The present invention relates to a power electronic valve of the triode, tetrode or pentode type for example, cooled by the circulation of a fluid and relates particularly to means permitting the cooling of the anode connection member to be improved.

In such electronic valves, a flow of electrons is emitted by a cathode towards an anode. This flow of electrons is modulated by one or more grids before arriving at the anode. The kinetic energy of the electrons is transformed into heat at the anode. For the power electronic valves, the energy to be dissipated is significant, to the extent that it is necessary to use cooling devices operating with a fluid whose circulation is forced. This fluid is often air for low powers and a liquid, especially water, for high powers.

Power electronic valves generally have the following configuration, in the case of a triode with a directly heated cathode, for example : the cathode has the shape of a cylinder having as its axis the longitudinal axis of the valve. Next is found a grid which surrounds the cathode and finally an anode which surrounds the grid. The heated part of the cathode constitutes, along the longitudinal axis, an active length emitting electrons: the electrons traverse the grid along radial directions and are picked up by the anode. The anode and the grid each have the shape of a hollow cylinder and they each possess, at their base, on the side of the foot of the valve, a member for an electrical connection with the outside, which has a cylindrical shape. These anode and grid connection members are mechanically integrated, by sealing, with the same insulating spacer. The anode constitutes a part of the leaktight enclosure inside which is produced the vacuum necessary for the operation of the electronic valve.

The cooling of the valve is brought about with the aid of a cooler constituted by two coaxial cylindrical envelopes, mounted around the anode, one end of

the outer envelope being fixed in a leaktight manner to a yoke of the valve, situated on the side of the foot of the latter. The outer envelope is equipped with an entry conduit through which the cooling fluid, water for example, arrives.

The circulation of the water is forced and the water circulates, for example, between the outer envelope and the inner envelope as far as the base of the outer envelope where the water is injected and progresses between the space formed between the inner envelope and the external wall of the anode. The transfer of the heat into the water is carried out in this area. The water is next removed by a second conduit with which the inner envelope is equipped.

The effectiveness of the cooling of the anode is linked, in a way known per se, to the characteristics of flow of the cooling fluid, especially to the pressure with which the water is injected into the cooler and to the dimensions of the space between the inner envelope and the external wall of the anode.

The configuration described above has one drawback; in effect the elements situated in proximity to the anode have a tendency to undergo a significant temperature rise due to thermal conduction. This is the case especially for the member for connecting the anode.

The anode connection member provides both the electrical link of the anode with the outside and a mechanical link between the insulating spacer separating it from the member for connecting the grid. This insulating spacer is preferably produced in ceramic.

UHF currents circulate at the surface of the conductors over a thickness which decreases as the frequency increases; this phenomenon is known by the name of skin effect. The raising of the frequency leads to an increase in losses by Joule effect, more particularly in the region of the link between the anode connection member and the insulating spacer.

In fact at this site it is not possible, because of the metal-to-ceramic seal, to lower the level of the losses by having recourse, as for the rest of the member, to a surface coating of a good conductor of electricity such as copper, for example.

The intense heating of the anode connection member can be injurious for the electronic valve. This heating is due to thermal conduction and to the Joule effect. The materials constituting the anode connection member and the insulating spacer, namely metal and ceramic, have different behaviour as the temperature is raised. The mechanical stresses induced in these materials then risk leading to fracture, either at the site of the metal-to-ceramic seal, or in the insulating spacer itself.

The invention aims to remedy this drawback by making it possible to stabilise the temperature of the anode connection member at an acceptable level.

The invention consists in diverting all or part of the fluid for cooling the anode, so as to provide a circulation of fluid over the anode connection member, favouring the area of the ceramic-to-metal seal.

The invention proposes a power electronic valve comprising :

- a hollow cylindrical anode mounted coaxially around a hollow cylindrical grid, which itself surrounds a cathode, the inside of the anode being hermetically closed off and subjected to a vacuum,

- an electrical connection member for the cylindrical anode, brazed on one side to the base of the anode,

- a cooler with a forced fluid circulation, constituted by two coaxial cylindrical envelopes mounted around the anode and defining a closed enclosure connected to an inlet conduit and to a removal conduit for the fluid, characterised in that the member for connecting the anode is brazed on the other side to a part of or is integral with the outer envelope of the cooler and in that this anode connection member

constitutes, between its two sides, a leaktight wall closing off the enclosure of the cooler and in contact with the cooling fluid.

It is anticipated in principle that the anode connection member is moreover integrated with an insulating spacer serving as support for a grid connection member and ensuring vacuum-tightness inside the anode. It is then arranged that the region where the anode connection member is sealed to the spacer is in contact with the cooling fluid.

In two embodiments, the part which is integrated with the outer envelope is a yoke which is brazed to the base of the anode. It is traversed by orifices and the circulation of the cooling fluid is diverted either partially or totally through these orifices towards the anode connection member so as to cool it. At least one of the orifices has its longitudinal axis situated between the inner envelope and the outer envelope of the cooler. At least one other orifice has its longitudinal axis situated between the inner envelope of the cooler and the external wall of the anode.

In another embodiment, the part which is integrated with the outer envelope is a ring. The anode connection member is in contact with the whole of the cooling fluid. The anode connection member provides the complete mechanical link between the anode and the ring and consequently between the anode and the outer envelope of the cooler. An opening is made between the end of the inner envelope of the cooler and the anode connection member for the passage of the fluid.

The invention will be better understood by virtue of the description which will follow, given by way of non-limiting example, and of the attached figures which represent :

- Figure 1, a sectional view of an electronic valve cooled according to the prior art,

- Figures 2, 3, 4, sectional views of three variants of the cooling system for the anode connection

member according to the invention.

In these figures the same references designate the same elements, but, for reasons of clarity, the dimensions and proportions of the various elements are not respected.

Figure 1 represents in section a power electronic valve 1 according to the prior art of the triode type with direct heating.

The valve 1 comprises a cathode 5 with direct heating, of cylindrical form having as its axis 3 a longitudinal axis of the valve 1.

The cathode 5 is mounted in a conventional manner as shown in the figure : it is fixed, on the side of a valve foot 4, on the one hand to a central stem 2, and on the other hand to a tubular support 19, by which it is electrically linked to a first and to a second connection member 12, 6. These connection members 12, 6 are metal and are both rendered mechanically integral with each other via an insulating spacer 7. A grid 8 surrounds the cathode 5. The grid 8 has the form of a hollow cylinder having as its axis the longitudinal axis 3.

The end 11 of the grid 8 which is found at the side of the valve foot 4 is connected to a third connection member 13 which is integrated with the second connection member 6 via an insulating spacer 14. Next is found, around the grid 8, an anode 15 which constitutes a part of an enclosure inside which is produced the vacuum necessary for the operation of the valve. The anode 15 has the general form of a hollow cylinder having as its axis the longitudinal axis 3 and one end of which, situated towards the foot of the valve 4 is connected by brazing, on the one hand to a yoke 22, and on the other hand to a fourth connection member 23 which is itself rendered integral with the grid connection 13 via an insulating spacer 25. All the insulating spacers are of cylindrical form and are produced preferably in ceramic. The links between the connection members and the insulating spacers are seals.

It will be noted that in the structure of the prior art, the anode connection member is welded only to the anode 15 and to the insulating spacer 25.

The electronic valve 1 further comprises a cooler 35 mounted around the anode 15. This cooler 35 is constituted by two envelopes 36, 37 of generally cylindrical form, which are coaxial, each having a first end 38, 39 closed off and a second end 40, 41 open. The outer envelope 36 is fixed at its base by its open end 40 to the yoke 22, in a leaktight manner, with the aid, for example, of screws 43 and of a leaktight joint 44.

The open end 41 of the inner envelope 37 is not joined to the yoke 22 so as to form an opening 47 permitting the passage of a cooling fluid.

The closed end 38 of the outer envelope 36 comprises an entry nozzle 49 through which is injected, in a conventional manner, a pressurized fluid, water for example. The water circulates between the outer envelope 36 and the inner envelope 37 and is injected at the site of the opening 47 into an enclosure formed by the inner envelope 37 and the anode 15. The water is next removed by an outlet nozzle 51 placed on the closed end 39 of the inner envelope 37.

The modifications contributed by the present invention will now be described.

Figure 2 represents a partial sectional view of the cooling system for an electronic valve according to the invention; the figure represents only one area in the vicinity of the anode connection, the rest of the construction being able to be identical to that which has been described with reference to Figure 1.

The base 40 of the outer envelope 36 of the cooler is fixed, in a leaktight manner, with the aid of screws 43 and of a leaktight joint 44, for example, onto the upper face of a yoke 55. The yoke 55 is fixed to the outer envelope 36 of the cooler on the side of its outer periphery while its inner periphery is brazed to the anode 15.

The anode connection member 23 is still brazed on one side 50 to the base of the anode 15 while the other side 51 is brazed to the lower face of the yoke 55. It is still integrated with the insulating spacer 25 via a ceramic-to-metal seal.

The brazing of the anode connection member 23 ensures the leaktightness of an enclosure 52 formed between the anode connection member 23 and the lower face of the yoke 55.

The anode connection member 23 thus mounted ensures leaktightness between the cooling circuit and the outside of the valve and between the cooling circuit and the inside of the electronic valve.

The circulation of the cooling water is carried out in the enclosure 52 by virtue of orifices traversing the yoke 55. Figure 2 is a section through two of these orifices designated by 53 and 54. The orifice 53 serves as entry orifice as it is situated on the yoke 55 between the outer envelope 36 and the inner envelope 37.

The orifice 54 serves as outlet orifice as it is situated on the yoke 55 between the inner envelope and the anode 15.

The open end 41 of the inner envelope 37 is not joined to the yoke 55 so as to form an opening 47 intended for the passage of a part of the cooling water.

This embodiment permits a partial diversion of the cooling water of the main circuit. In fact water can always pass through the opening 47. It is possible to control the flow of water necessary for the cooling of the anode connection member 23 in particular in the region of the seal with the insulating spacer 25 by varying the ratio of the pressure drops of the diverted circuit and of the main circuit and, also, the dimensions of the aperture 47.

Figure 3 represents in section another embodiment of the cooling circuit according to the invention.

In this embodiment, the end 41 of the inner envelope 37 of the cooler is now contiguous with the

upper surface of the yoke 55. Absolute leaktightness of this link is not necessary, the two members are in contact but it is also possible to braze them. There are no other modifications as regards the mounting of the other members with respect to what has been described in Figure 2.

The whole of the cooling water now passes into contact with the member 23 for connecting the anode 15.

Figure 4 represents in section another embodiment of the cooling circuit according to the invention.

In this embodiment the anode 15 connection member 23 is still brazed on one side 50 to the base of the anode 15 and onto the other side 51 on the inner flank of a ring 56 which is integrated with the base of the outer envelope 36 of the cooler.

The base 40 of the outer envelope 36 of the cooler is fixed in a leaktight manner, for example with the aid of screws 43 and of a leaktight joint 44, onto the upper face of the ring 56. The ring 56 is not linked to the anode 15.

The connection member 23 constitutes, between its two sides, a leaktight wall closing off the enclosure of the cooler.

The open end 41 of the inner envelope 37 is not contiguous with the anode connection member 23 so as to form an opening 48 intended for injection of cooling water.

In this configuration the injection of the water into the cooling circuit for the anode 15 is carried out at the site of the seal of the anode 15 connection member 23 with the insulating spacer 25. The effectiveness of the cooling is a maximum. But it is the anode connection member 15 which completely ensures the mechanical link between the anode and the outer envelope 36 of the cooler.

The invention is not limited to the configurations described above.

It is especially possible that the anode connection piece is brazed, on one side to the base of the anode, and on the other side directly to the base of the outer envelope of the cooler. The presence of a yoke (55) or of a ring (56) is no longer necessary.

CLAIMS

1. Power electronic valve comprising :

- a hollow cylindrical anode (15) mounted coaxially around a hollow cylindrical grid (8), which itself surrounds a cathode (5), the inside of the anode being hermetically closed off and subjected to a vacuum,

- an electrical connection member (23) for the cylindrical anode, brazed on one side (50) to the base of the anode (15),

- a cooler (35) with a forced fluid circulation constituted by two coaxial cylindrical envelopes (36, 37) mounted around the anode (15) and defining a closed enclosure connected to an inlet conduit (49) and to a removal conduit (51) for the fluid, characterised in that the member (23) for connecting the anode is brazed on the other side (51) onto a part of or is integrated with the outer envelope (36) of the cooler and in that this anode connection member (23) constitutes, between its two sides (50, 51), a leaktight wall closing off the enclosure of the cooler and in contact with the cooling fluid.

2. Power electronic valve according to Claim 1, characterised in that the part which is integrated with the outer envelope (36) of the cooler is a yoke (55) brazed to the base of the anode, this yoke possessing orifices (53, 54), at least one orifice (53) having a longitudinal axis situated between the inner envelope (37) and the outer envelope (36) of the cooler, and at least one other one (54) having a longitudinal axis situated between the inner envelope (37) of the cooler and the external wall of the anode (15).

3. Power electronic valve according to Claim 2, characterised in that an opening (47) exists between the end (41) of the inner envelope (37) of the cooler and the upper surface of the yoke (55) so that the circulation of the cooling fluid is partially diverted through the orifices (53, 54) of the yoke (55).

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4. Electronic power valve according to Claim 2, characterised in that the end (41) of the inner envelope (37) of the cooler is contiguous with the upper surface of the yoke (55) so that the circulation of the cooling fluid is completely diverted through the orifices (53, 54) of the yoke (55).

5. Electronic power valve according to Claim 1, characterised in that the part which is integral with the outer envelope (36) of the cooler is a ring (56), the anode connection member being brazed, on one side onto the inner flank of the ring (56), and on the other to the base of the anode (15), so as to provide a mechanical link between the anode and the outer envelope, and in that an opening (48) is formed between the end of the inner envelope of the cooler and the anode connection member (23) for the passage of the fluid.