May 26, 1959 J. S. HICKEY, JR 2,888,584

LIQUID-COOLED ELECTRODE

Filed June 22, 1955

Fig. 1.

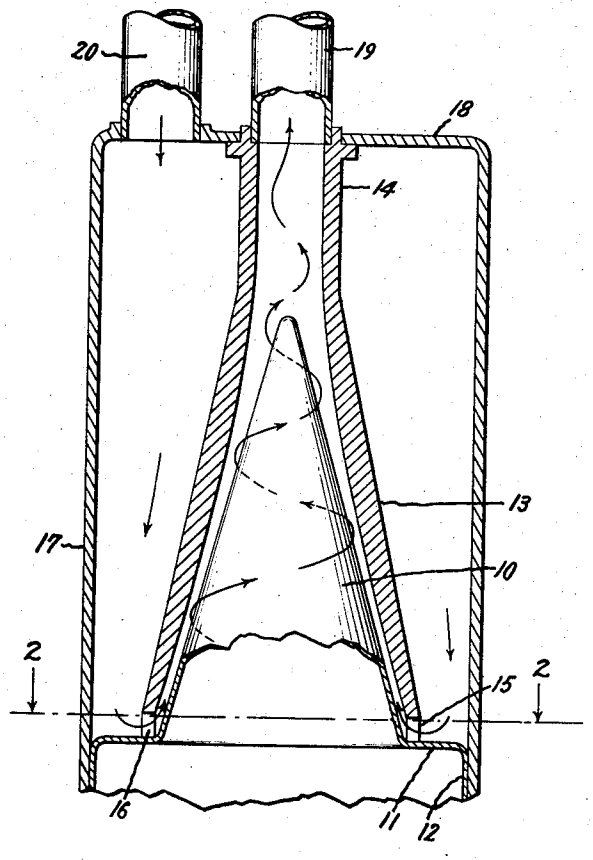
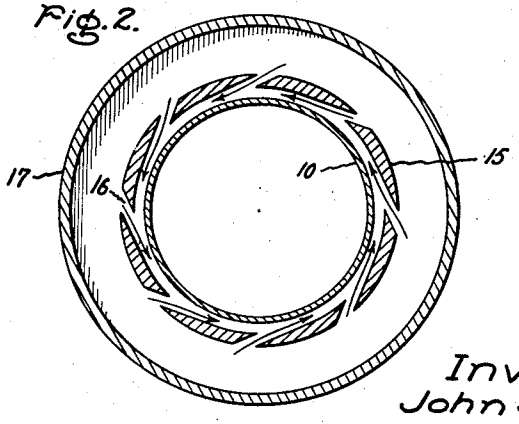


Fig. 2.



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LIQUID-COOLED ELECTRODE

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4 Claims. (Cl. 313—17)

My invention relates to improved liquid-cooled electrode assemblies and more particularly to an improved liquid-cooled conical electron collector.

In high power electron discharge devices of the velocity modulation or traveling wave type, for example, it is common practice to employ a hollow conical collecting electrode for collecting the electrons of the beam after it has interacted with the velocity modulation gaps or with the slow wave structure of the traveling wave tube. These electrons may have substantial kinetic energy which is converted to heat when they are collected and as higher voltage and higher outputs are utilized, the difficulties involved in adequately cooling the collector electrode increase. My invention contemplates a jacketed conical electrode which is cooled by liquid, preferably water, which is introduced into the space between the jacket and the large end of the conical collector in a tangential direction. The jacket or casing extends in spaced relation to the exterior of the collecting electrode throughout its length and preferably forms a space of substantially uniform cross-sectional area in the direction of flow. In this way, the cooling liquid is suitably confined and at the same time the rotational momentum is conserved so that an extended liquid path throughout which the liquid moves at a substantial velocity is provided without the necessity of providing guide baffles which are somewhat difficult to provide on the conical structure and which materially increase the cost involved. These baffles also increase the resistance to the flow of the cooling liquid and in this way increase the energy required to produce a flow of desired magnitude.

Accordingly, it is an important object of my invention to provide a new, improved and simplified liquid-cooled conical electrode.

Other objects and advantages of my invention will become apparent as the following description proceeds, reference being had to the accompanying drawing in which Fig. 1 is an elevational view in section of an electrode assembly embodying my invention and Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1.

Referring now to the drawing, I have shown my invention embodied in an electrode assembly including a conical electrode **10**, preferably formed of metal, such as copper, which has good electrical and thermal conductivity. As illustrated, the electrode **10** is provided at the larger open end thereof with an outwardly extending flange **11** terminating in a cylindrical flange **12** which may be sealed or bonded to a vacuum-tight envelope (not shown) in a manner well understood by those skilled in the art. It will be appreciated that the parts **10**, **11** and **12** need not be integrally formed and the mounting may be by a flange of heavier material which is bonded to the collector **10**. In accordance with my invention, the collector electrode **10** is surrounded by a hollow tapered casing or jacket **13** which extends throughout the axial length of the collector and terminates in a cylindrical tubular portion **14** adjacent the closed end of the electrode and in a cylindrical portion **15** adjacent the large end of the electrode **13**. As

illustrated, the end of the cylindrical portion **15** rests upon and is bonded to the outwardly extending flange **11**. Cooling liquid is introduced into the space between the electrode **10** and the casing **13** through a plurality of circumferentially spaced, tangentially directed openings **16** provided in the cylindrical portion **15** of the casing **13**. Liquid under pressure is supplied to these openings through a manifold provided by the cylindrical casing **17** which surrounds the casing **14** and forms a closed annular receptacle. As illustrated, the lower end of the casing **17** is bonded to the cylindrical flange **12** at its lower end and provided at its upper end with an end wall **18** to which the upper end of the casing **13** is secured. It will be appreciated that the casing **17** may be removably mounted by providing cooperating flanges on the casing **17** and cylinder **12**. An outlet pipe **19** connects with the end **14** of the casing and an inlet pipe **20** is secured to the end wall **18** and provides the supply conduit for the cooling liquid.

In accordance with an important feature of my invention, the casing **13** is shaped to provide a confined annular space of substantially uniform cross-sectional area in the direction of liquid flow. Theoretically, this would require a surface which is a hyperboloid of revolution. However, this constant area may be approximated by employing two conical sections of a slightly different taper and thus simplify the cost of manufacture without interfering with the efficiency of the cooling system. If the helical path of the cooling liquid remains at substantially constant pitch, the cross-sectional area of the annular path is also substantially constant in an axial direction. The water is introduced through the openings **16** with a large rotational component of velocity. The momentum of the liquid tends to increase the rotational velocity as the mean radius of the path of the liquid decreases toward the small end of the cone. The inner wall of casing **13** tapers less than the outer wall of electrode **10** so that the annular passage therebetween is of substantially constant area. This minimizes the losses which otherwise tend to substantially reduce the rotational flow. This flow is maintained without the use of expensive baffles which are otherwise required and which would require either an intricate machining operation or a rather difficult job of bonding a spiral baffle to the electrode or to the surrounding casing or to both the electrode and surrounding casing.

While I have described my invention in connection with a collecting electrode for an electron discharge device, it will be apparent that in its broader aspects, it is applicable to any other conical surface from which it is desired to remove a substantial amount of heat.

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

1. A liquid-cooled electrode assembly comprising a hollow conical electrode open at the large end for the entrance of electrons to be collected on the inner wall thereof, a first casing surrounding said electrode throughout its length and spaced therefrom to provide an annular passage of substantially constant cross-sectional area, said casing defining a plurality of circumferentially spaced openings directed substantially tangentially with respect to said passage near the large end of said electrode and a second casing surrounding said first casing in the area of said openings and providing a manifold for supplying cooling liquid under pressure to said passages.

2. A liquid-cooled assembly comprising a hollow conical member open at the large end thereof, a first casing surrounding said member throughout its length and spaced therefrom to provide an annular passage, said casing defining a plurality of circumferentially spaced openings directed substantially tangentially with respect to said passage near the large end of said member and a

second casing surrounding said first casing in the area of said openings and providing a manifold for supplying cooling liquid under pressure to said passages.

3. A liquid-cooled electrode assembly comprising a hollow conical electrode open at the large end for the entrance of electrons to be collected on the inner wall thereof, and having an outwardly directed flange surrounding said large end, a first casing surrounding said electrode throughout its length and spaced therefrom and providing an annular passage for the flow of cooling liquid, said casing defining a plurality of circumferentially spaced openings directed substantially tangentially with respect to said passage near the large end of said electrode, said first casing also extending beyond the closed end of said conical electrode and providing an outlet passage coaxial with said electrode, and a second casing surrounding said first casing and providing in cooperation with said flange a manifold for supplying cooling liquid under pressure to said passages.

4. A liquid-cooled electrode assembly comprising a hollow conical electrode open at the large end for the entrance of electrons to be collected on the inner wall thereof, a first casing surrounding said electrode throughout its length and spaced therefrom and providing an annular passage of increasing width and decreasing outer diameter toward the small end of said cone, said casing defining a plurality of circumferentially spaced openings directed substantially tangentially with respect to said passage near the large end of said electrode and a second casing surrounding said first casing in the area of said openings and providing a manifold for supplying cooling liquid under pressure to said passages, whereby said first casing cooperates with the outer wall of said electrode to conserve the angular momentum of said liquid imparted by said openings to improve the heat transfer between said liquid and said electrode.

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