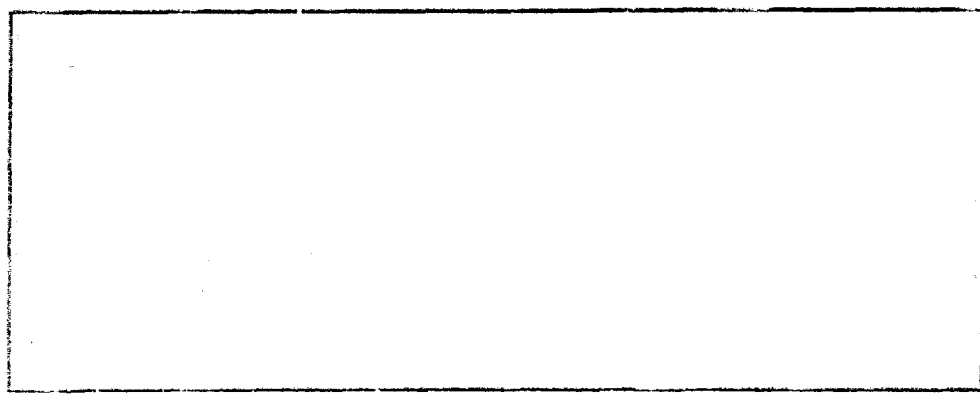


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# U.S. NAVAL MEDICAL RESEARCH LABORATORY



Submarine Base, New London, Conn.



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MEMORANDUM REPORT NO. 61-6

COLD WEATHER FACIAL PROTECTION DEVICE  
FOR ANTARCTIC PERSONNEL

MR005.12-5220-2.

14 July 1961

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## SUMMARY PAGE

### THE PROBLEM

To design a facial protective device for use by personnel serving in the Antarctic, since persistent reports of frostbite and severe discomfort have been made by Naval personnel serving there with Support Forces for the International Geophysical Year.

### FINDINGS

A lightweight facial protective mask has been designed which has kept wearers comfortable for periods as long as one hour in a cold test chamber at  $-70^{\circ}\text{F}$ . It has no external power source, but relies entirely on re-cycling of natural body energy (heat and moisture). The eye-protective section remained fog-free for the one-hour test period.

### APPLICATION

This mask should contribute materially to the comfort and operational efficiency of men who must perform outdoor work in extremely cold environments, such as Antarctica.

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### ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Project MR005.12-5220-2- (Study of Oral Health in the Antarctic). The present report is No. 6 on this subtask and was approved for publication on 14 July 1961.

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## COLD WEATHER FACIAL PROTECTION DEVICE FOR ANTARCTIC PERSONNEL\*

### INTRODUCTION

It has been reported by Frazier<sup>1</sup> that dental problems resulting from exposure to cold are the most annoying health problems encountered in Antarctic. The reports describe bizarre effects of the cold upon the teeth, severe toothache, fracture and loss of dental restorations, herpetic-like lesions of the lips and oral mucous membranes, and extensive gingivitis. Reported effects of the cold upon the face included frostbite and severe discomfort of the cheeks, nose, and forehead. Hemoptysis and frontal sinus headache also were recorded by Tolchin<sup>2</sup>, as occurring in outdoor workers without adequate facial protection.

Protective measures used to provide relative comfort included scarfs wrapped around the head and neck, a felt government-issue face mask, numerous cotton surgical masks tied one over the other across the face, and plaster casts formed to fit over the forehead, bridge of the nose and cheeks. None of these measures provided adequate protection. For instance, the felt (Gov't issue) mask worn for an hour or so at  $-50^{\circ}\text{F}$ . became heavily ice-encrusted on the inner and outer surfaces from the frozen exhaled moisture, (see Figure 1).

In addition to the problems discussed, certain physiologic changes have been shown to occur in men exposed. Consideration of a respiratory cycle in an extremely cold, dry atmosphere, reveals that each inspired breath is warmed and humidified at the expense of body energy. Less than half of this energy is recovered during expiration. It has been shown by Webster<sup>3</sup> that man in an ambient temperature of  $-22^{\circ}\text{F}$ ., subsisting on a 4000 calorie per day diet required 1018 calories to warm and humidify the inspired air. This is 25 per cent of his total daily energy requirement.

Although this investigation was started to contribute to the solution of a dental problem, it is obvious that there are other important factors which must be considered at the same time. An earlier attempt to solve the dental problem alone resulted in failure because other factors were ignored. This attempted solution to the dental problem was a boxer-type mouthpiece to pro-

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\* This paper was presented at the 39th meeting of the International Association for Dental Research, in Boston, Massachusetts, on 26 April 1961.

protect the teeth from the cold, reported by Stanmeyer<sup>4</sup>. However, the wearer discovered that his respiration was seriously obstructed and that he could not talk with the mouthpiece in place.

The object of this paper is to report the development and construction of a full facial protective device which incorporates features designed to provide protection for the face and eyes as well as the oral structures, and to minimize respiratory energy losses.

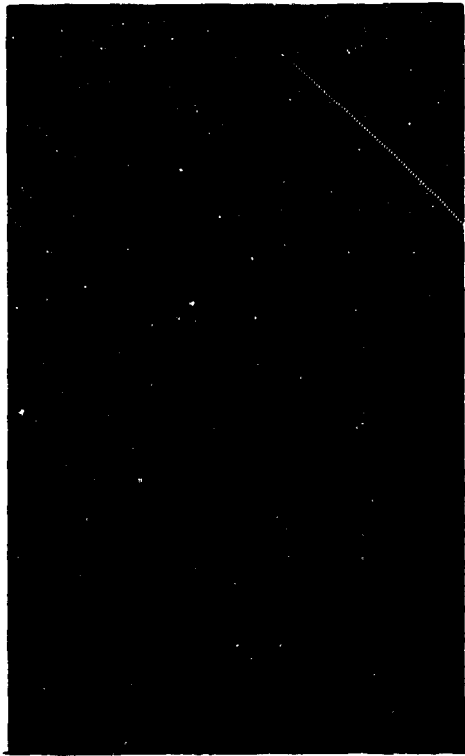
## MATERIALS AND METHODS

The basic consideration for the construction of a device to provide the required protection appeared to be an air-conditioning problem - that the Antarctic air required merely to be warmed and humidified to make it more acceptable for human use. There are a number of factors to consider in the design and construction of such a device. Several of the major factors are:

1. Energy and water sources for warming and humidifying the inspired air.
2. Operational requirements and wearing comfort.
3. Reaction of the component materials to cold.
4. Visual factors.

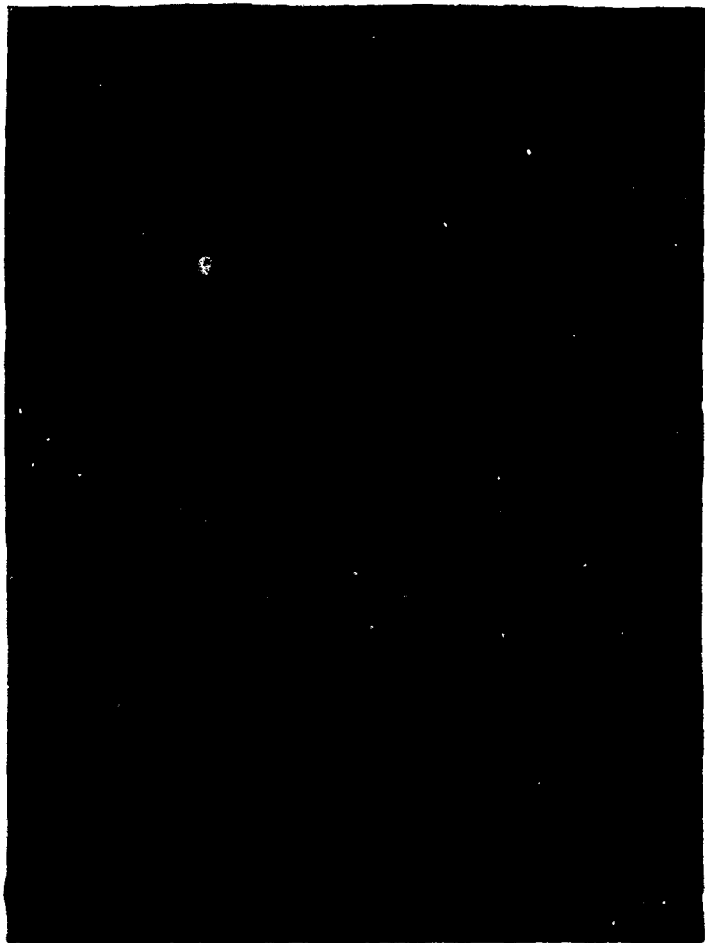
There are two basic ways to warm and humidify cold, dry air prior to its inspiration. The first method requires the use of an external power source, i. e. storage batteries, chemical energy (hand warmers) etc. to warm the air, and a moisture reservoir to humidify it. The second method utilizes an exchange chamber to transfer the heat and moisture from the exhaled breath to the inhaled air. The latter method was selected for the device primarily because it presented a means for the use of body heat and moisture otherwise lost. Also, a device using this method is more reliable and has less bulk and weight than one dependent upon an external power source, and is not subject to the vicissitudes of power failures.

Since the beginning of this investigation (September 1959) fourteen successive prototype devices have been developed and tested in a cold chamber (located at the U. S. Navy Underwater Sound Laboratory, New London, Connecticut), at  $-70^{\circ}\text{F.}$ , by a subject experienced in climate conditions prevalent in the Antarctic area. The deficiencies of each model were noted and the succeeding ones were constructed to overcome these defects in so far as possible.



**Figure - 1, Standard Issue Felt Mask**

**Figure 2, Cold Weather Facial Protective Device, NMRL Model No.14, for Use by Antarctic Personnel, and Currently being Tested in That Area.**



The current model, (see Figure 2), is a full face mask, consisting basically of two polyethylene shells, .060" thick, one superimposed upon the other with a 1/4" air space between them. The wearer inhales through an intake tube into the air space between the polyethylene shells and around an aluminum heat exchanger and barrier which provides circulation of the air within the dead space before it enters the mouth or nose. The exhaled air follows the above path in reverse.

The dead air space and the aluminum heat exchanger make it possible to retain some of the heat and moisture from the exhaled breath to be picked up by the cold dry inhaled air thus raising its temperature and humidity prior to reaching the mouth or nose.

The facial side of the mask is covered with a soft, pliable, polyethylene foam material formed to fit the contour of the face. Also on the facial side of the mask there is a smaller rubber barrier which isolates the mouth and nose from the eyes and upper facial protective features of the device.

The inner surface of the outer polyethylene shell was sprayed with aluminum paint to reduce radiation heat loss from the dead space.

The eye protective feature of the current device utilizes two transparent disks for each eyepiece. The outer disk is 1/2" clear lucite, the inner disk is thin (1/32") and coated on its inner surface with a patented moisture absorbent material.\*

## RESULTS

Tests of the present device in a cold chamber, temperature  $-70^{\circ}\text{F}.$ , revealed that the test subject's face was completely comfortable for one hour, as against extreme discomfort experienced after three minutes under identical conditions but without the device. Test periods were limited to one hour because the subject's hands and feet became cold after that time. The temperature,  $-70^{\circ}\text{F}.$ , was selected as the test temperature because it approximates the yearly average low temperature at the South Pole; however, temperatures as low as  $-120^{\circ}\text{F}.$  have been recorded.<sup>5</sup>

To measure the effectiveness of the mask, temperature measurements were made with a thermocouple placed between the maxillary central incisors of the subject under test conditions. Without facial protection, the

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\* "Klarscheiben" obtained from Draeger Oxygen Apparatus Corp., 432 Park Ave. South, New York 16, N. Y.

temperature of the inspired air was as low as 32°F. When the protective device was worn, recorded temperatures averaged 60°F. Thus, the inspired air was approximately 30°F. warmer when the subject was protected. The test reported that the conditioned air was completely comfortable and that there was no sensation of cold in the mouth or nose.

The protective device has a rebreathing air space of approximately 200 cc. The test subject's respiration rate was recorded and found to be constant throughout the test. The subject did not experience any respiratory embarrassment from this addition to his dead space.

Ice accumulation within the rebreathing space of early models created a resistance to breathing, however, this was not a problem with the present device during the test period. Some ice did collect within the rubber intake-exhaust tube but this was easily removed by striking it with a mitten-covered hand.

The eye protective disks did not fog during the test period. The solution to the fogging problem is attributed to the patented moisture absorbent disks (Klarscheiben). The effective life of these disks under Antarctic conditions is unknown. Additional disks may be required if the protective device is used for prolonged periods. The glare protection visor was not tested because it was not possible to simulate Antarctic glare conditions within the cold chamber.

Tests of the polyethylene material selected for the device revealed that it provides excellent insulation, remains flexible in the cold, is lightweight, and is ideally suited to withstand rough handling. Also, polyethylene is readily moulded into desired shapes for fabrication of the device.

The device was comfortable on the test subject's head and face, was easily donned and removed, did not interfere with the wearer's movements or with other cold weather clothing, i. e. parka, hood, etc.

The test subject's hearing was not obstructed by the device and his speech was understandable but somewhat muffled.

As a result of the foregoing favorable tests, five prototype models of the facial protective device are currently undergoing operational field tests at the four U. S. Antarctic Research Stations. The results of these tests will be available in October 1961.



## DISCUSSION

Since 1955, U.S. Navy dental officers have wintered-over in Antarctica. However, they have not observed some of the strange effects of the cold upon the teeth reported by some earlier Antarctic explorers. It is possible that personnel of more recent expeditions have not been exposed to the Antarctic elements in as drastic a manner as their predecessors were because of improved housing, living conditions, etc. However, these officers have reported a number of objectionable reactions to the cold manifested in the oral structures. These included:

- a. Toothache.
- b. Dryness of the mouth.
- c. Chapped and cracked lips which did not heal readily.
- d. Prolonged time required for the healing of cuts, abrasions, and irritations of the lips and skin.
- e. Herpetic-like lesions on the lips and mucous membranes.
- f. Hemoptysis among personnel working outdoors at South Pole station.

A preliminary search of the literature for material about cold weather facial protection devices disclosed that there were several such devices in existence. One was patented under the description of the Woods-Hafferty mask.<sup>6</sup> A model of this device was generously provided by Dr. Wood for testing. Tests on it in the cold chamber revealed that the device did not meet the desired requirements (fogged, was bulky, etc.).

Lieutenant Sidney Tolchin, MC, USN, who wintered over at the South Pole 1958-59, reported another device<sup>2</sup> which was developed by Captain E. E. Hedblom, MC, USN. This device was described as a conical mask which covered the lower half of the face but did not provide protection for the eyes and forehead.

Because of the deficiencies of the previously-mentioned devices for complete facial protection and reported inadequacies of others, it was decided to attempt the development of a device which would provide the desired protection.

It is recognized that a complete evaluation of the subject device must include a complete experimental balance of the subject's respiratory water and energy expended with and without the provided protection. The present device was developed to meet an urgent need--protection against cold discomfort. Further investigation into theoretical aspects of the device are planned.

Field testing of the device is essential before an idea of the mask's usefulness can be ascertained because there are certain Antarctic environmental factors which were not simulated in the cold chamber tests:

- a. The subject was not undergoing physical exertion-work.
- b. Effects of high winds and high altitude (the South Pole is 10,000 feet above sea level; winds up to 15-20 knots are common and it is arbitrarily stated that one knot of wind is equivalent to a temperature drop of one degree F.).
- c. Glare Conditions (Eye protection).

When reports of field tests are received, modifications of the device will be considered for meeting operational requirements as completely as possible.

Practically all of the outdoor work in Antarctica (Preparation of an air strip on the ice, pipe lines, construction of buildings, etc.) must be accomplished during the daylight period (6 months of the year).

One of the present problems is that the outdoor working periods are limited, being dependent upon temperature and wind conditions. It is possible that cold weather outdoor working periods might be doubled, if the men were provided proper protection as heretofore described.

One of the problems inherent in the wearing of a device which covers the mouth is communication. This problem has not been solved in the present device. The subject can hear but his ability to be heard is substantially reduced. It is hoped that a miniaturized two-way communication system will be developed that can be incorporated in this mask. Also, if possible, this system should include a directional beam feature, similar to GCA for airplanes, for assisting personnel who become lost in "Antarctic White-Outs". This peculiar phenomenon can occur unexpectedly within minutes and personnel have become hopelessly lost 50 yards from camp. One individual described the effect as "standing in the middle of a bottle of milk".

## SUMMARY AND CONCLUSION

A review of Antarctic facial protection problems has been presented and a prototype face mask described which has enabled the wearer to be comfortable for one hour in a cold test chamber at  $-70^{\circ}\text{F}$ ., as against extreme discomfort experienced after three minutes under identical conditions but without the mask. The mask is lightweight and provides protection for the face, eyes, oral structures, and the respiratory tree. It has no external power source, but relies entirely on re-cycling of natural body energy (heat and moisture). With the mask in place, the temperature of the inhaled air measured on the labial surface of the central incisors was  $60^{\circ}\text{F}$ . Without mask protection, temperatures measured under identical conditions were as low as  $32^{\circ}\text{F}$ . The eye protective feature remained fog-free for the one hour period. Ice accumulation within the mask was not a problem during the test period. Provision has been made for protection against snow blindness. The mask is currently being field-tested in Antarctica. How well it will succeed in providing the needed protection of oral structures, reduction of respiratory energy losses, and contribute to the comfort and operational efficiency of our Antarctic team, remains to be determined from the numerous individual reports that are being collected.

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