RECENT RESEARCH WORK IN DEEP SEA DIVING.¹

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The British Admiralty continues to place reliance in the rubber diving suit, and for the past three years, in collaboration with Messrs. Siebe, Gorman and Co., has been conducting research and practical experiments in deep sea diving, both with the rubber suit and with the German all-metal suit.

When one considers the objective of deep sea diving, which is equally the saving of life in a sunken submarine and the recovery of sunken trophy, it will be seen that the cumbersome all-metal suit has distinct disadvantages. Although allowing certain work to be carried out at a greater depth than can even now be obtained in a rubber suit, its comparative immobility and the difficulty in keeping its joints water-tight preclude its use in the rapid work necessary for saving lives entombed in a disabled submarine.

A similar dress is used by the Italians in their endeavour to recover bullion from the “Egypt,” but it has no legs and is used purely as an observation chamber, the diver telephoning the instructions necessary for placing grabs and demolition charges.

Let us turn to the rubber diving suit, and the methods employed in the British Navy for diving between 200 and 300 feet, a depth where much useful salvage can be carried out.

As the diver descends he is subjected to increasing water-pressure, which is transferred to the air in his suit, and hence to the air in his lungs. This increased alveolar pressure causes a corresponding increase in the amount of the gases in the body. The pressure of abnormal amounts of nitrogen in the body causes no inconvenience as long as the gas is in solution, but should the pressure be released too rapidly for the gas to escape through the lungs, bubbling occurs. A bubble in its action resembles an embolus and is the cause of caisson disease—the bugbear of all who work under increased air pressure. An increase of oxygen or carbon dioxide would cause poisoning. The amount of oxygen necessary to produce oxygen poisoning is not completely defined, but experiments on animals are now in process.

Should the diver be brought too rapidly to the surface, bubbling of nitrogen will cause caisson disease. The prevention of this has been known since the days of Paul Bert. It suffices to reduce the pressure gradually by bringing the diver up slowly, this being known as decompression. The present Admiralty Tables were drawn up as a result of the work of Professor J. S. Haldane, Professor A. E. Boycott, and Captain G. C. C. Damant, R.N., for the Admiralty Committee of 1907, and are used all over the world with most successful results.

These tables were calculated for a maximum depth of 204 feet, and a maximum stay on the bottom of one hour, or in an emergency for one hour and fifty minutes.

Now the time taken in bringing to the surface a diver who has been working at a depth of 204 feet for one hour, is 124 minutes, implying a considerable waste of

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working time, and a considerable feat of endurance when it is considered that he is hanging on a rope suspended in mid water, often in winter, or even in our summer, at a temperature of 40°—50° F., and in a strong tideway. To overcome this difficulty, Mr. R. H. Davis, Managing Director of Siebe, Gorman & Co., has designed and produced a steel chamber which, when submerged acts as a diving bell, and when closed as a decompression chamber. The Davis Submersible Decompression Chamber is lowered to the depth at which it is required to pick up the diver. It is fitted with "Salvus" oxygen breathing apparatus, depth and pressure gauges, thermos flask containing hot coffee, etc. This chamber was designed: (1) for the greater safety and comfort of the diver; (2) to enable him to use oxygen breathing apparatus to accelerate decompression; (3) to work at greater depths for longer periods; and (4) to be brought up immediately and safely to the surface in emergency. Oxygen breathing permitted by this chamber shortens the time of decompression by a half to a third and materially adds to the possibility of successful diving at depths of over 200 ft.

The importance of the use of oxygen in decompression, originally advocated by Paul Bert, has been recognized by physiologists who have followed him, and confirmed by Sir Leonard Hill and others who have carried out research on the subject.

In the months preceding the 1931 diving trials, Mr. R. H. Davis arranged for Captain Damant to calculate a new set of decompression tables to a depth of 300 ft. on Professor J. S. Haldane's system, taking into consideration five groups of tissues saturating at different rates and allowing for the accelerating effect of oxygen breathed from a certain point in the decompression scales. Mr. Davis placed his experimental plant and other facilities at the disposal of the Admiralty. Several hundred tests of these tables were made on goats, and it was found necessary to increase the safety factors largely (the system of calculating remaining the same). Eventually a decompression table was produced which had been thoroughly tested over the range in which the men were to dive, and the success of the deep water trials described below was largely due to this careful preparatory work.

What knowledge have we gained by the work of the last few years?—(1) Deep diving has emerged from the chrysalis stage. Investigations are still proceeding and much remains to be done, but sufficient knowledge has been gained to permit preparations for the routine training of a proportion of our divers in deep sea work. It is hoped that later on deep sea diving sections will be attached to our principal fleets.

(2) Oxygen breathing during decompression and the D.S.D.C. have made diving safer, and the time spent during decompression more comfortable. It has also effected a saving of from a third to a half of the time in decompression—a valuable gain now for the diver and the officer in charge of the salvage.

(3) Diving, and working at a depth of 300 ft. in a rubber suit, is both safe and practicable. One of our divers reached a depth of 344 ft. and came to the surface as one might return from an afternoon walk.

The use of oxygen in deep diving.—The intensive use of oxygen is viewed with mingled feeling in modern medicine, for while it confers many undeniable benefits, it is responsible under certain conditions, such as prolonged exposure, for undesirable poisonous effects.

In animals, exposure to 45 lb. pressure of oxygen quickly leads to convulsions, and
as the pressure rises, the quicker is the onset and the more likely is pneumonia to supervene. With mice and rats the convulsion period is preceded by extensive washing operations, which after a time, depending on the pressure, change into running convulsions. These last a few seconds and are usually succeeded by a period of inactivity. When the pressure is reduced convulsions are again noticeable, often even if no previous convulsions have occurred.

A few minutes' exposure to a 100 lb. pressure of oxygen produces severe convulsions in the smaller animals.

Exposure to 45 lb. and under takes longer to produce toxic effects, mice convulsing in about 20 minutes. At the end of 30 minutes two rats had shown no symptoms, as was the case with two monkeys. 40-45 lb. seems to be near the critical pressure for animals; below this they are fairly safe, except that during long exposure they appear to go into a stupor; over 45 lb. they are much more liable to convulsions and pneumonia.

Luckily we have no cases of oxygen poisoning to record among the divers; even allowing for the use of oxygen during decompression we have a safe margin.

We have found in our limited experience with oxygen (1) that, like the small boy in the soap advertisement, the divers are happiest when they get it. (2) They state that after their dive, when they climb into the D.S.D.C. and commence breathing oxygen they feel very refreshed. This may in part account for the feeling of fitness on the bottom, since even though breathing atmosphere air, they are even then exposed to two atmospheres of oxygen. (3) The exposure of one diver to 88 minutes' breathing of oxygen at an average pressure of two atmospheres, produced no evil effects, except subsequent sleepiness. (4) After three-months' diving there was a slight diminution of lung fibrosis in all ten divers. (5) In one case functional albuminuria was prevented by the use of oxygen.

What standard of fitness has been regarded as essential for deep sea diving?—Except that the diver should be possessed of a very stable mentality our experiences do not suggest that it is necessary for the deep sea diver to be any more fit than a shallow water diver.

Volunteers for deep diving must have had over two years' experience in shallow diving, and be under the age of 30. While deep diving was in the experimental stage, to be on the safe side only the very fittest were chosen. This was partly to ensure that if the work proved very arduous, the diver would have the stamina to stand up to it, and partly to eliminate all those subject to illnesses which, if they occurred during the trials, would hang up the man's diving. From the information gained it is hoped to be able to reduce the standard of fitness now that routine training has been instituted. Previously the thin spare type was regarded in our Navy as the most suitable for diving. Our experiences suggest that the thin type has not always the same physiological and psychological reserves. Deep diving, since the pressure against which the diver has to work is greater, requires a more powerful build of man. Personally I like to see a moderate supply of adipose tissue; the work is sufficiently hard to work off any excess, and a small fatty layer protects against the cold. The entrance medical examination was mainly directed to obtain a stable heart, a sound labyrinthine system, and healthy lungs. It was required that these systems should stand up to some hard work and, if necessary, hard knocks.

The examination was similar to that of the Air Ministry, and my thanks are due to them for their assistance, and especially to Wing-Commander Tredgold.
Some of the candidates accepted had one defect, but this was only permitted if it was not considered likely to produce an adverse effect on the diver. One of the divers had a well-marked hyperpiesis but he came through the season just as well as the others, and actually was much healthier afterwards than before. His blood-pressure at the beginning of the season was 143/93, and at the end of the season 132/80.

A test that I call the 250 test, which I found useful in inducing albuminuria if any disposition to it existed, revealed an interesting condition in one diver. The test consisted of touching the toes with the fingers 250 times in ten minutes; to be satisfactory, the pulse-rate should not exceed 130 on completion, and should return to within 10 per cent. of the pre-test rate in twenty minutes. One diver was found after this test to have his urine loaded with albumin. When this test was repeated and oxygen was breathed instead of air, no albumin could be detected. This test was carried out by him thirty-seven times in six months and the result was always the same. Renal efficiency tests suggested that this was a case of functional albuminuria. Other cases of this complaint were subjected to similar tests, and in every case the amount of albumin was diminished or eliminated altogether by the use of oxygen.

Another test employed, which is not in general use, was the mental excitability test; it was a modification of a similar test invented by the Japanese. Small strips of blotting paper, treated with carbol fuchsin, and mounted on plaster were placed on the palm of the hand, and a control strip was placed on the chest near the axilla. The test relies on the assumption that sweating of the palms is due to mental excitement or pain and is not due to heat. I considered the result positive if the stain on the palm was about twice as pronounced as that made by the control strip. This test gives moderately accurate results.

Value of certain medical tests and results obtained.—These trials have afforded an opportunity for exhaustive and continuous application of certain tests; moreover they supplied what must be regarded as something approaching the optimum figures for the tests, for owing to the rigorous medical excluding examination and the healthy lives the candidates lead, it would be difficult to find a healthier body of men.

At the initial medical examination very many tests were applied, not so much to exclude candidates as to throw light on the efficiency of the test for separating the likely successful divers from the likely unsuccessful divers. Therefore, blood-pressures, pulse-response tests, 40 millimetres test, balancing and labyrinthine tests, and vital capacity tests were applied daily, before and immediately after diving. As would be expected, daily variations were always present and existed during different times of the same day, but they were slight. Towards the end of the diving week, blood-pressures were on the up-grade, and vital capacities falling, all very slightly. The long week-ends effectually restored the levels to par. Further, this tendency could be observed at the end of the three months' diving season. This was most noticeable in the diastolic blood-pressures. Incidentally, the men with a slight hyperpiesis showed the better stamina.

I attach great importance to a stable labyrinthine system, since the diver may have to work in bad lighting conditions. Contrary to the usual experience, the holder of the best records for the 40 millimetre test showed the least desire to hold out under unfavourable conditions. To hold with one's breath a column of mercury
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at 40 mm. for 2 mins. 23 sec. is almost unheard of. This diver exhibited wonderful endurance in achieving this figure, but his endurance on the bottom was strictly limited; psychologically he was not so stable, and it might have been something in this direction which hampered him when diving. He had repeated attacks of caisson disease and therefore was removed from the deep diving list. Very little difference could be detected in the figures obtained before and after diving. One noticeable after-effect, probably due to oxygen, was an overwhelming desire for a nap a few hours afterwards, even after sitting in the experimental chamber in London.

Working conditions on the sea bottom at 300 ft.—At 300 ft. the divers have to work against a pressure of ten atmospheres, and in addition have to contend with the low temperature of the water; so it is desirable that they should have some protecting layer of fat.

By means of a toy which I have had made, I have studied the heart condition of the diver when working and when at rest on the sea bottom. It consists of a microphone fixed over the apex of the heart, connected through the divers' helmet to an amplifying set on the surface, and thence to a loud-speaker or headphones. By means of this device I found that the diver at work on the bottom had, in spite of the pressure of ten atmospheres, an increasing pulse-rate of only five beats per minute over his pulse-rate for similar work on the surface. I attribute this to the slowing influence of oxygen, for at this depth the diver has the benefit of the equivalent of two atmospheres of oxygen—the oxygen in the air being responsible for one-fifth of the total air pressure.

I am having another device made to record the respiratory rate of the diver. It consists of an electric belt worn round the thorax, and connected through to the surface to four electric bulbs. It is so arranged that at rest bulb 1 lights on inspiration and dims on expiration; under working conditions bulbs 2 and 3 are illuminated depending on the depth of inspiration; bulb 4 means maximum expansion.

The condition of a diver on returning from work at 300 ft.—He is as fit as and often fitter than when he went down. Diver after diver has told me the same, and their statements are substantiated by a number of records. I quote a case at random: Blood-pressure before diving, 123/79; after, 116 and 85. 40 mm. test, before diving column maintained for 62 seconds, after dive 64 seconds. Pulse-rate per 5 seconds, 7, 6, 7, 6, 7, 6, 8; after dive, 6, 6, 6, 6, 6, 7. Pulse-rate resting, before dive 74; after dive 72. Pulse response test: pulse on completion of test, 116; at end of one minute, 92; after diving, 108 and 82. Vital capacity before dive, 5,250; after dive, the same.

Are there any dangers peculiar to deep diving?—None that we have yet encountered. More care is necessary to prevent the diver coming to the surface too rapidly, since he is more heavily charged with nitrogen. The danger zone for oxygen poisoning is more nearly approached, but we are careful to keep outside the zone. So far no case has been encountered and we do not anticipate having to cope with this danger. Carbon dioxide poisoning requires attention, since 1 % in the helmet on the surface becomes 10 % at a depth of 300 ft. There was one mild case this year.

Slight attacks of giddiness may be experienced on the bottom. This we believe in most cases—in one we have positive proof—to be due to the diver descending too rapidly, and, by putting too great a strain on his tympanum, upsetting the labyrinthine system, reflexly.
In 1930 one diver died from complications following caisson disease, and by some it was considered that psychological forces presently to be described played a contributory part. With regard to this case I wish to make it clear that the caisson disease encountered in deep diving in no way, as far as we have encountered it, differs from the forms manifested in shallower diving or tunnel work. It cannot be too strongly stressed that the cure for caisson disease, whether caused by tunneling, shallow, or deep diving, is the same—immediate and adequate recompression. No matter how serious the case, if recompression is properly carried out, the treatment should succeed.

Caisson disease may assume a host of forms. If the reader considers the different places in which the bubbles may form, he can evolve the symptoms which will ensue from the mechanical obstruction caused thereby. Some places are, however, more prone to caisson disease than others—for example the blood, muscle, nerves and organs may be affected. Bubbles tend to form where circulation is poor, but except where decompression is seriously inadequate, the blood and viscera escape. Even where decompression is at fault, recompression will save the case; especially is this so where the D.S.D.C. is used, for the diver is under observation and treatment is greatly facilitated. This year (1931) in deep diving we had 16 cases of "bends"—an extremely painful manifestation of caisson disease caused by a bubble in a sensory nerve or nerve ending. These cases were all cured by a recompression pressure of a few pounds. Of these, five occurred in the same diver and this necessitated precluding him from further deep diving. It seemed to me that these bends were more likely to occur on damp days. It is certain that when divers suffer from a neuritis-like after-effect, these attacks always coincided with wet weather.

Oxygen breathing was carried out during recompression, and here, as in decompression, an appreciable saving of time is effected. The recompression chamber is comfortable, and the diver has one or two attendants and can read or play cards during the lengthy process of recompression.

Some men appear to be more liable to caisson disease than others; it is one of the dangers to which all divers and tunnel workers are subjected if adequate decompression is not given, and it is not peculiar to deep sea work, nor was it caused by the new train of symptoms which I am about to describe. However it is considered by some that these symptoms played a contributory part in the case of the diver who died.

The sequence of these new events and their influence on diving were as follows:

During the 1930 season, when working, or in many instances resting, at from 270 to 300 feet, the diver experienced what to him were new sensations; he found that it was much more difficult to assimilate facts, and to exercise the quick decision essential for successful diving. It might be summed up as a slowing cerebration. Some of the divers went a stage further, for when they returned to the surface they stated that they had "passed out" when on the bottom. It was known that if this was so it could not have been for long, for they had answered by their telephone the instructions they were continually receiving. Others stated that they had experienced a detached feeling, as if they were under an anesthetic. Another when asked to describe deep sea diving said:

"You notice the dark more, though it may not be darker. The light is a comfort and
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company. You notice things more if there is nothing to do; I get comfort from seeing the fish, it takes your mind off everything else."

This diver also had patchy loss of memory; his main statement is more a history of mental tension, but it is valuable inasmuch as it shows that in 1930 at any rate, a tension existed in some of the divers whereas in 1931 we failed to get any evidence of its existence. Another diver said: "You get keyed up in deep water"; he also had some difficulty in remembering the work he had done.

An old hand at diving, when asked for a description, gave the following account:—

"You have to be more careful in deep water; in deep water you know that you are concentrating." He described how "you think of each heave as you turn a spanner." Adding . . . "If you go down with a set purpose it becomes an obsession; it will become the main thing and you will forget everything else."

He described how he thought very deliberately:—

"I have finished my job, what shall I do next?—of course I have finished and now I must go up."

He described how he was aware of every action.

"If my hand goes out I think of my hand going out."

He gave the following as an analogy:—

"If I saw a thing of value, say half crown, in the street, I would pick it up. Down below I would look at it and think—'What is that, shall I pick it up?—yes, I will pick it up,' and then I would feel my hand go out."

The latter is, I think, the best description of how most of the divers felt in 1930 when between 270 to 300 feet. Some felt it less, others more. With two exceptions all the divers looked and felt fit when they returned to the surface. The exceptions were white faced and "windy" when they came out of the D.S.D.C.; these two were regarded as unsuitable for further deep diving.

These accounts given by the divers had to be sifted and action taken to discover the cause of their loss of memory. Sir Leonard Hill was of the opinion that the cause was mental and not physical. The Admiralty Deep Diving Committee asked for and obtained the assistance of the Medical Research Council in investigating these new disorders, and Professor Culpin was appointed to investigate the problem. From the descriptions given him he considered that these symptoms were more likely to be expressions of a mental than a physical disorder, and he stated that he had met with a similar condition of so-called loss of consciousness in cases of shell-shock. Professor Culpin then interviewed these divers and reported that with three exceptions they were free from symptoms. Two of the three were the men who, as a result of their experience on the bottom, had been declared unfit for further deep diving. In these two cases Professor Culpin succeeded in restoring missing pieces of memory. The third exception had only had a very slight loss of memory. The same method which had succeeded with the other two men was employed, but the endeavour to piece together his memory failed. This man was permitted to continue diving; this year he felt no abnormality and was regarded as our most successful diver.

The following is a complete report of a diver who arrived at the surface blanched and windy, and was excluded from further deep diving. He was one of the divers
whom Professor Culpin successfully treated for loss of memory. I am indebted to Professor Culpin for this summary of the account given at his interview with the diver.

The interview was directed to obtain an insight into the psychology of the diver as well as to restore, if possible, missing links of memory. The detailed account which the diver gave when in a mildly hypnoidal condition, warranted the assumption that his memory had been restored. Regarding his own psychology, the diver volunteered the following information:

"I don't like to attract attention, nor would I care to go alone into a teashop which I did not know, for I would feel that everyone was watching me; I would rather go hungry! Discipline irks me, I am afraid of doing the wrong thing, I often have the feeling of being watched, it affects me when in charge of strange men. I keep to myself, and I am afraid, sometimes worry what others think about me."

As a child he dreaded his father. Coming nearer to the events which affected his diving, he said:

"I never remember being afraid of the dark, but I have always been afraid of enclosed spaces; I get a feeling of being sealed in."

The terror (his own words) came on first when skylarking with others he found himself at the bottom of a scrum and was nearly suffocated. Once as a child he was thrown into the sea, and since then has not liked it, although he has passed swimming tests he does not like going out of his depth. As a diver he was frightened of making mistakes. The old fear of being closed in came back to him:

"It had not worried me for a while, but it came on that time just before I went off—on the bottom—that stirred it up, and I have had it ever since."

He then described his deep diving in 1930.

"I felt dizzy at 240 ft., and at 270 ft. I felt like being in a nightmare. It felt like going under ether, I think that is what made me think of going unconscious. I had a feeling of being closed in and went off. I did not tell them what I told you, I just said that I had been unconscious. On that occasion I felt tingling in my limbs, and I thought that the heavy pressure was crushing me into my suit. I thought that if I ever get out of this I'll never dive again. After this I cried off deep diving, but thought it over and afterwards asked to be allowed to carry on."

He described his last dive, which was at 300 feet, as follows:

"I left the ladder determined to get to the bottom; at 250 ft. I got a recurrence of the tingling, and a feeling of lying on my back. I decided to rest for a couple of minutes and then go on. I slid 10 ft., and felt I was going unconscious. I made signals to be pulled up and kept repeating them, I lost the use of my limbs and let go everything. While hanging on the shot rope, I saw my own face in the front glass, it was outside the glass and looked all greenish. I was dressed in my shore-going suit! I heard the order, 'Pull the diver up,' again and again, as if someone in the suit were saying it. When I got to the submerged chamber I did not appreciate the oxygen as usual, I wanted fresh air."

At the interview with Professor Culpin he was placed on a couch, with closed eyes, and directed to go over the descent "as if it were happening now." With some urging he repeated the performance, and seemed to recall the whole of the period for which he had claimed to be unconscious. At one stage he cried:

"Pull me up, for God's sake pull me up. I feel as if I'll never get up. I'm tied to the bottom, my mouthpiece is caught under my nose. It is getting lighter now, I can see the chamber."
Then he was made to sit up and tell the story again. This time he gazed straight ahead and talked as if he was still going through his experience, and he was able to add a few details to his first account:

"I felt that I was being pulled against resistance, as if a fellow was trying to hold me down, I am fed up and want to get out—worried because I can't open my by-pass; I seem to take two minutes trying to open it."

In the talk which followed he agreed that incidents he had forgotten had now come back to him. It was decided that neither this diver nor the other who had also been under observation, was sufficiently stable mentally for further deep diving.

Candidates found to have a similar psychology are to be debarred, at least for the present, from deep diving. To prevent this type being selected, an interview, designed to look for these symptoms, was included in the medical examination for deep sea divers at H.M.S. "Excellent," and those passed by me were further vetted by Professor Culpin.

The ten divers for the 1931 season were examined and passed as free from symptoms, although the tenth was only passed after consultation between Professor Culpin and myself. The first nine divers encountered nothing abnormal, and no loss of memory or other unusual sensation was noticed during this diving season. Most of them, however, when in the experimental chamber at Siebe, Gorman's, at an air pressure equivalent to a depth of 300 ft., did experience a momentary giddiness. If they were reading, the print became blurred for an instant. This sensation was not repeated when working at 300 ft. After seven weeks' diving the tenth diver developed acute claustrophobia when at a depth of 270 ft. He is of the suppressed nervous type, who habitually exercises self-control. This attribute he has developed to a remarkable degree. The other divers told me that he was inclined to be erratic, and that he much disliked being the first to go down to an increased depth, or to be the first diver of the day. On the day when he broke down he unfortunately was the first diver of the day. He was only partially conscious of his own nervousness; for instance, he does not like going into the officers' mess; if he is in uniform ashore he feels he is being watched; more important—he was frightened of the dark as a child, and even now is very frightened of horses, nothing could induce him to pat a horse. In reply to the questions as to certain of his mental speculations, he admitted, "I often think of where I come from, but I must not talk of it or they would think I am qualifying for an asylum." A history such as this seems to point to mental instability, but apart from these peculiarities—and they are, or certain of them are possessed by many of us—he appeared to have a very equable temperament, and the deciding factor in accepting him was his splendid physique.

During the chamber tests he gave a strong positive reaction to the Mental Excitability Test, but he insisted that he had not felt anything unusual. After the present breakdown he confessed that he had felt queer on one occasion. When asked if the feeling had been similar to that immediately preceding his breakdown, he said—

"You cannot possibly compare the two conditions: in London, in the chamber, it was light, and there were others with me; on the bottom it is dark and lonely."

While he was diving I kept him under as close observation as I could without
rousing suspicion. On one occasion his pulse-rate on the bottom was much too fast for the work he was doing, and I suspected from his conversation on the telephone, which sounded very artificial, that he was not altogether happy. I considered removing him from the trials, but this was a drastic procedure, especially as my suspicions were based on such flimsy evidence. On his last dive he had been six minutes at the bottom at 270 ft. when he urgently demanded to be brought up, he gave no reason but constantly repeated his demand. He did not appear to be in a panic but was most imperative in his request. Right up to this point he had been conversing on the telephone, and giving instructions to the surface regarding the hoisting or lowering of wires connected with his work. We had great difficulty in making him remain at his decompression stops, his one desire was to get up and get to the submerged chamber, if not to the upper deck. The chamber was specially lowered to a greater depth than usual, to comply with his request. The chamber attendant reported that, on arrival in the chamber he looked normal, but very white, and his eyes looked glassy. During decompression he became more cheerful and tried to describe what had happened on the bottom. He said, "Have you ever felt you would like to murder a 'so-and-so'? Well that is what I felt like on the bottom when I came to, and found myself trying to unscrew my front glass; my one idea was to get out of the helmet and into the chamber."

When he emerged from the D.S.D.C. he seemed like one who has sustained a severe mental shock; his ocular appearance and whitened face supported this impression. Physically he was badly shaken, but no more. He was overcome by the situation, and deeply self-conscious of failure; indeed the main difficulty in restoring him was to overcome this idea. He was striving desperately to recover his self-control. He could not bring himself to recount his experiences verbally, but agreed to write them down.

The following extracts are from his own written statement.

"I was at the time kneeling on my right knee and head down (the required position for putting clips on the door) when suddenly I came over rather funny. It was a distinctly different feeling. I stood up, the tank wire in my right hand, and thinking it was CO₂, I began to breathe deep and hearty, thinking of course that in a couple of minutes I would be able to resume work. Then I seemed to go quite limp, a feeling of no life or energy. This was new to me, whether it was a part of CO₂, I didn't know, because I have never experienced a real dose of CO₂; anyhow, after stopping and doing the drill for CO₂, I thought I would be alright, but suddenly something seemed to—say—snap inside my head; and I started to, what I thought, go mad at things.

"I had small laps of this, on and off. Breathing became difficult, possibly I might have asked for more air, I couldn't say for certain. I really did try, and fought hard to beat off this madness, but it all seemed of no avail. I didn't get worse, but such as it was, it was quite enough for me. I wasn't in a real panic, and ready to do anything that came to hand, although I did make a hash in some things. Anyhow my one ambition at that moment was to get my helmet off, the quicker the better. I fought hard to stave off this feeling, but it wouldn't go. I should say that unless one had experience of this kind of thing it would be very difficult to imagine and realize such. I felt slightly relieved when, after closing my ejector, I left the bottom. After going say—30-40 ft. up, I came to the conclusion that I was coming up a wire. I stopped, and I was pretty well O.K. I thought to myself, why I should think so I suppose was for the simple reason that the shot rope is the shot rope and every diver knows what it is and that I was going all wrong."
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"Naturally in that moment of, say recollection, I decided, although much against my inner feelings, to go down the wire, and leave the bottom a bit like a diver is expected to. Down the wire I went, and arrived on top of the tank, slid off, and stood up. I don't remember how I actually left the wire, and got to the shot rope, anyway, I must have found the shot rope because I came up it. At this time, i.e., when I was standing at the foot of the shot rope ready to ascend, I was perfectly normal, I felt my ejector, was it already closed? Or did I close it then? I can't remember, at any rate I did ensure it was closed before I left the bottom.

"I left the bottom, and as regards my ascent, can remember travelling light, or I should say light at one period. Of course, as regards the phone, which the Petty Officer attends to, I was simply saying things that I wanted to, and was not interested in the answers, I say not interested, but to take everything into consideration, I didn't look or wait for any answers, one must say that I was pure and simply giving orders. I had a check at — ft. I don't know, but at the time I dimly remember 110 ft., of course that being the check that coincided with the decompression tables. Since then I have been told it was 90 ft.

"I felt something happen on the shot rope, and I guessed it was the chamber being lowered to a depth that would be of some help to me, which afterwards proved to be correct. I received the check signal at—90 ft., and although I answered it, I really, inwardly, didn't want to. Once again my sane ambition was to get either on deck, or in the chamber, and have the helmet and glass taken off. Of course now at the present moment I am alright and as one might guess, I feel a wee bit self-conscious of myself, but still at the time, I felt that I never wanted to be dressed as a diver again. Between now and then my views might change, but that remains a future answer.

"After doing a check which was very short, presumably a minute, again I had the greatest of all fights to stop there and do it. I had the phone message to go to the chamber. Just above me was the chamber, and I gladly got on to the ladder, and although in such a 'paddy' and 'panic' with myself, I did try and do things as I always had done. I undone the front weight lanyard, and let the attendant take the weight off, then I got secure in the chamber and got my front glass off. After stepping on the ladder and letting him take my front glass off, I didn't feel as happy as I 'thought I would, because things seemed in the same condition somewhat. It was a relief, however, to have the front glass off, and the helmet soon followed. While on the bottom I thought it would be absolutely good, to have the helmet off, but, when it was off I didn't feel as I have before. I told the attendant everything was O.K., because physically I was alright, and again, my sense of self-consciousness came into play. But taking it all round, I just didn't have and couldn't display the usual amount of life that I have done on previous occasions. From then onwards I felt pretty well alright."

When he arrived on the upper deck he was on the verge of, at least, a complete mental breakdown. To keep his mind temporarily off the subject, he was sent on shore with two of his fellow divers and plied to the brim with alcohol. The danger in his case was that he would attempt to suppress the incident and relegate it to his subconscious mind. To avoid this I persuaded him that night verbally to recount, his experiences on the bottom. Practically no hypnoidal effort was required to produce the horror of that morning's dive, and the picture of stark mad terror which even the interview could produce, left an impression which is very difficult for me to describe to you. My impression was of sitting in the stalls and watching the acting of a Grand Guignol. To such a pitch did he arouse his emotions, that he clawed at his face to remove the imaginary face glass and tore his clothes which he mistook for his diving suit.
The production of an abreaction produces as satisfactory a result as the surgeon's
knife in abscess formation, and it was so in this case; from this on, the dam was
loosened, and he was enabled to talk to the others of his experiences; previously he
had refused to talk on the subject.

Since the incident two shallow water divers were reported as "windy." In each
case I found the cause to be claustrophobia. In one, who was very particular about
his air supply, I found that as a boy he had nearly been suffocated in a pillow fight,
and ever since had been terrified about not getting enough air.

To sum up: The four failures in deep diving, and two in shallow diving, have
many points in common. These men were of the suppressed nervous types, who
habitually exercise control. Shy, reticent and self-contained, they work best by
themselves and do not relish observation. They are usually of a philosophic, rather
than a practical, disposition.

The most desirable method of selection to avoid mental instability is a matter
of opinion, but my experience suggests that for the present such a state of mental
instability, slight as it is, debars from deep diving. Some advocate a very complete
psycho-analysis, others preferring to rely on a very complete history of the diver
from his first dive, coupled with a very close observation by instructors and officers,
such observation being minutely recorded. The latter method depends on skilled
and accurate observations which must be carefully recorded, but when the observer
and observations are known, this is the method par excellence. At the time of these
experiments this method of collecting facts had not yet been instituted, hence resort
was made to the former method, which depends on an accurate forecast, by an
expert, after careful study as to how the candidate is likely to react in given circum-
stances, mainly of the darkness and loneliness which may be encountered on the
bottom of the sea, both of which are now largely mitigated by powerful arc lamps,
an efficient telephone and observation chambers.

I do not wish you to think that the problem presented by these factors is to be
regarded as comparable to the prominence which I have given to it in this paper. I
have spent extra time on the subject because it is new. It is not peculiar to deep sea
work, for we have found it in shallow water divers. It is something already in the
constitution, which comes to the surface; fear of the unknown would be just as
likely to produce the same symptoms in the persons I have mentioned.

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