body in hot water (42 °C) until deep body temperature improves. Monitoring of this really requires special equipment, hence the need for medical care. The arms and legs are not immersed in order to prevent a rush of cold blood from these extremities to the body core.

This could cause an AFTER DROP in which the core temperature drops further. If the victim's core temperature is already low this could have a disastrous effect.

The rewarming process must be gradual and overall. The application of local heat (eg hot water bottles, rubbing to stimulate circulation) must be avoided. Giving alcohol to a hypothermic patient is like putting a nail in his coffin - alcohol opens up the blood capillaries and encourages cold blood from the body surface to return to the core.

Once the subject has responded to treatment he should be placed in a warm bed and given warm, high-energy food and drink.

Hypothermia is clearly a condition to be avoided, and one which, with forethought, IS easy to avoid.

HYPERTHERMIA

Heat exhaustion or HYPERTHERMIA is caused when the body is unable to cool the core temperature sufficiently by sweating, etc.

SYMPTOMS

1 Dizziness, restlessness and headaches.

2 Difficulty in breathing.

3 Rapid pulse and excessive sweating.

4 Cold, clammy appearance of the skin.

5 High temperature.

6 Twitching and cramp.

7 Loss of consciousness.

TREATMENT

Allow the patient to rest in a cool place and give the subject plenty of water to drink with some salt added.

In serious cases pack ice around the patient.

NITROGEN ABSORPTION

Nitrogen is an almost inert gas which combines with other elements only with difficulty. However, when air or oxy-nitrogen mixture is inhaled, the nitrogen comes into contact with the blood while passing through the walls of the alveoli in the same way as oxygen. The average human body, at sea level, contains about 1 litre of dissolved nitrogen. The amount of gas contained in solution varies relative to the pressure acting upon it. This it does in accordance with HENRY'S LAW. Henry's Law states that:

> "At a constant temperature the mass of gas that dissolves in a given mass of liquid with which it is in contact is always directly proportional to the partial pressure of that gas."

Since the amount of nitrogen dissolved in a fluid depends upon the pressure, at 2 bars absolute the body should contain about 2 litres of nitrogen, at 3 bars absolute 3 litres and so on. This is roughly true, providing the time of exposure is long enough.

Of the nitrogen in the body, approximately half the amount at atmospheric pressure is contained in the blood and watery tissues, while the remainder is held in the fatty tissues. However, although there is less fat than water in the body, nitrogen is 5 times more soluble in fat than in water, so the presence of excess fat in the body predisposes a person to decompression sickness.

Inert gas dissolves in the body at first quickly and then more slowly, until no more gas will dissolve. This condition of equilibrium is called SATURATION and the time taken to reach this state the SATURATION TIME. The saturation time for a man is not accurately known but is thought to be about 8 hours (nitrogen). The rate at which portions of the body become saturated will vary; some areas have a relatively poor blood supply, and will become saturated more slowly than others, like fatty tissues, which will absorb about 5 times as much inert gas as will watery tissues.

It should be noted that nitrogen and helium have significantly different saturation and DESATURATION rates, helium being much quicker than nitrogen, hence requiring less decompression.

The use of nitrogen mixtures for saturation are generally restricted to shallow depths, mainly for hyperbaric welding habitats, etc.

Saturation is only relative, since if after spending 8 hours at 8 bars absolute (70 m) a person goes quickly to 15 bars absolute (140 m), that person is now only half saturated at the new depth.

DESATURATION

The process of desaturation is the reverse of saturation. If the partial pressure of the gas in the lungs is reduced, either through a change in pressure or the breathing medium, the new pressure gradient will induce the inert gas to diffuse from the tissues to the blood, from the blood to the gas in the lungs and then out of the body with the expired breath. Some parts of the body will desaturate more slowly than others, for the same reason they saturate more slowly - poor blood supply, or a greater ability to absorb gas.

There is a major difference between saturation and desaturation. The body will accommodate relatively large increases in the partial pressure of the inspired gas without any ill effect. However, the same is not true for desaturation, where a high pressure gradient (towards the lower outside) can lead to serious problems.

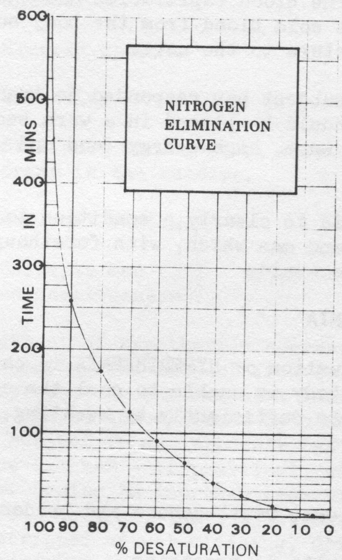

Figure 3-20 Nitrogen Elimination Curve

DECOMPRESSION

If the pressure of a liquid, which has been partly or completely saturated with gas, is reduced, some of the gas comes out of solution.

In the process, bubbles of gas are produced in the liquid. An illustration of this is the removal of the crown cap on a bottle of fizzy lemonade.

The blood and tissues of the body can apparently hold gas in a super-saturated degree before bubbles will form. This allows a diver to ascend a few metres without experiencing decompression sickness, while allowing some of the excess gas to defuse out of the tissues and be passed out of his body. By progressively ascending in increments, and then waiting for a period of time at each level, the diver will eventually reach the surface without experiencing decompression sickness.

In actual air diving practice, a diver will not remain at depth long enough to become fully saturated with nitrogen. In a short dive only those tissues which saturate quickly will absorb any appreciable quantity of gas, and they will desaturate easily. The amount of time that a diver must spend at these predetermined STOPS is laid down clearly in a DECOMPRESSION TABLE. These tables have been developed through research and experimentation by commercial diving companies and naval test programmes. They have been composed to provide guide lines for controlled decompression for a wide range of diving circumstances. The factors involved include such considerations as DEPTH and BOTTOM TIME of the dive, and whether or not the diver has made more than one dive within a **time** period, all of which will have some influence upon the quantity of nitrogen which will have been absorbed. Established decompression tables must be rigidly followed to ensure maximum diver safety.

Not all decompression is carried out by staged ascent to the surface; if the depth of the dive is less than 10 metres no stops or stage decompression are required. Also, within certain limits,

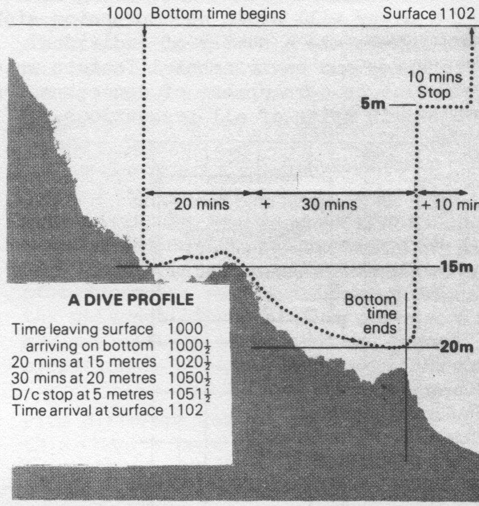

Figure 3-21 A Dive Profile

the diver can be brought out of the water, repressurised in a chamber, and then decompressed on the surface. The use of pure oxygen during surface decompression can reduce the time which will be required for controlled decompression. If used, pure oxygen will significantly reduce the partial pressure of the nitrogen in the alveoli, creating a higher pressure gradient than would otherwise be present.

A common practice for decompression in oxy-helium diving is the LINEAR decompression. The divers undergo a slow bleed to the surface maintaining a slightly higher partial pressure of oxygen. This slow bleed may be in the order of 25 minutes per metre, becoming as long as 50 minutes per metre near the surface.

Although decompression procedures have been thoroughly tested in the laboratory and field, adherence to procedures and compliance with the standard tables does not guarantee that a diver will avoid decompression sickness. There are a number of individual differences and environmental factors which may influence development of decompression problems in spite of all precautions.

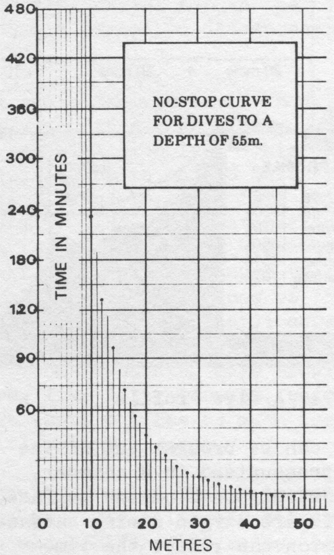

Figure 3-22 No-Stop Curve for Dives to a Depth of 55 m.

These include age, degree of obesity, excessive fatigue, lack of sleep, alcoholic indulgence, impure oxygen being used for decompression (this can be a common problem overseas and all oxygen used for decompression should be checked for purity before use), or anything which, in general, contributes to a poor physical condition or poor cirulatory efficiency.

Professor Haldane, working in the early 1900s, advanced the hypothesis <u>that bubbles will form in the body only if the pressure of gas inside was more than $2\frac{1}{4}$ times the pressure outside.</u> Thus it is safe to ascend directly from 10m (2 Bars absolute) to the surface (1 Bar absolute) since bubbles do not form. This is also true for greater depths, eg 50m (6 Bars absolute) to 20 m (3 bars absolute). This is usually known as the FIRST STOP WITH SAFETY and may be stated as follows:- <u>A diver may always be allowed to ascend safely to half his absolute depth.</u>

This is useful if it is necessary to bring up a diver in an energency, since while he is ascending, his correct stops may be determined.

DIVING AND ALTITUDE

To take account of the reduced surface pressure when carrying out dives at altitude, for instance in a mountain lake, adjustments must be made to decompression tables.

BONE NECROSIS

DYSBARIC OSTEONECROSIS, ASEPTIC BONE NECROSIS is a long-term condition which is generally assumed to be caused by the blockage of nutrient vessels of the bones by bubbles formed during decompression, and can result in a weakening in the mechanical strength of the affected bone. Bone necrosis in the compressed air worker or diver begins as a symptomless LESION detectable only by radiography. It occurs typically in the HUMERUS, FEMUR or TIBIA, although lesions in other bones have been detected. Commercial divers are generally susceptible to necrosis because of their increased durations and decompression tables used. Necrosis is common to both air and mixed gas diving.

Current medical practice offshore requires a diver to have periodic LONG BONE X-rays in order to detect any symptoms of the disease.