

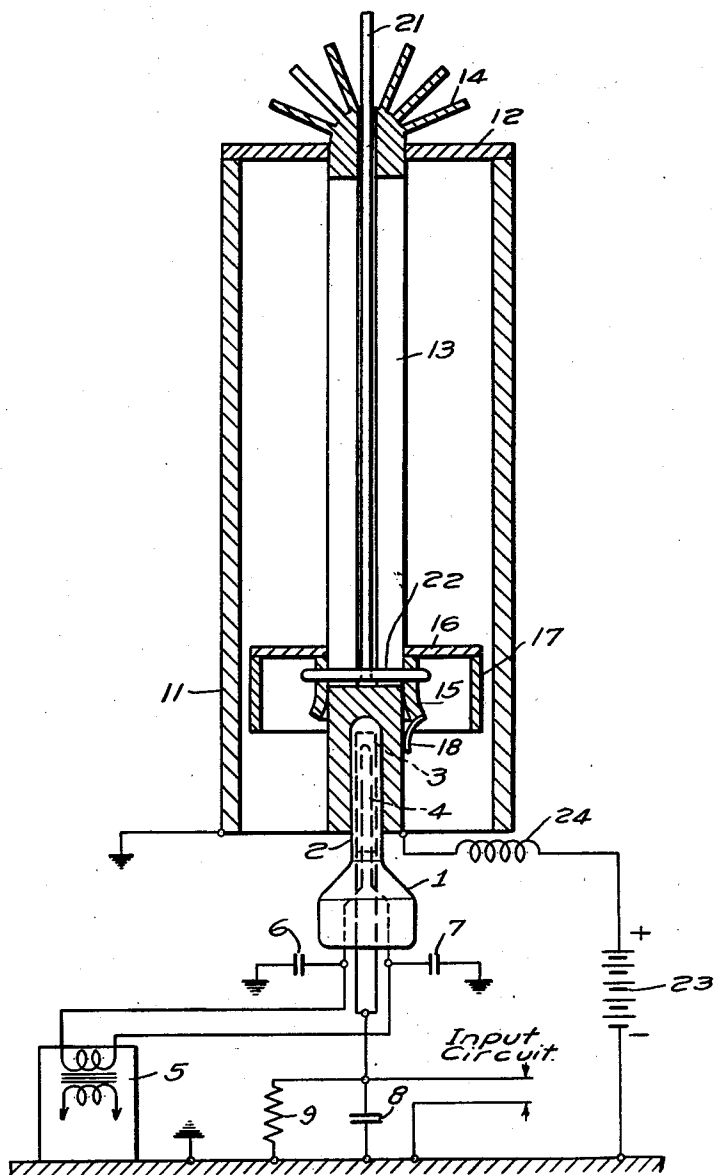
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TUBE COOLING MEANS

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TUBE COOLING MEANS

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My invention relates to electrical discharge tubes and circuits therefor, and in particular to tubes and circuits of this type which are designed to operate at extremely high frequencies.

One object of my invention is to provide an arrangement for efficiently cooling the anode of an electrical discharge device.

Another object of my invention is to provide a structure for supporting an electrical discharge device and for efficiently connecting it to an oscillation circuit of the concentric line type.

Another object of my invention is to provide a structure which performs the combined functions of efficiently cooling the anode of an electrical discharge device while coupling it for efficient operation in conjunction with an oscillation circuit of the concentric line type.

Still another object of my invention is to provide an electrical discharge device adapted to act as an oscillator, amplifier or detector of radio currents of extremely high frequencies with a composite structure which performs the functions of supporting the discharge tube efficiently cooling its anode and providing a tunable oscillation-circuit of the concentric line type which is so coupled to the discharge tube as to permit efficient operation in conjunction therewith.

Other objects of my invention will become apparent on reading the following specification taken in conjunction with the drawing in which the single figure illustrates an electrical discharge tube provided with a composite cooling device and oscillation circuit embodying the principles of my invention.

Electrical discharge tubes which are designed to amplify, oscillate or detect alternating currents of extremely high frequencies, such, for example, as those radiating waves having a length of the order of one meter usually have relatively small physical dimensions; and, where they are to transmit even moderate amounts of power, a problem arises in attaining efficient dissipation of the heat set free at their anodes. One typical tube of the type just discussed has an anode comprising a copper shell forming a portion of the tube wall, the control electrode and cathode being positioned in the interior of this shell and sealed thereto by a glass wall portion positioned at one end of the copper shell. The anode shell constitutes a major portion of the side walls and also forms one end of the tube, and the cathode and grid leads project from this glass wall portion at the other end of the tube.

In accordance with the prior art, radial vanes of considerable dimensions were attached to the copper anode shell for the purpose of dissipating the heat set free at the anode during operation of the tube. Efficient operation of such a tube for generating or amplifying ultra-short waves likewise requires that the length of the electrical circuits traversed by the ultra-short current shall be reduced to relatively small values, and the stray capacitance to ground and between portions of the circuit should be reduced to the minimum possible value. Because of the difficulties arising from stray capacitance, it has been found that oscillation circuits comprising variable plate-condensers and inductances which are conventional in ordinary radio circuits, create difficulties and that much more satisfactory operation for ultra-short wave work results if oscillation circuits of what may be called the concentric transmission-line type are employed. Such oscillation circuits may comprise a tubular conductor having a cylindrical conductor of smaller diameter positioned along its axis, the two conductors being connected with each other by a plate at one end.

An application Serial No. 224,544 by Sheldon I. Rambo, filed August 12, 1938, for High frequency coupling condensers, and assigned to the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pennsylvania, illustrates the use of an oscillation circuit of the concentric line type in combination with an electrical discharge tube of the type which has just been described. To utilize the concentric line as an oscillation circuit it is electrically coupled to the anode of the electrical discharge device, and in order to minimize stray capacitance and other sources of inefficient operation, it is desirable to make the connection between the concentric line and the anode of the discharge device as short and compact as is possible. In the Rambo arrangement the expedient has been resorted to of surrounding the radiating fins which cool the anode of the discharge tube device by a dielectric sheet in contact at its outer periphery with a metal sheet which is directly connected to the central conductor of the concentric line. In this arrangement the dielectric sheet in effect constitutes the dielectric of a capacitor connecting the anode of the cooling tube to the concentric line. Because of the large diameter of the anode-cooling-fin structure the dimensions of this condenser are considerable, resulting in considerable stray capacitance, a large energy storage in the capacitor and a considerable power loss

in the capacitor dielectric and elsewhere. Furthermore, the capacitance inherent in these large dimensions constitutes a fixed capacitance which amounts practically to a limitation on the magnitude of the highest frequency to which it is possible to tune the circuit.

In accordance with my present invention I avoid the use of radial cooling-fins on the anode of the discharge tube but instead employ the structure of the concentric line, in effect, as a cooling device to dissipate the heat set free at the tube anode.

In this way I am enabled to further decrease the linear dimensions of the entire ultra-short wave system as well as to avoid the dielectric and other losses inherent in the capacitor coupling employed in the Rambo system.

With the foregoing principles in mind, the drawing shows an electrical discharge tube 1 having an anode 2 comprising a copper shell forming the wall over the entire upper end of the tube. A control electrode 3 and an incandescent cathode 4 of conventional type are located in the interior of the anode portion 2 and are sealed vacuum-tight to the lower end thereof by means of glass in a manner too well known in the art to require description. Current to heat the cathode 4 is supplied from a transformer 5 having a grounded casing and the cathode leads are grounded through two condensers 6, 7 near their point of entrance to the tube 1. The control electrode 3 is connected to one terminal of a conventional input circuit, the other terminal of which may be grounded and this ground is connected to the grid through a condenser 8 and a resistor 9. The connections of the tube 1 so far described are conventional ones and may be replaced by any other suitable connections for impressing the voltage of an input circuit between the cathode 4 and the control electrode 3.

The tube 1 may conveniently be mechanically supported by the concentric line structure comprising a grounded metallic tube 11 which may be affixed to a grounded supporting frame. The tube 11 may have one end closed by a metal plate 12 which supports in the central axis of the tube 11 a cylindrical core 13. The end of the core 13, which is opposite to the plate 12, is machined out to receive with a perfect fit the anode 2 of the tube 1. Since the core 13 tightly fits the tube anode 2, it constitutes an efficient means for conducting away the heat dissipated within said anode during operation of the tube 1. Heat flows from the anode 1 longitudinally of the core 13 to the opposite end thereof which is provided with a series of radiating vanes 14 to help in maintaining the temperature of the end plate 12 as near to that of the room as possible. Some of the heat flowing along the core 13 flows into the end plate 12 and from the latter into the tube 11 so that these last named elements likewise help in dissipating the heat generated within the anode of tube 1.

In order to tune the concentric line consisting of tube 11, anode plate 12 and core 13, a structure comprising a collar 15, a disk 16, and an annular ring 17 is arranged to slide along the core 13. The outer diameter of the ring 17 is made slightly less than the internal diameter and the tube 11, as a result of which the structure 15, 16, 17 is capacitively coupled to the tube 11 by the annular spacing last mentioned. The collar 15 forms a tight sliding fit with the core 13 and if necessary to maintain good electrical contact thereto, sliding brushes such as element

18 may be provided in a manner well known in the electrical art.

When the collar 15, 16, 17 is displaced along the core 13, the space between the disk 16 and the end plate 12 is traversed by an electrical field and the entire arrangement constitutes a tuned oscillating circuit having an extremely low decrement. The wave length of this electrical circuit is at a maximum when the disk 16 is adjacent the end plate 12 and is at a minimum when the disk 17 is adjacent the open end of the tube 11.

In order to tune the concentric line just described, provision is made for sliding the collar 15 along the core 13. The adjusting arrangement comprises a rod 21 which may be of metal, or may be of some insulating material such as micarta, which is preferably of a very small diameter, and which extends through a small hole bored in the central axis of core 13. Two deep and narrow slots connecting the central hole in member 13 with its periphery extend for a considerable distance of the length of member 13, and permit a pin 22 which is set in the end of the rod 21 and extends through holes in the collar 15 to move the latter along the core 13 when a push or pull is exerted on the outer end of the rod 21.

To energize the electrical circuits of the tube 1 a source of voltage 23 is connected through a choke coil 24 with the lower end of the rod 13.

Since most of the heat generated in the anode 2 flows longitudinally along the core 13, it is highly desirable that the impedance to heat flow of the latter shall be minimized. For this reason the core 13 is preferably made of copper or some other good heat conductor and the size of its central hole and appurtenant slots is made as small as possible. The temperature difference between the lower and the upper end of the core 13 may be kept to any desired low value increasing the diameter of the core 13 to the necessary diameter.

To give a specific illustration of one embodiment of my invention, I have found that where the tube 1 was of the type sold under the trade designation WX-3005 and operated to dissipate 150 watts of power at its anode in conjunction with a core 13 having a length of 12 inches and a diameter of 1.6 inches, the temperature difference between the upper and lower ends of the core 13 was less than 100° C. with ordinary room temperatures surrounding the apparatus. This provides a safe operating temperature for the tube 1.

In accordance with the patent statutes I have described a specific embodiment of my invention, but the principles thereof will be applicable in many other ways which will be evident to those skilled in the art.

I claim as my invention:

1. In combination with an electrical discharge device adapted to transmit ultra-short radio waves and having an anode comprising a metallic portion of its wall, air-cooling means including an oscillation circuit comprising a substantially solid central core having a high heat conductivity in good heat exchanging relation with said anode having a surrounding tubular portion connected to said core at the end remote from said discharge device by an end plate.

2. In combination with an electrical discharge device adapted to transmit ultra-short radio waves and having an anode comprising a metallic portion of its wall, air-cooling means including

an oscillation circuit comprising a substantially solid central core having a high heat conductivity in good heat exchanging relation with said anode having a surrounding tubular portion connected to said core at the end remote from said discharge device by an end plate, said oscillation circuit being provided with an annular member slidable upon said core and separated from said tubular member by an annular gap.

3. In combination with an electrical discharge device adapted to transmit ultra-short radio waves and having an anode comprising a metallic portion of its wall, air-cooling means including an oscillation circuit comprising a substantially solid central core having a high heat conductivity in good heat exchange relationship with said anode surrounded by a tubular conductor connected at one end to said core, said oscillation circuit being provided with an annular member slidable upon said core and separated from said tubular conductor by an annular gap, and cooling vanes upon the end of said core adjacent said metal plate.

4. In combination with an electrical discharge device adapted to transmit ultra-short radio waves and having an anode comprising a metal-

lic portion of its wall, air-cooling means including an oscillation circuit comprising a substantially solid central core having a high heat conductivity and a recess at one end accurately fitting the exterior of said anode, a metal tube surrounding said core and a metal plate at the other end of said core connecting it to said metal tube, and means for cooling the end of said core adjacent said metal plate, said core forming the main path for flow of heat from said anode to said metal plate.

5. In combination with an electrical discharge device adapted to transmit ultra-short radio waves and having an anode comprising a metallic portion of its wall, air-cooling means including an oscillation circuit comprising a substantially solid central core having high heat conductivity and having a recess at one end accurately fitting the exterior of said anode, a metal tube surrounding said core and a metal plate at the other end of said core connecting it to said metal tube, an annular member making a sliding fit upon said core and having an annular gap of small dimensions between its periphery and the internal surface of said tube.

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