

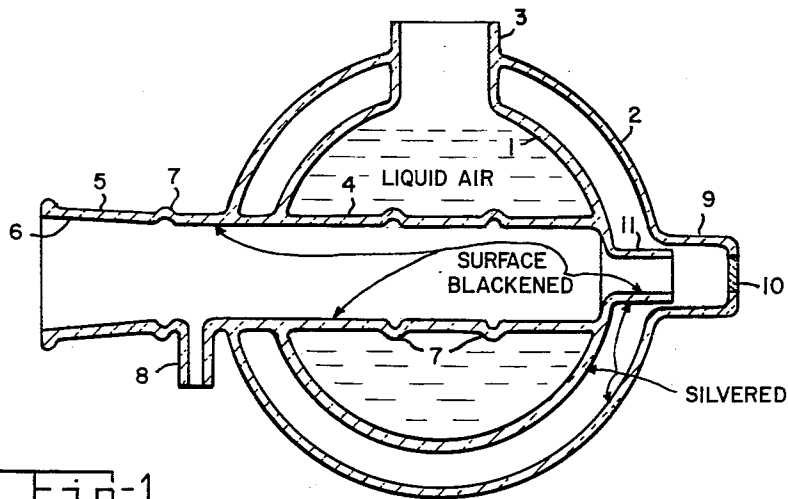
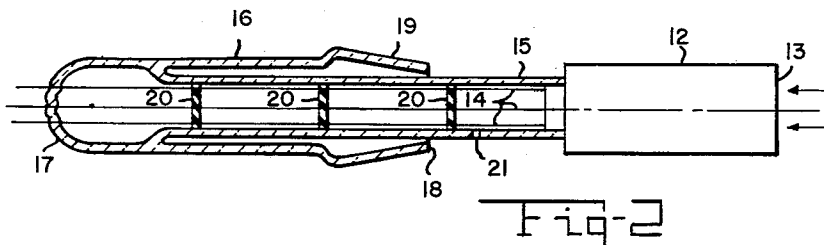
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DEMOUNTABLE PHOTOMULTIPLIER REFRIGERATOR

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1

3,018,397 DEMOUNTABLE PHOTOMULTIPLIER REFRIGERATOR

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The measurement of small light fluxes by a photomultiplier is limited by the dark current, i.e. the output of the device in the absence of incident radiation. The dark current is due largely to thermionic emission and caesium vapor pressure, both of which may be reduced by lowering the temperature. It is the purpose of this invention to provide refrigerating apparatus for lowering the temperature of a photomultiplier to that of liquid air at atmospheric pressure in order to reduce the dark current sufficiently to permit the measurement of extremely small light fluxes. Further objects of the invention are to provide a refrigerating apparatus that will allow the photomultiplier to operate in a vacuum, that will allow the photomultiplier to be readily removed for adjustment, that is easy to construct and that can be simply adapted to any type and size of photomultiplier tube.

The invention will be described in more detail with reference to the specific embodiment thereof shown in the accompanying drawing in which:

FIG. 1 is a sectional view of the refrigerating apparatus, and

FIG. 2 is a sectional view of a probe-like support for the photomultiplier tube adapted to support the tube within the refrigerating apparatus.

Referring to FIG. 1, the refrigerating apparatus comprises a spherical container 1 located inside and concentric with a larger spherical container 2. A port 3 extends from container 1 through container 2 to the atmosphere, the axis of the port extending through the common center of the spherical containers. A cylindrical housing 4 concentric to an axis passing through the center of the containers and at right angles to the axis of port 3, extends from one side of inner container 1 through its opposite wall and the wall of outer container 2, and terminates in a flared portion 5 the inner surface 6 of which is ground to form one half of a ground glass joint. The cylindrical housing is also provided with expansion rings 7 and an evacuation side arm 8. A tube 9, coaxial with housing 4, extends from outer container 2 and is closed by a transparent window 10 of fused quartz. A smaller open tube 11, also coaxial with housing 4, extends from inner container to a point slightly inside tube 9. The surfaces bounding the space between the outer and inner containers and the outer surface of tube 11 are silvered. The inside surfaces of tube 11 and cylindrical housing 4 as far as ground portion 6 are blackened. A suitable material for the apparatus so far described, with the exception of the quartz window, is Pyrex glass.

The photomultiplier and its probe-like mounting for supporting it inside cylindrical housing 4 is shown in FIG. 2. The photomultiplier is represented by cylinder 12 and, since the construction of the various commercially available photomultiplier tubes is well known in the art, need not be described in detail. A commercial example is the EMI6256B. The tube is designed to receive incident light on its end 13 from the direction of the arrows. The necessary electrical connections 14 extend from the other end of the tube. The photomultiplier is attached to one end of a Pyrex glass tube 15, the other end of

2

which is sealed to the inside of a larger Pyrex glass tube 16. The conductors 14 pass through and are sealed to the closed outer end 17 of tube 16. The other end of this tube terminates in a tapered portion 18, which has a ground surface 19 adapted to mate with ground surface 6 of housing 4 in FIG. 1. Conductors 14 may be supported inside tube 15 by discs 20 of a suitable insulating material such as Teflon. A perforation 21 in tube 15 permits its evacuation as will be seen later.

In use, the photomultiplier 12 is supported inside housing 4 by tube 15, which is attached to tube 16, which in turn is supported by ground glass joint 6—19. The length of tube 15 is such as to support end 13 of the photomultiplier tube close to tube 11, so that light may pass through window 10 and tube 11 to the photomultiplier tube. Tube 11 acts as a light trap to prevent light which may enter the space between containers 1 and 2 from reaching the end 13 of the photomultiplier. The assembly is evacuated by connecting a vacuum pump to side arm 8 in housing 4. Since the space between containers 1 and 2 communicates with housing 4 through perforation 21, complete evacuation can be accomplished through side arm 8. The ground glass joint 6—19, when sealed with grease, will permit vacuums of from 10^{-5} to 10^{-6} mm. Hg to be obtained. Refrigeration is produced by the boiling of liquid air held in the inner container 1 and surrounding the cylindrical chamber 4. The liquid air is introduced through port 3 which also serves as a gas vent.

About two liters of liquid air are required to cool the refrigerator and photomultiplier tube from room temperature. Thereafter, only about one liter must be added every five hours since heat from sources other than objects in chamber 4 is largely prevented from reaching the liquid air by the evacuated space between containers 1 and 2 which prevents conduction and convection and by the silvering which reflects incoming radiation.

We claim:

1. Refrigerating apparatus for a photomultiplier tube comprising: an inner spherical container and an outer spherical container of greater radius than said inner container and having a common center therewith, whereby a space is defined between the outer surface of the inner container and the inner surface of the outer container; a port for introducing liquid air into said inner container and venting gases from said inner container, said port being an open tube extending from said inner container and passing through and sealed to the wall of said outer container and having an axis passing through said common center; a light input tube extending a short distance from said outer container and having its outer end closed by a transparent window, said light input tube having an axis passing through said common center normal to said port axis; a light trap tube coaxial with said light input tube, having an outside diameter less than the inside diameter of said light input tube and extending from said inner container to a point within said light input tube; means forming a cylindrical refrigerated chamber within said inner container, said means being an open tube of greater diameter than said light trap tube and coaxial therewith, said chamber tube having one end ring sealed to the inner surface of said inner container near said light trap tube and, at a diametrically opposite point, passing through and sealed to the walls of said inner and outer containers so that its other end is outside said outer container; a photomultiplier tube; a probe-like means having said photomultiplier tube attached to one end for supporting said tube in said chamber adjacent to said light trap tube, said means being attached to said chamber tube at its outer end by a gas tight demountable joint; and an opening in said chamber tube outside said outer container for evacuating said chamber

3

and the space between said inner and outer containers.

2. Refrigerating apparatus for a photomultiplier tube comprising a glass inner spherical container and a glass outer spherical container of greater radius than said inner container and having a common center therewith, whereby a space is defined between the outer surface of the inner container and the inner surface of the outer container; a port for introducing liquid air into said inner container and venting gases from said inner container, said port being an open glass tube extending from said inner container and passing through and sealed to the wall of said outer container and having an axis passing through said common center; a light input tube of glass extending a short distance from said outer container and having its outer end closed by a quartz window, said light input tube having an axis passing through said common center normal to said port axis; a glass light trap tube coaxial with said light input tube, having an outside diameter less than the inside diameter of said light input tube and extending from said inner container to a point within said light input tube; means forming a cylindrical refrigerated chamber within said inner container, said means being an open glass tube of greater diameter than said light trap tube and coaxial therewith, said chamber tube having one end ring sealed to the inner surface of said inner container near said light trap tube and, at a diametrically opposite point, passing through and sealed to the walls of said inner and outer containers so that its other end is outside said outer container, the outer end of said tube terminating in the

4

outer part of a tapered ground joint; a photomultiplier tube; means for supporting said photomultiplier tube within said refrigerated chamber and adjacent to said light trap tube, said means comprising a first glass tube closed at one end and having its other end terminated in the inner part of a tapered ground joint adapted to mate with the said outer part in said chamber tube, a second glass tube smaller than the inside diameter of said first glass tube ring sealed at one end to the inside of said first tube and extending through said ground joint part for attachment to said photomultiplier at its other end, the necessary electrical conductors for said photomultiplier passing through said second tube to said first tube and through the closed end of said first tube, and a perforation in said second tube; and an opening in said chamber tube outside said outer container for evacuating said chamber, said first and second tubes, and the space between said inner and outer containers.

3. Apparatus as claimed in claim 2 in which the inner surfaces of said chamber tube and said light trap tube are blackened and in which the surfaces bounding the space between said inner and outer containers are silvered.

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