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ELECTRIC DISCHARGE TUBE EQUIPPED WITH ANODE
COOLED BY THE BOILING COOLING PRINCIPLE

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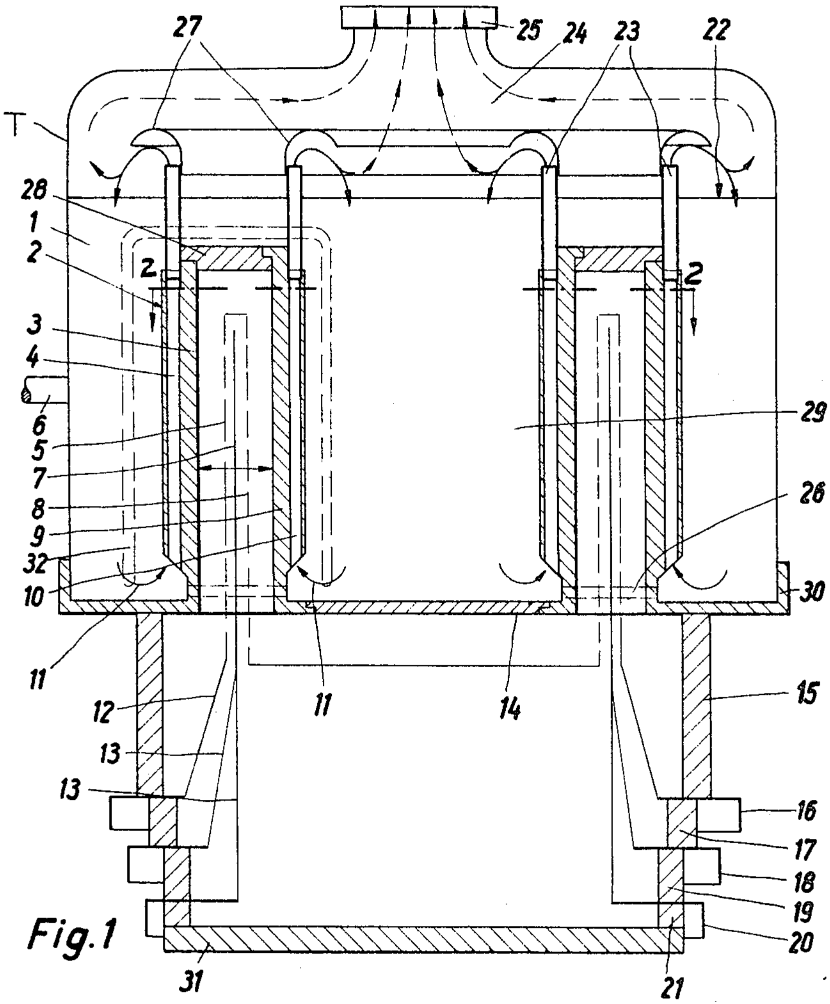

Fig. 1

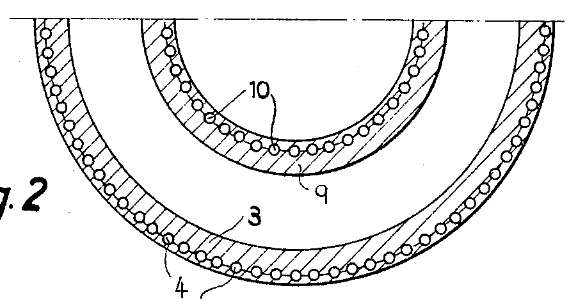

Fig. 2

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ELECTRIC DISCHARGE TUBE EQUIPPED WITH ANODE COOLED BY THE BOILING COOLING PRINCIPLE

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The present invention relates to an electric discharge tube, especially to a high-power tube which is equipped with a cooling system, particularly to a cooling system operating on the principle of so-called boiling cooling.

Conventionally, high-power discharge tubes comprise an axially symmetrical cathode, i.e., a cathode which is symmetrical with respect to rotation, which cathode emits radially both inwardly and outwardly and is surrounded by an electrode arrangement which itself is axially symmetrical. This electrode system is made up of at least two electrodes, namely, a grid electrode and an anode. Both the grid electrode as well as the anode are so configured as to have U-shaped cross sections, so that the grid and the anode encompass the cathode somewhat in the manner of a tunnel.

One of the advantages of the above-described tube structure is that, due to the fact that the heating filaments are put to use on two sides, the over-all length of the arrangement is smaller than if the filaments were utilized on but one side. For example, a tube whose heating filament arrangement is utilized on but one side can be operated only to the reversing point of the emission characteristic; this, depending on the precise arrangement of the structure, will be of the order of only 30 to 45% of the saturation emission. If, however, the same filament arrangement is utilized on both sides, the reversing point of the characteristic will be at 60 to 70% of the saturation emission. Nevertheless, the specific grid load, i.e., load per unit area, is very low thanks to the use of the double grid surface. Furthermore, the basic temperature of the grid, if used in a two-sided filament arrangement, is less than if a one-sided filament arrangement is used, even at no load, inasmuch as, in the one-sided system, there is no inner anode to offer any shielding.

The present invention, therefore, concerns itself with a tube of the above type, namely, a tube having a cathode that emits radially both inwardly and outwardly and an anode which is constructed so as suitably to coact with such a cathode. Such an anode is in the form of an inverted annular trough of U-shaped cross section which overlies the cathode, and it is the basic object of the present invention to provide a way in which such anode is cooled very effectively, thereby to allow the tube to operate at high efficiency.

With the above primary object in view, the present invention resides, basically, in the fact that the inner anode cylinder—the anode, due to its inverted trough-like configuration, can be considered as incorporating two concentric cylinders which form an annular space between themselves, it being in this space that the cathode is arranged—is provided, in the region of its inner surface, with a plurality of axially extending cooling channels and the outer of the two anode cylinders is provided, in the region of its outer surface, with a plurality of further, axially extending cooling channels.

In practice, the anode is arranged within a tank, so that an outer coolant chamber is formed between the outer surface of the outer anode cylinder and the inner surface of the tank, while an inner coolant chamber is formed within the cylindrical space defined by the inner surface of the inner anode cylinder. These two coolant chambers may, and in practice generally will be, in communication with each other. The cooling channels in both of the anode cylinders have their lower ends in communication with the respective coolant chamber, in consequence of which coolant—usually water—in the coolant chambers will, upon heating up of the anode cylinders and the resultant vaporization of some of the coolant in the channels, be drawn into the channels.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a sectional elevational view of an electric discharge tube incorporating a cooling system in accordance with the present invention.

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1 and shows only the anode and the cooling channels.

Referring now to the drawing, the same shows a discharge tube in which the heating filaments **7** for the cathode are arranged on a circular cylinder. (For the sake of convenience, the term "cylinder" will hereinafter be used to refer to parts which are axially, i.e., rotationally, symmetrical.) The filaments are arranged within a grid electrode **5**, **8** of inverted U-shaped cross section. The grid electrode itself is arranged within an anode **2** which, as the other parts described so far, is axially, i.e., rotationally, symmetrical, and will, therefore, be referred to as being a cylinder. The anode **2**, too, has a U-shaped cross section, as formed by the two vertically oriented, generally coaxial anode cylinders **3** and **9** which are connected, across their top, by a connecting ring **28**, the same being soldered to the cylinders **3** and **9**. The lower central opening formed by the cylinder **9** is closed by a bottom wall **14** which is set into the cylinder **9** and which serves as a vacuum tight seal for the electrode system. The cylinder **9** together with its bottom **14** thus forms an inner coolant chamber **29** which serves as a boiling cooling vessel, while an outer coolant chamber **1** is formed between the outer surface of the outer anode cylinder **3** and the inner wall surface of a boiling cooling vessel or tank shown at T.

FIGURE 1 also shows the electrical leads to the various electrodes, which leads terminate in suitable connecting rings. Thus, the two leads **13** for the heating filaments **7** terminate in rings **18** and **20**, the grid electrode **5**, **8** is connected via leads **12** to ring **16**, and the anode is connected directly to a ring **30**. The individual connecting rings are held in place by means of suitable insulating rings **15**, **17**, **19** and **21**, there also being a bottom plate **31**.

The anode cylinder **3** is provided, near its outer peripheral surface, with a series of circumferentially distributed, axially extending cooling passages or channels **4**, each of which is a separate channel, while the anode cylinder **9** is provided, near its inner peripheral surface, with a series of further circumferentially distributed, axially extending cooling passages or channels **10**, each of which is likewise a separate channel (see FIGURE 2). The lower ends of channels **4** are open and are in communication with the outer coolant chamber **1**, while the lower ends of the channels **10** are open and in communication with the inner coolant chamber **29**. Connected to the upper ends of the cooling channels **4** and **10** are exhaust conduits **23**, these conduits themselves being spaced from each other thereby to form interspaces between themselves, it being via these interspaces that the inner and outer coolant chambers **29**, **1**, are in communication with each other, so that the level of the cooling water in the two chambers will be the same, as shown at **22**. Arranged above the exhaust conduits **23** are deflector baffles **27** which are so shaped that the water-air mixture which comes out of the exhaust conduits **23** is diverted toward the water level 22, as shown by the arrows drawn in solid lines. The steam formed in the steam collector chamber 24 is exhausted via a steam exhaust 25, as shown by the arrows drawn in dashed lines.

The water in the coolant chamber is replenished via a fresh water supply pipe, shown at 6, this pipe communicating with the cooling chambers. This pipe will, in practice, communicate with the tank T at a point lower than that shown in the drawing, so as to allow the water to be drained from the tank T when desired.

In operation, the water in the channels 4, 10, will be heated and partly vaporized. The water-steam mixture shoots upwardly at great speed, so that the anode surface to be cooled will be continuously contacted by fresh coolant, the water flowing into channels 4, 10, from the outer and inner cooling chambers, respectively, as shown by the arrows 11 leading into the bottom of the channels 4, 10. The upwardly flowing water-steam mixture is then deflected by the baffles 27, so that the water coming out of the channels 4, 10, will be returned to the respective coolant chambers while the steam collects in the chamber 24 and is ultimately drawn out through the exhaust 25.

The cooling effect is enhanced by making the channels, which, in practice, are preferably of circular cross section, relatively narrow so that when the water is vaporized, the size of the thus-formed vapor bubbles is limited. Instead, the vapor bubbles shoot upwards and carry along the water particles, it being the latter which—still in liquid state—serve to cool the anode cylinders 3, 9. For example, the channels 4, 10, may have a diameter of about 10 millimeters.

If desired, the water level in the two cooling chambers can be equalized by means of a number of radially extending conduits 26, penetrating through the cylinders 3 and 9 near the bottoms thereof, thereby establishing a fluid communication between the inner and outer coolant chambers. According to a further feature of the present invention, the conduits, which may be constituted by hollow webs or tubes, are made of metal and are distributed evenly about the circumference of the anode, thereby establishing a high-frequency short-circuit between the two anode cylinders 3, 9, as is often desired.

According to another feature of the present invention, the water can be supplied to the interior cooling system i.e., the coolant chamber 29 and the channels 10, via an insulated conduit which passes through that part of the discharge tube which does not pertain to the actual discharge chamber. Such a conduit would pass through the bottoms 31 and 14.

According to another feature, the inner cooling chamber 29 may be emptied by means of a number of U-shaped channels 32 which, however, have to be mounted so as not to be in heat-exchange contact with the anode cylinders.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. An electric discharge tube equipped with an anode which is cooled by the boiling cooling principle, the tube comprising, in combination: a tank, and an anode arranged in said tank, said anode being constituted by two vertically oriented concentric cylinders which are connected together across the top, thereby to form an anode of inverted U-shaped cross section, there being arranged within the annular space formed between said two cylinders a cathode that emits radially in both directions; a plate closing the lower end of the inner of said two concentric cylinders for forming a vacuum tight seal for the anode and cathode; there being an outer coolant chamber formed between the outer surface of the outer one of said two concentric cylinders and the inner surface of said tank within which said anode is arranged, and there being an inner coolant chamber formed within the cylindrical space defined by the inner surface of the inner of said two concentric cylinders and said plate; said outer cylinder being provided, in the region of said outer surface thereof, with a plurality of circumferentially distributed, axially extending cooling channels whose lower ends communicate with said outer coolant chamber; and said inner cylinder being provided, in the region of said inner surface thereof, with a plurality of further circumferentially distributed, axially extending cooling channels whose lower ends communicate with said inner coolant chamber; in consequence of which coolant in said coolant chambers will, upon heating up of said anode cylinders and the resultant vaporization of some of the coolant in said channels, be drawn into said channels.

2. An electric discharge tube as defined in claim 1, further comprising means for placing said inner and outer coolant chambers in communication with each other.

3. An electric discharge tube as defined in claim 2 wherein said means comprise a plurality of circumferentially distributed conduits extending radially through said two concentric cyilnders near the bottoms thereof.

4. An electric discharge tube as defined in claim 3 wherein said conduits are made of metal, thereby establishing a high-frequency short-circuit connection between said concentric cylinders.

5. An electric discharge tube as defined in claim 4 wherein said conduits are tubes.

6. An electric discharge tube as defined in claim 4 wherein said conduits are hollow webs.

7. An electric discharge tube as defined in claim 1, further comprising means for supplying fresh coolant to said tank.

8. An electric discharge tube as defined in claim 7 wherein said coolant supply means communicate with said outer coolant chamber.

9. An electric discharge tube equipped with an anode which is cooled by the boiling cooling principle, the tube comprising, in combination: a tank, and an anode arranged in said tank, said anode being constituted by two vertically oriented concentric cylinders which are connected together across the top, thereby to form an anode of inverted U-shaped cross section, there being arranged within the annular space formed between said two cylinders a cathode that emits radially in both directions; there being an outer coolant chamber formed between the outer surface of the outer one of said two concentric cylinders and the inner surface of said tank within which said anode is arranged, and there being an inner coolant chamber formed within the cylindrical space defined by the inner surface of the inner of said two concentric cylinders; said outer cylinder being provided, in the region of said outer surface thereof, with a plurality of circumferentially distributed, axially extending cooling channels whose lower ends communicate with said outer coolant chamber; and said inner cylinder being provided, in the region of said inner surface thereof, with a plurality of further circumferentially distributed, axially extending cooling channels whose lower ends communicate with said inner coolant chamber; in consequence of which coolant in said coolant chambers will, upon heating up of said anode cylinders and the resultant vaporization of some of the coolant in said channels, be drawn into said channels; and a number of exhaust conduits each connected to the upper end of a respective coolant channel.

10. An electric discharge tube as defined in claim 9 wherein said exhaust conduits are spaced from each other, the interspaces therebetween forming a communication between said inner and outer coolant chambers.

11. An electric discharge tube as defined in claim 10 wherein said exhaust conduits are open at their top above the level of the coolant in said communicating inner and outer coolant chambers, the tube further comprising baffle means arranged above said exhaust conduits for de-

flecting the water-steam mixture issuing therefrom back toward the coolant level.

12. An electric discharge tube as defined in claim **11**, further comprising means communicating with said tank at the top thereof for drawing off steam.

13. An electric discharge tube as defined in claim **1** wherein said cooling channels have a small cross section thereby to limit the size of vapor bubbles formed in the coolant.

14. An electric discharge tube as defined in claim **13** wherein said coolant channels have an approximately circular cross section.

15. An electric discharge tube as defined in claim **14** wherein the diameter of said circular cooling channels is approximately 10 millimeters.

16. For use in an electric discharge tube, an anode which is cooled by the boiling cooling principle, said anode comprising two concentric anode cylinders, the inner of said cylinders being provided, in the region of its inner surface, with a plurality of axially extending cooling channels and the outer of said cylinders being provided, in the region of its outer surface, with a plurality of further, axially extending cooling channels, and a plate closing the lower end of said inner cylinder and forming together therewith a chamber for a coolant which, upon boiling, vaporizes and is drawn into said cooling channels.

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