

United States Patent

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 19, 20, 21, 34, 44; 165/1, 13, 31, 32, 37, 38

[56] References Cited

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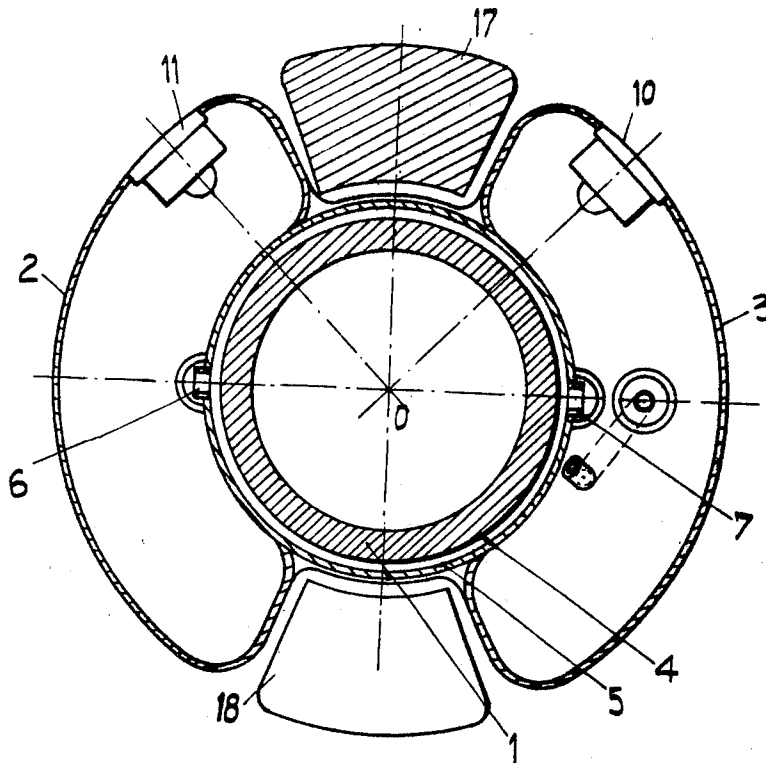
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[54] **COOLING SYSTEM FOR AN ELECTRON TUBE**
RELEASED ON A TRAJECTORY
2 Claims, 5 Drawing Figs.

[52] U.S. Cl. 313/18,
 313/20, 313/44, 165/32
 [51] Int. Cl. H01j 7/28,
 H01j 61/52

ABSTRACT: A cooling device for electron tubes, exploiting the vaporization of a liquid contained in sealed tanks, surrounding the tube anode. The vaporization of the liquid is controlled by a valve associated with the tanks. The blowoff pressure of this valve is equal to the vaporization pressure at the selected temperature of operation.



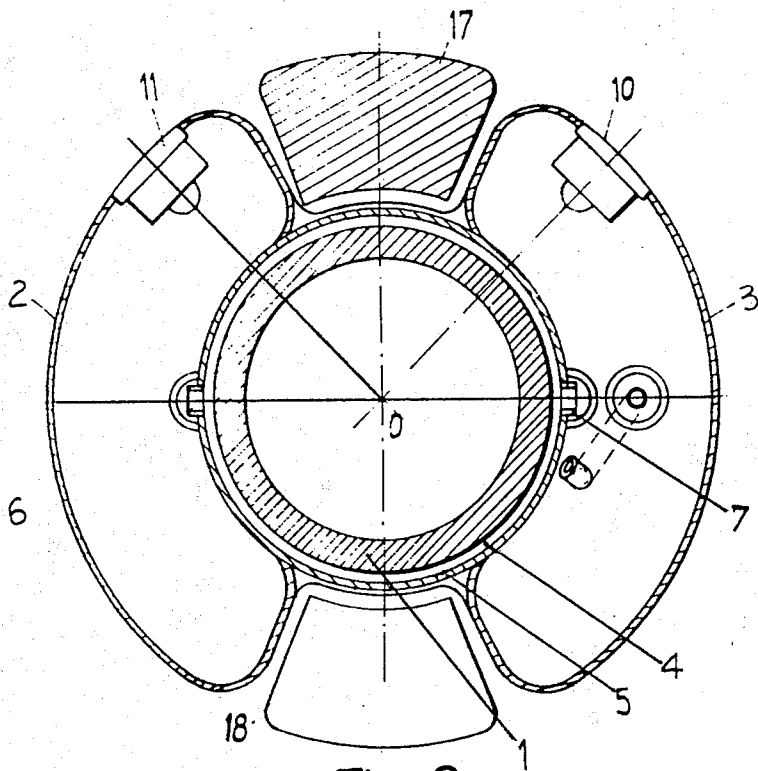


Fig. 2

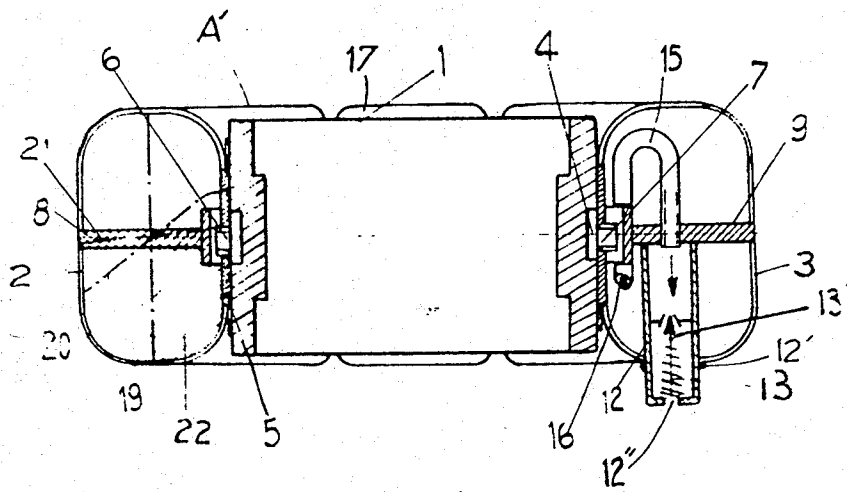


Fig. 1

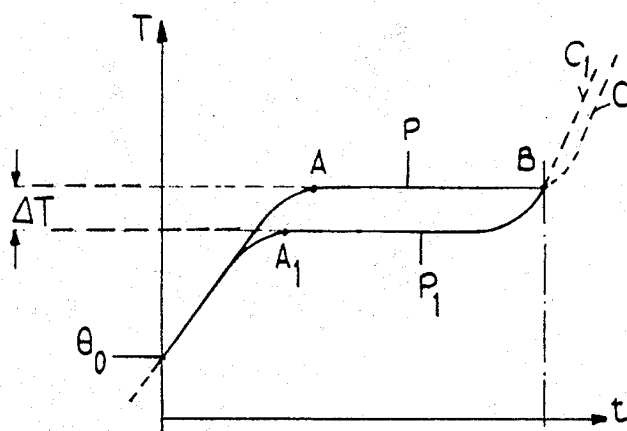


Fig. 3

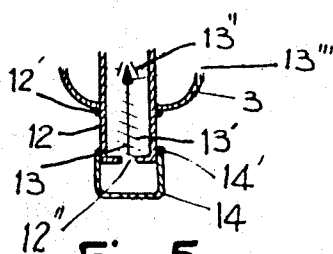
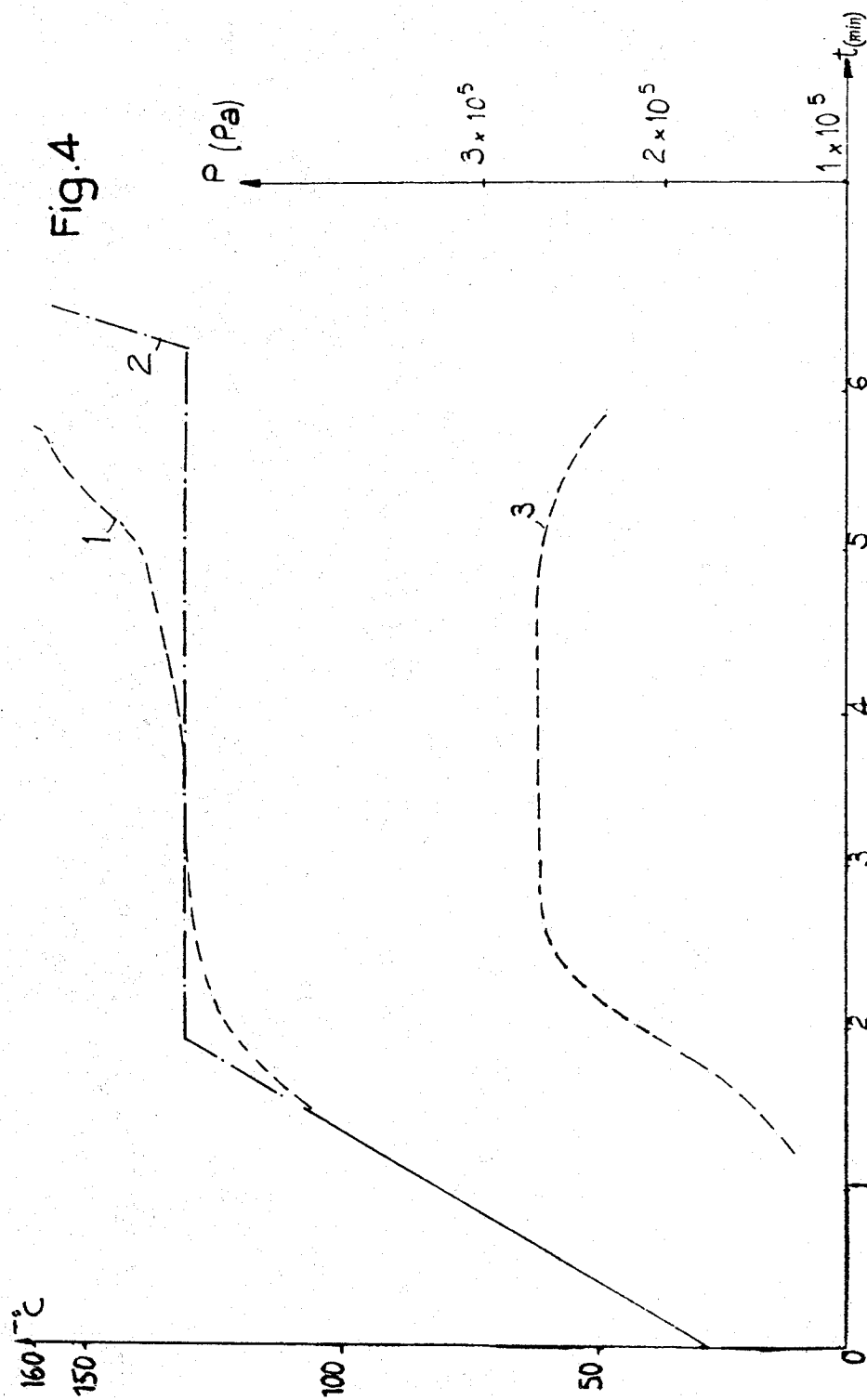


Fig. 5



COOLING SYSTEM FOR AN ELECTRON TUBE RELEASED ON A TRAJECTORY

The present invention relates to electron tube cooling systems which can operate independently.

It is well known, where the cooling of the anodes of electron tubes is concerned, to employ a fluid in contact therewith to dissipate the energy collected thereby. These fluids, either gaseous or liquid, may be air, water, etc.

The circulation of the fluid may be achieved in a variety of ways depending upon the nature of the fluid and upon the particular conditions. Thus, the fluid fed in at the input to the cooling system is discharged to the exterior after passing over the anode, or it is regenerated after passing over the anode, before being reintroduced at the input.

Other systems having a limited useful life use a fixed quantity of fluid which is neither renewed nor regenerated.

For this kind of systems to operate correctly, however, means must be provided for regulating the rate of consumption of the fluid during operation.

According to the invention there is provided a cooling arrangement for dissipating heat generated by a heat producing system comprising: a tight enclosure for a predetermined amount of cooling liquid in thermal contact with said system, said enclosure comprising a valve; and means for adjusting the blowoff pressure of said valve as a function of the vaporization pressure of said liquid at a predetermined temperature.

For a better understanding of the invention and to show how the same may be carried into effect reference will be made to the drawings accompanying the following description and in which:

FIG. 1 illustrates an elevational section of one embodiment of the invention;

FIG. 2 illustrates a plan view of the device of FIG. 1;

FIG. 3 shows a diagram explaining the operation of the device according to the invention;

FIG. 4 illustrates the experimental figures obtained with the device of FIG. 1; and

FIG. 5 illustrates a detail.

FIGS. 1 and 2, in which similar references designate similar elements, illustrate an embodiment of a device according to the invention.

The hot part of the tube is formed, for example, by a ring 1, incorporated into the tube, and the cooling system by two sealed tanks 2 and 3, provided centrally with respective partitions 8 and 9 and filled with water.

A circular tight groove 4 is formed either in the wall 5, common to the two tanks, or in the ring 1, as in the example illustrated, and provides communication between the two tanks through the medium of the labyrinth orifices 6 and 7.

The two partitions 8 and 9 and the tank walls are made of a material having good thermal conductivity in order to facilitate heat transfer to those zones which are bathed by the water. The partitions have holes, which have not been illustrated, to provide communication between the two parts of each tank and increase the heat-exchange area.

Each tank has an aperture 10 and 11, which can be closed off by means of a plug, which plugs have not been illustrated, sealed, for example, by means of rubber O-ring seals.

One of the tanks 3 is equipped with a steam blow out pipe 12, which passes through the tank wall and is sealed in relation thereto by a solder ring 12'.

Inside the pipe 12, there is a valve 13 with a bias spring 13', the latter seating against the tube 12 through which, in operation, the vapor is bled off at 12''.

The vapor is bled off through a tube 15 the end 16 of which is located above the water level.

The baffles 6 and 7 are designated for preventing water from flowing from one tank into the other during handling of the assembly.

In gaps between the two tanks the magnets 17 and 18, required for the operation of the electron tube, are located.

The volume of the tanks is determined as a function of the time of operation and power to be dissipated, and a quantity of

water corresponding to about half the total volume of the tanks is introduced through one of the orifices 10 or 11. With the two tanks open to atmospheric pressure, a check is made to ensure that the levels in the tanks are the same and then the orifices 10 and 11 are sealed by tight plugs.

In operation, when the tube heats up, the heat is conducted to the water by the partitions 8 and 9 and the walls of the tanks 2 and 3.

The references 19, 20 and 21 indicate water levels in the tanks 2 and 3, when the tube, having been ejected the face A' forward from the missile which carried it, undergoes a longitudinal deceleration of 0, 1, or 10 g. and is at the same time imparted a radial acceleration of the order of 1 g., the liquid then respectively occupying the volumes situated approximately at the left of the line 19, above the line 20, and above the line 21.

The hatched portion of the tanks, as shown in FIG. 1, is thus a zone in which there is no liquid when the said longitudinal deceleration and radial acceleration conditions are produced, i.e. at the end of some minutes of operation of the device, and at the time when the temperature reaches a sufficient level for the valve to go into action. Throughout the whole time of operation of the cooling device, the orifice 16 of the steam pipe 15 which opens out into this zone, is in contact exclusively with steam, so that there is no possibility of the liquid phase entering the tube 15 and escaping to the exterior. If this were to happen, it would seriously jeopardize the operation of the device and could even render it totally ineffective.

FIG. 3 is a theoretical graph outlining the operation of the devices in accordance with the invention, whilst FIG. 4 shows experimental values.

The arrangement of the invention operates as follows:

With the operating voltage applied to the tube anode, the power dissipated raises the temperature of the cooling fluid in the tanks, which temperature will be assumed to be initially θ_0 (FIG. 3). When the temperature reaches the value at which the vaporization pressure of the fluid is equivalent to the blowoff pressure of the valve 13, namely the point A on the graph of FIG. 3 (assuming that the valve bias pressure has been set in an environment which is at atmospheric pressure P), the said valve opens and bleeds off steam. From this moment on, the whole of the power dissipated by the anode serves to vaporize the liquid, whose temperature remains stationary at the level AB defined in FIG. 3. The system continues to operate in this way until the liquid is exhausted, this corresponding to the point B in FIG. 3. Beyond the point B, i.e. assuming that the voltage is still applied to the anode after the fluid has been exhausted, the anode temperature starts rising again as indicated by the section C of the characteristic. In the same FIG., A₁ B C₁ is the curve which would be obtained with this same device, with the valve calibrated in the same way for an external pressure P₁ of around 1 millibar. In this case, the valve would open at a vapor pressure lower by about one bar than the pressure previously considered and therefore, at a temperature lower by ΔT than that corresponding to operation at atmospheric pressure.

FIG. 4 shows experimental values obtained on a prototype of the device in accordance with the invention, using 100 grams of water, the dissipated anode power being 800 watts, the environmental pressure being normal atmospheric pressure (760 mm. Hg or 14.7 p.s.i.), the valve being set to 2.7 bars (2.7×10^5 PA) absolute. The temperature plotted is that of the tube body at a point located between the tanks 2 and 3.

In this figure:

1. is the experimental curve of temperature versus time;
2. is the theoretical curve of temperature versus time (in the operating conditions of the experiment);
3. is the curve of the absolute pressure in the tanks as a function of time (Y-axis on the right of FIG. 4).

As the figure shows, the device may operate during a few minutes.

FIG. 5 illustrates a modification of the valve used in the device of FIG. 1.

In this modified form, to allow for the possibility that the valve 13 does not provide a perfect seal between the seating 13'' and the valve member 13''', a sealed cap 14 is soldered over the pipe 12 at 14', using a low melting point solder (FIG. 5). The melting point of this solder is equal to the vaporization temperature as determined by the calibration of the valve, or is lower than it by no more than about 30°.

In operation, according to its melting temperature, the seal 14' melts either when the valve 13 opens or some time before, and allows the vapor to escape.

By way of example, one of the materials used to produce the seal 14' is the ternary eutectic alloy Pb, Bi, Sn, known by the name of Darcet alloy which melts at 96° C., the proportions by weight being: Pb : 0.32; Bi : 0.155, and Sn : 0.525.

The cooling arrangement of the invention is particularly useful in space research techniques, where the time of operation required is limited to the time of operation of the missile in which they are mounted. This kind of application justifies the hypothesis of an external pressure of 1 mb., which is the pressure prevailing at an altitude of some tens of kilometers.

The same device could be operated continuously by replacing the plugs closing off the orifices 10 and 11, by input and discharge piping systems, the water being circulated around the hot part of the tube through the groove 4, for example, from reservoir 3 to reservoir 2.

Of course, the invention is by no means limited to the embodiment described and illustrated which has been given only by way of example.

I claim:

1. A cooling arrangement for dissipating heat generated by an electron tube in motion with longitudinal and radial accelerations, out of reach, said arrangement comprising: a tight enclosure for a predetermined amount of cooling liquid in thermal contact with said tube, said enclosure comprising a valve opening out into the environment at one of its two ends; means for adjusting the blowoff pressure of said valve as a function of the vaporization pressure of said liquid at a predetermined temperature, a pipe positioned within said enclosure and having an input and an output, said output being tightly connected to said valve at the other end of said valve, said input being disposed such that, for any position of said arrangement during said vaporization, said input is free from any contact with said liquid.
2. A cooling arrangement as claimed in claim 1, wherein said valve is obturated at said end opening out into the environment by a cap sealed with a sealing material, the melting point of said sealing material being below said predetermined temperature.

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