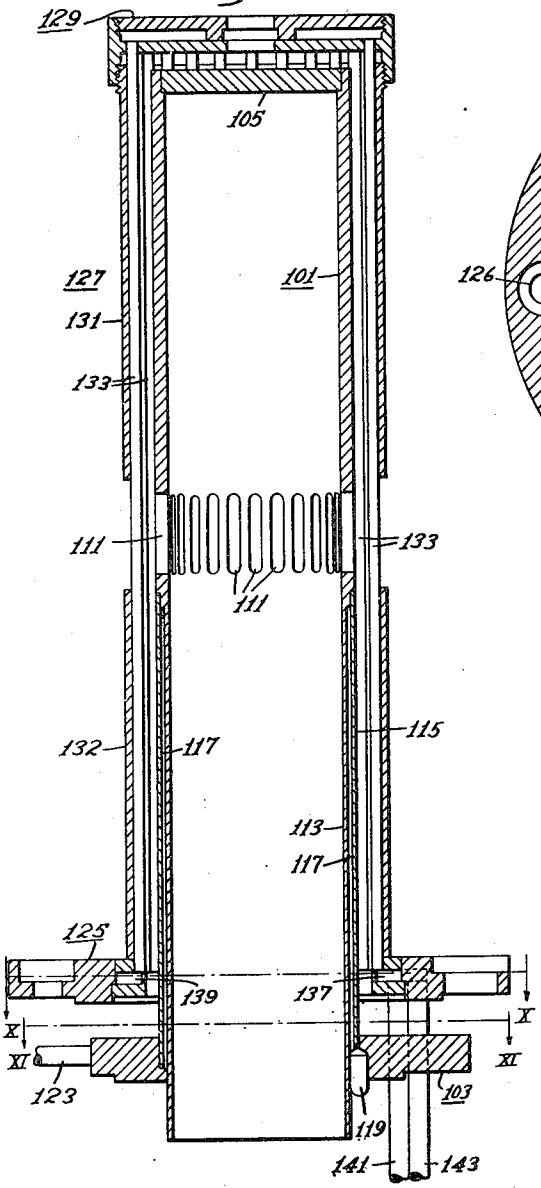


Fig. 10.

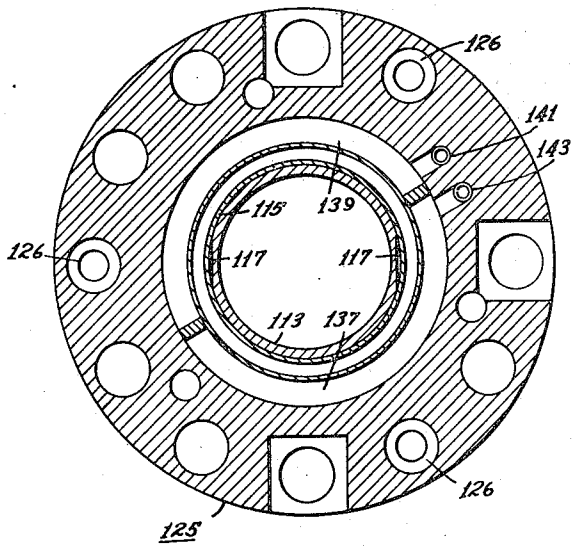
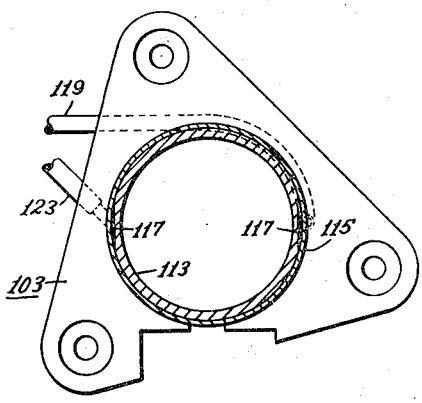


Fig. 11.



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UNITED STATES PATENT OFFICE

2,451,987

ELECTRONIC TUBE FOR ULTRA HIGH FREQUENCIES

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Application March 17, 1944, Serial No. 526,883

10 Claims. (Cl. 315—6)

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This invention relates to an electronic tube and has particular relation to an electronic tube of the Resnatron type for generating ultra-high frequency power.

A Resnatron tube, as constructed in accordance with prior teachings, generally comprises a pair of resonators adapted to have electromagnetic field oscillations of substantially the same frequency established therein. The resonators are positioned adjacent each other with a cathode mounted within the first resonator and an anode mounted within the second resonator. Openings in the adjacent walls of the two resonators permit a flow of electrons from the cathode to the anode. One or more grids are positioned between the cathode and anode and preferably include a control grid formed about the openings in the wall of the first resonator and an accelerating grid formed about the openings in the wall of the second resonator. Means are then provided to supply direct current to heat the cathode and to impress a direct current voltage difference between the anode and cathode, the accelerating grid and cathode, and the control grid and cathode.

The Resnatron tube operates as a tuned-plate, tuned-grid, class C oscillator with the first resonator in the control grid-cathode circuit and the second resonator in the anode or plate circuit. The oscillating fields within the resonators are in phase with each other and the vectors of the electric components of the fields are substantially parallel to the electron paths between the cathode and anode. The direct current voltages on the anode, cathode and grids are such that a group of electrons are liberated from the cathode only during the peak portion of each half period of the oscillating field in the first resonator in which the field is in a direction to aid the direct current voltage fields in effecting liberation of electrons and movement of the liberated electrons toward the anode. Thus sharp pulses of electrons are liberated at regular intervals.

The liberated electrons are rapidly accelerated by a fixed high voltage on the accelerating grid and enter the second resonator with considerable energy. Thus the liberated electrons first receive energy from the field of the first resonator as well as the direct current accelerating grid-cathode and anode-cathode voltage fields but the speed of the electrons is such that they enter the field of the second resonator while it is in a direction opposing their motion. As a result the electrons give up energy to the field of

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the second resonator to produce the desired oscillations therein.

A portion of the power developed in the second resonator is fed back to the first resonator to maintain the desired oscillations therein. The remaining power is extracted from the second resonator by some means such as a coupling loop, and supplied to an output transmission line.

The Resnatron tube, when properly constructed, operates as described to generate high frequency power. However, prior Resnatron tubes are very difficult to manufacture and assemble. In addition various weaknesses in the construction considerably shorten the life of the tube in operation as a high power generator.

One of the difficulties encountered in prior Resnatron tubes involves the provision of a readily manufacturable anode of such rigid construction and provided with adequate cooling means as to withstand the rigors of high power operation. To obtain a satisfactory output, a plurality of electron streams are necessary. Considerable heat is thereby generated at the anode so that adequate cooling is extremely difficult. Moreover, soldered joints have been found to be extremely undesirable in such an anode not only because of the assembly problem involved but also because they are a potential source of leaks through which cooling fluid may escape.

Another problem concerns the provision of a compact unit having a high power output. In this connection the necessity for cooling the anode, the two grids and the cathode and cathode leads as well as the provision of means for tuning the resonators and for properly mounting and aligning the parts offer numerous and extremely difficult problems.

It is accordingly an object of my invention to provide a new and improved electronic tube of the Resnatron type.

Another object of my invention is to provide a novel Resnatron tube which is compact and may be readily manufactured and assembled.

A further object of my invention is to provide a novel Resnatron tube of a sturdy, readily manufacturable, construction suitable for high power operation.

Still another object of my invention is to provide an improved anode structure for an electronic tube.

A still further object of my invention is to provide an improved anode structure for a Resnatron tube which provides adequate cooling facilities and avoids the use of soldered joints.

In a Resnatron tube embodying my invention

both of the resonators are of a generally cylindrical shape and they are mounted concentrically, with the first resonator positioned within a concentric, cylindrical re-entrant protuberance in the second resonator. The cathode comprises a plurality of filament wires formed into a generally cylindrical, cage-like, structure positioned concentrically within the first resonator. The anode also has a generally cylindrical form and is concentric with and encircles the cathode but is mounted within the second resonator. Thus a plurality of electron paths are provided which extend radially from the filament wires to the anode. Grids are provided in the adjacent walls of the two resonators with openings permitting passage therethrough of the electrons.

The anode comprises a plurality of individual units positioned to cooperate with each other in forming the generally cylindrical anode unit. Each unit of the anode comprises a convoluted section of a hollow pipe of conductive material through which a cooling fluid is to be passed. The convolutions of the anode units include one or more pipe portions radially opposite each filament wire and other portions positioned alongside the radius from each wire to outline a groove into which the electrons project. This groove acts as a trap for the electrons produced by secondary emission.

The novel features which I consider characteristic of my invention are set forth with more particularity in the appended claims. The invention itself, however, with respect to the organization and method of operation thereof as well as additional advantages and objects may be best understood from the following description of a specific embodiment with reference to the accompanying drawings; in which:

Figure 1 is a sectional view of a Resnatron tube constructed in accordance with my invention;

Fig. 2 is an enlarged, partial cross-section of the Resnatron tube taken along lines II—II of Fig. 1;

Fig. 3 is an elevation view of one of the anode units;

Fig. 4 is a top view of the anode unit shown in Fig. 3;

Fig. 5 is an enlarged, cross-sectional view of the cathode unit taken along the axis;

Fig. 6 is an enlarged sectional view of a portion of the cathode unit and the control grid taken on a different plane than Fig. 5 along the axis;

Fig. 7 is a greatly enlarged, cross-sectional view of the cathode unit taken along line VII—VII of Fig. 6;

Fig. 8 is a bottom elevation view of the tube shown in Fig. 1;

Fig. 9 is a sectional view illustrating the control and accelerating grid members in their assembled positions;

Fig. 10 is a cross sectional view along line X—X of Fig. 9; and

Fig. 11 is a cross-sectional view along line XI—XI of Fig. 9.

As shown in Fig. 1, the main part of the Resnatron tube is enclosed within a generally cylindrical chamber 13 comprising an upper plate unit 15, two coaxial cylindrical metallic members 17 and 19 of the same diameter spaced apart by a coaxial glass cylinder 21 of the same diameter sealed therebetween, with the upper cylindrical member 17 secured to the upper plate unit 15 and the lower cylindrical member secured to the top of an intermediate plate unit 23. The bottom of the intermediate plate unit 23 is connected to still another coaxial, cylindrical metallic member 25 secured to a base plate 27. A cathode unit 29 extends through a central opening in the bottom plate 27, being secured thereto by a cap 31 and a support 33. A cooling fluid chamber body 35 is threadedly mounted in a central opening in the upper plate unit 15. The entire chamber 13 is sealed and a vacuum is created therein by a vacuum pump (not shown) attached to a passage 37 in the side of the chamber 13 as shown in Fig. 8.

The cathode unit 29 is shown in considerable detail in Figs. 5, 6 and 7. It includes a plurality of cathode filament wires 39 spaced from each other but arranged to form a generally cylindrical, cage-like, structure about the axis of the chamber 13. The upper ends of the filament wires 39 are soldered about the circumference of a threaded nut 41 which is mounted on the upper end of a first tubular member 43 which forms one conductor for the direct current supplied through the filament wires to heat them to operating temperatures. The lower end of the first tubular member 43 extends through the base plate 27 and is threadedly mounted on a small body 45 through which cooling fluid is supplied.

Each filament wire 39 extends radially outward from the nut 41 in a horizontal plane for a short distance and then downwardly parallel to the axis with the lower end of the filament wire extending radially inward to be secured to a second tubular member 47. The second tubular member 47 is concentric with and surrounds the first tubular member 43 and forms the other conductor for the filament current. The first and second concentric tubular members 43 and 47 are spaced from each other by a plurality of insulating pellets 49.

It is to be noted that some kind of seal must be provided between the spaced first and second tubular members 43 and 47 to enable a vacuum to be established within the chamber 13. The second tubular member 47 extends through the base plate 27 and is secured to the end of a short concentric metal tube 51, the end of which is sealed with a glass seal 53 to the end of another concentric metal tube 55 of smaller diameter connected to the member 43. However, when the Resnatron tube is operating the heat developed causes axial expansion of the members 43 and 47 and tubes 51 and 55. To prevent excessive buckling of the filament wires and/or breaking of the glass seal by unequal expansions, the combined expansions of the first tubular member 43 and the tube 55 under the temperature changes produced in the operation of the Resnatron tube is substantially balanced by the expansion vertically, of the filament wires, the second tubular member 47 and the tube 51. The tubular members 43 and 47 are preferably of copper and the tubes 51 and 55 are preferably at Kovar so that a good glass seal can be made. This compensation for expansion under heat plus the provision of flexible filament wires permits the soldering of the wires in place.

A third concentric tubular member 57 surrounds the second tubular member 47 with the outer diameter of the latter being equal to the inner diameter of the former. A pair of flat sides 59 are provided on the circumference of the second tubular member 47 as shown in Fig. 7. These flat sides 59 extend over most of the length of the second tubular member 47 but do not extend along the end portions thereof. Thus two pas-

sages are provided intermediate the ends of the second tubular member 47 and these passages are interconnected by a groove 61 about the circumference of the second tubular member as shown in Figs. 6 and 7. An opening 63 is provided at the lower end of the third tubular member 57 opposite each of the flat sides 59 formed in the second tubular member 47. These openings 63 coincide with openings in the support 33 to which the third tubular member 57 is secured and a cooling fluid, such as water, is adapted to be supplied to one of the passages through an inlet pipe 67, the fluid passing upward along the passage, around the groove 61 and downward along the other passage and out the outlet pipe 69.

Within the first tubular member 43 is a fourth concentric tubular member 71 having a smaller external diameter than the internal diameter of the first tubular member. The fourth tubular member 71 is mounted at its lower end on the body 45 and at its lower end surrounds a coaxial shaft 73 which extends through the body 45 to bear against the end plate 75 of a flexible bellows 77. The bellows 77 is enclosed within a housing 79 in which a rotatable adjusting shaft 81 is threaded. The lower end of the adjustable shaft 81 has a hand-wheel 83 mounted thereon to facilitate rotation of the shaft. Within the housing 79 the end of the adjustable shaft 81 carries a member 85 which abuts against the end plate 75 of the bellows. When the adjustable shaft 81 is rotated by the hand-wheel 83, the end plate 75 of the bellows 77 is moved vertically to in turn raise or lower the shaft 73 extending into the lower end of the fourth tubular member 71. The upper end of this shaft 73 is attached to a fifth concentric tubular member 87 which extends beyond the filament wires 39 and has a tuning plate 89 mounted on the upper end thereof. Another flexible bellows 91 surrounds the fourth and fifth tubular members 71 and 87 with its ends connected between the tuning plate 89 and the upper end of the first tubular member 43.

A passage for additional cooling water is then provided from another inlet pipe 93 attached to the body 45 through the space between the shaft 73 and the fourth tubular member 71, openings 95 provided in the thin wall end portion of the fifth tubular member 87, the center of the fifth tubular member 87 to the tuning plate 89. The tuning plate 89 is provided with passages 97 for the flow of cooling water from the center of the fifth tubular member 87 to the space between the fourth and fifth tubular members 71 and 87 and the bellows 91. From the bellows 91 cooling fluid may pass downward in the space between the first and fourth tubular members 43 and 71 to another outlet pipe 99 in the body 45.

Another concentric cylindrical member 101 of conductive material, designated hereinafter as the control grid member, surrounds the cathode unit with its lower end mounted on a horizontal plate 103 supported by three insulators 104 from the base plate 27 of the chamber 13. An end plate 105 spaced from the tuning plate 89 closes the upper end of the control grid member 101. The lower end of the control grid member 101 including the horizontal plate 103 is spaced from the cathode unit 29 so that the cathode unit and the control grid member may be maintained at different direct current potentials. Another concentric tube 107 is mounted on the support 33, surrounds the lower part of the cathode unit and cooperates with the lower part of the control grid member 101 to form a quarter wave length high frequency choke.

The control grid member 101 with its end plate 105 cooperates with the cathode unit 29 including the tuning plate 89 and bellows 91 and the tube 107 to form a first cavity resonator, with the cathode filament wires 39 positioned therein.

To prevent the escape of high frequency power through the space between the first and second tubular members of the cathode unit and the glass seal across the end thereof and through the filament direct current leads, a sixth concentric tubular member 109 is provided in the cathode unit between the first and second tubular members with its upper end secured to the first tubular member and its lower end cooperating with the second member to form a quarter wave length high frequency choke. This provides a very low impedance at point A to high frequency currents to prevent such currents from passing out the filament leads.

The control grid member 101 forming the exterior wall of the first resonator has a plurality of slot-like openings 111 therethrough opposite the cathode filament wires 39, one slot-like opening being provided radially opposite each filament wire. In this manner a control grid is formed in the wall of the first resonator. The lower end of the control grid member 101 is composed of two concentric tubes 113 and 115, the inner tube 113 having an external diameter equal to the internal diameter of the outer tube 115. Two flat sides 117 are provided in the circumference of the inner tube 113 which extends from the lower end thereof almost to the slot-like openings 111 (see Figs. 7 and 11). Cooling fluid is then supplied through an inlet pipe 119 to one of the passages created by a flat side, the fluid passing upward along this passage to an annular groove 121 about the inner tube 113 which interconnects the two passages and then down the other passage and out an outlet pipe 123.

Another horizontal plate 125 is mounted directly above the plate 103 and has a central opening therein through which the cathode unit 29 and control grid member 101 extend. Plate 125 is also supported on the base plate 27 by a plurality of insulators which do not appear in Fig. 1 but which are mounted in openings 126 in Fig. 10. Mounted on this plate 125 is another cylindrical unit 127 which is concentric with and surrounds the control grid member 101, being spaced therefrom. The unit 127 is hereinafter referred to as the accelerating grid unit. The accelerating grid unit comprises a plurality of vertical pipes 133 of conductive material arranged to outline a cylinder concentric with, and surrounding, the control grid member 101. The pipes 133 are spaced from each other, as shown in Fig. 2, so that in the region of the filament wires, the spaces between adjacent pipes are radially opposite corresponding filament wires 39 and openings 111 in the control grid member 101, whereby the pipes 133 form a grid. Secured to and surrounding the pipes 133 above the filament wires is a conductive metal cylinder 131 and a similar cylinder 132 surrounds the pipes 133 below the filament wires. A cap 129 is secured across the top of the cylinder 131 and has openings in the bottom thereof into which pipes 133 extend, the cap 129 having an internal passage in communication with the open ends of all of pipes 133. The lower ends of the cooling pipes 133 extend into the horizontal plate 125, each pipe being in communication with one of two passages 137 and 139 therein. An inlet pipe 141 for supplying the

water or other suitable cooling fluid is connected to one of these passages 139 and an outlet pipe 143 is connected to the other passage 137. Thus, cooling fluid flows upward through half of the pipes 133 and downward through the other half.

The lower end of the water chamber body 35 has a plate 145 secured thereon which is spaced from the cap 129 on the accelerating grid member 127. This plate 145 is circular and supports a cylindrical metallic member 147 which in turn is used to support the anode structure. Another cylindrical, metallic member 149 of slightly larger diameter than the anode supporting member 147 is mounted on the horizontal plate 125 and extends upwardly with its upper end surrounding the anode supporting member 147 and cooperating therewith to form a quarter wave length high frequency choke. These two members 147 and 149 with the plate 145 on the bottom of the water chamber body 35, the horizontal plate 125 and the accelerating grid unit 127 form a second cavity resonator.

The anode comprises a plurality of anode units 151 as shown in Figs. 2, 3 and 4. These units are arranged in a circle about the accelerating grid and within the second resonator. Each anode unit 151 comprises a convoluted section of a hollow pipe of a highly conductive material, such as copper, through which water or other suitable cooling fluid is to be passed, the two ends 153 and 155 of the hollow pipe of each unit extending upwardly from the convolutions with one end 153 being connected to a water chamber 157 in body 35 supplied from an inlet pipe 159 and the other end 155 connected to a water chamber 161 in body 35 which in turn is connected to an outlet pipe 163.

The convolutions of the pipe section of an anode unit include a plurality of coextensive pipe portions which are substantially parallel to, and slightly longer than, the vertical portions of the filament wires 39 and the openings in the control and accelerating grids.

To follow the convolutions of the anode pipe, the passage of cooling water therethrough may be traced. The water comes down portion 171 through lower portion 172, up portion 173, through upper portion 174, down portion 175, through lower portion 176, upper portion 177, through upper portion 178, down portion 179, through lower portion 180, up portion 181, through upper portion 182, down portion 183, through lower portion 184, up portion 185, through upper portion 186, down portion 187, through lower portion 188, and up portion 189. As shown in Figs. 2, 3 and 4 the pipe portions 171 and 189 are adjacent each other and in engagement and are positioned along the outer wall of the second resonator opposite an opening in the accelerating grid. Thus the center line of an electron path, illustrated by dotted line 190, extends from the filament wire through the two grids to the junction line between the portions 171 and 189. Of course, electrons moving from the filament wire to the anode actually fan out on each side of the center line. Other pipe portions 172, 173, 174, 175 and 188, 187, 186 185 extend from the portions 171 and 189 on opposite sides of the electron path center line and outline a groove into which the electron path projects. The groove opening faces the filament wire and is wider than the actual electron path. It is to be noted that while each convoluted section has openings therethrough, the pipe portions are positioned with a pipe portion intercepting

substantially every straight line through space from the cathode to the anode. Thus each unit 151 presents a substantially continuous anode surface, in effect, to the corresponding filament wire.

When a plurality of the anode units 151 are assembled in the second resonator, the portion 179 of each unit engages the portion 181 of the adjacent unit radially opposite another filament wire. The portions 175, 176, 177 and 178 of the one unit and 185, 184, 183 and 182 of the other unit also cooperate to form a groove into which the electron path projects.

To afford a feed-back coupling between the second resonator and the first resonator, a plurality of coupling wires 191 are attached at one end to the cathode unit 29 in the first resonator and extend through the grids into the second resonator. Preferably four of these coupling wires 191 are arranged at regular intervals about the circumference of the cathode unit, the number, of course, depending upon the amount of feed-back power required to operate the first resonator. As shown in Figs. 2, 5 and 6, each of the coupling wires 191 is secured to the end of the first tubular member 43 and extends radially through a set of openings in the grids for which the corresponding filament wire is omitted, the outer end portion of each wire being bent at right angles to form a conducting member adjacent to but spaced from the anode. Thus, each coupling wire, in effect, provides a capacitance connected between the anode and cathode.

The first and second resonator are designed so that the electric field vectors of the fields therein are along radial lines. Consequently, alternate points of minimum and maximum voltage appear along the length of the cathode unit within the first resonator. The coupling wires 191 may be connected to the cathode unit at any point other than a zero voltage point. However, it is preferable to connect the coupling wires at a point of maximum voltage on the cathode unit with respect to the control grid. This is the point of minimum current and with the first resonator tuned to substantially the same resonant frequency as said second resonator, the anti-resonant impedance of the cathode-grid circuit acts as a resistance connected in series with the capacitance existing between the coupling wires 191 and the anode. The high frequency voltage drop across this resistance from cathode to control grid is then leading in phase by 90 degrees relative to the high frequency anode to accelerating grid voltage which means that the control grid to cathode voltage lags behind the anode to accelerating grid voltage by 90 degrees. Further details of this feed-back coupling arrangement are set forth in my copending application Serial No. 526,882, filed March 17, 1944. Of course, other coupling arrangements may be employed, such as a coupling loop in each of the two resonators with the two loops interconnected by a coaxial transmission line, but the spacings between the various elements as well as the potentials impressed thereacross must be chosen with respect to the phase relation between the oscillating fields in the first and second resonators.

It is to be noted that the anode structure is supported from the water chamber body 35 while the cathode unit 29 and the grid members 101 and 127 are supported from the bottom plate 27. To facilitate alignment of the various parts, the upper plate unit 15 and the intermediate plate unit 23 include relatively thin flexible dia-

phragms 193 and 195, respectively, which may be distorted by adjusting screws 197 and 198 to shift the parts relative to each other. Screws 197 may also be used to raise or lower plate 145 slightly to time the second resonator.

Direct current voltages are impressed on the various elements of the Resnatron tube as shown schematically in Fig. 1. A source of direct current potential, such as a battery 199 has its positive terminal 201 connected to the water chamber body 35 and therefore to the anode. An intermediate tap 203 on the battery 199 is connected to the plate 125 supporting the accelerating grid unit 127 and the negative terminal 205 of the battery 199 is connected through a threaded plug 207 in the body 45 to the first tubular member 43 of the cathode unit 29 which is connected to the upper ends of the filament wires 39. The second tubular member 47 supporting the lower ends of the filament wires 39 is grounded through the threaded plug 209 in the support 33. A transformer 208 energized from an alternating source 210 is connected between plugs 207 and 209 to supply filament heating current. The control grid member 101 is connected through its supporting plate 103 and a resistor 211 to the negative terminal 205 of the battery 199.

Typical voltages which have been used in operating a Resnatron tube constructed in accordance with Fig. 1 established the anode at 10,000 volts and the accelerating grid at 7,000 volts. The control grid member is originally at zero voltage but when the oscillations are initiated current flows from the control grid to the cathode and the resulting potential developed across the resistor 211 build up the control voltage to approximately —1,000 volts.

In operating the Resnatron tube the first resonator is tuned by means of the tuning plate 89 adjusted through the hand-wheel 83 to substantially the same frequency as the second resonator. The direct current voltages are then applied to the elements in the tube and oscillations are initiated, building up gradually in the well known manner until the control grid reaches operating voltage. Then in a half-cycle when the field within the first resonator is in a direction to aid movement of the electrons, a group of electrons are liberated from the cathode filament wires during the peak portion only of the half-cycle and move toward the anode, picking up energy from the high frequency field of the first resonator and from the direct current voltage fields between the anode and cathode and the accelerating grid and cathode. Since the accelerating grid is at a comparatively high positive voltage, it supplies considerable energy to the electrons and greatly increases their speed. With this greatly increased speed the electrons are timed to enter the second resonator approximately one quarter of a cycle after leaving the cathode filament wires. With the 90° phase displacement between the fields of the first and second resonator, the field of the second resonator is then in a direction opposing the motion of the electrons. As a result the electrons give up energy to the field of the second resonator, producing the oscillations therein. The electrons reach the anode terminal during, or at the end of, the half cycle in which the field of the second resonator opposes their motion.

When the electrons strike the anode pipe other electrons are produced by secondary emission. When the field within the second resonator changes direction shortly thereafter, the secondary electrons are pulled away from the anode. The presence of portions of the anode pipe alongside the electron path center line, however, decidedly weakens the strength of the field within the groove outlined thereby, so that the secondary electrons which are produced within the groove do not escape outside of the groove before the field is again reversed, when the field is again reversed the secondary electrons are immediately drawn to the anode. In this manner the anode structure provides a trap for the secondary electron.

Some of the power generated in the second resonator is fed back to the first resonator through the coupling wires 191 to maintain the oscillations in the first resonator. The remaining power generated in the second resonator is extracted therefrom by a coupling loop 213 and feed to a coaxial output line 215 attached to the Resnatron tube.

Although I have shown and described a specific embodiment of my invention, I am aware that many modifications thereof may be made. I do not intend, therefore, to limit my invention to the specific embodiment disclosed.

I claim as my invention:

1. An electronic tube comprising an anode, an elongated cathode portion adapted to project electrons along a path toward the anode, said anode comprising a convoluted section of a pipe of conductive material through which a cooling fluid is to be passed, the convolutions of said pipe section including a plurality of substantially coextensive pipe portions substantially parallel to said elongated cathode portion, one of said pipe portions being positioned at a preselected point intercepting the center line of said path, and other of said pipe portions being positioned on opposite sides of said center line between said one pipe portion and said cathode and defining with said one pipe portion a groove into which said electron path projects with said one pipe portion at the bottom of the groove.

2. An electronic tube comprising an anode, an elongated cathode portion adapted to project electrons along a path toward the anode, said anode comprising a convoluted section of a pipe of conductive material through which a cooling fluid is to be passed, the convolutions of said pipe section including a plurality of substantially coextensive pipe portions substantially parallel to said elongated cathode portion, one of said pipe portions being positioned at a preselected point intercepting the center line of the path and other of said pipe portions being positioned on opposite sides of said center line between said one pipe portion and said cathode and cooperating with said one pipe portion to outline a groove into which said electron path projects with said one pipe portion at the bottom of the groove, said plurality of pipe portions being positioned with spaces therebetween but with a pipe portion intercepting substantially every straight line through space extending from the cathode toward said groove.

3. An electronic tube comprising a hollow body resonator adapted to have electromagnetic field oscillations established therein, an anode mounted within said resonator and comprising a convoluted section of a pipe of conductive material through which a cooling fluid is to be passed, means including a cathode and circuit means connected between said cathode and anode for projecting groups of electrons from said cathode to said anode along a path through said resonator substantially parallel to the electric vector of the oscillating field therein, the convolutions of said

anode pipe including a plurality of pipe portions positioned alongside said path and constituting a trap for electrons produced by secondary emission when said groups of electrons strike said anode.

4. An electronic tube comprising a hollow body resonator adapted to have electromagnetic field oscillations established therein, an anode mounted within said resonator and comprising a convoluted section of a pipe of conductive material through which a cooling fluid is to be passed, means including a cathode and circuit means connected between said cathode and anode for projecting groups of electrons from said cathode to said anode along a path through said resonator substantially parallel to the electric vector of the oscillating field therein, the convolutions of said anode pipe including a plurality of pipe portions outlining a groove into which said electron path projects, said pipe portions being positioned with spaces therebetween but with a pipe portion intercepting substantially every straight line through space extending from the cathode into said groove.

5. An electronic tube comprising a hollow body resonator adapted to have electromagnetic field oscillations established therein, an anode mounted within said resonator and comprising a convoluted section of a pipe of conductive material through which a cooling fluid is to be passed, the convolutions of said section including a plurality of substantially parallel and coextensive pipe portions at substantially right angles to the direction of the electric vector of the oscillating field within the resonator, means including an elongated cathode substantially parallel to said pipe portions and circuit means connected between said cathode and anode for projecting groups of electrons from said cathode to said anode along a path through said resonator substantially parallel to the electric vector of the oscillating field therein, one of said pipe portions being positioned at a preselected point intercepting the center line of said path, other of said plurality of pipe portions being positioned on opposite sides of said center line and cooperating with said one pipe portion to outline a groove into which said electron path projects with said one pipe portion at the bottom of the groove.

6. An electronic tube comprising a hollow body resonator having a generally cylindrical form with a coaxial, reentrant protuberance therein, a plurality of filament wires forming a generally cylindrical cage-like cathode structure mounted coaxially within said protuberance, the wall of said protuberance having a slot-like opening therein radially opposite each filament wire, and an anode comprising a plurality of convoluted sections of pipe through which cooling fluid is to be passed mounted adjacent each other within said resonator along the outer wall thereof and forming a ring surrounding the cathode structure, the convolutions of said plurality of sections outlining a groove radially opposite each of said filament wires with the groove opening toward the filament wire.

7. An electronic tube comprising a hollow body resonator having a generally cylindrical form with a coaxial, reentrant protuberance therein, a plurality of filament wires forming a generally cylindrical, cage-like cathode structure mounted coaxially within said protuberance, the wall of said protuberance having a slot-like opening therein radially opposite each filament wire, and an anode comprising a plurality of convoluted

sections of pipe through which cooling fluid is to be passed mounted adjacent each other within said resonator along the outer wall thereof and forming a ring surrounding the cathode structure, the convolutions of said plurality of sections including a plurality of pipe portions outlining a groove radially opposite each of said filament wires with the groove opening toward the filament wire, said pipe portions having spaces therebetween but being positioned with a pipe portion intercepting substantially every straight line through space extending from each of the filament wires toward the anode.

8. An electronic tube comprising a first hollow body resonator having a generally cylindrical form with a coaxial, reentrant protuberance therein, a second hollow body resonator having a generally cylindrical exterior mounted coaxially within said protuberance, said first and second resonators being adapted to have high frequency electromagnetic field oscillations established therein, a plurality of filament wires forming a generally cylindrical, cage-like cathode structure mounted coaxially within said second resonator, the outer wall of said second resonator and the wall of said protuberance having openings therein radially opposite each of said filament wires, said outer wall about the openings therein forming a control grid, and an anode comprising a plurality of convoluted sections of pipe through which cooling fluid is to be passed mounted adjacent each other within the first resonator along the outer wall thereof and forming a ring surrounding the cathode structure, the convolutions of said plurality of sections outlining a groove radially opposite each of said filament wires with the groove opening towards the filament wire.

9. An electronic tube comprising a vacuum-tight chamber, a pair of hollow body resonators within said chamber, one of said resonators having a central, reentrant protuberance therein, the other resonator being positioned within said reentrant protuberance, a cathode positioned within said other resonator, a cylindrical anode positioned within said one resonator and surrounding said cathode, the walls of said protuberance and said other resonator having openings therein between said cathode and anode, said one resonator being formed of two parts, said chamber including a first end plate upon which one part of said one resonator of which said protuberance is a portion, said other resonator and said cathode are mounted, a second end plate upon which the second part of said one resonator and said anode are mounted, and a side wall member interconnecting, and sealed to, said first and second plates and including a flexible member adjustable to change the position of said plates relative to each other.

10. An electronic tube comprising a first hollow body resonator having a generally cylindrical form with a coaxial, reentrant protuberance therein, a second hollow body resonator having a generally cylindrical exterior mounted coaxially within said protuberance, said first and second resonators being adapted to have high frequency electromagnetic field oscillations established therein, a plurality of filament wires forming a generally cylindrical, cage-like cathode structure mounted coaxially within said second resonator, the outer wall of said second resonator and the wall of said protuberance having openings therein radially opposite each of said filament wires, said outer wall about said openings therein form-

ing a control grid, and a ring-like anode mounted coaxially within said first resonator along the outer wall thereof and surrounding said cathode structure with the inner periphery of said ring-like anode having a groove formed therein radially opposite each of said filament wires.

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