July 10, 1962 P. DESERNO ETAL 3,043,973

COOLING THERMALLY STRESSED PARTS OF ELECTRON TUBES

Filed May 28, 1958

Fig. 1

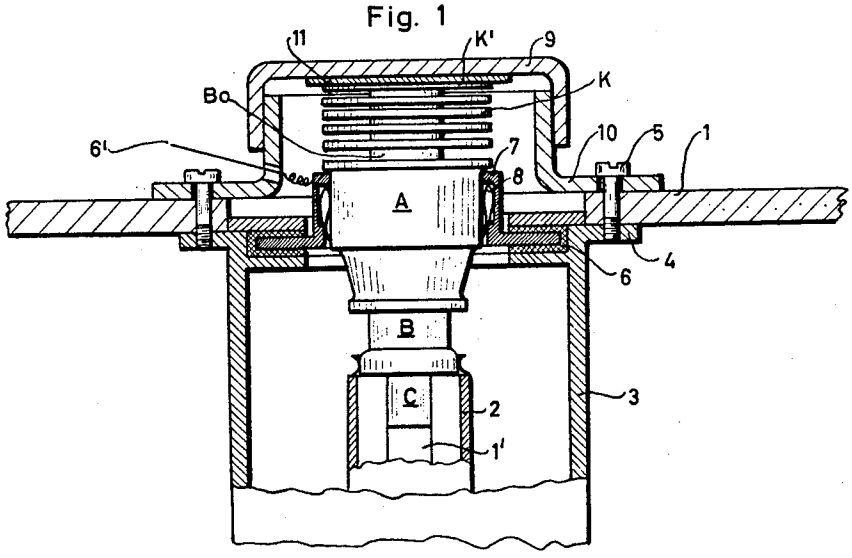


Fig. 2

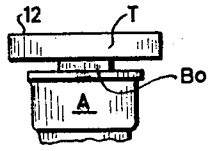


Fig. 3

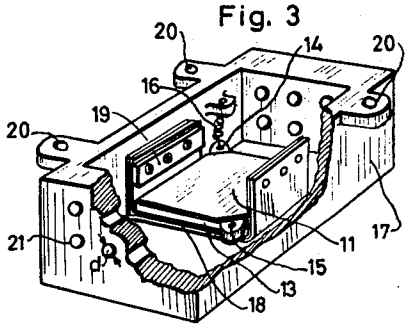
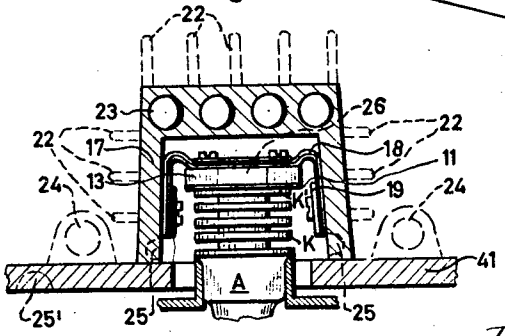


Fig. 4



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COOLING THERMALLY STRESSED PARTS OF ELECTRON TUBES

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6 Claims. (Cl. 313—40)

This invention is concerned with cooling parts of electron tubes which are subjected to great thermal stress. In most instances such part will be the anode. Means must be provided for such part so as to conduct the heat developed thereby through the vacuum vessel to the outside. The corresponding electron tube may be operated in a desired circuit, for example, as an amplifier, oscillator or in a mixing stage, etc.

The cooling of parts of electron tubes which are subjected to considerable thermal stress is usually effected, as shown and described, for example, in Electronics, February 1945, pages 98 to 102, by providing the corresponding part with heat transfer means in the form of a short bolt carried to the outside of the vacuum vessel, such bolt carrying a cooling head which may be screw connected with the bolt or soldered thereto and being provided with a number of cooling fins or ribs, and means for blowing cooling air against such fins. The arrangement is intended to largely inhibit transfer of heat to other metal parts which are disposed in the neighborhood of the part to be cooled.

This known arrangement has the drawback of requiring a motor-operated fan for blowing the air against the cooling fins as well as ducts for the cooling air. The operation of the fan produces in some instances mechanical vibrations effecting the tube or other sensitive parts and thereby causing disturbances, for example, undesired modulation, etc. Moreover, failure of the fan introduces the danger of damage to the tube by excessive heating, requiring complicated protective circuits which, however, are likewise not entirely immune to failure.

These drawbacks could possibly be avoided by making the cooling head for the thermally stressed part very large, so as to obtain sufficient cooling by heat transfer to the ambient air, thereby making the use of the fan unnecessary. However, this expedient, while feasible, is not satisfactory because the required cooling head would assume unwieldy dimensions and the assembly of the corresponding electron tube in high frequency apparatus would be rendered very difficult.

The object of the invention is to show a way which makes it, among other advantages possible to avoid the above indicated drawbacks and difficulties arising in connection with the cooling of electron tube parts which are subjected to great thermal stresses.

According to the invention, this object is realized by the provision of a heat transfer member which is removably connected, preferably by press-fit, with the electrode subjected to great thermal stress or with the part thereof extending to the outside, and in turn connecting the heat transfer member in good heat transfer relationship with a heat radiating wall, for example, an outer wall such as the front wall of the high frequency apparatus in which the corresponding tube is used. The requirement, if posed, that the part of the electron tube which is subjected to great thermal stress be electrically insulated against the heat transfer member, against the heat radiating wall, or both, may be met simply by the provision of an electrical insulating layer, for example, a thin mica layer, between the corresponding part of the electron tube and the other part or parts involved.

The various objects and features of the invention will appear from the description of embodiments thereof which will be rendered below with reference to the accompanying drawing. In the drawing,

FIG. 1 shows partly in section, a portion of a tube and a cooling device therefor mounted on the front wall of a high frequency apparatus;

FIG. 2 shows an embodiment of a cooling head comprising a bolt-like member terminating in a plate-like part for engagement with a heat transfer member;

FIG. 3 indicates an embodiment comprising a resiliently rockably disposed heat transfer member; and

FIG. 4 shows an embodiment of a cooling device disposed for dissipating heat to the ambient air while preventing heat transfer to a wall part or parts of the high frequency apparatus.

The tube shown in FIG. 1 which is mounted on an outer wall such as the front wall 1 of a high frequency apparatus may be, for example, an oscillation generator for very short electromagnetic waves, having a disk triode comprising the anode A, the grid lead-in B, the cathode lead-in C, the cathode circuit with the inner conductor 1' and the outer conductor 2, and the anode circuit with the outer conductor 3. The latter outer conductor 3 also serves for mounting the oscillation generator on the front wall 1, which is effected by means of the flange 4 and screw means 5. A capacitive blocking in the form of an annular cross-sectionally U-shaped part 6 insulates the anode lead-in against direct current from the outer conductor 3, the part 6 holding a tubular member 7 containing annularly disposed contact springs 8 for connecting with the anode A. Numeral 6' indicates means for connecting the anode voltage.

The disk triode is of broadly known structure and is provided with a cooling head K which is by means of a bolt Bo directly connected with the tubular anode inside of the vacuum vessel, in good heat transfer connection therewith. The anode A of the tube, which is assumed to be the part under great thermal stress, is cooled by a device comprising a heat transfer or cooling member 9 which is in press-fit engagement with the plane end surface K' of the cooling head K and in turn in good heat transfer connection with a part forming a heat radiating surface, in the assumed case the outer or front plate or wall 1 of the corresponding high frequency apparatus, the connection being effected by means of the flange 10 and the screws 5. It is assumed in addition, that the cooling head K, which will be at anode potential, is to be insulated from the front wall 1 against direct current flow, which is effected by means of an insulating layer, for example, a mica layer 11 carried by the heat transfer member 9 and thus disposed between such member and the surface K' of the cooling head K. The thickness of the mica layer 11 may amount to a few tenths of a millimeter. The heat insulating property inherent in the mica surprisingly does not become operative, which is apparently due to the large cross-sectional area over which heat is transferred from the cooling head K to the heat transfer member 9.

In the operation of the above described arrangement, in connection with an electron tube with relatively greatly loaded anode operating, for example, with 20 to 30 watt loss effect, the heat produced at the anode is transferred to the cooling bolt Bo. In prior structures, the heat transferred from the bolt Bo to the annular fins or ribs of the cooling head would be removed by convection and the action of cooling air. In the invention, the heat conducted from the anode over the bolt Bo is transferred directly to the heat transfer member 9 by way of the last fin or rib K'. The heat is transferred from the member 9 by way of the flange member 10 to the front

wall 1 and thence in part by convection and essentially by radiation to the ambient air.

Extensive investigations have revealed that the cooling effected by the invention is extraordinarily efficient, causing hardly noticeable heating of the frontal wall of the high frequency apparatus, which is apparently due to the fact that the heat transferred by convection from the last cooling fin K' is distributed over a large surface and thus quickly given off to the ambient air.

Part of the heat is also transferred by radiation from the fins of the cooling head K to the members 9 and 10, if such fins are provided, thus increasing the efficiency of dissipating the heat.

The heat transfer member 9 may be made in the form of a cap as shown, which is in easily removable press-fit engagement with the cylindrical part of the member 10; however, the member 9 may also be made in the form of a U-shaped bar disposed in press-fit engagement on a similarly shaped member 10. Removable screw connections may be provided in either embodiment so as to secure reliable press-fit engagement between the parts K', 9 and 11, respectively, as well as between the parts 9 and 10. The last noted embodiment comprising a U-shaped heat transfer member 9 will result in the additional advantage of providing in case of vertical arrangement thereof a chimney-like effect for dispelling heated air and permitting inflow of cooling air.

The invention inherently does not require a cooling head of the customary type, provided with cooling fins. For the purpose of the invention, there may be provided a cooling head comprising a bolt-like member Bo terminating in a plate or disk-like part T as indicated in FIG. 2, forming an end surface 12 for press-fit engagement with the heat transfer member.

Practical requirements often require compensation of some mechanical inaccuracies in the mounting of the electron tube. Such inaccuracies may, for example, be present when the tube does not lie with its axis accurately perpendicular to the heat transfer surface or, rather to say, if the press-fit surface of the heat transfer member 9 extends at an angle to the surface to be engaged thereby. It could happen in such case, responsive to forcible attachment of the heat transfer member 9, that the tube is undesirably displaced or that its glass seals are damaged; on the other hand, insufficient pressure upon attachment of the heat transfer member may result in providing heat transfer engagement between the parts 9, 11 and K' over only a small part of the available cross-sectional area. These difficulties, in accordance with a further object and feature of the invention, may be avoided by making the heat transfer member in the manner of a resiliently rockable part which is connected with the heat transfer surface by means of flexible heat conductors.

An example of such an embodiment is shown in FIG. 3, representing only the resiliently rockable member and means for effecting the heat transfer; the parts shown must be visualized in place of the parts 9, 10 and 11, shown in FIG. 1. The rocking member may be a rectangular or circular metal plate 13 suspended within a housing at two opposite points 14 and 15 by means of springs 16, only one of such springs being visible in the figure. The metal plate 13, analogously to the embodiment according to FIG. 1, may be provided with a thin insulating layer, for example, a mica layer 11, for engagement with the part K' of the cooling head K of the electron tube. The heat transfer from the cooling head K over K' to the plate 13 is effected by way of flexible heat conductors consisting in the illustrated embodiment of thin and relatively wide copper bands or strips 18. Four or five copper bands each with a thickness of one-tenth millimeter or less, may be used. These bands 18 are connected with the plate 13 in good heat transfer relationship, for example, by screws, rivets, brazing and the like, and are also carried to the side walls 17 of the housing to which they are firmly connected by clamping strips 19 secured thereto by screws or the like. Any suitable and known means for securing the parts in position may be used provided only that they are connected together in good heat transfer relationship. The housing 17 may be mounted on the front wall of the apparatus by means of ears such as 20 which are provided with holes or slots for receiving screws. The arrangement secures the housing 17 in intimate heat transfer connection with the heat radiating wall 1 of the apparatus.

In order to avoid undue pressure within the housing 17, there are provided vent holes 21 in oppositely disposed walls thereof. The diameter *d* of these holes is so slight that electromagnetic waves which may be propagated from the electron tube into the housing are aperiodically damped and cannot be further propagated through the holes 21 in the form of guided waves. Accordingly, the diameter of these holes is to be less than one-half of the operating wave length.

When the housing 17 of the structure according to FIG. 3 is placed upon the heat radiating wall 1 (FIG. 1) the rockable plate 13 with its mica layer 11 will engage the surface K' of the cooling head K of the electron tube, firmly contacting the surface K' throughout the extent thereof. The heat is transferred from the anode to the bolt Bo, thence to the heat transfer plate or member 13 and by way of the resilient or flexible heat conductors 18 to the walls of the housing 17. There is thus a relatively large surface available for the heat transfer, which is formed by the housing 17, such housing at the same time serving as a cover for the electron tube. The housing 17 dissipates part of the heat and residual heat is transferred to the wall 1 of the apparatus from which it is dissipated to the ambient air by radiation.

It may be desired, in some cases, to prevent heat transfer to a wall of the high frequency apparatus on which the cooling device is to be mounted. This may be done by disposing the cooling device so that it is in good heat transfer relationship with the ambient air, that is, preferably so that the heat transfer or cooling members 9 or 13 protrude at least in part from the apparatus or form part of the surface thereof, and by providing means for preventing heat transfer from such member to the wall part or parts of the apparatus which are to be protected against heat transfer thereto.

FIG. 4 shows an example of an embodiment for realizing the above indicated operation. Parts corresponding to similar parts in FIGS. 1 to 3 are similarly referenced. The heat transfer member, namely, the housing 17, serves in this embodiment as the part which dissipates the heat by radiation. Cooling ribs or fins 22 may be provided along the side walls and/or along the bottom wall of the housing 17 to facilitate heat radiation. In place of the cooling fins or additionally thereto, there may be formed ventilating channels at least in some of the housing walls, for example, in the bottom wall and/or in the side walls. Such ventilating channels, in conjunction with further ventilating channels 24 will contribute toward cooling of the apparatus wall.

It may be advantageous to provide in some cases heat chokes at the places which are to be protected against heat transfer which may be done in simplest manner by reducing the cross-sectional area ahead of the places to be protected. The cross-sectional area may be reduced, for example, by milling grooves 25 in to the walls of the housing 17 ahead of the edges thereof which engage the apparatus wall 1, thereby reducing the contacting areas and therewith reducing heat transfer by conduction from the housing 17 to the apparatus wall 1. Corresponding grooves 25' may also be formed advantageously in the apparatus wall 1.

As shown in FIG. 4, the metal plate 13 may be provided with a recess 26, formed therein, which may also be in the form of an opening extending through the entire plate. This opening or recess may serve for receiving a

part protruding from the cooling head K. Accordingly, the metal plate **13** may be matched to the configuration of the structure of the tube parts from which the heat is to be transferred, as may be desired or required in any individual case. All that is necessary is, to provide for good heat transfer.

The invention also permits utilization of known cooling means providing for an air current which may be blown, for example, through the openings **23** in FIG. 4. Openings or channels such as indicated at **23** may also be provided in the side walls of the housing **17**. The advantage of the corresponding cooling is that it can be effected with extremely small expenditure, for example, with a very small fan, resulting in expelling an amount of heat greater than is possible in prior structures. A further advantage is that the cooling air is kept away from the part that is to be cooled, namely, the electron tube or the heat transfer bolt B*o* extending therefrom, thus avoiding contamination of the tube and of the resonator connected therewith, by dirt particles deposited thereon. The auxiliary ventilating by the use of a blower will not be necessary in the case of normal outside temperatures or, if provided, will not have to be operated as a rule; it may be provided as a standby in case the apparatus should have to be operated at extremely high outside temperatures.

The embodiments described in the foregoing utilize surfaces which are in press-fit engagement to provide good heat transfer. In place thereof or in addition thereto, there may be provided good heat conductive inserts which are either made of ductile material or are inherently elastic. Such inserts may also be provided in place of the heat chokes such as **25** in FIG. 4.

The invention may also be used for cooling other types of electron tubes, for example, travelling wave tubes, magnetotrons, discharge vessels and the like, provided only that they are with respect to the electrode to be cooled technologically comparable to the described tube.

Changes may be made within the scope and spirit of the appended claims.

We claim:

1. High frequency apparatus comprising at least one disk type tube having an electrode subject to continuous high thermal loads, said electrode having a cooling head extending through an opening in the outer wall of the high frequency apparatus, a cooling element disposed at the exterior side of said outer wall, means for yieldably pressing said cooling element in good heat conducting engagement with the cooling head of said electrode, the electrode-contacting face of said cooling element being formed from an electrically insulating material, and heat radiating means operatively connecting said element in good heat conducting relationship with said outer wall.

2. High frequency apparatus comprising at least one disk type tube having an electrode subject to continuous high thermal loads, said electrode having a cooling head extending through an opening in the outer wall of the high frequency apparatus, a rockable cooling element disposed at the exterior side of said outer wall, means for yieldably pressing said cooling element in good heat conducting engagement with the cooling head of said electrode, and heat radiating means operatively connecting said element in good heat conducting relationship with said outer wall, said yieldable means being resilient and operatively connecting said rockable member with said heat radiating means.

3. Apparatus according to claim 2, wherein said resilient means comprises relatively thin copper bands.

4. Apparatus according to claim 2, comprising means carried by said heat radiating means for increasing the radiating surface thereof.

5. High frequency apparatus comprising at least one disk type tube having an electrode subject to continuous high thermal loads, said electrode having a cooling head extending through an opening in the outer wall of the high frequency apparatus, a cooling element disposed at the exterior side of said outer wall, means for yieldably pressing said cooling element in good heat conducting engagement with the cooling head of said electrode, an electrically insulating layer disposed between said cooling element and said cooling head, and heat radiating means operatively connecting said element in good heat conducting relationship with said outer wall.

6. High frequency apparatus comprising at least one disk type tube having an electrode subject to continuous high thermal loads, said electrode having a cooling head extending through an opening in the outer wall of the high frequency apparatus, a cooling element disposed at the exterior side of said outer wall, means for yieldably pressing said cooling element in good heat conducting engagement with the cooling head of said electrode, heat radiating means operatively connecting said element in good heat conducting relationship with said outer wall, and means for limiting the transfer of heat from said heat radiating means to said outer wall.

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