

July 4, 1950

G. L. USSELMAN ET AL
HEAT DISSIPATING JACKET

2,513,828

Filed Aug. 28, 1947

4 Sheets-Sheet 1

Fig. 1.

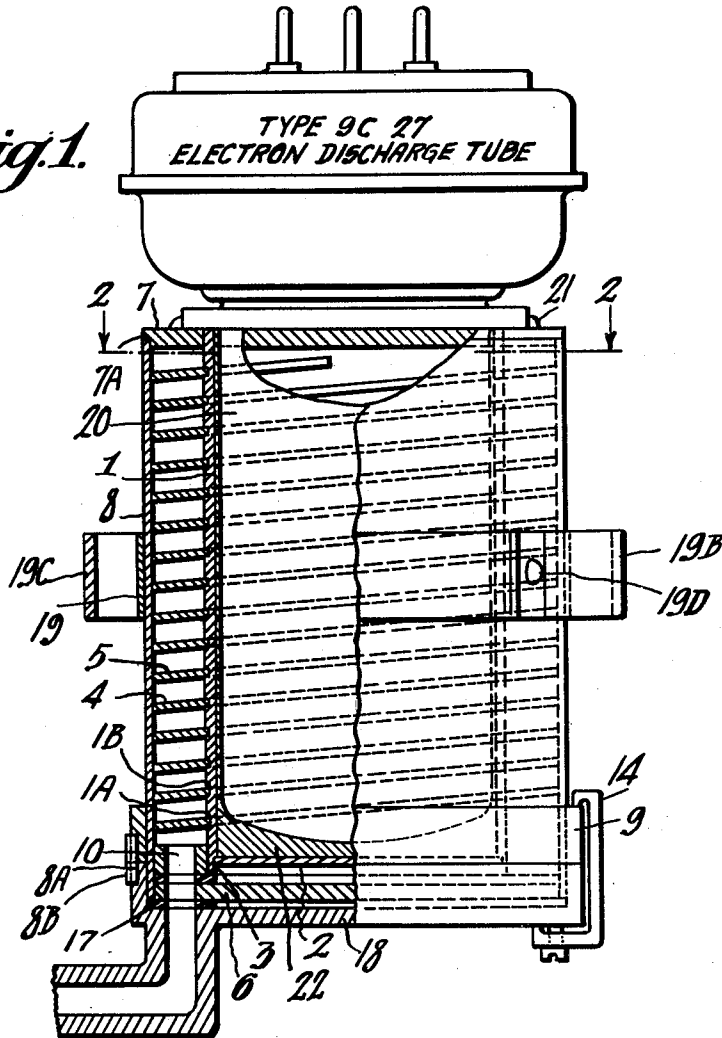


Fig. 6.

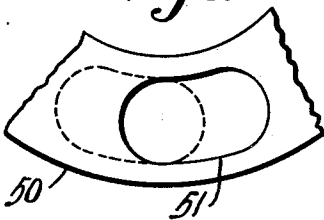
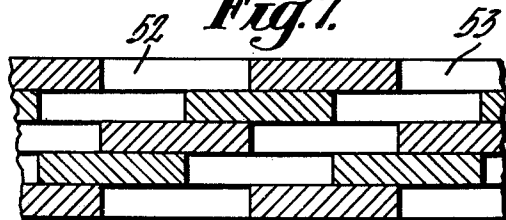


Fig. 7.



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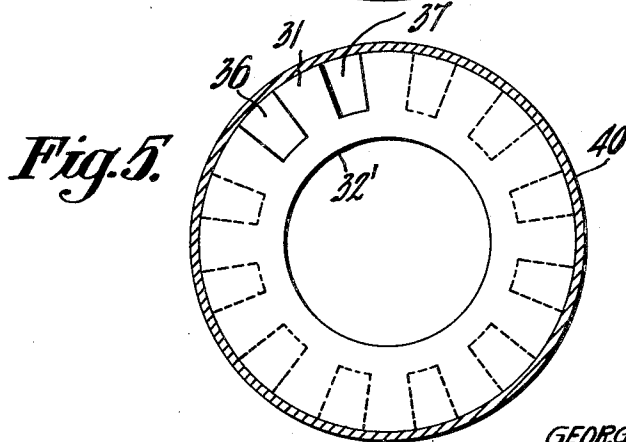
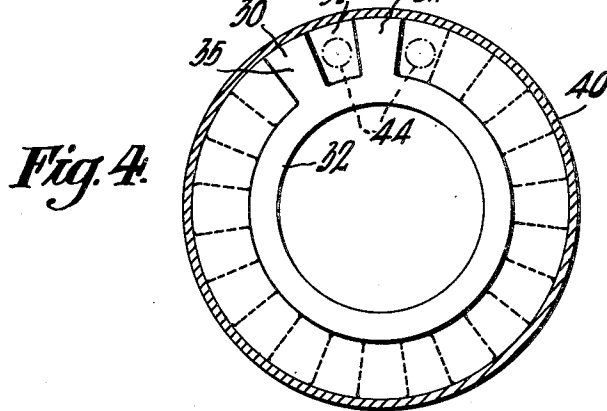
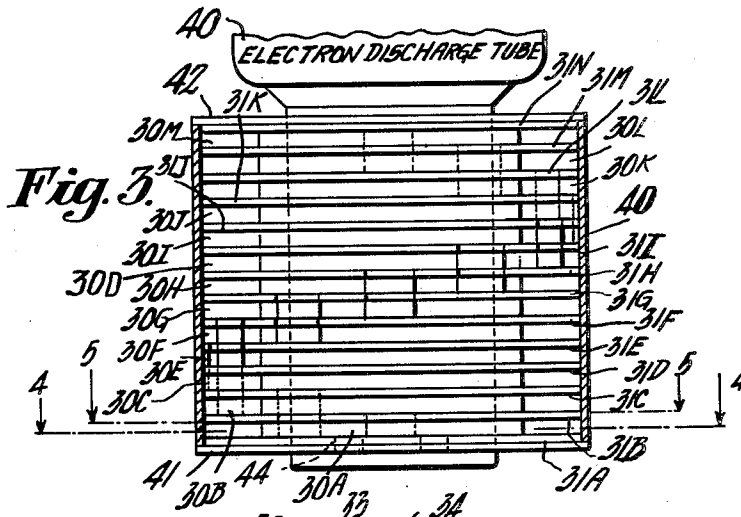
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4 Sheets-Sheet 3



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HEAT DISSIPATING JACKET

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3 Claims. (Cl. 250—27.5)

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This invention relates to improved methods of heat dissipating, and more particularly deals with water cooled jackets, for cooling the anodes of power vacuum tubes, and the methods of making them.

An object of this invention is to provide efficient cooling devices which are an improvement over Hansell Patent 2,146,541 and Young Patent 2,406,121.

Another object of this invention is to improve the cooling of vacuum tubes and to provide an efficient fluid conductive path which circulates around the anode of the tube. In the prior art, the manufacture of water cooled jackets for vacuum tubes was generally a time consuming operation, by virtue of the difficulty of removing rather large quantities of copper from a solid block, copper being utilized because of its desirable high heat conductivity.

In this invention the improved construction of the cooling jacket which surrounds the anode is obtained by utilizing relatively thin edge-wound strips of copper, or continuous rings which spiral around the outside of a cylindrical jacket to form a double helical path for the cooling fluid.

Single spiral paths for cooling ducts (as shown by the prior art) have a tendency to unevenly cool the anode of a vacuum tube; that is, the temperature of the fluid flowing in cooling ducts at the inlet end portion is cool, while the fluid flowing through the outlet end portion runs hot. In some cooling systems of the prior art, the single spiral ducts have not been found fully effective because the coolant flow is broken up into little swirls with "stagnant" pools in recesses which will cause hot spots and uneven cooling. My invention distributes the cooling effect on the anode more evenly than the single spiral duct, because with the double spiral cooling duct the inlet cooling or cold path compensates for the adjacent outlet or hot fluid path, thereby tending to equalize the fluid temperature of the entire tube anode. This equalization of temperature in the fluid ducts reduces the tendency of the water to boil.

Vacuum tubes employing a fluid cooling system of this invention are particularly adapted for use in the circuit of a high power transmitter of 50 kilowatts or so having a push-pull tank circuit with grounded grids. The transmitter can be operated at the higher radio frequencies.

The water cooled anode devices of this invention in some ways are more desirable than air cooled tubes. Because of the smaller space occupied, there is less stray electrical capacitance,

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which stray capacitance is objectionable at the higher radio frequencies. There is less tendency to have gas collect in the anode end of the tube. The gas which collects in the anode end of the tube frequently causes arc-over between the tube electrodes. Vacuum tubes provided with the anode cooling system of this invention have a 15° to 80° temperature rise, compared with a 3° to 5° temperature rise with tubes not cooled by the system of this invention. This hotter anode temperature drives the tube gases to the cooler glass end of the tube where they can do no harm or cause no arc-overs.

In another form of this invention the heat dissipating jacket is formed by assembling within a tubular housing a plurality of annular discs with a suitable number of holes or slots of suitable size and shape to form a double spiral fluid path.

A still further modification of this invention is the arrangement of a plurality of vertical up and down fluid passages formed by disc laminations.

This invention will best be understood by referring to the accompanying drawings, in which:

Fig. 1 is an elevational view, partly in section, of an improved cooling jacket of this invention; Fig. 2 is a cross-sectional view of Fig. 1, the section being taken on line 2—2 of Fig. 1;

Fig. 2A is an elevation showing the fluid inlet and outlet partly in section, the section being taken on line 2A—2A of Fig. 2;

Fig. 3 is an elevation, partly in section, of another embodiment of this invention, wherein a spiral cooling path is obtained by a plurality of spaced stamped rings;

Fig. 4 is a cross-sectional view of Fig. 3, the section being taken on line 4—4 of Fig. 3;

Fig. 5 is another cross-sectional view of Fig. 3, the section being taken on line 5—5 of Fig. 3;

Fig. 6 is a plan view of a further modification of the embodiments shown in Figs. 3, 4 and 5;

Fig. 7 is a cross-sectional view of Fig. 6;

Fig. 8 is a cross-sectional view of a still further embodiment of the invention;

Fig. 9 is an elevational view, partly in section, of Fig. 8; and

Fig. 10 is a cross-sectional view of Fig. 9, the section being taken on line 10—10 of Fig. 9.

Referring now to Figs. 1 and 2 of the drawings, an inner or anode cooling tube 1 has a shouldered portion which is fitted with a bottom plate 2 and is silver-soldered at the joint 3. The anode of the vacuum tube is to be soldered to the inside wall of tube 1 in a manner to be described later. Shallow double spiral slots 1A and 1B are cut

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around the outside surface of the tube. Located in the slots 1A and 1B, and silver-soldered thereto, are two spiral fins 4 and 5 of edge-wound copper each having approximately twelve and one-half turns, although, in the interest of clarity, only approximately eight and one-half turns are shown in Fig. 1. The outer surface of the assembly of edge-wound copper strips 4 and 5 is turned preferably on a lathe. Two thick rings 6 and 7 are silver-soldered on the ends of tube 1, as shown. Ring 6 has two circular openings, one being a water inlet 10, the other being a water outlet 11. The lower ring 6 and upper ring 7 each have substantially the same inside diameter as the outside diameter of tube 1 in order that they can be slipped over the tube ends and silver-soldered thereto. Rings 6 and 7 are slipped over the ends of tube 1 and silver-soldered to it in the same manner as are the two spiral fins of edgewise wound copper. When the fins are turned down on the lathe, the lower ring 6 is also turned to the same outside diameter. A tube or sleeve 8 surrounds fins 4 and 5; also ring 6 and a portion of ring 7. The outer sleeve 8 has an internal diameter such that, after it is heated, it will just slip over the fin assembly when the latter is cold. A shoulder portion 7A is provided in the upper portion of ring 7 which has the same diameter as the outside of fins 4 and 5, so that the outer sleeve 8 can slip on easily when the sleeve is heated prior to being silver-soldered. The sleeve 8 is slipped on until it fits upon the shoulder groove 7A of ring 7. In a few seconds the sleeve has cooled sufficiently for a tight shrink fit; then the ends of sleeve 8 are silver-soldered to the rings 6 and 7. After the soldering operation, the sleeve may be finished to size and polished. The sleeve 8 being heated and slipped over the other part of the jacket while it is cool, provides a shrink fit, so that no cooling fluid can leak past the edge-wound copper spiral fins. A hold down ring or band 9 is made to closely fit over the sleeve 8 and is secured to the lower portion thereof by being silver-soldered or brazed at the end. A semicircular key-way 8A is provided in ring 9 to line up the fluid ducts with the inlet and outlet apertures and similar apertures in a support plate 18, which plate retains the fluid supply tubes or piping. The key 8B is a round pin of one-quarter inch diameter extending up three-eighths inch from the base plate 18 to which it is attached. The key engages the semicircular or half-round key-way in clamping ring 9 of the jacket. This key-way is milled into the ring 9, to about half the diameter of the pin. It forms a half-round groove on the outside of ring 9 and is located on the circumference mid way between the inlet and outlet cooling fluid openings. The groove extends about half way up the height of the clamping ring. The cooling jacket is retained in its proper position by pin 8B engaging key-way 8A in ring 9.

In order to understand the flow of the cooling fluid, the following description is given. Consider the cooling jacket to consist of the tube 1 on which are wound two spiral fins or edgewise wound copper; that is, fin 4 and fin 5. Also, that on the ends of tube 1 are soldered rings 6 and 7. The upper end of spiral fin 4 is soldered to the top ring 7, forming a block 13A. Likewise the lower end of spiral fin 4 is soldered to the lower ring 6, forming a block 13. The lower end of spiral fin 5 is soldered to the lower ring 6, forming a third block 13B. However, the

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upper end of spiral fin 5 is open (as indicated at 12 in Figs. 2 and 2A), and has about a three-sixteenth inch gap between it and ring 7. The two cooling fluid openings or ports 10 and 11 through lower ring 6 are located immediately one on each side of block 13B, so that the cooling fluid flows up the groove on one side of spiral fin 5 and down the other groove on the other side of spiral fin 5, after passing through the gap as indicated at 12. The fin 4 acts as the other confining wall.

In order to conveniently handle the cooling jacket and its associated vacuum tube, a split band 19 is clamped around the outside of tube 8 by means of a clamp screw 19A. Two handles 19B and 19C are secured 180° apart on band 19 by means of rivets 19D.

The cooling jacket assembly is held down to base 18 by hooked bolts 14, 15 and 16 which catch on top of the jacket and pass down through the base. A gasket 17 around the holes in the bottom of the jacket prevents water leakage. The water hose connects to nipples 18A in base 18. The hold-down hooked clamp bolts 14, 15 and 16 are shown only as an example, and may be of different construction.

In the operation of soldering the anode 20 of the electron discharge device to the inside wall of tube 1 after the jacket is assembled, I prefer the following process: The jacket assembly is set down in an electric furnace or heater. A small surplus amount of pure tin is then put into the space within tube 1 and is melted. A small amount of solder flux is put in to "tin" the inside of the jacket to insure a tight joint between the anode and tube 1. The tube anode 20 is cleaned to remove all grease and dirt. Then the tube anode is slowly lowered into the tube 1. By working the anode up and down slightly, the tinning of the surface will be insured, and this will also work out any gas bubbles. As the tube anode is pushed in all the way, a small amount of tin will run out of the jacket at the top, leaving a small ring of tin (indicated at 21) around the tube anode flange. The tube anode should then be held down by any suitable means (not shown), after the furnace power is cut off; and the power is maintained "off" until such time as the tin 22 hardens. As the molten tin cools, some of the surplus at the top will be sucked down into the jacket. Also, the bottom plate 2 will move slightly upward. Other soldering metals, such as for example, cadmium may be used when a solder of a higher melting point is desired.

It will be noted that the principle of the grooves or spirals employed in the construction shown by Figs. 1 and 2 is basically equivalent to that of a double thread cut in a shaft, wherein at one end is provided an end plate (such as ring plate 6) to segregate the two spirals, and to furnish a connection to one spiral for the inlet 10 and a connection to the other spiral for the outlet 11. The fluid blocks 13, 13A and 13B are provided to prevent the cooling fluid from flowing from the inlet spiral through only a part of the circular groove to reach the outlet spiral. As mentioned above, the block 13B is placed between the inlet and outlet points in the circular groove. A feature of this construction is that the flow of the coolant is continuous and constant and upward throughout the entire path of an inlet spiral, and then down through the circular outlet spiral groove and out through the outlet 11. With this improved arrangement, there are provided

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ascending and descending streams of cooling fluid adjacent the tube anode. There are no pockets where the cooling fluid flow may be slowed or stopped. Also, the tube anode is cooled evenly, so that the top and bottom ends are at substantially the same temperature.

Another modification of this invention which also provides a double, circular fluid duct is shown by Figs. 3, 4 and 5 of the drawings. This double spiral or circular duct arrangement is made by assembling a plurality of two different sized and shaped ring spacer metal stampings or laminations, one being provided with two tapered teeth to form fluid barriers, and the other lamination having two slots to form the fluid ducts and being constructed of thinner material than the first mentioned stamping. As an example, silver plated brass or copper may be used for the metal stampings. One lamination 30 of the pair has its tapered toothed outline clearly shown in Fig. 4; thirteen of these are used. The other lamination 31 with its two slots approximately 15° on centers is shown in Fig. 5; fourteen of these are used. These laminations may be made of any desired thickness, or of any other suitable metal. In one embodiment as shown in Figs. 3, 4 and 5, the lamination 31 was one-sixteenth ($\frac{1}{16}$) of an inch and the lamination 30 one-eighth ($\frac{1}{8}$) of an inch thick. The lamination 30 is provided with a central aperture 32, a slotted portion 33, and projections 34 and 35 approximately 15° apart on centers. The lamination 31 has a central aperture 32', which is of the same diameter as that of aperture 32 (shown in Fig. 4), and has two fluid paths 36 and 37 formed by the slots in the laminations. An outer sleeve 40 is located outside the projections 34 and 35. A base plate 41 is soldered to sleeve 40. Also, the top cover plate 42 is soldered to the upper portion of sleeve 40. The cooling jacket assembly is clamped down on to a base like the showing in Fig. 1, when in use. The holes or inlet and outlet ports in the cooling jacket fit over similar inlet and outlet holes in the base for supplying cooling fluid.

In the construction of this modified device, the jacket is assembled by stacking the laminations 30A to 30M, inclusive, and 31A to 31N, inclusive, in their correct position within the outer tube 40, as indicated in Fig. 4. Each projecting portion 34 and 35 progressively advances one space, as shown by the broken lines in Fig. 4. The laminations are stacked by any suitable means, such as with an assembly jig. During the stacking process a high melting point solder (such as a silver alloy which has a melting point of about 1200° F.) is placed in thin strips or small quantities between the laminations. The laminations 31 with the slot openings start at the bottom and rotate counter clockwise (if desired the opposite rotation could be used) around the jacket (looking from the lower end). They progress around back of the jacket, as illustrated, and come in view again at the upper end of the jacket. Of course, the cooling fluid makes a complete circulation around the jacket before entering through the next slot going up or down. The circulation is such that the fluid in every other groove is going upward clockwise and the fluid in every other alternate groove is coming downward counter-clockwise. The fluid grooves are bound on the sides by lamination 30 and sleeve 40. The fluid grooves are each bound on the tops and bottoms by laminations 31. The assembly is then carefully removed from the jig, clamped or weighted, and placed in an oven which melts the silver alloy

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and solders the assembly into one solid block. Next, the sleeve 40 is heated and slipped over the cooler block, for shrink fit, and soldered at both ends with a slightly lower melting point alloy. It may be noted that only the ends of the sleeve 40 need be soldered to the laminations. The laminations fit close enough to the sleeve so that the very small amount of the cooling liquid which might leak down will do no harm. If the sleeve is heated before it is slipped over the cold block of laminations, it will, of course, fit tightly on cooling. The operation of the cooling fluid of this device is substantially the same as that described in connection with Figs. 1 and 2; namely, the cooling fluid enters the inlet and flows upward in one of the spirals until it reaches the top duct, wherein it meets a blocked portion of the duct, thus causing the fluid to flow down through the other spiral path and out through the outlet at 44. It should be noted that the cooling fluid flows substantially all the way around the jacket before going through a slot to another level of laminations, at which time it again flows around the jacket, etc.

Figs. 6 and 7 show constructions wherein the laminations are composed of a plurality of rings 50 having slotted arcuate portions 51. The rings 50 are assembled one on top of the other, with the arcuate slot 51 of each ring advancing about half of its area beyond an adjacent ring, as it is assembled, to provide the double spiral cooling ducts 52 and 53, as indicated in the sectional showing of Fig. 7. The process of making and soldering this form is substantially the same as that described in Figs. 3, 4 and 5.

Likewise, the operation is similar to that mentioned above in connection with Figs. 1 and 2.

Figs. 8, 9 and 10 disclose a modification of this invention in which each annular ring 60 is provided with six equally spaced round holes 61, as indicated in Fig. 8. The number of holes may be 6—8—10, or any desirable even number. The rings 60 are assembled so that the holes 61 register with each other to form a fluid duct, as shown in Fig. 9. The holes 61 in the annular rings 60 are shown as connecting tubes in Fig. 9, by the dotted lines.

In Fig. 9 there is shown a top plate 62 and a bottom plate 63. The top plate 62 is an annular ring of the same shape as rings 60, except for the omission of the six holes 61. Top plate 62 is used as an end closure member for the top of the jacket. The bottom plate 63 serves as the bottom end closure member of the tube anode jacket and is provided with two suitably threaded hose nipples 64 and 65; one of the nipples 64 serves as the inlet for the fluid supply, and the other nipple 65 serves as the outlet. Intermediate spacing rings 60A and 60B (shown by Fig. 10) provide slotted channels 67, 68 and 69 for circulation of the cooling fluid from one opening to another at the top and bottom portions. Spacing rings 60 are assembled at 60° with respect to the slot 67 of ring 60A, as indicated by the dotted lines, in order to provide a progressive cooling path from inlet 64 to outlet 65.

It will be noted that Fig. 8 has been oriented to be looked upon as being a sectional view of Fig. 9, and the holes are marked with "up" and "down" to indicate how the water or cooling fluid would be circulated through the jacket. Only six holes 61 are shown in the ring 60. It might be desirable to use a greater number of holes so as to increase the cooling area of the jacket. The greater the volume of water which passes

through the tubes, the lower will be the temperature of the jacket. After assembling the parts of the jacket, as shown in Fig. 9, the discs 60 are fused together by a suitable brazing material, preferably in an oven, to prevent oxides from forming. It is preferred that the brazing material have a melting point higher than the melting point of pure tin, or cadmium, or whatever tube solder is used, since it is desirable to mount the vacuum tube anode 66 in the jacket using tin or cadmium to solder the tube in place. The inner openings of the annular discs should be of a size appropriate for the particular size of the tube to be mounted, and the number of discs 60 should be large enough to provide a suitably long jacket for the anode 66.

What is claimed is:

1. A fluid cooling system for an electron discharge device of the type having an external metallic anode, comprising two tubular metallic members concentrically arranged, one of said tubular members adapted to be soldered directly to the outside surface of the metallic anode of said electron discharge device, a double spiral fluid path arranged adjacent the anode of said electron discharge device and within said tubular members to provide adjacent ascending and descending fluid streams, metallic end closure members located at each end of said tubular members, and fluid inlet and outlet members located at one end of said closure members and in fluid communication with said double spiral fluid path.

2. A fluid cooling system arranged to be in intimate contact with an external anode of an electron discharge device having at least an anode and a cathode, comprising a cylindrical metallic member surrounding and secured in intimate contact with the anode of said electron discharge

device, a pair of spiral fluid ducts located around said cylindrical member, a cylindrical outside closure member surrounding said fluid ducts, a metallic ring plate closing the anode end of said cylindrical outside closure member, a disc end plate closing the other end of said cylindrical outside closure member, and fluid inlet and outlet means located at the lower disc plate adjacent the anode of said electron discharge device and in fluid communication with said fluid ducts.

3. A device for cooling an electron discharge device of the type having a glass envelope and an external metallic anode comprising a pair of cylindrical metallic cooling members surrounding the device to be cooled, one of said cylindrical metallic cooling members soldered to the outside metallic wall of said anode a pair of spaced spiral strips forming two fluid ducts located within and in intimate contact with the inner walls of said tubular members, blocks located at the top and bottom portions of said fluid ducts, and fluid inlet and outlet members in fluid communication with said ducts and at the lower portion of said cooling device.

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