This invention relates to an electron tube shield and more particularly to an electron tube shield in which the flow of cooling air is closely controlled for optimum effect.

Shields are used for electron tubes for three general purposes. These include (1) as a means for holding the tube in place, especially under conditions of high vibration; (2) as an electromagnetic and electrostatic shield to minimize interference; and (3) as a means for controlling the cooling of the tube. Many tube shields are available which adequately perform the functions enumerated above in (1) and (2). However, most of these shields fail to provide means for adequately controlling the cooling of the vacuum tube under all conditions of operation.

In the proper design of electronic equipment, it is essential that the cooling requirements for such equipment be carefully considered and the equipment designed so that adequate cooling will be provided under all conditions of operation. In the design and layout of equipment, it is necessary to provide for the possibility of malfunctions increase significantly. Cooling requirements become especially critical in compactly built equipment, such as that used in airborne applications. The design engineer must therefore give careful consideration to cooling requirements in the design and layout of equipment.

Probably, the most significant contribution to heat generation in electronic equipment has its origin in vacuum tubes, especially in tubes having high power dissipation. To help solve the vacuum tube heat dissipation problem, tube shields are extensively used. In solving this problem many existing devices depend on the thermal conductivity of metallic contact fingers to dissipate heat, while others depend upon convection air currents to conduct heat away from the tube envelope. Experimentation has indicated that an ideal method for cooling a vacuum tube is by producing an approximate laminar flow of air between the tube envelope and a shield spaced from this envelope by a predetermined gap. For any particular design which generally takes into account such factors as the dimensions of the tube, its heat dissipation, and the velocity and the nature of the air flow, there is an ideal gap width between the tube envelope and the surrounding shield which produces optimum cooling results. The ideal width for this gap can be determined from empirically derived formulas which take into account the above enumerated factors.

The glass envelope diameters of off the shelf vacuum tubes of any given type vary within such wide tolerances that it is impossible with conventionally designed tube shields to control the air gap between the envelopes of such tubes and the tube shield surface without very closely selecting the tubes utilized. Of course, tube selection becomes both expensive and time consuming. The device of this invention overcomes this problem by providing means which self-adjusts the air gap between the tube envelope and the surrounding shield to a predetermined desired value. This air gap is maintained at the predetermined value for tube envelopes which vary in diameter about a nominal dimension. The air flow is efficiently channeled through the predetermined air gap and is maintained at a predetermined optimum amount. The device of this invention in this manner provides a tube shield having predetermined optimum cooling characteristics for all tubes used therewith.

This end result is achieved by providing an inner cylindrical flexible wrap-around member positioned within an outer cylindrical member, with the free ends of the inner member which are parallel to the longitudinal cylinder axis overlapping each other. The inner member further has a plurality of dimples or projections on the inner wall thereof. A pair of resilient O-rings are positioned between the inner and outer cylindrical members providing a cushion therebetween and allowing for variation in diameter of the inner member to accommodate various tube diameters. The O-rings also provide a seal between the inner and outer cylindrical members preventing a diversionary air flow therebetween. When the tube shield is placed over the electron tube, the inner cylindrical member wraps around the electron tube envelope assuming its shape. The projections on the inner wall of the inner member contact the glass envelope of the tube to form an air gap having a width in accordance with the size of the projections. This air gap will thus be of the same width for tubes having diameters which vary about a nominal value.

It is therefore an object of this invention to provide a tube shield having improved cooling characteristics.

It is a further object of this invention to provide a tube shield in which a predetermined air gap is maintained between the tube envelope and shield for various tube envelope diameters.

It is still a further object of this invention to provide a tube shield in which the width of the air gap between the tube envelope and the shield is automatically adjusted to a predetermined desired value.

Other objects of this invention will become apparent from the following description taken in connection with the accompanying drawings in which—

FIG. 1 is an exploded perspective view of a preferred embodiment of the device of the invention;

FIG. 2 is a cross-sectional elevation view of a preferred embodiment of the device of the invention; and

FIG. 3 is a cross-sectional view of the embodiment illustrated in FIG. 2 as viewed along a plane represented by the line 3--3 in FIG. 2.

Referring now to FIGS. 1-3, a preferred embodiment of the device of the invention is illustrated. An outer cylindrical member 11 has positioned concentrically within it an inner cylindrical member 15. Outer cylindrical member 11 has an inner ring 12 riveted to its wall by means of rivets 14. Inner ring 12 has a pair of slots 17 positioned opposite each other into which the O-rings 22 are attached to the outer wall of inner cylindrical member 15 are fitted. Projections 19 are slidably mounted in slots 17 so that inner cylinder 15 is free to move about its longitudinal cylinder axis relative to outer cylinder 11 within limits defined by slots 17. Tube 21, inserted in tube socket 22 which in turn is fixedly mounted on chassis 23, is held in place by means of spring 26, one end of which abuts against the inner top wall 30 of outer cylinder 11, the bottom end of which abuts against the top of the tube envelope. A pair of resilient rubber O-rings 23 and 24 are fixedly attached to inner wall of outer cylindrical member 11, for example, by cementing thereto. Inner cylindrical member 15 has a plurality of uniform dimples or projections 37 formed on the inner wall thereof. The ends 33 and 49 parallel to the longitudinal cylinder axis of cylindrical member 15 form free overlapping flaps.

Inner cylindrical member 15 is fabricated of spring-like material so that the diameter of this cylinder will adjust in accordance with the diameter of the tube 21 over which the tube shield is placed. With the tube shield inserted in place over the tube 21, as indicated in FIG. 2, inner cylindrical member 15 wraps around the tube with the projections 37 abutting against the envelope
the tube. The diameter of inner member 15 adjusts itself in accordance with the diameter of the tube 21. The width of the air gap 35 formed between inner shield member 15 and the envelope of tube 21 will be determined solely by the size of projections 37 and will not vary in accordance with the diameter of the envelope of tube 21.

The base 42 of the tube shield is fixedly attached to chassis 23 by means of screws (not shown) which are inserted through apertures 44 in base 42. Base 42 has a pair of oppositely positioned projections 47 therein which mate with slots 49 in outer cylindrical member 11 to hold cylindrical member 11 to base 42 as operating in conjunction with the spring action of spring 26. A handle 59 is attached to cylindrical member 11 to facilitate the detachment of this member from base 42. An aperture 53 between the tube socket 22 and the shield 42 serves as an inlet for air flow through the tube shield while aperture 54 in wall 39 serves as an outlet for the air flow. Resilient O-ring 57 attached to cylindrical member 11 prevents cooling air from escaping between cylindrical member 11 and base 42.

As can be seen from FIG. 2, with the tube shield installed over the tube, projections 37 rest against the tube enveloped with inner flexible cylindrical member 15 being compressed against O-rings 33 and 34 to provide a seal between inner cylindrical member 15 and outer cylindrical member 11. O-rings 33 and 34 act as cushions which allow the expansion of cylindrical member 15 to accommodate to the circumferential dimensions of tube 21. It is to be noted that cylindrical member 15 can accommodate for imperfections in the envelope of tube 21 such as, for example, the positioning of this envelope askew the tube base 56. In view of the seal provided by O-rings 33 and 34 between outer cylindrical member 11 and inner cylindrical member 15 the air flowing at inlet port 53 goes in its entirety through air gap 39 and is not diverted to any extent to the space between the inner and outer cylindrical members. For each design then, the air flow through air gap 39 can be predictably controlled.

The dimension of air gap 39 can be empirically derived for any given design. A typical empirical formula utilized in determining this air gap is as follows:

\[ q_{o} = \frac{W}{\theta_{o}} = \frac{1.211W}{360} \times 10^{14} \times \frac{D_{1} + D_{s}}{b} \text{ W/m}^{2} \text{C} \]

where:
- \( q_o \) = tube dissipation (watts)
- \( \theta_{o} \) = permissible tube temperature rise above inlet air (°C)
- \( W \) = air flow rate
- \( l_{e} \) = length of tube 21
- \( b \) = radial space between tube and inner cylindrical member 15
- \( D_{o} \) = diameter of tube 21

It can be readily seen from Equation 1 that \( b \), the radial space between the inner tube shield and a tube envelope can be determined for a given design and to ensure optimum cooling should be maintained at the determined optimum value.

The device of this invention thus provides a simple yet effective means for maintaining the air gap used for cooling in a tube shield. This gap can be maintained despite variations in the diameters of tube envelopes about a nominal value for a given type of tube. Means are also provided for efficiently channelling the air flow through this gap. It is to be noted that while members 15 and 11 have been indicated to be metallic, that non-metallic members may be used to equal effect in cases where electrostatic and electromagnetic shielding are not required. Inner member 15, of course, must be flexible so that its diameter will adjust to the diameter of the tube.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

I claim:
1. A shield for use with an electron tube comprising an outer cylindrical shield member, an inner shield member concentrically positioned within said outer shield member, said inner shield member being adapted to be wrapped around the tube with the ends thereof substantially parallel to the axis of revolution of the cylinder formed thereby being free and overlapping each other, said inner member having a plurality of uniform projections on the inner wall thereof, said projections adapted to be contiguous with the tube envelope, and resilient ring means between said inner and outer members and concentric with said inner and outer members for urging said inner member radially inwardly of said outer member, said ring forming an air-tight seal between said inner and outer members.

2. The device as recited in claim 1 and additionally comprising means for supporting said inner member within said outer member, said inner member having limited freedom of rotation about the longitudinal axis thereof relative to said outer member.

3. In an electron tube shield, means for maintaining a predetermined air gap between the shield and the walls of tubes having diameters which vary about a predetermined nominal value comprising an outer cylindrical shield member, an inner shield member concentrically positioned within said outer shield member, said inner shield member forming a cylindrical flexible wrap around piece having ends substantially parallel to the axis of revolution of the cylinder formed thereby, said ends being free and overlapping each other, said inner member having a plurality of uniform projections on the inner wall thereof, and resilient ring means having a radial thickness greater than the normal difference in radii of the inner surface of said outer member and the normal outer surface of said inner member and positioned between said inner member and the outer envelope for urging said inner member radially inwardly of said outer member.

4. The device as recited in claim 3 and additionally comprising means for mounting said inner shield within said outer shield with limited freedom of rotation of said inner shield about the axis of revolution thereof relative to said outer shield.

5. The device as recited in claim 4 and additionally comprising an inlet air port at one end of said tube shield and an outlet air port at the other end thereof.

6. An electron tube shield comprising an outer cylindrical member, one end of which is at least partially covered, an inner member positioned concentric with and within said outer member, said inner member forming a cylinder with ends thereof parallel to the longitudinal axis of the cylinder being free and overlapping each other, said inner member having a plurality of uniform projections on the inner wall thereof, a pair of resilient rings positioned between said inner and outer members, said rings having a radial thickness greater than the normal difference in radii of the inner surface of said outer member and the normal outer surface of said inner member and being concentric with said inner and outer members, and spring means attached to the inner wall of said partially covered end of said outer member and extending downwardly within said inner member for holding the tube in place within said tube shield.

7. The device as recited in claim 6 wherein said inner member has a pair of projections in the outer wall thereof and said outer member has a pair of slots in the inner wall thereof, said slots being positioned to slidably receive said projections, the longitudinal axis of said slots being normal to the longitudinal axis of the cylinder formed by said outer member.
8. An electron tube shield comprising an outer cylindrical member, one end of which is at least partially covered, an inner member positioned concentric with and within said outer member, said inner member forming a cylinder with ends thereof parallel to the longitudinal cylinder axis being free and overlapping each other, said inner member having a plurality of uniform projections on the inner wall thereof, a pair of resilient rings attached to the inner wall of said outer member positioned between said inner and outer members, said rings being concentric with said inner and outer members, said inner member having a pair of pins projecting from the outer wall thereof, said outer member having a pair of slots in the inner wall thereof running normal to the longitudinal cylinder axis of said outer member positioned to receive said pins, spring means attached to the inner wall of said covered end of said outer member and extending downwardly within said inner member for holding the tube within said tube shield, and a cylindrical base having a pair of projections on opposite sides thereof, said outer member having a pair of slots at one end thereof adapted to engage said projections, said base having an aperture therein adapted to serve as an air inlet, said outer member having an aperture at the end thereof opposite said one end adapted to serve as an air outlet.

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