June 14, 1966 A. BESSON ETAL 3,255,813

COOLING SYSTEM FOR ELECTRON DISCHARGE DEVICES

Filed Dec. 27, 1961 4 Sheets-Sheet 1

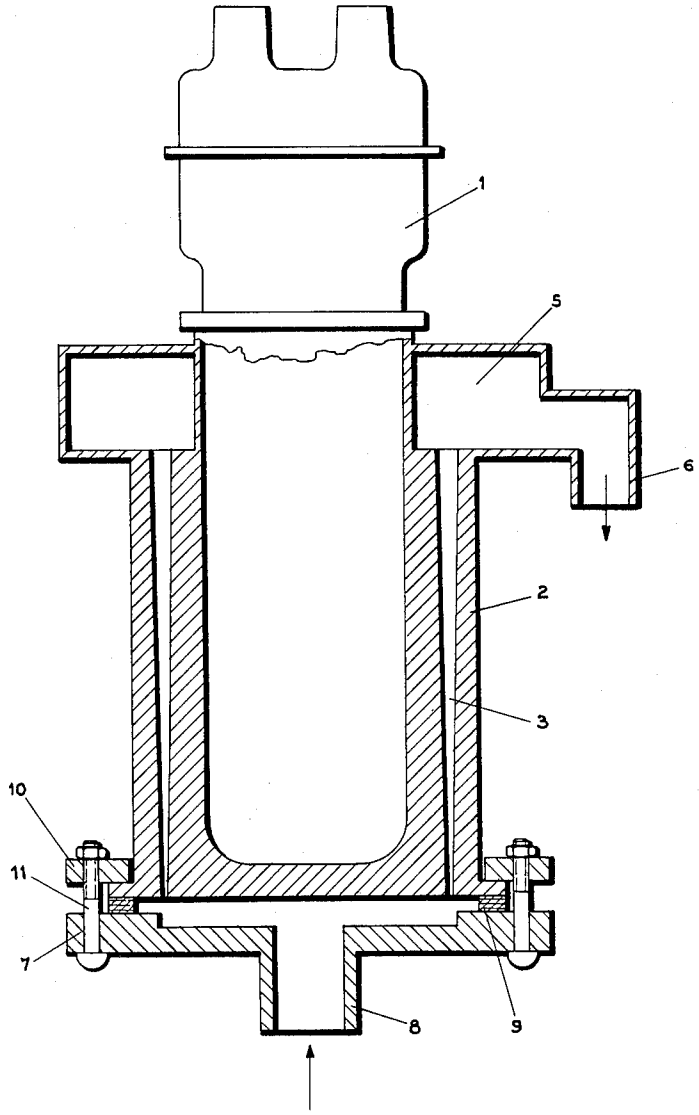

FIG. 1

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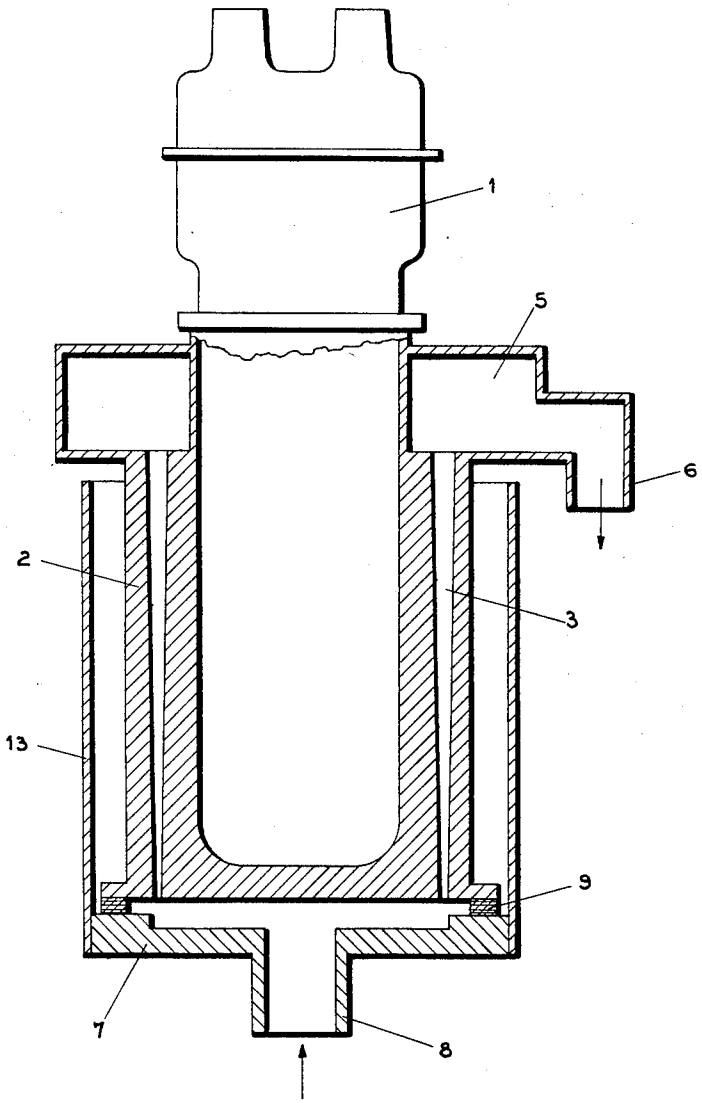

FIG. 2

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COOLING SYSTEM FOR ELECTRON DISCHARGE DEVICES

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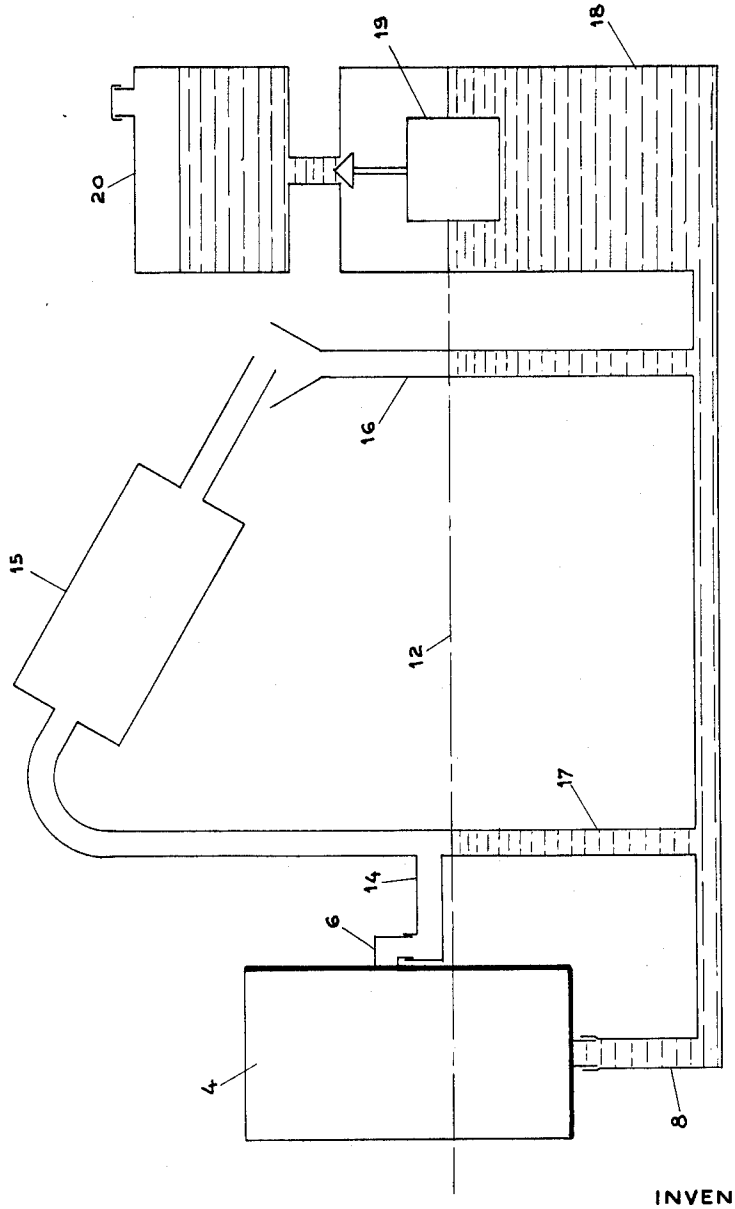
FIG. 3



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COOLING SYSTEM FOR ELECTRON DISCHARGE DEVICES

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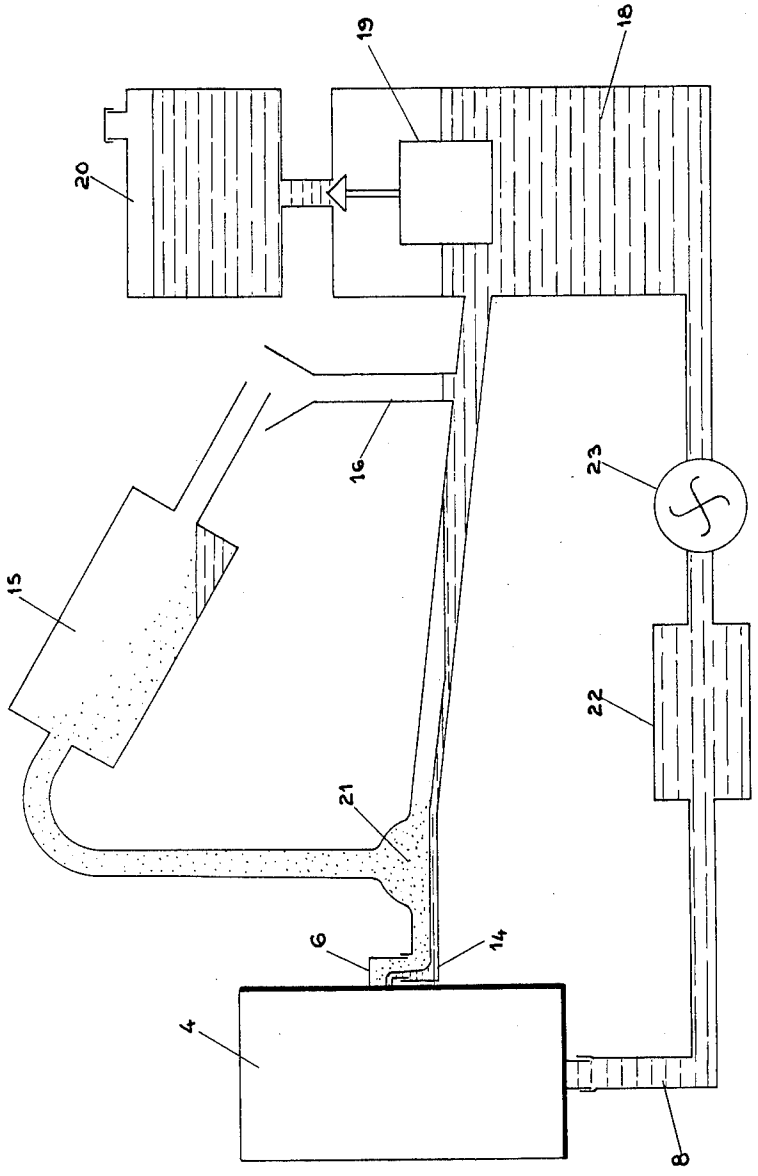
FIG. 4



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COOLING SYSTEM FOR ELECTRON DISCHARGE DEVICES

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Claims priority, application France, Jan. 9, 1961, 849,149
12 Claims. (Cl. 165—80)

The present invention relates to a cooling system for electron discharge devices and, more particularly, to cooling systems with a cooling medium for the anodes of high-power electron tubes which is permitted to boil over as it performs its cooling function.

A cooling system is known in the prior art having a boiling cooling medium for anodes of electron tubes of high power in which a relatively thick or massive anode, pierced by channels parallel to the axis thereof and open at the top and at the bottom, is placed within a tank in such a manner that the water which is admitted toward the bottom of the anode no only enters into the channels but also bathes the external wall of the anode up to a certain level corresponding to a partial occupation of the channels by the liquid. The vapor bubbles which form at the contact surface between the anode and the water rise within the portions of the channels left free by the liquid and produce a movement or circulation resulting in very effective cooling. After the ejection thereof through the top of the channels, the vapor bubbles condense within a vapor chamber and return toward the source of supply of water.

The inconvenience of this prior art system resides in the necessity of having a tank surrounding the anode which increases the capacity of the anode with respect to the ground and, in turn, presents a serious inconvenience when used with short waves or ultra short waves.

The object of the present invention is a cooling device with boiling action that avoids the afore-mentioned inconveniences and shortcomings.

Accordingly, it is an object of the present invention to provide a cooling system for high-power electron discharge devices which effectively obviates the shortcomings and inadequacies encountered with the prior art devices.

It is another object of the present invention to provide a cooling system accompanied by boiling of the cooling liquid which produces an intensive cooling of the anode of an electron discharge device by simple means.

A further object of the present invention resides in the provision of a cooling system for an electron discharge device utilizing boiling of the cooling medium which avoids any increase of the capacity of the anode with respect to ground caused by the presence of the cooling system.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein

FIGURE 1 is a longitudinal cross-sectional view of an electron discharge device cooled by a cooling system in accordance with the present invention.

FIGURE 2 is a longitudinal cross-sectional view through an electron discharge device cooled by a modified embodiment of a cooling system in accordance with the present invention.

FIGURE 3 is a schematic showing of a cooling system in accordance with the present invention, and

FIGURE 4 is a schematic showing of a modified embodiment of a cooling system in accordance with the present invention.

The cooling device according to the present invention comprises, in combination, the following features:

(a) channels provided within the body of a relatively thick or massive anode, which are parallel to the axis thereof and which are open at the top and bottom;

(b) a vapor chamber above the outlet of the channels at the top; and

(c) a tight joint disposed above the inlet of the water, with or without pressure, near the bottom of the anode to permit this water to enter exclusively into the channels through the anode bottom and thereby to prevent the water from contacting the external surface of the anode.

It is noted that whereas the combination of features (a) and (b) is known in the cooling device with boiling action described hereinabove, the combination of the features (a) and (c) has already been utilized in cooling devices by circulation of water without boiling features, for example, as disclosed in the French Patent No. 1,146,457, filed on Apr. 5, 1956, in the name of Societe Francaise Radioelectrique. Nevertheless, the present invention expressly consists in the complete combination of the three features (a), (b), and (c) within a cooling device with boiling action of the cooling liquid.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate corresponding parts, and more particularly to FIGURE 1, reference numeral **1** designates therein a high-power electron tube of which the anode **2** is either constituted itself or formed integral with a thick or massive body made of one or several pieces according to any known manufacturing technique, this body being pierced by channels **3** parallel to the axis of the tube and being open at the top and at the bottom whereby these channels constitute the feature (a) of the present invention.

Preferably, these channels are provided with a transverse cross section which increases in the direction of the circulation of the vapor bubbles, that is, present a flaring in the direction from the input at the bottom to the output at the top. This form offers the advantage of considerably reducing the shocks and violent vibrations which occur when the vapor bubbles formed have the tendency of rapidly disappearing. Additionally, it improves the heat exchange by permitting the bubbles to remain in good contact with the liquid from which they originate.

There is provided in the upper portion of the anode a vapor chamber **5**, constituting the feature (b) of the present invention; the vapor chamber **5** is provided with a vapor evacuation pipe **6**.

The input pipe **8** for the water, with or without pressure, terminates in a member **7**, and, in accordance with feature (c) of the present invention, a joint **9** is provided to permit the water to enter exclusively into the channels **3** and to prevent the water from contacting the external surface of the anode **2**. In this manner, no tank is necessary to contain the water, which reduces considerably the electrical capacity to ground of the assembly of the device.

The tightening of the water-tight enclosure delimited by the joint **9** may be effected by a clamping ring **10** and bolts **11**.

Within the device of FIGURE 1, it is necessary, when a replacement of the tube is effected, to close a water input valve for the pipe **8**. To avoid this necessity, it may be of interest, as shown in FIGURE 2, to provide the part **7** with a cylindrical wall **13** of a diameter very slightly larger than that of the anode, intended exclusively to prevent a spilling of water when the tube is withdrawn without closing the input valve. This wall **13** together with the piece **7** forms, in fact, a receptacle or tank but of a

diameter much smaller than that of the tanks of known devices, whereby its unfavorable influence on the capacity is relatively slight.

Additionally, the existence of this receptacle or tank, as shown in FIGURE 2, is not incompatible with the characteristic of the present invention, for after re-installation of the tube with the tight joint **9**, the water intended for the cooling arrives only at the bottom of the anode within the enclosure delimited by this joint **9**, whereas the water which remains between the anode **2** and the wall **13** represents only stagnant water without pressure in very small quantity which ends up by evaporating during the operation of the tube.

The water supplied to the tube may be: (1) either without pressure, with a level maintained by the tank with constant level such that the water occupies a portion of the length of the channels, the remaining portion thereof being occupied by the vapor or by the emulsion of the liquid entrained by the bubbles; (2) or under pressure, maintained by a pump of which the output is regulated in such a manner that the water fills entirely the channels but does not fill entirely the vapor chamber above the channels nor the evacuation piping in such a manner that there exists space for the vapor within this chamber and this piping.

FIGURES 3 and 4 represent two embodiments of installations corresponding, respectively, to each of these two modes of operation.

As shown in FIGURE 3, the rectangle **4** designates schematically a tube according to any one of FIGURES 1 and 2, with water inlet at **8** and vapor evacuation at **6**. The pipe **6** is engaged with a sufficient tightness within the piping **14** which conducts the vapor into the cooling condenser **15** from which the water is returned to the cycle through the channel **16**. The channel **17** recuperates the condensate which might have formed within the piping **14**. The constant level **12** is maintained by a tank **18** with constant level owing to a floating closure member **19** and a feed tank **20**.

In FIGURE 4 in which the same reference numerals designate analogous elements to FIGURE 3, the difference with FIGURE 3 resides in the fact that between the tank **18** and the channel **8** there are arranged a pump **23** and a cooling heat exchanger **22**. This pump **23** forces the water across the cooler **22** in such a manner that the water occupies entirely the channels, as shown in FIGURES 1 or 2, but does not occupy the entire cross section of the channel **6** to leave space to the vapor. The separation between the water and vapor takes place within the chamber **21**, the water returning to the cooling cycle through tank **18** and the heat exchanger **22**, whereas the vapor follows the condensation cycle within the condenser **15** and is returned to the cooling cycle through the channel **16**.

This device, which is a cooling system by circulation with boiling notwithstanding, rendered possible by the combination of the tight joint together with channels and vapor chamber according to the present invention, offers the advantage of permitting the flow of water through the channels maintained at very low temperature, for example, lower than 10° C. The circulation of this water, with a relatively little significant rate of flow, is necessary in order that the temperature of the liquid within the channels of the anode rises only slightly. The tight joint permits this circulation, and the vapor chamber permits collecting the bubbles which form at the contact between the metal and the water. However, it is known that the use of a liquid at very low temperature for cooling together with boiling permits a considerable increase in the power dissipated per surface unit. For example, if the temperature is lower than 10° C., the dissipation may amount to 1 kilowatt per cm.^{2}.

Thus, there may be recognized in this last-described feature another important advantage of the combination of the present invention in addition to the reduction of capacity mentioned hereinabove.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of many changes and modifications within the spirit and scope thereof, as known to a person skilled in the art, and we, therefore, do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:
- channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;
- vapor chamber means in communication with said outlet means;
- means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;
- and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said massive body, thereby maintaining said liquid exclusively beneath said massive body.

2. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:
- channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof, said channel means having a progressively increasing cross section in the direction from said inlet means to said outlet means;
- vapor chamber means in communication with said outlet means;
- means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;
- and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said massive body, thereby maintaining said liquid exclusively beneath said massive body whence it can escape only through said channel means.

3. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:
- channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;
- vapor chamber means in communication with said outlet means;
- means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;
- tank means disposed about said body;
- and liquid-tight seal means disposed about said inlet means to prevent the escape of said liquid to the space surrounding said massive body thereby maintaining said liquid exclusively beneath said massive body whence it can escape normally only through said channel means, said seal means being provided between the inside of said tank means and the liquid-

filled space supplied with cooling liquid by said feed means.

4. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;

and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said massive body, thereby maintaining said liquid exclusively beneath said massive body;

said massive body and said vapor chamber means forming a unitary structure.

5. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling of said liquid during operation of said tube including pressure means for circulating said liquid through said space up to said predetermined height;

and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said body thereby maintaining said liquid exclusively beneath said body whence it can flow off only through said channel means.

6. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling of said liquid during operation of said tube including static pressure means for maintaining said liquid substantially at the constant level of said predetermined height within said channel means in the absence of additional pressure means;

and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said body, thereby maintaining said liquid exclusively beneath said body in a space which, in the direction of normal flow, communicates only with said channel means.

7. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;

tank means disposed about said body;

and liquid-tight seal means disposed about said inlet means to prevent the escape of said liquid to the space surrounding said massive body thereby maintaining said liquid exclusively beneath said massive body whence it can escape normally only through said channel means, said seal means being provided between the inside of said tank means and the liquid-filled space supplied with cooling liquid by said feed means;

said massive body and said vapor chamber means forming a unitary structure.

8. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof, said channel means having a progressively increasing cross section in the direction from said inlet means to said outlet means;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;

tank means disposed about said body;

and liquid-tight seal means disposed about said inlet means to prevent the escape of said liquid to the space surrounding said massive body, thereby maintaining said liquid exclusively beneath said massive body away from the lateral surfaces of said massive body, said seal means being provided between the inside of said tank means and the liquid-filled space supplied with cooling liquid by said feed means.

9. A cooling arrangement for electron tubes having a body as anode, comprising in combination:

channel means within said body having inlet means at the bottom thereof and outlet means at the top thereof;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space comprised of said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling of said liquid during operation of said tube;

and liquid-tight seal means disposed around said inlet means to prevent the escape of said liquid to the space surrounding said massive body outside of the surfaces thereof intermediate said inlet and outlet means to thereby confine said liquid exclusively to a space beneath said massive body and the channel means in communication therewith.

10. A cooling arrangement for electron tubes having a massive body as anode, comprising in combination:

channel means in said body having open inlet means at the bottom thereof and open outlet means at the top thereof, said channel means having a progressively increasing cross section in the direction from said inlet means to said outlet means;

vapor chamber means in communication with said outlet means;

means for feeding cooling liquid to said inlet means to fill the space including said channel means and said chamber means with said liquid up to a predetermined height with the remaining part of said space being normally occupied by vapor produced by boiling on the part of said liquid during operation of said tube;

tank means disposed about said body;

and liquid-tight seal means disposed about said inlet means to prevent the escape of said liquid to the space surrounding said massive body, thereby maintaining said liquid exclusively beneath said massive body away from the lateral surfaces of said massive body, said seal means being provided between the inside of said tank means and the liquid-filled space supplied with cooling liquid by said feed means;

said massive body and said vapor chamber means forming a unitary structure.

11. A cooling arrangement for high power electron tubes comprising in combination:

a massive elongated anode body having top, bottom and side surfaces;

channel means extending longitudinally in said anode body having open inlet means at the bottom surface thereof and open outlet means at the top surface thereof;

means for injecting a cooling liquid into said channel means via said inlet means to a predetermined level;

vapor chamber means in communication with the outlet means of said channel means for collecting vaporized cooling liquid present in said channel means; and

seal means disposed in liquid-tight contact with the bottom surface of said anode body around said inlet means for preventing contact between said cooling liquid and the side surface of said anode body.

12. A cooling arrangement for high power electron tubes comprising in combination:

a massive elongated anode body having top, bottom and side surfaces;

channel means extending longitudinally in said anode body having open inlet means at the bottom surface thereof and open outlet means at the top surface thereof;

means for injecting a cooling liquid into said channel means via said inlet means to a predetermined level;

vapor chamber means in communication with the outlet means of said channel means for collecting vaporized cooling liquid present in said channel means; and

seal means disposed in liquid-tight contact with the bottom surface of said anode body around said inlet means for preventing contact between said cooling liquid and the side surface of said anode body, the side surface of said anode body being at all times during normal operation in direct contact with the outer atmosphere.

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