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SOLAR HEAT LOAD ON AVIATOR'S HELMET (APH-5)

1. The Problem

The APH-5 helmet is a currently authorized item of issue to Army Aviators. It is a close-fitting helmet (little or no ventilation) and contains considerable styrofoam and other padding material of high thermal insulating capacity. Even in a cool environment, the wearer finds the helmet warm. In a warm environment, or in the bright sunlight, the head sweats and the wearer becomes uncomfortably warm to a degree which may affect performance or lead him to lay his helmet aside. The helmet is painted OD and the question arises as to whether the solar load to the head would be decreased, with significant benefits to the wearer, if the helmet were painted white or some other color of high reflectivity.

2. Methods

Four brass heads were mounted in the window of a 63°F air conditioned room, facing south. Three of these heads were dressed in helmets (1 OD and 2 white) and one was left bare (Fig. 1). The helmets designated OD and White #1 are the APH-5 aviator helmets presently being issued to Army flying personnel. White #2 is an experimental helmet similar to the APH-5 in configuration but differing from the standard APH-5 in that it is constructed with a laminated nylon shell. This shell was fabricated by the Quartermaster Research and Engineering Command for research purposes.

To assess temperature differences, thermocouples were attached with dark tape to the crown of the head. In addition, thermocouples were attached to the outer surface of each helmet on a spot directly over the thermocouple on the head. Transparent tape (Scotch tape) was used to secure these thermocouples so as to retain the absorption characteristics of the helmet. A radiation meter was used to measure the amount of solar energy received. When equilibrium had been established with the blinds down (no sunlight) the shades were raised and the rate of heating of the heads determined.

From the reading of the solar radiation meter, the amount of radiation received was noted, and for the bare head, assuming an absorption coefficient of 0.9, the rate of rise caused by this energy absorption could be determined. From this and the rate of temperature rise of the heads with the helmets on, the rate of heat input due to solar radiation could be computed.

In addition to these experiments, when the heads exposed to the sun had become relatively constant in temperature, they were shaded and cooling curves were taken of each head. These cooling curves are used to

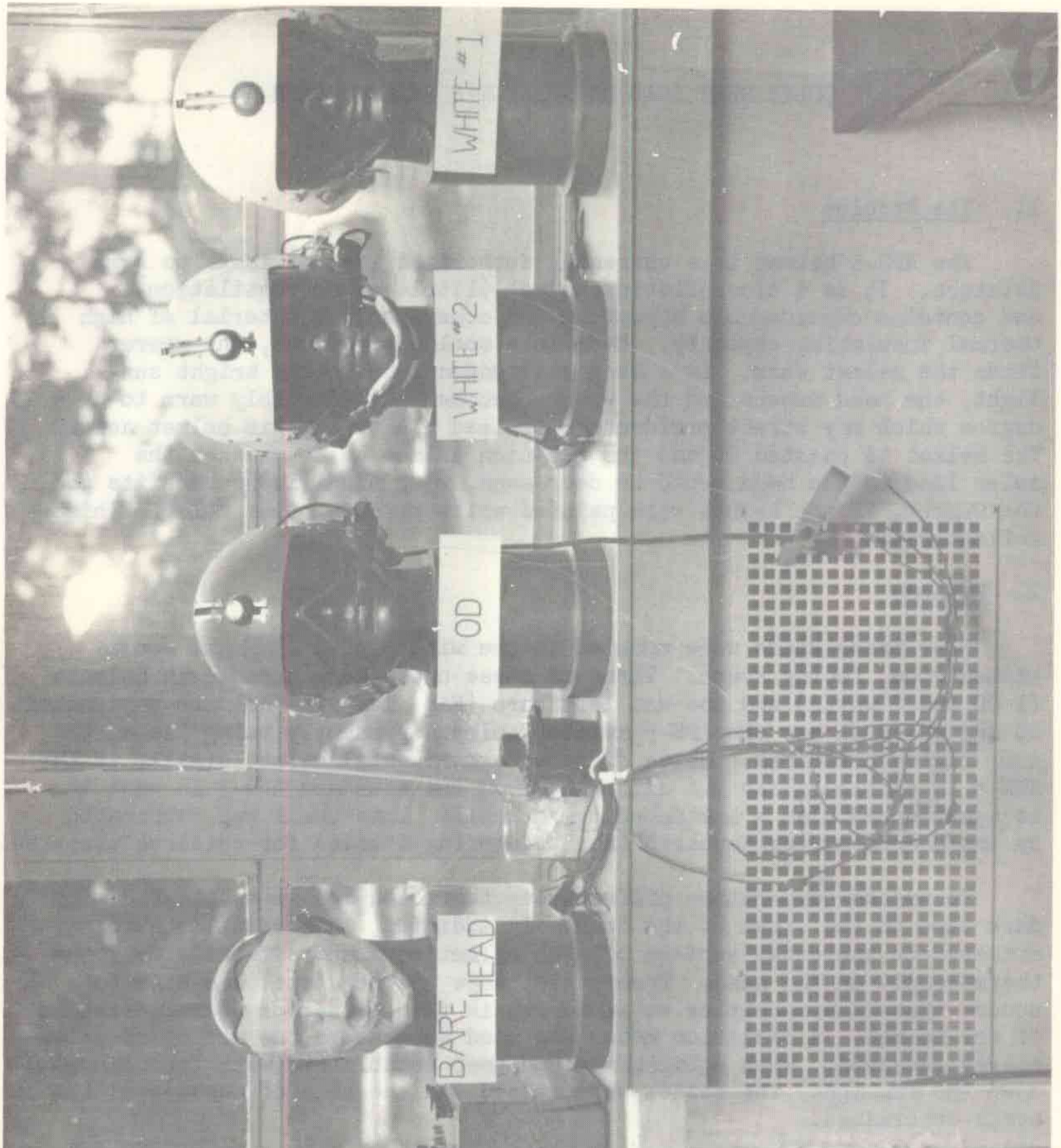

Figure - 1

give an estimate of the insulation provided by the helmets to the head.

3. Results

The results from the heating and cooling experiments are given in Table I.

TABLE I

Summary of Solar Warming and Cooling

	Bare Head	OD Helmet	White #1 Helmet	White #2** Helmet
Rate of Warming Head (F°/Min)	0.41	0.12	0.066	0.048
Heat Load on Head# (KCal/Head/Hr)	16.2*	4.7	2.5	2.0
Temperature Rise on External Surface of Helmet (F°)	—	23.2	7.3	6.5
Cooling Rate (F°/Min/°Excess Temp)	0.080	0.0053	0.0076	0.0086

It will be noted that although 16.2 KCal/hr. energy was incident on the helmets and the surface temperatures rose 23.2, 7.3, and 6.5°F respectively, only 4.7, 2.5, and 2.0 KCal/hr. of heat reached the heads. This is due to the heavy insulative characteristics of the helmets. From 2.2 to 2.7 KCal/hr. less heat reached the heads covered with the white helmets compared with the OD helmeted head. Although this is a significant physical difference, it is small in physiological terms compared with the other sources of heat which the body, including the head, must dispose of under the conditions of use in order to maintain thermal balance. Inactive man, in the shade, must lose approximately 100 KCal/hr. of heat to maintain thermal balance. In the sun the total body heat load is increased to more than 200 KCal/hr. Thus the decrease in heat load resulting from the use of a white helmet in preference to

- Head solar area = $0.03M^2$

* - Amount of radiation received (solar radiation meter) x 0.9 (absorption coefficient)

**- The differences between White #1 and White #2 were not statistically significant

OD would be roughly only 1% of the total.

Another factor which must be considered in this problem is the thermal insulative characteristics of the helmet. Inactive man in the shade loses approximately 7 KCal/hr. through his uncovered head area. With either of the helmets in place, this figure is decreased to 1.5 KCal/hr. Thus the head, which represents approximately 7% of the total body mechanism for the dissipation of heat, becomes almost ineffective due to the thermal insulative characteristics of the helmet.

No empirical data are available to indicate whether the psycho-physiological factors involved have a significant effect on performance.

4. Conclusions and Recommendations

In view of the above physical and physiological situation, the following conclusions and recommendations seem warranted: painting the helmet white instead of OD will decrease the physical solar load significantly (i.e., 2.2 - 2.75 KCal/hr.) and should be done if there are no other overriding reasons to the contrary. However, the physiological gain to be expected from this is insignificant (heat load decrease of approximately 1%) compared with the total heat load (200 KCal/hr.) the inactive wearer must handle when wearing the APH-5 helmet in a warm environment and/or in the bright sun.

Since these results indicate that color difference in the helmets does not contribute a significant physiological heat load, statements by users concerning differences in heat effects must be due primarily to other helmet variables or psychological factors. When a pilot compares the heated surfaces of the white and the OD helmets by use of his hand, a difference in external surface temperature is noted. This may lead him to generalize that the same heat differential is present in the internal area of the helmet.