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TECHNICAL NOTE

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IMAGE INTENSIFYING SYSTEM FOR LOW LIGHT LEVEL SIGNAL DETECTION

By

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A B S T R A C T

An image intensifying system has been developed indigenously in the Laboratory. With this system the photomultiplier photocathode is cooled passively by liquid nitrogen, so as to improve its detection sensitivity at low light level. It has been designed in such a way that it can operate continously for several hours. Two types of systems have been developed; one for cooling the end window, transmission type photocathode and another, for the side window, reflectance type photocathode. It has been found that the system reduces the cathode dark current by a factor of about 10^6 in case of S-1 type of photocathode.

INTRODUCTION

Efficient cooling of photomultiplier tubes is in general, required in experiments involving the detection of very low light levels. Quite a few designs for cooled photomultiplier housings are available on a commercial basis[1] catering to only a few specific needs of the experiment. Also, some experimentalists[2] have designed such systems to suit their requirements for interchangability of different photomultipliers. All such systems are either based on thermoelectric cooling of the photocathode or freon cooling with ethylene glycol as the circulating liquid[3]. The minimum temperatures achieved near the photocathode, in all such cases range from -10°C to -50°C. Only S-11, S-20 and bialkali type of photocathodes can be cooled with these systems. S-1 type of photocathodes which require much lower temperatures for optimal reduction of dark current, can not be efficiently cooled by such systems. Again, the front window in the system which gets frosted after some time, has to be provided with slow heating arrangement. Also, the photomultiplier pins and sockets have to be potted to seal it against any moisture deposition on the dynode chain resistance. Again, the cooling down time for all these systems is very large.

Under the circumstances, it was strongly felt that a new versatile cooling system capable of attaining better than - 100°C temperature, free from moisture problems and having very small cooling downtime, is required for various end uses in several experiments. Feeling the need, two systems were designed and fabricated in the laboratory, one for 2½" diameter end-window type photocathodes and the other for 1½" diameter side-window type photocathode.

Constructional Details

The system diagrams for the two photomultiplier cooling housings, are given in figs.1 and 2. The system, in principle, consists of the two main sections; the first one is the cooled housing jacket along with the quartz window mounted on a flange and the second one consists of the photomultiplier mounting complete with dynode resistance chain, sitting in a lightly tight fit position within a nylon ring. This section is provided with the pumping port, a penning head connector and two ceramic-to-metal seals used as electrical feedthroughs.

The cooled housing jacket in the first section consists of two concentric cylinders welded in a way such that the annular portion in between the two cylinders acts as a liquid nitrogen container while in the space provided by the inner cylinder lies the photomultiplier. The cooling jacket is provided with two openings, one for pouring in the liquid nitrogen and other as an outlet for the evaporated liquid. The entire system is made of stainless steel 304 and all the joints have been argon arc-welded.

The system is evacuated to an ultimate vacuum of better than 3×10^{-5} torr. Evacuation has been found to be necessary to drive out the moisture for the housing, otherwise the moisture sits on the photomultiplier pins and results in arching across the two pins when the voltage is applied between the cathode and the grounded anode. Evacuation also assures almost negligible frosting of the quartz window as well as the photomultiplier window. Also, evacuation helps to cool the system slowly and thus, any possibility of thermal shocks to the tube is completely removed.

Initially, a small quantity of liquid nitrogen is fed to the cooling jacket to stabilize the system and the photocathode at a particular low temperature. Finally, the jacket is filled with liquid nitrogen. Photocathode dark current is reduced to a minimum after about one hour of cooling. Once the lowest dark current is attained the system becomes ready for operation. It may be interesting to note that the dark current in the present system reduced to a minimum in a much shorter time as compared to ther systems (described in references[1,2,3]).

RESULTS

The present system has only been tested quantitatively with photocathode of S-1 spectral response, while qualitative work has also been done with S-11 and S-20 photocathodes. The temperature versus dark current curve for S-1 photocathode as provided by the manufacturers is being given in fig.3. The dark current at $-100^{\circ}C$ temperature reduces by a factor of about 10^6 as can be seen from the figure 3. After cooling the system for about two hours, the dark current for photomultiplier 7102 (S-1) was checked at a cathode voltage of -1000 V. The dark current at room temperature was about 2000 A and it reduced to about 2 pico amp, giving a ratio of better than 10^6. This matches rather well with the manufacturer's specifications.

Low light signals were measured in an experiment already operational in the laboratory. The light signals were from an afterglow of molecular oxygen and 1.27 micron emission was measured using a photometer, a combination of interference filter and the cooled photomultiplier system (the present system). A signal to dark current ratio at about - 100°C was measured to be approximately 15 at a typical O_2 pressure.

The present system is also being used in different experiments for measuring 7619 A° signals from O_2 afterflow and also for monitoring the intensity of OH emission (3064 A°).

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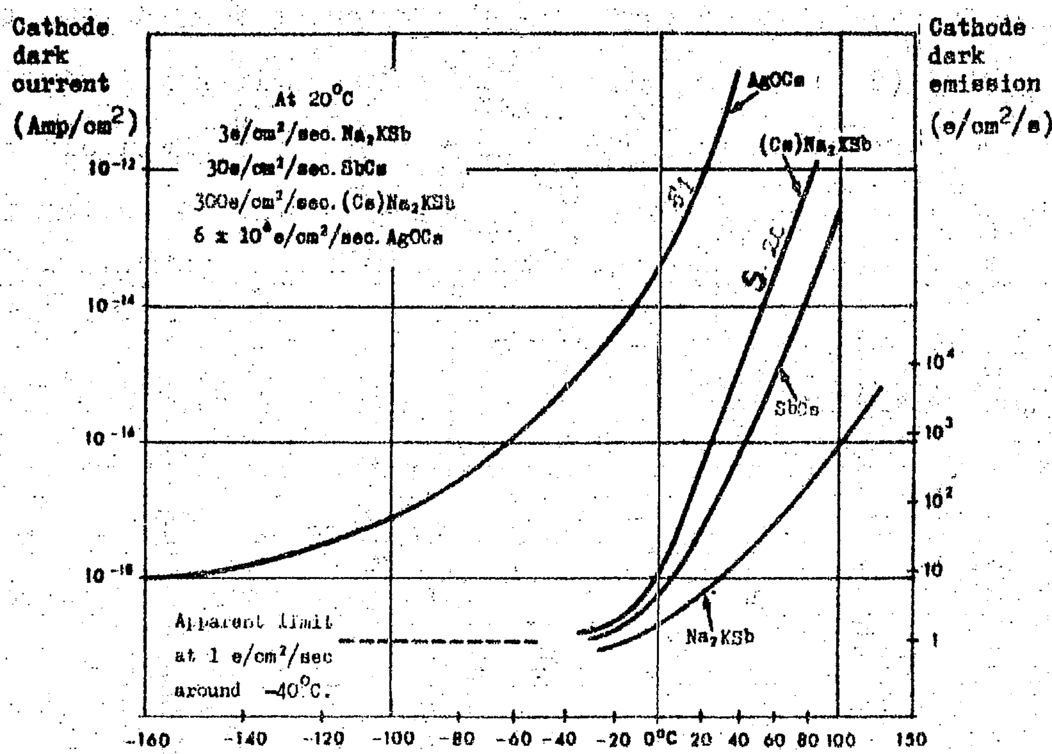
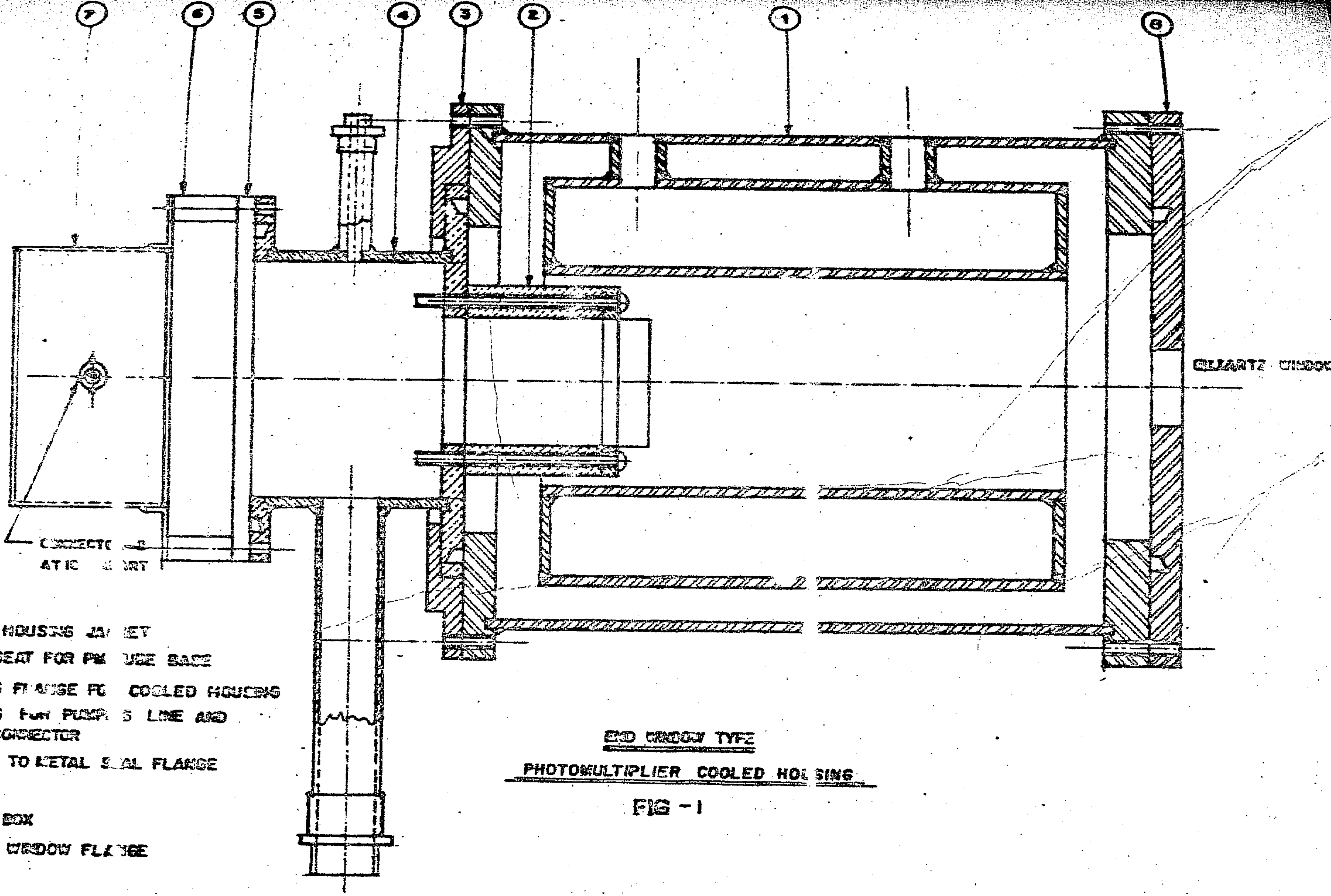
REFERENCES

1. Products for Research, Inc., Massachusetts, USA
2. Benedetti, P.A and Grassi S., Applied Optics 19, 832 (1980)
3. J.N.Desai, Private communication.



Apparent variation of cathode dark current with temperature for typical photomultiplier tubes. $(\log \frac{1}{T})$

Fig.3



1 COOLED HOUSING JACKET
2 NYLON SEAT FOR PM TUBE BASE
3 COUPLING FLANGE FOR COOLED HOUSING
4 COUPLING FOR PUMPING LINE AND GAUGE CONNECTOR
5 CERAMIC TO METAL SEAL FLANGE
6 SPACER
7 CIRCUIT BOX
8 QUARTZ WINDOW FLANGE

END WINDOW TYPE
PHOTOMULTIPLIER COOLED HOUSING

FIG - 1

PHOTOMULTIPLIER COOLED HOUSING

SIDE WINDOW TYPE

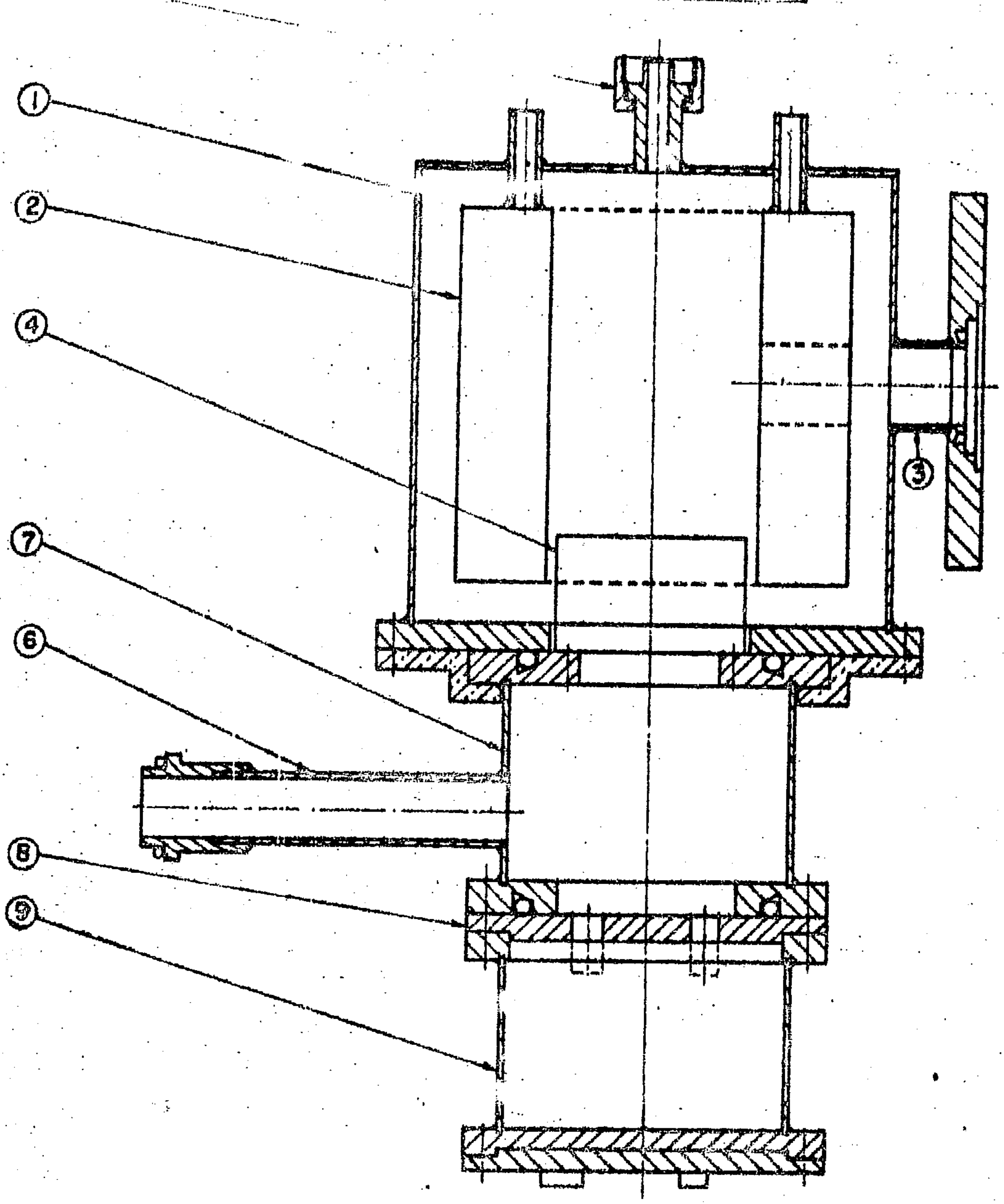


FIG. 2

1 OUTER HOUSING
2 LIQ. NITROGEN RESERVIOR
3 COUPLING COLLER
4 P.M. TUBE NYLON SEAT
5 GAUGE HEAD CONNECTOR.
6 PUMPING LINE
7 COUPLER FOR PUMP & ELEC FEED THROUGH.
8 METAL TO CERAMIC SEAL
9 ELECTRICAL CONN. BOX.