lenses, or, preferably, a prescription facemask instead of contact lenses.

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## POSTSCRIPT -

## CONTACT WEARERS - BEWARE!

Following a recent offshore accident (1981), where a diver lost his cornea secondary to an infection contributed to by a contact lens, the Association of Diving Contractors Medical Committee has warned that contact lens (hard or soft) should NOT be worn in the water, in the chambers, or on deck while offshore or in any isolated area. They quote the National Society for the Prevention of Blindness (USA) has having come out strongly against the use of contact lenses in industry, a warning equally applicable to a person on a vessel or oil rig. Far from protecting the eyes, they may pose a greater hazard and safety goggles or full face shields must be still worn. Dangers may arise from situations where some chemical needs to be washed from the wearer's eyes by another person, should small foreign particles become trapped beneath the lens, or a lens become displaced causing a sudden change in vision. The problem of "spectacle blur", the occurrence of blurred vision which may occur for over an hour after lens are put in or taken out, could reduce safety in industrial situations such as on a rig.

## LOW LEVEL SUPPLEMENTARY HEATING FOR DIVERS

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For the great majority of divers who work at present without the benefits of supplementary heating, some degree of body cooling is normal. Often, particularly in the temperate and cold water areas of the world, such body cooling is a matter of great practical importance. Within relatively short duration dives the familiar perceptions of cold discomfort, shivering, and numbness of the extremities become apparent. These reactions serve as personal warning signs for the diver to limit the safe duration of his dive, because the consequences of further exposure include more severe loss of sensory and motor functions which are hazardous to safety.

However, short duration diving tends to be both unproductive and expensive. For this reason many commercial diving contractors use supplementary heating for long duration tasks. Supplementary heating is even more important in deep water because the insulation performance of diving garments becomes very poor at depth, and the dense breathing gas must also be heated. The supplementary heating systems presently in use rely on a free flooding hot water suit fed through an umbilical hose from a surface installation. Thus the diver loses some of his freedom by being tied to the surface, and the very high heat losses of the heating arrangement consume a great deal of power. These features are of no consequence for diving performed from an installation such as an offshore oil rig, but there remain many types of diving for which such systems are either inconvenient or impossible to use. Scientific work, photography, military, police, and recreational diving are some cases in point.

Work recently completed at the CSIRO Division of Energy Technology was aimed specifically at providing the free diver with an inexpensive light and easily used local supply of supplementary heating. The first task was to find a portable energy store which could be capable of releasing heat steadily and safely underwater, and to ensure that this heat could be distributed over the diver's body. Some of the high energy chemical reactions that might be suitable are inherently too fast, and would generate high temperatures or even explosions. On the other hand, many of the slower chemical reactions and storage systems are not energetic enough, and many kilograms of reactant would be required to keep a diver warm for a few minutes.

The reaction of magnesium metal with water was found to be a good compromise. One kg of magnesium releases more than 4 kWh of energy when it reacts with water, and at temperatures like 20 - 30°C the reaction is so slow that there is no danger of explosion. To be of use for diver heating, the reaction rate must be accelerated, and this was done by using the magnesium in the form of particles mixed with controlled quantities of a cathode material such as cast iron or steel turnings. The two metal mixture behaves like a multitude of short circuited batteries producing neat rather than electrical energy and the reaction rate in sea water is controlled by the mixture ratio, the sizes of the particles, and the method of packaging. For example a small tissue paper sachet containing 10g of mixture is capable of generating between 1 and 10 Watts of power for periods up to 3 hours, when flooded with sea water. Like tea bags, which they resemble closely, they can be kept for many months in dry storage and must be discarded after use. Unlike tea bags they generate hydrogen gas and warm the sea water in which they are dunked.

The first laboratory and field tests involving people were designed to assess the thermal performance of actively heated mittens. The fingers could be prevented from becoming cold and numb for about two hours, even in freezing water. It was later found that by using the diver's personal wet suit, and placing an array of local heating pads in the torso area between overlapping areas of the suit, a useful degree of body heating could be achieved. Controlled tests with several professional and experienced amateur divers revealed that the telltale subjective signs of cold discomfort, shivering, and numbness of the extremities could be delayed, so that the voluntary diving duration of heated subjects was significantly increased.

A most interesting finding was the extraordinary efficiency with which such increases of duration could be obtained by quite low levels of supplementary heating. The voluntary tolerance time for a man in shallow water in a wet suit can be measured or even calculated with reasonable accuracy if the amount of muscular activity is known. At a water temperature of 11.5°C for instance, a person doing light work will become fairly cold in 100-110 minutes without any supplementary heating. If the diver is equipped with local heating pads that deliver, say, 50W, the time required to become cold increases to 230 minutes. This is a substantial improvement in tolerance to cold, but the amount of heating required is only about one quarter of the amount required to keep a person warm. For most of the dive, however, the person would consider himself reasonably comfortable. In an ideal situation it would be desirable to install 200W of heating to keep the subject warm indefinitely. However it is very much more cost effective to reduce the supplementary heating to a low level and to accept a tolerance time that is reasonable.

The high effectiveness of the low level supplementary heating system is related to the way the body protects itself when it starts to become cool. The skin temperature in the extremities and limbs of a cooling person drops as a result of decreased blood flow to the skin. This markedly reduces the rate of heat loss to the environment as the exposure progresses. If the rate of heat loss is not too high it may take a very long time to accumulate a substantial heat debt and reach a tolerance limit. Small changes to the heat supply can therefore have large effects on tolerance time.

ADDENDUM

Cost

Based on the high cost of analytical grade imported magnesium, the 'materials only' costs are $0.15 per sachet. This would be much reduced with appropriate sources.

Availability

Availability is not good because we have been unable to offer patent protection to potential licensees. However Mr Crawford Grier of Croft Cottage, Croft Road, Oban, Scotland, has expressed an interest in manufacture. The Antarctic Division at Channel Highway, Kingston, Tasmania 7150, have been manufacturing in house. Their contact is the officer-in-charge of R & D, Mr Atilla Vrana.

Safety

Local heating pads must not be placed on the skin because local temperature may rise above the burn threshold of about 45 C. However, we have found that pads may be safely placed between overlapping areas of wet suit. A Farmer John pattern of suit without modifications allows placement of heating pads over most of the torso area. We have been interested in possible toxic effects on skin, of metals such Chromium, Manganese and Nickel which are present in cast iron. X-ray fluorescence analysis shows these metals to be present in trace amounts in samples of water taken from the vicinity of the skin during heated dives. However their concentration does not significantly exceed the levels to be found in clean sea water. One cause for concern is that such water samples tend to be slightly alkaline, a pH value of 9.6 was found for water squeezed from active local heating pads. For some people not tolerant to alkalinity this may be a problem, but application of a barrier cream prior to diving should give effective protection. No evidence concerning skin problems has been reported to date, the total exposure probably being a hundred hours or so and about 50 subjects.

## $O_2$ BE ALIVE

Gavin Dawson

Oxygen is a gas, lethal at low concentrations, poisonous at high concentrations and extremely dangerous at pressure. 2,000 pounds per square inch in a cylinder of medical oxygen can cause a lot of damage! It is considerably more than you would put in your motor car tyres! Today I intend to concentrate on hyperbaric oxygen. I am not going to go into any statistics or complicated tables. We have been running the chamber at Prince Henry's Hospital for 11 and a half years and have not treated all that many patients, but we do have a lot of clinical impressions and good results in certain directions.

Before starting on hyperbaric oxygen let us take a quick tour around the field of oxygen; its role in life, industry, aviation, rocketry, combustion, steel manufacture, mountaineering and diving. We will not spend too much time on diving. This already has been very well covered in the previous paper.

Here we are on planet earth and for some reason breathe 20.98% oxygen. Oxygen was discovered in 1774 by Joseph Priestly and independently by a Swedish chemist, Scheele, at the same time. Both produced oxygen by heating mercuric oxide. Its uses are vast.

In aviation, pilots of high flying aircraft wear oxygen masks. You may not think oxygen was vital for the flight of Gossamer Albatross but if you ask Brian Allen he will tell you that it was! He did not have any extra oxygen apart from fresh air and his lowest recorded altitude on the Channel crossing was six inches. He did need oxygen to produce the energy and horsepower for his leg muscles that were peddling that man-powered machine 22.5 miles across the Channel. Oxygen was used as a rocket propellant in the doodle-bug V2 designed by Von Braun which pestered London towards the end of the Second World War. Liquid oxygen and 75% ethyl alcohol were the propellants. America's first man into space, Alan B Shepherd, in 1961 ascended in Mercury Redstone. Then came Atlas and Friendship 7 and John Glenn's first orbit. Titan 3C launched the Gemini space capsule and Ed White was the first American to walk in space. He naturally depended on oxygen for his life support system and the rocket depended on oxygen for its propellant. Finally in