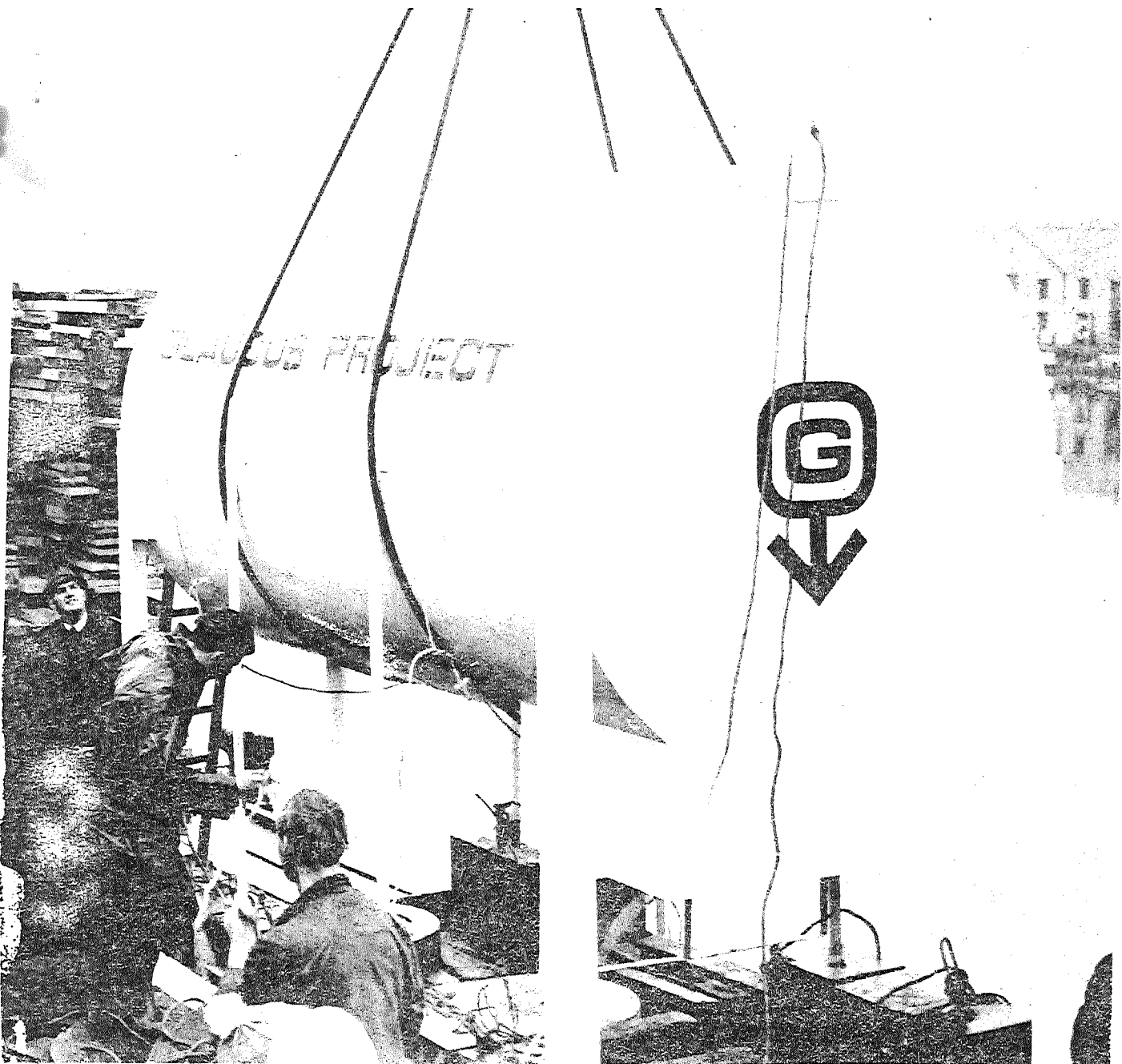


GLAUCUS PROJECT REPORT



SUMMARY.

Two divers have been maintained in good health for a period of seven days at 35 feet. A simple semi-closed circuit air purification system was used, and food and supplies brought down by divers. Continuous communication with the surface was available. An oxygen rebreathing technique was used for decompression.

The limitations of the techniques used are discussed, with reference to possible future experiments. It is considered that self-contained systems allowing extended periods of work in shallow water could be developed and utilised economically in the immediate future.

By Colin Irwin and John Heath, B.Sc.

17 Dunbar Road,
Talbot Woods,
Bournemouth,
Hants,
England.

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INTRODUCTION.

By the end of 1964 the French & Americans had completed long term living experiments beneath the sea. In true British fashion, the scientific section of an amateur organisation, the Bournemouth Sub-Aqua Club, designed an experiment to maintain two people at a pressure of two atmospheres for one week.

The design of the installation was based on previous diving experience, whilst the physiological data was compiled from previous work done in this country notably by the Royal Navy. In the early part of 1965 Colin Irwin and John Heath were given the facilities of the library of the Royal Naval Physiological Laboratories, thanks to the close co-operation of Surgeon Lieutenant Commander Elliott. When the final data were produced they were checked through by Dr. Elliott, who was able to make many useful suggestions. The complete experiment was then costed from the price of the house to the hire of cranes at the Plymouth end of the operations, and a report was produced and submitted to the committee of the said club. After a great deal of consideration it was decided that the money, about £1,000, could be raised, and that much of it could be regained at the end of the experiment from the sale of film, advertising and news.

AIMS.

Although experiments have been carried out to keep men at 2 atmospheres for more than several days it was important, if we were to progress, for us to be confronted with the practical as well as theoretical problems in such a dive. Although these problems had been solved before, it was important that we should try new techniques to broaden this field of knowledge.

The experiments other than merely living at this depth were as follows:-

1. To maintain an artificial atmosphere which is independent of the surface.
2. To try out two different decompression schedules of a similar type.
3. The use of a plastron gill to shift CO₂ and large molecules, especially hydrocarbon.
4. To study the ecology of the sublittoral zone and to examine the vertical zonation down to 40 feet.
5. To observe the diurnal migrations of *Carcinus* and *Cancer*.
6. To test the structural strength, buoyancy control and manoeuvrability of a living installation.
7. To observe the reactions of two men (having no unusual diving experience), under the conditions of the above experiment.
8. To maintain a constant surface cover such that the underwater house should be of a semi-independent nature.
9. To conduct the experiment at a cost commensurate with industrial requirements.

DESIGN.

(a) The installation required the following properties:-

1. It should be large enough to accommodate the two men without producing boredom, cramp or constipation.
2. It should be small enough to be manoeuvrable by average cranes, boats and lorries.
3. Its buoyancy should not be beyond twenty tons, so that the net weight with ballast would not exceed the lifting capacity of the dock crane at Plymouth.
4. It should have a non-contaminating W.C., which should have an entrance through the bottom to allow free access by divers.
5. The house should be clear of ballast tray to allow for the divers manoeuvrability such that when on dry land the supports would take the downward weight of the house, and when in the water the supports would take the upward strain of the buoyancy.
6. The buoyancy of the house should be adjustable to allow installation.

DESIGN (Cont.)

7. The interior should have maximum floor space to allow divers to change as well as :-

- a) two bunks six feet long with four inch dunlopillo mattresses.
- b) table for eating, writing and general use.
- c) portholes to provide entertainment.
- d) storage space for soda lime and gas cylinders.
- e) lighting.
- f) telephone and communications.
- g) soda lime absorbing trays.
- h) W.C.
- i) flooring.

Taking these points in order, the design shown in figure 1. was produced. It was twelve feet long and seven feet in diameter, thus having a net cubic capacity of about 480 cubic feet and a buoyancy of 13 tons. When the house was on its tray and legs, it had a net height of twelve feet, allowing one foot of skirting around the entrance, 3 feet clearance for divers, and one foot for ballast below the house. The corner legs were angular to take the weight of the house on dry land, whilst the others helped to take the strain of the buoyancy when submerged. The ballast tray was twelve feet by seven feet, being constructed of quarter inch sheet metal and standard 'H' section girders, having a one foot skirting to prevent the shift of ballast. The house itself was cylindrical to give it strength, and the entrance at one end was four feet by three feet, but divided into two so that one entrance opened into the house, whilst the other three by two entrance opened into the separate W.C. There was a third entrance at the far end of the house, underneath the permanent bunk, for the power and communication cables, made out of a two foot length of four inch diameter tubing, the purpose of which was to prevent the possible fouling of any umbilical system by divers outside the house or the aquanauts inside the house. The two bunks were placed one across the far end, and one at right angles to it to form an 'L', which, when folded against the wall, would give floor space 6'6" by 4'6", which was considered adequate for changing and any work that had to be carried out during the course of the day. The table was three feet square and, like the bunk, folded against the wall when not in use. When these items were in use they were held against the walls by hinges, and supported from the ceiling by chains and shackles. On the opposite wall to the folding bunk were shelves which provided storage for gas analysis apparatus, telephone and any personal items. Below these shelves were housed the gas cylinders. The soda lime absorbing trays were placed on rungs above the permanent bunk as it was thought that the highest percentage of CO₂ would circulate in this area owing to the divers sitting directly below the trays for most of the day, an additional tray being placed on the table during the day for added absorption. Each tray was of the photographic developing type and was 30" by 20". There were four trays in all. There were three portholes, two placed at the far flat end for observation and entertainment, and one placed in the bulk head of the W.C. compartment so that any member of the personnel could be under constant observation at all times. The W.C., like the table and bunk, bolted down from the wall so that any person on

DESIGN (Cont.)

climbing in would give the okay signal, fold the seat down and attach it firmly by a chain to the roof, plastic bags of a disposable nature being used, which the user would replace. Thus the W.C. unit being of a disposable nature as far as atmosphere etc., were concerned would be completely non contaminating. To assist entry and exit a permanent ladder was welded beneath the entrances, and handles were welded inside the house. The flooring was formed of a lattice work to allow drainage of excess water and condensation into the bilges, and in turn there was a bilge plug to allow drainage of water into the sea, thus the bilges when flooded could be used as additional ballast.

Two taps were installed, one welded into the outer casing and one into the bulk head of the W.C., thus by opening the first tap, the main house compartment could be flooded, and by connecting the two with a piece of flexible tubing and opening both, the W.C. could be flooded. This arrangement was designed to allow changing of air in either compartment (notably the W.C.) or adjusting the ballast for which the W.C. could act as a separate ballast tank.

The power supply was 12 volts D.C., so that should any person take a shock, it would not be of a serious nature. The power was supplied from the surface by a generator, the current of which was stepped down by a transformer. There was also a bank of car batteries which could act as emergency power should the generator fail, but change over between power supplies could only be made at the surface. This power was used for illumination inside the house which was comprised of four strategically placed interior car lights whilst a fifth car head light and industrial reflector was installed for the purpose of accurate observation over the closed circuit television and accurate use of the gas analysis apparatus. The bright light could only be turned off and on from the surface, whilst the other lights had their own switch panel inside the house. The telephone was of the army field type, which was run off batteries and operated by winding a handle to attract attention at the other end of the line, this was thus independent of the main power supply. The closed circuit television (which was provided by Marconi), took power from the generator, though the power for the camera inside the house was in the same cable as control and reception, and did not require a separate power supply, as for the lighting. This was advantageous as the power for the camera was of a high voltage. All camera controls were at the surface.

As a final note, all interior furnishings were constructed from Dexion for simplicity and to avoid contamination of the atmosphere which might have been caused by formaldehyde bonding resins and adhesives. Lifting lugs were placed on the outside of the house as shown, so that the strain when lifting would be taken down the length of the cylinder.

RECOMMENDATIONS.

- (b) As in the present experiment power was supplied by a surface generator which was maintained by the surface crew, either there will have to be a surface engineer to maintain a constant power supply (at all times) or the power will have to be contained within the house. As the house was found to be extremely unstable, vertically, it is recommended that its volume of air be kept constant during ascent and descent. Further, as carrying ballast is tedious, ballast tanks would be of assistance. If the house is to be towed,

RECOMMENDATIONS (Cont.)

- (b) then it would be advisable to make it of a streamlined shape, as most of it will be submerged during towing.

The interior design of the present house was adequate, though the water locked W.C. proved inconvenient, and it would be advisable to redesign this item. The furnishings should be of a rugged nature, and the house should be divided into wet and dry portions thus making for greater comfort and efficiency.

It is not possible to produce a recommended design at this stage as this will depend on the specific requirements of the house, e.g., operating depth, decompression system, number of personnel, transporting methods, duration and type of work to be carried out are all factors affecting the design.

DRY RUN.

- (a) The purpose of the dry run was to test the efficiency of the artificial atmosphere control, particularly the CO₂ absorbers, the oxygen bleeds and the Lloyd gas analysis apparatus. We also wished to test the interior design - an item which one continually hits one's head on might possibly become intensely annoying during the course of the week. Further, any psychological disturbances, such as claustrophobia, might manifest themselves during this two day period.

As the atmosphere could support us for at least twelve hours without undue discomfort we should stay in for twenty-four hours to test the artificial atmosphere. In cautiousness this figure was doubled to forty-eight hours. With all installations fitted out as for the dive in September, the aquanauts were sealed off with containers of water over the relevant entrances. At 10 p.m. on Friday 27th. August, all communications and parcels were delivered as for the real run, though only six inches of water had to be traversed. All went well except on the second day one subject (C.J.I.) went off his food, and only wished for cool refreshing items. During the course of the day J.H. found it progressively more difficult to breathe, whilst C.I. had the same complaint to a lesser degree. In the latter part of the day J.H. found great difficulty in breathing and C.I. vomited twice, and the experiment was terminated. As many people as possible were encouraged to smell the atmosphere to help to find the cause of the trouble, and the two personnel had a medical check up, and were found to have bronchial murmurs. Upon reflection the considered possibilities for the trouble were:-

- a) soda lime dust,
- b) arsine,
- c) paint fumes,
- d) formaldehyde bonded resins in plywood,
- e) mercury,
- f) stagnant water.

Taking these possibilities in order, the first problem was dealt with by insisting upon the wearing of smog masks when the soda lime was changed, and care was to be taken in the handling of this medium to prevent the formation of dust. Considering the amount of rust inside the house and the symptoms, it was concluded that arsine was not the cause.

DRY RUN (Cont.)

(a) To eliminate paint fumes a representative of International Paints was consulted, and upon his advice another coat of paint was applied and baked on, using a Tropic Heat Generator. All plywood was removed and replaced with Dexion, although it was considered, in view of the symptoms, that this was not the cause. All mercury spilt from the gas analysis apparatus was promptly rendered harmless with sulphur during the course of the experiment, and considering the quantity and symptoms this again was considered not to be the cause of the trouble. Although it was thought that polluted water did not produce the bronchial murmur in the two subjects, it was considered possible that it produced the vomiting in C.I., as the water for sealing the entrances was acquired from a backwater of Poole Harbour.

With these precautions taken and in view of the fact that the house during the course of the experiment (unlike the dry run) would have a semi closed system, and finished soda lime would be discharged direct to the sea, which would not become stagnant, it was thought that the experiment would be successful without the necessity of a further dry run. Apart from this failing, all other systems functioned correctly, including the artificial atmosphere control, the design, the lighting, and communications.

(b) PERSONNEL.

Subjects.	Colin Irwin, John Heath.
Crew.	Gerry Heath, Nigel Pearson, Rex Farnworth, Eric Dayman, Ken Waylen, Richard Gardener, John Goldsworthy, David Way.

DRY RUN LOG.

(c) FRIDAY - 27th. Aug.

G.H. and N.P. on watch.

- 10.00 p.m. Aquanauts sealed off. Telephone communications O.K.
- 10.40 Telephone extended to B.D.H. Building and tested - O.K.
Both quite happy, undressed for bed and are about to have sleep.
Both have had a drink of port.
- Extra mercury for gas analysis apparatus was handed aboard and dilute sulphuric acid (1 in 13) is to be acquired first thing in the morning.
- THERE ARE TO BE NO CALLS TO THE HOUSE UNTIL MIDNIGHT.
- 11.25 Water level checked - O.K. Wind catching bows of dinghy, causing slight choppiness.
- 11.28 C.I. disturbed by water slopping about - contacted watch by 'phone. He is going back to sleep.

DRY RUN LOG (Cont.)

R.F. & Friend now on watch.

- 12.00 a.m. 'Phone call to wake aquanauts. They are preparing for a gas analysis.
- 12.17 C.I.'phoned to enquire about noise made during replenishing of water in dinghy.
C.I. lying in bed, J.H. doing gas analysis.
- 12.30 C.I.'phoned to tell us air O.K. and asked for radio silence until 6.00 a.m. as they want to sleep.
- 1.00 Water level checked (low) - 12 buckets needed to reach O.K. Aquanauts sleeping soundly. J.H. on left side, C.I. on right side. Both undisturbed by noise made while refilling water.
- 1.30 Water level O.K.
J.H. restless, now lying on his back. C.I. sleeping soundly.
- 2.00 Water O.K.
J.H. has been restless and has turned over on to his left side again. C.I. has also turned on to his back.
- 2.30 Water level O.K.
When aquanauts were checked before filling J.H. was still on his left side, but C.I. had turned on to his left side. Both aquanauts were slightly disturbed when water was topped up. After topping up both were still asleep, but J.H. had moved on to his back, C.I. is also on his back, but has his knees in the air.

We changed shift and E.D. is now on watch.

- 3.00 a.m. Water checked - O.K.
C.I. very restless, J.H. O.K. asleep on left side.
- 3.30 All is quite O.K.
J.H. has not moved nor has C.I. since I checked at 3.00 a.m. Water level keeps going down. 2 buckets a half-hour.
R.F. is still asleep.
- 4.00 Water took two buckets.
C.I. is very restless. J.H. has turned over on to his left side.
(Extremely low ebb tide.)
- 4.30 Tide making it very difficult to obtain water.
Aquanauts undisturbed, sleeping comfortably.
- 5.10 Sea has gone so far out that it is impossible to get salt water so I have put in fresh.
C.I. and J.H. undisturbed.
- 5.30 Water situation under control.
C.I. & J.H. undisturbed.
- 6.00 Everything O.K.
J.H. is on his right side. C.I. on his back.
Still no salt water - 3 buckets of fresh.

DRY RUN LOG (Cont.)

K.W. and N.P. now on watch.

- 6.30 a.m. Both lying on left side.
Water O.K.
- 7.0 'Phone call all O.K.
Filled up dinghy - 4 buckets.
C.I. awake - J.H. asleep.
- 7.30 Water level O.K.
J.H. dressing, C.I. looking through porthole.
C.I. then rang up to ask for strong coffee.
- 7.50 Rang up C.I. to tell him the coffee was ready.
Delivered coffee. C.I. then rang to say coffee
was alright.
- 8.06 C.I. 'phoned to ask N.P. to enquire about indicator
colour change in the soda lime.
- 8.10 Checked water level - required 2 buckets.
- 8.30 Checked water level - required 2 buckets.
- 8.45 Both sitting against the end of the cylinder.
Rang up to complain about banging on cylinder.
- 8.55 C.I. rang up to complain about condensed food. He
said it was horrible. Requested chicken soup,
chicken legs with crusty rolls with thin smear of
butter.
- 9.00 C.I. rang up to request more water in boat.
- 9.05 Put 3 buckets of water in dinghy.
Rang up C.I. to tell him. He said he wanted more
water as air was bubbling out from inside.
- 9.40 C.I. and J.H. both sitting with their backs to the
porthole and of the cylinder.
Filled up boat - 2 buckets.
- 10.20 C.I. rang to say water needed topping up as air was
bubbling out of electricity inlet.
- 10.25 Filled up boat and bucket at other end.
- 10.35 J.G. arrived and rang up to tell them about the acid.
- 10.36 D. rang up about getting more paint.
- 10.40 Rang up to say soda lime was coming.
- 10.45 J.L. arrived and rang up to say he has got the acid.
- 11.15 Rang C.I. He said the results of the test were - O₂ 19.5
CO₂ 1.7
Filled dinghy and bucket - 9 buckets.
- 11.35 CO₂ - 2% Oxygen 20.0 were the results of the
latest test. O₂ 20.0
CO₂ 2%
- 11.40 P.S. rang up to ask how they spent the night.
Wise cracks were passed out of the cylinder.

DRY RUN LOG (Cont.)

R.G. now on watch.

- 12.00 p.m.
- 12.10 G.H. rang to ask if a parcel from Normalair was wanted. C.I. asked for it to be sent down.
- 12.10 C.I. & J.H. were both reading.
Water level was O.K.
- 12.30 Rang to ask if they wanted food.
They did not, but they did want glasses.
- 12.40 Glasses, cups etc., passed into Glaucus. Food wanted at 1.00 a.m.
- 1.00 a.m. Food sent in and short crew requested to have the menu for Sunday.
2 buckets full of water added.
The menu will be prepared after lunch.
- 1.35 Two bottles of Mackeson sent in, undrunk.
Seen to be O.K.
Bottles from J.C.
- 1.55 Ground crew R.G. felt ill, went home. G.H. to continue his watch.
Topped up water in the bucket.

G.H. now on watch.

- 2.00 J.H. & C.I. resting.
J.L. brought down fly sheet. Will call back Sunday a.m.
- 2.05 Informed C.I. of change of watch and repeated request for menus for Sunday. Food O.K.
- 3.05 Boiled egg, soup, salad, fruit for breakfast and the same for lunch is the menu for Sunday.
- 3.45 p.m. C.I. reported being sick at 3.44 p.m.
Temperature in the house (72°F) 22°C. Water (condensation) is running down the walls of the tank and into the bilges. J.H. is O.K.
- 4.55 C.I. asked for the water to be systematically changed without breaking the air seal.
- 4.56 C.I. was asked if the water could be changed in 30 minutes time to allow the tide to come in, which makes the access to the water easier. He was also asked the reason for the water change. He thought that the water might have infected him with something, and it was getting very dirty anyway.
They have asked for fresh fruit (apples, grapes, peaches, etc.) for their supper.
- 4.58 Rang up to ask for the empty thermos and J.H. answered. He said that C.I. had been sick again and that he (J.H.) found it difficult to breathe easily (he said it hurt), and if conditions did not improve they would leave the cylinder after a further half-an-hour.
I was asked to pass this information to J.G.
- 5.00 The Sketch reporter spoke to C.I. and J.H. over the 'phone and saw them through the porthole.
- 5.01 J.G. climbed on to the cylinder and smelt the air that was let out of the valve. He said that it smelt hot and painty. This was verified by D.W.
Analysis CO₂ - O.K. but there were paint fumes.

DRY RUN LOG (Cont.)

It was decided to bring the aquanauts out now, and the dinghy was removed from the entrance. J.G. was first inside to smell the atmosphere, and verified his earlier statement that the air was painty.

5.05 The Aquanauts came out.

5.15 The Squanauts sent for a medical check-up.

THE EXPERIMENT.

SITE.

(a) To keep down the cost of the experiment the site had to be on the South coast of England, although this had the advantage of giving an added objective to the experiment, namely, conducting an experiment of this type in poor diving conditions, unlike previous experiments, which have been carried out in the Bahamas, Mediterranean and Red Sea. In choosing the site, the following points were considered:-

- 1) Clarity of water,
- 2) Shelter,
- 3) 38 feet of water allowing for legs of house.
- 4) Static installation close at hand; and
- 5) Proximity to Naval Hospital and Decompression chamber.

Areas fitting these requirements are the Harbour Wall, Portland, and the Breakwater, Plymouth.

The former could not be used because of Defence regulations, however, with thanks to the close co-operation of Her Majesty the Queen's Harbourmaster and C. in C. Plymouth, the fortress by the breakwater was secured for our experiments in Plymouth Sound. It was decided that the house should be sunk south by south-west of the fortress, where it would be in 40 feet of water at high water, and 30 at low water, giving a mean tide level of 35 feet. This site would be well sheltered from all gales except severe west by south-west and would also be out of the way of shipping, notably the M.F.V. which supplied the fort. Fortunately C. in C. Plymouth allowed us to use the fort as a central control station from which power and communications were given, thus in all weathers the surface crew were in stable dry conditions.

INSTALLATION.

(b) For installation, the house was loaded with all equipment and calculated ballast and lowered into the water. With this amount of ballast she should have floated with one foot above the waterline. However, even when excess water was blown off with compressed air she remained negative, so she was brought out and ballast was removed until correctly adjusted. This miscalculation was probably due to incorrect data as regards the accurate weight of the ballast blocks, which were composed of eight crane test weights weighing half-a-ton each, and a large number of supposedly three-hundred weight ingots, as well as a ton of half-hundred weight railwayline chairs, which could easily be handled under the water. When all was considered satisfactory she was strapped alongside a tug and taken the two mile trip up to the site at about one to two knots under perfect conditions of a flat calm. She was attached to the vessel's capstan when the vessel had been secured in position by a bow rope to

INSTALLATION (Cont.)

(b) the fortress and a stern rope to the breakwater. Two surface crew divers inside (who had been there since she had been put in the water at the dock side to blow off any excess water) now vented the house and allowed it to sink.

As Glaucus sank, the rate of descent was controlled by the Ship's capstan, the two divers inside Glaucus blew off excess water to avoid excessive strain on the capstan, but made her buoyant accidentally at 6 ft., bringing her to the surface. It was then thought advisable to make the house negative again by loading more ballast, but this laborious task was soon abandoned in favour of sinking the house by venting off air as in the first place. However, water was not to be blown out, as the ship's Captain thought the capstan could take the strain of 6 tons. This was completed with success.

A local fishing boat was hired, which was to be on 24 hour call for the duration of the experiment. Using this vessel, the ton of small ballast was placed aboard the house so that she could be made dry and the communications and power links were set up. All systems were tested, and as it was found that the television did not function, it was decided to bring out the camera and the cable, and instal a new cable and make the connection at the surface, as it was believed that the terminals had previously got damp and had thus caused a short. These delays brought us a day behind schedule, so the experiment was commenced on Thursday 16th. September, although the camera was not installed and functioning until a day later. This did not matter though, as the television was a luxury and not a necessity.

CONTROL.

(c) During the course of the week under water the Aquanauts had three hot meals a day and additional hot drinks when diving. They analysed the atmosphere every eight hours, and adjusted it at least every six. During periods of relaxation they listened to the radio, read, or observed the marine life outside the house through the entrance. Unfortunately during the first half of the week the area was subjected to a west by south-west wind of force eleven, which produced excessively rough seas above the house, and as already mentioned the site is not sheltered under such conditions. However, the house sat firmly upon the sea bed, and the only ill effect (apart from the harsh conditions the ground crew experienced) was a six inch swell in the entrance, which tended to force the aquanauts eardrums in and out with successive waves, as has been experienced by submarine personnel when using a snorkel. Although in itself the storm was no great hardship, it did mean that the visibility took a long time to recover, so that experiments four and five could not be carried out.

During any period, a constant eye was kept on the aquanauts over the closed circuit television, and it was the duty of the current ground crew to cook and take down the meals, together with any other items such as camera, reagents, newspapers, and dry towels. Should at any time and for any reason, a decision to terminate the experiment be made, the final decision rested with the ground crew and not with the aquanauts, as the latter under such conditions might not be in a position to make a decision.

All events during the course of the experiment were recorded in the log, and telephone communications were made before any action. When diving, personnel dived with members of the surface crew using buddy lines and floating coralline cords attached to the house, carried an excess of air for the anticipated dive, and wore apparatus with quick releases which were known to be reliable, i.e., which would not release unawares. In addition precautions were taken, though the aquanauts were not to swim more than ten feet above the house,

CONTROL (Cont.)

- (c) and naturally did not carry snorkels. The W.C. functioned as intended, though as one got excessively cold under such conditions the aquanauts tended to restrain themselves. This reaction was anticipated to some extent, and it was considered that constipation for 2 days would not do any harm. As the rise and fall of the tide was about ten feet, the incoming tide had to be blown off with compressed air, and during the ebb tide excess air bubbled into the W.C. from the house, through holes in the W.C. skirting, and from there through slightly higher holes to the exterior. This process helped to cleanse the air in the W.C. For the purposes of tidal control, additional compressed air bottles had to be brought down during the course of the week.

ASCENT.

- (d) To raise the house the reverse procedure to installation was followed: The lavatory was flooded, the ton of small ballast was taken off, power was cut off, as possible severing of cables could have produced a short, the lavatory compartment was flooded with air, and the house rose to the surface. However, as she rose to the surface she accelerated with the increase in buoyancy. Consequently Glaucus cleared the surface by some 3 ft. making her some 6 tons negative. This development provided enough force in a downward direction to sink her sufficiently to compress enough air to make her negative and take her to the bottom. This incident was due to too much ballast being unloaded before the ascent. A second attempt was made, and though it was hoped to prevent a sinking by opening bottles of compressed air during the ascent, this also failed. As a precaution the two aquanauts were taken to H.M.S. Drake, where they were given an extremely thorough medical examination and kept under naval observation for two days, in anticipation of any delayed symptoms. As both personnel were absolutely mentally and physically fit, experiment one and two can be considered a success.

RECOVERY.

- (e) Boards were secured over the entrance so that when the house rose to the surface, water would not gush in during the subsequent incipient descent. This system worked. The House was then towed, by the fisherman's boat in a moderate wind, with no-one inside to blow off excess water. Fortunately this was completely successful so that our previous cautiousness over manoeuvring was to some extent unnecessary.

RECOMMENDATIONS.

- (f) Owing to the extreme cold it is recommended that a more efficient diving suit be developed, as well as, insulation and heating for the house. If personnel intend to work beyond visible limits of the house, it is necessary that communications between diver and house is positive, i.e. safe, though this was found to interfere with work, and it is therefore suggested that ultrasonic communication be used. This would also increase the divers efficiency of work owing to diver communication. 'Aquasonics' is at present the best marketed equipment in this field.

RECOMMENDATIONS (Cont.)

- (f) If houses are to be used deeper down, then mixtures will be required. If these contain He, then house-diver recirculation should be developed to save the expense of wasted Helium. However, H₂ mixtures might be substituted for He. Owing to the visibilty of water and the buoyancy of the diver, the diver's movements are hampered, and for this reason power tools should be developed, with appropriate pneumatic or hydraulic power supplies.

PERSONNEL.

- (g) Subjects, Colin Irwin.
John Heath.
- Resident Divers. John Goldsworthy,
John Lowe,
Roy Munroe,
Chris' Barratt,
Richard Smith,
Bernard Hindle,
Laurie Andrews,
Eric Dayman,
Alan Bairstow,
Mike Fancourt,
Gerry Heath,
Rex Farnworth.
- Temporary Crew. Cliff Lock,
John Hoy,
Jimmy James,
David Way,
Colin Newsome,
Philip Smith,
Nigel Pearson.
- Professional Boatman. Charlie Chappell.

DAY 1.

THURSDAY, 16th. SEPT. 1965.

TIME.

- 15.15 hrs. C.I. & J.H. went into the house prepared everything ready for 'go'. CO₂ O₂
- 18.30. Both came out for a final meal and breather while the house was completely flushed through by L.A. and E.D. (working in the house).
- 21.00 C.I. & J.H. entered house to begin experiment.
- 21.20 Lights have failed (Generator ran out of petrol) switched to emergency lighting. Towel and socks required for J.H. (R.S. diving P.C.D.)
- 21.30 Generator restarted and normal lighting switched on.
- 22.00 J.H. doing gas analysis now. 'Phone back at 22.30 for result. J.H.'s own slimline and club slimline in the House.

DAY 1. (Cont.)

<u>TIME.</u>		CO ₂	O ₂
22.00	R.S., C.B., M.F. and E.D. now on watch until 06.00 Friday 17th.Sept.1965.		
22.40	'Phoned from control room for result. Both aquanauts sleeping together, 'phone back at 17th.Sept. 00.40 hrs.	1.6%	19%

DAY 2.

FRIDAY 17th.SEPT.'65.

<u>TIME.</u>		CO ₂	O ₂
00.40 hrs.	'Phoned from control for report of general RDS. conditions. J.H. answers 'phone and his report was: both aquanauts awake and feeling well. They had switched out their lights and so we (M.F., and myself) switched on main light so that they could find switch. J.H. said that the air was bubbling out of house entry skirt. We informed them that at about 02.00 hrs. the house light would be switched out and changed to batteries while generator was refilled. No gas tests taken or reported at this time. (About 00.30 hrs. night watch informed us of southerly gale force 9 imminent - aquanauts not informed.)		
00.50	End of 'phone call.		
01.07	M.F. reported that sea was calm (like a mill pond), around fort - no sign yet of gale force 9.		
02.15	Generator stopped, batteries on.		
02.18	Batteries off, Generator on.		
02.40	C.B. & E.D. now on duty. M.F. & R.S. to bed.		
02.45	C.I. & J.H. awakened by 'phone. Both O.K.		
05.50	'Phoned house, spoke to J.H. all O.K.		
07.00	J.G., B.H., L.A. and A.B. taken over watch.		
07.05	J.H. and C.I. switched some of the lights off to sleep and one of them refuses to operate again. Main floodlight is necessary for the gas analysis so this was switched on. Arrangements made for J.H. to ring back with the results.		
07.40	Contacted C.I. and J.H. by 'phone to enquire who Dr.Wilson was. Gas Analysis results:-	1.6%	18%
	Ring at 08.15		
08.45	C.I. & J.H. rang to see if breakfast was coming - it was, L.A. is about to take it down, Radio aerial wanted when anyones in Plymouth.		
09.00	Breakfast is now on its way down - G.H. giving cover in boat.		
09.05	Empty tins and soda lime bottles floating on surface. G.H. collecting them into his dinghy. Wind getting up. Air bottles being lashed to pontoon by J.G. and B.H.		
09.15	Boat returning.		

DAY 2 (Cont.)

TIME.

CO₂ O₂

- 09.20 L.A. reports air in Glaucus clean and sweet. G.I. and J.H. feel "a bit damp". A slight smell of paint in the house, but nothing to worry about. Wind force 5.
- 10.36 R.S. 'phoned to tell them we are switching the floodlight off. At 10.00 hrs. R.S. 'phoned to advise on failed light. Key for B.O.C. bottles has been found in house. J.H. reported that the air cylinder had been used to compensate for rise in tide. New cylinder required before next high tide, also accurate depth of house in sea to be taken in next 12 hrs. (All lungs charged by J.G. except those in House). 1.7% 16.8%
- 11.45 Generator $\frac{1}{4}$ full - topped up - No stop.
- 11.50 A.B. dived with newspapers, books and spare light bulb at 11.30., dropped spare weight belt at entrance and noticed "a piece of wood" nearby. 'Phone C.I. at this time, J.H.'s dropped his slide rule. A.B. ran out of air, surfaced and came back to the fort. A.B. says J.H. & C.I. heard him bubbling down to them so they sang and shouted and A.B. could hear them quite plainly. Very slight leak at left hand (inside) porthole.
- 12.15 Both aquanauts feel like defaecting but are afraid they will get very cold if they do, so they will wait for low tide and have a go. Flood lights switched on.
- 12.35 R.S. & B.H. now on duty. Floodlight being switched off.
- 13.10 Weather report at 11.55 GMT. Gales veering Westerly, Force 9 imminent. J.H. & C.I. told they said it was very calm in the tank.
- 13.33 Bubbles seen on surface above house. 'Phoned house report: 'Venting W.C. because tide causing noise of bubbles from house to W.C. chamber.'
- 13.37 C. 'phoned. Any food scraps we have, they want to feed the fishes.
- 13.45 A. 'phoned the house to see if the plastic containers had been left there after breakfast. They have and will be brought up with the lunch things. C.I. & J.H. plan to have a bubble after lunch.
- 13.47 J.H. 'phoned to ask for the main light to be turned on. This was done.
- 14.01 'Phoned house to check that we can change to batteries - main light off. Generator off for oil check. Gas analysis result - 1.7% 15.2%
- 14.09 All above completed. (14.01).
- 14.33 House 'phoned control room to have lights switched on. Generator output was not switched on. Aquanauts checking soda-lime colour.
- 14.34 Lights switched on.

DAY-2 (Cont.)

TIME.

CO₂ O₂

- 14.45 Lunch dispatched. Bubbles sighted on surface - 'phoned house - "only flushing out". Air in house smells clean.
- 15.9 House 'phoned from control to confirm dive this afternoon at about 16.15 hrs. Aquanauts are very keen to dive close to house.
- 15.20 House 'phoned from control Telegram for C.I. 118 P.M. Verwood - "Congratulate please send Post Card from new resort. Best of luck with the mermaids - Kozulaska."
- 15.22 House 'phoned from control to check aqua-lungs in house, none required.
- 15.40 Control 'phoned from house. C.I. said that they would be ready at 16.30 for dive outside house.
- 16.02 'Phone house to control - J.H. requires bits & bobs from his bag like polythene bags and wire to be brought down by next diver.
- 16.04 'Phone house to control. Several verses of "We're off to see the "Wild West Show" received over intercom. Aquanauts told to conserve telephone batteries.
- 16.20 'Phoned house from control - arranged to collect dirty pots etc., for washing. Told we are allowed to collect corals but not Sea Urchins, Crabs or Lobsters.
- 17.04 'Phone house - control. J.H. & C.I. had decided to go swimming on their own, but they were told not to until the boat arrived with B.H. and R.S. because of bad vis. as they may get lost. Boat now arriving at surface buoys - correction, boat just driven back by gale which is too powerful for the outboard.
- 17.13 C.I. is about to swim once round the house while J.H. stands on the Tray and observes him.
- 17.15 The weather man from the fort has just been in to say that a Storm force 10 is imminent. C.I. & J.H. have been told to go into the house.
- 17.22 J.H. 'phoned C.I. is using W.C. and as soon as he's back J.H. will do a gas analysis and if necessary raise the O₂ level to 20% - they wish to be informed of any worsening of the weather. Temp. in house is 15.8°C. and J.H. feels extremely cold.
- 17.37 C.I. finished in W.C. now back in house changing - he is shivering badly.
RDS:- Correction - we lunged below surf around fort and along tower cable.

DAY 2. (Cont.)

TIME.

CO₂

O₂

- 17.50 R.S. & B.H. have snorkeled round to the house and are in there now. One of them is bringing back the thermos flask lid so that tea can be sent down.
- 18.03 R.S. & B.H. are back - they cannot get any tea to the lads at present. C.I. is changing the soda lime, J.H. is doing a gas analysis. If the storm gets worse rather than better they would like their dinner as soon as possible.
- 18.10 J.H. wants to be told when the swell starts to cover the breakwater.
- 18.24 Boat sighted off Barbican - pitching very badly in the storm - about 1½ miles off now.
- 18.45 House was called - twin 40 cu.ft. bottles will be sent down as they are almost out of air.
- 18.49 The tide is now beginning to come over the breakwater, the house has been mobilised towards the west-end of the breakwater - it is streaming over continually.
- 18.51 Light Analysis
They are prepared to flood the bilges if necessary for more stability. 2% 12.3%
- 18.50 C.B., E.D., L.A. and R.F. on watch.
- 18.55 Looks like dinner will be cancelled. Will attempt to take tinned stuff down.
- 19.02 Hot Soup (Scotch Potato) and cold chicken is planned for dinner if we can get it down to the house.
- 19.15 J.H. 'phoned to say "Can do without food, and might be able to manage on the air we have."
- 19.30 E.D. & R.S. took 80 bottle, two twin 40's and food down to house.
- 19.45 E.D. & R.S. returned with Life Jackets inflated.
- 20.30 Generator topped up.
- 20.40 J.H. 'phoned and asked for the main light to be put on and he asked what the weather position was like.
- 21.02 J.H. 'phoned CO₂ unknown, O₂ 27%, this was raised in case they had to get out in a hurry overnight. The main light was switched off. - 27%
- 21.14 'Phoned control to house. R.S. to J.G. to inform them of weather conditions and find out if the experiment would be called off at earliest opportunity. Reply was that conditions below were not serious, but that they were preparing for the worst. I then spoke to C.I. to discuss the emergency procedure.
- 21.45 C.I. 'phoned control to ask for a call at 22.15 as they were going to snooze before the gas analysis.
- 22.15 'Phone, control to house - start of gas analysis.

DAY 2 (Cont.)

TIME.

CO₂

O₂

22.32 'Phone from house to fort - aquanauts want call at 11.20 and at two hourly intervals after this. No gas results to report but O₂ level presumed high. Main light switched out.

23.20 All O.K. in house. No movement, and both of these boys have been sleeping. Call again at 01.20 Friday 18th.

DAY 3.

SATURDAY 18th. SEPT. 1965.

TIME.

CO₂

O₂

00.20 Pontoon has broken moorings at one end. Informed Admiralty Service duty watch.

01.20 All O.K. in house. No movement.

03.20 Everything O.K. in house - 'phone again at 05.20

05.10 Topped up the generator.

05.20 Everything O.K. in house.

07.30 Everything O.K. in house, said they did not need any more air.

08.00 J.H. 'phoned to say that one light had broken and that he was going to check another and asked for two divers sometime.

08.12 J.H. asked for the main light for gas analysis.

08.20 Boat arrived with A.B., B.H., & J.G.

08.30 A.B., J.G., & B.H. took over day shift.

08.40 'Phoned to house to enquire about pots etc.

09.15 J.H. 'phoned from the house - main light off.

Gas analysis results:-

0.88% 26.5%

Oxygen rather high intentionally in case they had to leave the house during the night - they will bring this content down.

09.25 J.H. 'phoned to say that there were now 3 lights out and suggested that bulbs of a more suitable voltage be used.

9.30 Breakfast delivered by J.G.

9.40 Flood light switched on.

10.0 Flask of tea delivered by J.G.

10.55 C.N. 'phoned J.H. & C.I. J.H. said his chest was a bit troublesome, also his throat. Said he had been apprehensive of the gale, though they had not felt any movement.

Transformers tapping changed to 12V, because 4 lamps had blown.

DAY 3 (Cont.)

TIME.

CO₂ O₂

- 11.05 J.H. 'phoned from house to request floodlight, C.I. asked if we could fit an aerial for his radio. C.N. spoke to J.H. and C.I. 10 mins. ago.
- 11.15 Two girls visiting the fort, one of them "Virginia" spoke to J.H. who was more interested in his CO₂ figures (at present this was 1.02% - O₂ not yet tested.)
- 11.20 One telegram for C.I. read over 'phone from his Parents. C.I. requested us to send a telegram for his Mother's Birthday tomorrow. O₂ figure now 23.1% which they intend to lower now that the storm is subsiding. If we cannot arrange aerial, send them set down, or alternately 2 nice girls - "They are no use on a telephone". 1.02% 23.1%
- 11.45 C.I. 'phoned asking what was for lunch and he was told grilled plaice, mashed potatoes, tomatoes with rice pudding and coffee to follow. VISIBILITY - 12". C.I. wants as many tomatoes as possible, J.H. wants 2.
- 14.00 J.Hoy, J.J. & K.J., Slim McDonald (Southern IT.U) and LEFKOS GRECO (Westward T.V.) arrived.
- 14.10 Both want envelopes for letter writing. Both O.K. Lunch delivered by J.G.
- 14.20 J.G. leaves house. Reported on 'phone that lunch was fabulous. J.G. returns again with coffee.
- 14.27 'Phoned house all O.K. S.T.V. taking movies.
- 14.30 'Phoned C.N. at the Berni Grand to see if Slim can take pictures of the aquanauts in the house; answer "Yes", but no show until we come to some arrangement with them about fee - Slim agreed.
- 14.35 J.H. 'Phoned and asked for the main light to be put on.
- 14.45 Gas Analysis result:- 0.7% 18.1%
- 14.55 Main light off.
- 15.25 Rang the house to warn them that we were going on to emergency lighting to check the generator. Also to tell them that S.M. was on his way down to film them in the house.
- 15.30 'Phoned again to switch on main lighting, and also to tell them to ring us when Slim arrives so that we may put the floodlighting on for his filming. J.Hoy., J.J. and K.J., have left in the boat and they will be returning to do a watch at 06.00 tomorrow (Sunday 19th.)
- 15.45 C.I. rang to inform us that S.M. had arrived, so we switched on the floodlighting.
- 15.50 C.I. 'phoned from the house to 'blah' so that Slim could get a picture of him using the 'phone. Lefkos had a quick word and asked them how they were getting on.
- 16.00 C.C. now back with the coat - short discussion on best method of getting more cylinders down to the house.

DAY 3 (Cont.)

TIME.

CO₂ O₂

All Aqualungs now charged (decanted by J.G. & B.H.)

- 16.15 'Phoned the house, told to hold on a minute because they are filming.
- 16.19 C.I. 'phoned from the house - quick discussion about the changing of cylinders - decided to remove the one empty one and put 3 full 110 cu. ft. cylinders into the house, also we'll fit up a radio aerial for them. S.M. has just left the house and is snorkeling back with the camera.
- 16.26 C.I. 'phoned from house:- 1.32% 19.28%
Floodlight switched off.
- 16.48 'Phoned C.I. to tell him that the boat left and he was to expect company shortly. Lefkos Greco has got permission from myself (J.G.) to dive and speak to the aquanauts, A.B. is kitted up to do the underwater work, and B.H. will be doing the surface supervision. Visibility still nil.
- 17.14 Boat is in position and Lefkos has gone down.
- 17.16 A.B. is down and bottle changing is proceeding. There was difficulty in positioning the boat.
- 17.51 J.H. reported that they have got the cylinders inside GLAUCUS, and they were just connecting the aerial for the radio.
- 18.00 hrs. Job completed, aerial connected.
- 18.15 Boat left for shore with J.G. and B.H. and the two visitors, one of which (Slim) has promised to lend us his walkie-talkie. A.B. is getting changed.
- 18.20 'Phone call to house to see if aerial works, it does.
- 18.42 'Phone to house to see if either C.I. or J.H. have used the W.C. today - neither have since yesterday. The water level is rising a little in the house and they are going to crack another cylinder.
- 18.58 'Phoned house to see if mashed spuds, scrambled eggs, cold tongue, tomatoes would be acceptable as we have not been supplied with beef for stewing as per menu. This they said would be O.K. as long as there was plenty of hot food. J.H. says that one of the 110 cu.ft. cylinders sent down by A.B. is empty.
- 19.05 Boat arrived with J.G., and A.B. going back to camp. C.N., R.M. and C.L., and G.H. come on shift. New T.V. cable brought aboard.
- 19.15 Spoke to J.H. to inform him of change of watch. When asked about his chest he remarked that it hurt a bit when he breathed in deeply, as in the Dry Run. His throat however was O.K.
- 20.00 R.M. say J.H. to report that due to late arrival on watch, dinner was likely to be up to 2 hrs. late, as it consisted of stewed beef, which had only just been found lurking in a corner.

DAY 3 (Cont.)

TIME.

CO₂ O₂

- 20.45 R.M. to ask if they wanted pears, peaches or loganberries for sweets - J.H. said loganberries. Neither wanted evaporated milk (C.I. commented). (NOTE: no pineapple available despite menu!!)
- 22.10 Spoke to C.I. who was hungry but cheerful. Said he was thinking of going out spearfishing as grub did not seem to be coming!! Also asked for woolly clothing which he had requested 2 days ago. All 3 kitted up and ready to go down.
- 22.30 3 divers went down with food and 1 jumper for J.H. J.H. asked for main light to be switched on for gas analysis.
- 23.05 The divers are now taking the television cable and camera down. J.H. & C.I. report meal fine.
- 23.40 R.M. & C.N. return with empty food containers. C.N. remaining below to fix up camera.
- 23.55 C.N. announced his intention of coming up since the T.V. was not operating.

DAY 4.

SUNDAY, 19th. SEPT. 1965.

TIME.

CO₂ O₂

- 00.07 hrs. T.V. is working after a fashion!
- 00.22 C.N. has arrived back and we have joined an extra 25 ft. of cable to the T.V. He thinks the reason for a bad television picture is lack of light.
- 00.25 The people on duty are now going to have a very much delayed supper!

Result of Gas Analysis Test 1.	1.4%	20.6%
" " " " Test 2.	1.38%	21.04%
- 00.35 C.N. thinks that the lack of light is due to the fact that the voltage has been lowered to 12 volts.
- 00.50 C.I. 'phoned asking to be wakened at 0400 and he wanted the main light turned off.
- 01.50 Turned on floodlight (all the lights had been turned off by C.I. & J.H.) in order to monitor on T.V. Both appeared to be resting peacefully (i.e. no convulsions) and the cylinder was not, repeat not, full of water.
- 01.55 G.H. off watch till 5 o'clock.
- 02.05 C.N. changed transformer tapping to 15 volts in order to step up floodlight output for T.V. camera. Result - much improved picture, quite suitable for monitoring - however more light needed to get top class picture.
- 02.28 T.V. check. Both C.I. & J.H. appear to be sleeping peacefully. C.N. off watch, also C.L.

DAY 4 (Cont.)

<u>TIME.</u>		CO ₂	O ₂
02.50	T.V. check. Both bodies have moved. C.I. now asleep on his back with his knees up; J.H. also moved; may have been switching on of lights for T.V. that disturbed them. Will try it again later.		
03.25	T.V. check. Can see both bodies in their bunks; no change.		
04.00	'Phoned house, saw J.H. get out of bunk and answer 'phone. Changed to emergency lighting whilst topping up the generator, changed back again in about five minutes. (Don't forget to switch off mains switch on control box and the switch next to the red warning light (right hand) on the receiver), before changing to emergency lighting, and back on again after the generator is started. J.H. requested a call at six.		
05.00	T.V. check - all quiet; Floodlight doesn't seem to bother them.		
06.00	'Phoned house. Watched J.H. & C.I. change the soda lime; they both looked a bit sleepy; they in fact, got back into bed and asked for the floodlight to be turned off. Called C.N. & C.L.		
06.35	J.J., J.B., A.B., R.F., and K.J., arrive on fort from boat in thick mist.		
07.10	R.M., C.N., and C.L. disappear off watch.		
07.25	Lights go on in house - they are awake. Main light switched on. A.B. contacts them by 'phone - all is O.K. T.V. picture fine. Confirmed breakfast is on way. They have marmalade already.		
07.37	'Phoned house and asked if they had enough eating utensils. They had.		
07.45	J.J. is now diving with breakfast.		
07.49	C.I. & J.H. getting up and stowing things away for breakfast. J.J. arrived and made V sign into T.V. camera. C.I. & J.H. wish to have some sleep after breakfast as they didn't get to bed early.		
08.03	J.J. still in house - breakfast being consumed. J.J. back now. We noticed he was panting in the house.		
08.35	J.J. lads appeared cheerful in house. J.H. was beginning to feel cold after getting out of bed and donned sweater. I noticed that my breathing rate was up in the house and my voice sounded 'tinny'. Felt cold in water and in house. One of the cornflake containers was upset. Returned to the surface with empty flasks. Saw 3 starfish in bottom round house. VIS. 4.5 Ft.		
08.42	Main light switched on for gas analysis test.		
09.21	Aquanauts wearing smog masks while soda lime is being spread.		
10.00	J.H. 'Phoned to say that a tap on the gas analysis apparatus was leaking and the results were only approx. CO ₂ 1.2 and O ₂ 14.5. He said that they want some more air as one bottle was empty, they used one up on high tide, and they	1.2%	14.5%

were using one now. They wanted the main light off and J.H. asked if we could get some vaseline for the Gas Analyser.

- 10.17 J.H. & C.I. sleeping.
- 10.30 Boat arrived. J.G., D.W., C.N., B.H., M.F., C.N. V. and kids came aboard. D.W. & J.Hoy taking photos of the T.V. set. Telephone calls to try and place the "Models". 5 galls petrol, $\frac{1}{2}$ gal. castrol XL.
- 10.54 C.I. 'phoned to say that if possible the vaseline should be sent down with his dinner. Boat left taking M.W., A.B., C.N. & V.N. & the kids, also taking empty 5 gall. drum for more petrol. Gas analysis apparatus has been moved on to the table to enable us to see them using it.
- 12.26 R.S. rang C.I. and then D.W. spoke to C.I. regarding camera. C.I. then spoke to J.G. and said to keep mentioning the vaseline.
- 12.31 Message passed on, grease supplied until vaseline arrives.
- 12.24 Gas analysis equipment put away, can now see C.I.
- 12.47 Rang to say divers on way with grease. C.I. seems very restless, continually changing his position.
- 12.49 D.W. rang to say main light would be switched off. D.W. also asked for polythene containers to be sent up with divers.
- 12.50 Boat has arrived back with S.M., who wants to take more pictures of aquanauts.
- 13.6 Diver down, a lot of activity in GLAUCUS.
- 13.7 D.W. rang J.H. to find out if exposure meter has arrived, it had and J.H. is now getting a light reading. Light reading F.5 from porthole at 1/75 sec. range 7 ft.
- 13.16 Rang to see if any difference with emergency lighting. There was, C.I. said grease unsatisfactory.
- 13.18 Rang to ask if plates required. They are not. Asked for other pressure cooker to be sent up.
- 13.24 C.I. rang to ask what was for lunch, when told they asked for lots of it as they are starving, and also a packet of biscuits to eat when they feel hungry.
- 13.32 C.I. asked for main light to be put on. This was done.
- 13.36 Asked C.I. to seal up entrance as Navy divers may be on their way down, and we want to know what they want before they are allowed in (if they are allowed in).
- 13.40 Divers (Navy) appear to be going away.

DAY 4 (Cont.)

TIME.

CO₂ 02

- 13.41 C.I. rang and asked to speak to D.W. and told D.W. to be courteous to the Navy as they are coming alongside the fort to ask J.G. for permission to dive on GLAUCUS.
- 13.54 J.G. rang to tell the boys that the Navy divers would be paying them a visit.
- 13.55 The food has now arrived.
- 14.3 D.W. rang to say main light would be switched off.
- 14.22 Rang to say main light would be put on again.
- 14.46 Generator now being checked, after advising house that emergency would be used.
- 15.10 Generator cut out, emergency lighting switched on reason - the petrol was turned off!
- 15.11 Generator now on.
- 15.25 J.J. about to go down with dry clothing and biscuits. R.S. manning the dinghy.
- 15.27 K.J. rang to say that J.G. was on his way. J.H. said that two Navy divers had been in but had now left again.
- 15.45 C.I. rang grease no good, must have vaseline today for gas analysis.
- 15.56 J.H. going out for dive, towels wanted. J.J. taking them down as requested by C.J.
- 16.3 C.I. rang C.N. to ask him to float the pressure cooker up, and the food containers as well, to the dinghy above. C.I. mentioned about the vaseline again.
- 16.13 Pressure Cooker just gone up. C.I. said he thought J.J. was accompanying J.H. in his dive.
- 16.20 J.H. ready for his dive, C.I. said.
- 16.22 C.I. rang to check if the diver was ready to accompany J.H., (Carol) said that J.J. was on his way down with the towels, and to accompany J.H. in his dive.
J.H. left house accompanying J.J., proceeded along television cable, towards fort. On reaching fort, he examined a star fish and picked up a small encrusted piece of rock. Then indicated that he was running short of air (this should be checked before dive in future), and made his way fast back to the house via television cable. Empty bottle returned to surface for charging.
- 16.30 Boat arrives with C.B., A.B., E.D., for night shift. J.Hoy., J.J. and K.J. leave now for Bovisands & Bournemouth - leaving best wishes for the boys and crew when they return from respective lands of Nod. Best Wishes J.Hoy.
- 16.31 J.J. to collect towels from dingy above GLAUCUS. (Carol) asked them how many bottles of air they required, C. said 2. Everything going fine, said C.I., J.Hoy & R.M. manning boat.

DAY 4 (Cont.)

TIME.

CO₂ O₂

- 16.39 C.I. rang to ask me if I was enjoying myself, as J.H. was changing - I told him it was better than going to see a strip tease show.
- 16.53 C.I. rang to ask about Megaphone. J.J. is seeing to it. C.I. also asked to tell the divers not to get mud on the bottle necks as it blocked the valves.
- 17.17 D.W. rang J.H. about Leica Camera, on how to operate it. Camera to follow shortly. D.W. asked C.I. if he could switch the main light out. C.I. said O.K. C.I. & J.H. are taking a rest.
- 19.30 Advised that dinner would be down in about 10 mins., also taking camera and C.I.'s overall down.
- 19.33 Checked with aquanauts and turned main light on.
- 19.35 J.H. 'phoned to say that they didn't know the oxygen content so they switched on oxygen bleed at 17.30 which has just been switched off.
- 19.45 C.B. & E.D. now adrift in rubber boat and cannot start outboard, so J.H. is going to the rescue in his outboard dinghy. The dinner may get to the house even yet. (It did, plus camera).
- 19.54 C.I. & J.H. now unpacking dinner. They look tired. Twin slimline, Standard Scubair valve and Normalair pressure gauge dropped while recovering C.B. from water in dark.
- 20.07 Boat returning under own power.
- 20.37 Turned main light off.
- 22.35 J.H. called and asked to be called at 23.30 hrs.
- 23.30 Called J.H. All O.K. Call at 01.30
- 23.56 Stan Gobbi 'phoned to say tell Mike Ward to have pictures taken of the T.V. Monitor with the Marconi sign from the camera control stuck over the top of the Monitor. (Camera setting F4 1/30 sec. with as good a picture of C.I. & J.H. as possible. He sends regards to all workers and congratulations to C.I. & J.H. for their success so far.

DAY 5.

MONDAY, 20th. SEPT. 1965.

TIME.

CO₂ O₂

- 00.20 hrs. Generator $\frac{1}{4}$ full, topped up.
- 01.30 Called J. All O.K. Call again 03.30
- 01.36 $\frac{1}{4}$ pint oil in generator.
- 03.30 Everything O.K. J. asked to be called at 06.00 hrs.
- 06.30 Watch changed. Team (2) and R.F. on duty.
- 07.05 J.H. rang to order chewing gum, envelopes and Vaseline. Charlie (Boatman) agreed to purchase same. J.M. also wants his dirty clothes taking to laundry. No gas analysis since 10.00 yesterday.

TIME.

002

02

- 07.06 Called boat back to take above order.
- 07.09 Rang to house to ask them to send empties up to L.A. above in rubber dinghy.
- 07.15 Empties retrieved and coming to Fort.
- 07.20 L.A. had difficulty starting Outboard on dinghy.
- 07.25 Outboard packed up, G.H., J.G., L.A. going to rescue in other dinghy.
- 07.30 Both dinghys back at pontoon.
- 07.40 Petrol and Oil levels checked, petrol topped up. Oil O.K.
- 07.45 Main light switched off. Arranged to put smelly fish on tray of house to attract "congers etc."
- 08.45 G.H. 'phoned and read a report from the "Sketch". J.H. said they would like a copy down in GLAUCUS and also one to the Prep. Lab. Millport. He requested that when the next meal arrived spoons should be sent down.
- 09.05 J.L. & J.G. have just returned from taking breakfast to G.H. which was delivered at 08.30. J.L. then did a circular sweep around metal buoy to approx. 20' radius, looking for C.B.'s Lung.
- 10.10 C.B. arrived with boat, bringing Vaseline, Envelopes and chewing gum, went back 10.15, due to return mid-day with Mike and Petrol.
- 10.15 Rang to House - they want Vaseline, Envelopes, Chewing Gum, Ball point Pen, taking to house with lunch.
No Mid-day morning drink required.
Air cylinders in house 2 $\frac{1}{4}$ " 110s". One can come out this afternoon and they could take another 2 in. They are using approx. 1 $\frac{1}{2}$ " 110s" per day (24 hrs.)
- 10.20 Generator walked off its Board so rag was placed under one corner which seems to have "anchored" it.
- 10.35 M.F. 'phoned to say he was coming down on Tuesday until the weekend.
- 10.55 J.H. 'phoned to ask if we could bring a big mixture bottle down this afternoon instead of the compressed air originally asked for.
- 11.50 'Phoned to house before changing to batteries for topping up Generator. All O.K.
- 11.53 Back on Generator. L.A. & J.L. decanting.
- 12.10 J.L. reports we have only 3" 100"s of air left. J.H. wants about another 2 in the house to complete the experiment. About another 10 or 12" 100"s will be needed by divers. I am now going to Bovisands in dinghy to ask J.L. to order about 12 or 14 bottles of air.
- 12.30 Boat arrived and M.W. spoke to J.H. & C.I.
- 12.55 'Phoned to house, asked J.H. to send up containers but he said this meant using air to lower the water

TIME.

- in the skirt so I told him not to do this as L.A. would come down for them. M.W. says that the photos D.W. took yesterday from the Television came out very well.
- 13.20 'Phoned to house to tell J.H. L.A. was coming for containers.
- 14.05 Lunch delivered by L.A. along with Vaseline, envelopes, biro, chewing gum, Telegram. L.A. looking for B.B.'s lung. Boat with M.W. and R.S. returns to shore.
- 15.00 J.H. 'phoned to say that they had a 2 ft. 6 in. Pollack swimming round the tank.
- 15.13 J.H. requested the main light on.
- 15.52 J.H. 'phoned and asked us to listen to C.I. he was singing at the top of his voice in the W.C. The main light was then switched off. Emergency lighting was then switched on. Gas Analysis - 1.5% 18.54%
- 16.00 Generator almost empty - refilled and the oil topped up. C.L. has just arrived.
- 16.17 C.I. 'phoned and asked where B.H. was as he had been kitted up for 15 minutes.
- 16.50 C.I. is back from his exercise - two containers sent up.
- 17.15 'Phoned C.I. to ask him to uncover the T.V. camera, as he had covered it when he was changing.
- 17.50 J.H. requested the main light on.
- 18.10 All cylinders changed. Took C.I. out at 16.20 for about 30 mins. J.L. ordered 12" 110s" from B.O.C. which are being delivered tomorrow (Tuesday) 08.30 at Fishermans Dock. J.H. has just 'phoned to ask for floodlight to be switched off and to report CO₂ 1.8% - O₂ 18.4% One large "Mixture" cylinder has been delivered to house and two empty "Airs" removed at 17.30. 1.8% 18.4%
- 18.30 Boat arrived with change of shift - J.G., R.S. & R.M.
- 18.37 'Phoned the house to notify them of the change of shift and have a short discussion on the decompression procedure. Due to the depth being greater than anticipated, C.I. & J.H. thought a decompression stop is necessary. J.H. suggested that the excess ballast be removed, the toilet flooded, and then during Thursday morning they be floated to the surface, towed by C.C.'s boat round to the Pontoon and lashed there, coming out later in the afternoon, the ballast would need to be removed before Wednesday night which means probably starting tomorrow. Another point is that as the ascent would be quite rapid it may be an idea to give them something to clear their ears (nasal script or like). With the house floating the water pressure inside the house would be about 5', and J.H. & C.I. think this would be quite sufficient under the circumstances.

DAY 5. (Cont.)

TIME.

CO₂ O₂

- 19.15 Harbour Police arrived - paying a visit and wanted to see "Britain's First Aquanauts".
- 19.43 J.H. 'phoned from the house to enquire about the noise, he wondered if a submarine was approaching them. He was quite surprised to learn that there was. A Cachelot class submarine has just come through the Western entrance and is mooring up about 250 yds. due north of the fort.
- 20.25 Picture on Monitor very poor. Switched on floodlight for a few seconds - picture O.K. J.H. & C.I. both stirred.
- 20.50 Reason for no picture was the fact that they had turned the lights out. C.I. has just put one on and has picked up a magazine to read.
- 20.58 He must be a bit restless, he has turned the light out again.
- 21.15 Topped up generator - it was using the last dregs.
- 21.20 Trouble with the rubber dinghy - G.H. started the motor and moved round the pontoon when the buoyancy section apparently "suddenly deflated" and sat him in water. It was pulled on to the pontoon and G.H.'s dinghy was used to take R.S. & R.M. round to the Buoy.
- 21.30 Sudden activity in the house as the divers reach it and pass in the food. J.H.'s bed has been chained up and the table swung into position.
- 22.08 R.S. & R.M. back from the house.
- 22.36 J.H. 'phoned. They want to be woken at 01.00 hrs. to change the soda lime.
- 22.40 Lights out in the house.

DAY 6.

TUESDAY, 21st. SEPT. 1965.

TIME.

CO₂ O₂

- 00.00 hrs. Floodlight switched on for 30 secs. C.I. & J.H. both sound asleep, not disturbed by light.
- 00.30 Floodlight switched on for 30 secs. No stirring.
- 01.10 J.H. woken.
- 01.25 J.H. wants to be woken at 06.00
- 01.40 Floodlight on for a few seconds, J.H. & C.I. "Flat out" and not disturbed.
- 02.00 J.G. to bed, R.M. on for 2 hrs; no change.
- 02.35 Generator cut out, switched to emergency lighting, oil topped up and empty fuel tank filled. Floodlight switched on - no movement.
- 02.40 T.V. check. J.H. seems to be half off the bed, probably having a nightmare.

DAY 6. (Cont.)

TIME.

CO₂

O₂

- 03.25 T.V. check. J.H. has moved back again - all's well.
- 04.03 T.V. check. All quiet. R.M. off and G.H. on for the last 2 hrs. Don't forget G.H., J.H.'s call at 06.00.
- 06.30 'Phoned J.H. and told him the time.
- 06.40 Day shift arrived C.B., R.F., E.D. and also A.B.
- 06.50 Generator topped up with fuel.
- 07.03 Main light switched on and there was no sign of movement in GLAUCUS - 'phoned, J.H. said that the soda lime looked O.K. and they were going to sleep a bit more.
- 08.02 J.H. is up. Checked that they had the plastic containers. E.D. is going down for them.
- 08.17 The T.V. picture went black so the house was 'phoned to see if anyone was in the way. J. said that the bulb in one of the lights had blown. This he replaced. The T.V. Monitor needed adjustment to regain the picture.
- 08.30 C.N. rang. Wants details of today's activities 'phoned to him this evening. (Poole 176).
- 08.35 Told C.I, E.D. is on his way to pick up containers. Also sending down new light bulb.
- 08.40 CO₂ - 1.38 Oxy. 17.06, as passed by J.H. 1.38% 17.06%
- 09.15 C.I. wants cutlery he has requested for 2 days. 2 complete sets sent down.
- 09.25 Telephone slightly weak a reception from GLAUCUS. Can hear them strength 2.
- 09.28 Picture went black on T.V. Checked with house. J.H. hid camera with his head.
- 09.55 C.I. & J.H. signalled by T.V. that they couldn't contact in by telephone. They could hear us but not vice versa. J.H. wrote a message for us to the effect of needing to use the W.C. He is putting a spare battery on 'phone. Spare battery in but no effect on 'phone. R.F. top end, replacing our batteries, no effect. R.F. stripped down our 'phone O.K. J.H. has found his 'phone is faulty. J.H. has now converted his speaker so as to cut out faulty mouthpiece, and is now speaking clearly through the ear piece.
- 10.45 A lady from the "Evening News" 'phoned for information on a story re:- Prince Philip's telegram. She was told to contact Mike Ward of the "Sketch".
- 10.47 Mike 'phoned enquiring about boat times out to the Fort.
- 12.00 Telegram from Prince Philip arrived.
- 12.03 Generator stopped. Filled up and cleaned plug.
- 12.12 Generator going again.

DAY 6. (Cont.)

TIME.

CO2

O2

- 12.15 Told J.H. about telegram. Probably coming out this P.M. VIS. about 8 feet.
- 13.00 J.H. & C.I. now changing Soda lime.
- 13.13 Tupperware to be floated up in pressure container. J.H. wants 2 bottles of air and 1 of mixture today, and 2 more bottles tomorrow.
- 13.19 J.H. wanted a spare 'phone receiver if possible to try to exchange them.
- 13.40 'Phoned to tell J.H. that lunch was on the way and he asked me to tell the submarine in the vicinity to stop using his 'asdic', he said it was 'pinging'.
- 13.55 J.H. & C.I. are jumping up and down and making a general row. I think they've heard the divers.
- 14.05 A.B. took lunch down with C.B. who couldn't make it because of ear trouble. A search was made for C.B.'s twin set with no result. Large pollack and crab seen.
- 15.45 J.H. 'phoned to say he was going to use the W.C. and then would be ready for a swim at 16.20 hrs. E.D. will take down bottle & valves for C.I. Lunch was excellent they report.
- 16.30 J.H. & E.D. going for a swim.
- 16.40 J.H. back in house now.
- 17.30 Asked C.I. to push pressure containers out. Asked when we were bringing down air.
- 18.07 CO₂ - 1.44 Oxygen 14.6 Switched oxygen bleed on 1.44% 14.6% at 18.07.
- 18.17 Main light off.
- 18.50 Rang to say bottle of special mixture on its way down.
- 20.00 Rang to tell them their dinner was on its way down. Team (2) are now on duty. We relieved Team (1) at 18.30 hrs.
- 20.20 G.H. has just left for Bovisands to collect 5 galls. of petrol for the generator.
- 20.24 GLAUCUS inhabitants are now eating dinner.
- 20.40 Rang to house before changing to batteries, and topping up generator.
- 21.25 Main light switched on for Gas Analysis.
- 22.00 Result:- 1.50% 16.18%
main light switched off.
- 22.30 J.H. & C.I. are in bed - the lights are off - I think they are going to sleep. P.S. has just 'phoned me from Bournemouth. He said that the GLAUCUS committee members in Bournemouth are unanimous in asking that if it is humanly possible, C.I. & J.H. stay until the 7 full days are up. He asked me to try and get some underwater shots tomorrow of divers taking food down to GLAUCUS, and any similar shots that

DAY 6. (Cont.)

TIME.

CO₂ 02

I can get. He is coming to Plymouth tomorrow (Wed.) night with C.N. and will come out on the 06.00 hrs. boat to try to do some underwater filming on Thursday.

22.50 All lungs have been charged in the dark by J.L. and L.A. who are now going to bed until 02.15 when I am to call J.L.

23.20 T.V. check. Both appear to be sleeping peacefully. J.L. left no message as to when to call them so I will call them about 00.30 hrs.

23.55 T.V. check. Both appear to be sleeping peacefully.

DAY 7.

WEDNESDAY, 22nd. SEPT. 1965.

CO₂ 02

TIME.

00.30 hrs. Called house on 'phone both were sleeping peacefully, but they both sat up quickly when I rang the bell. All seems O.K. J.H. wishes to be called again at 04.00

00.40 Switched to batteries, topped up generator. J.H. & C.I. up checking soda lime - all seems well.

00.43 Both aquanauts have returned to bed. Electricity switched back to generator.

01.18 T.V. check. Both appear to be sleeping peacefully.

01.53 T.V. check. C.I. sleeping peacefully, but J.H. although peaceful is on the edge of his bed. I am leaving main light on for a few minutes hoping to see him move back.

01.55 J.H. has just moved but is still on the edge of his bed. I will switch light off for a few minutes.

02.04 Checked J.H. again on T.V. - is still on the edge of his bed.

02.15 T.V. - both as above.

02.35 " " "

02.48 " " " going now to awaken J.L.

02.55 J.L. on watch. Both heaters - Ops. room out of paraffin.

03.09 Checked on T.V. J.H. appears to be sleeping peacefully.

03.30 " " " " " "

04.00 'Phoned J.H. both men awoke. J.H. changing day bottles over.

04.30 Filled up petrol tank on generator. Fresh supply of petrol had been left in yard - found by luck should be placed near generator.

05.00 Watch taken over by L.A.

DAY 7. (Cont.)

TIME.

CO₂ O₂

- 06.10 'Phoned GLAUCUS both J.H. & C.I. feeling fine.
- 07.05 J.G., R.F., R.M. & R.S. now on watch (boat arrived 06.45. C.I. & J.H. both awake & notified by 'phone but not much conversation because they have both got their masks on to change the soda lime. J.H. is asleep.
- 07.07 C.I. asked for the main spot to be switched on, so that he could do a gas analysis. C.I. doing analysis in front of camera.
- 07.45 J.H. rang to give the analysis readings - 1.20% 21.98%
- 08.00 Short conversation ensued (Ref. log entry 22.30 Tues. 23rd.Sept.) about the need to stay down for the full week and also the need for underwater photos. It was previously agreed (subject to further thought), that P.S. take his photos up to 17.30 hrs. approx. Thursday, the ballast be shifted and they be brought to the surface that night if possible (21.46 hrs. low water) decompress during the night and leave the house Friday morning.
- 08.27 Floodlight switched off. Gas analysis has been put away, and the table. The bed has been put down and C.I. is preparing for bed.
- 08.32 Both in bed now and C.I. has switched some of the lights out.
- 08.50 R.S. has just dived to the house and the floodlight is also now on.
- 08.57 R.S. & R.M. on their way back with containers. Floodlight off.
- 09.30 Breakfast received in the house both of them tucking into it. B.O.C. have just been rung to order one bottle of oxygen. If we take one empty back we may have one at any time.
- 10.15 C.I. rang to ask for the floodlight on to do another gas analysis. He also mentioned whether I had contacted Reynold's Tugs for the tow back, but I informed of our plan to use C.C.'s boat if it was possible.
- 10.30 C.I. rang to ask for depth to be taken at low water, from bottom of hatch vent to surface. J.G. volunteered.
- 11.02 J.H. called - Gas Analysis result:- 1.26% 23.6%
- 11.10 T.V. observations - Gas analysis apparatus put away. Absorber trays changed. Both aquanauts now resting.
- 11.13 Sounding taken at entrance to house - 33.5 ft. (at 2 hrs. after low).
- 12.40 Boat arrived bringing B. to take photos.
- 12.50 Boat taken C.D., E.D., L.A., J.L., A.B. for dive on the Whitesand Bay wreck.
(09.00 Confirmatory telegram received from Prince Philip).

DAY 7. (Cont.)

TIME.

CO₂ O₂

- 13.10 Generator almost empty - filled up.
Mist almost completely cleared - now a fairly bright sunny day - Vis. should have improved from the 6 feet or so at 08.00 hrs. when no sunlight was available.
- 13.35 Both containers are now out of GLAUCUS, and being picked upon the surface by R. in the boat.
- 13.43 J.H. now doing Gas Analysis.
- 13.56 R.S. rang for light reading through porthole to entrance. No reading through hatch, F5 through porthole.
- 14.30 Confirmatory telegram arrived from "Philip".
- 15.00 'Phoned to ask if a letter found in a thermos was to be posted - it was.
- 15.20 CO₂ 1.34% O₂ 26.0 results of latest analysis. 1.34% 26.0%
- 15.38 Masks on and changing soda lime. 'Phone to tell them to kit up as soon as they've finished.
- 15.50 Aquanauts are now kitting up for a dive.
- 15.52 R.S., R.M. & B.H. left landing stage to accompany C.I. & J.H. on their dive.
- 16.00 R.S. has taken two standards into the house and while fitting is explaining the camera sequences especially the getting out of the house without disturbing any mud.
- 16.10 Both kitted up and preparing to leave.
- 16.12 C.I. has left the house - J.H. is watching his exit.
- 16.14 J.H. has left the house.
- 16.15 Floodlight switched off. R.S. is filming with P.S. Calypso-Phot, B.H. is using John Foulkes' Leica.
- 16.23 C.I. is back in the house.
- 16.35 J.H. ditto.
- 17.10 J.H. carrying out Gas Analysis.
- 17.30 J's report on Gas Analysis as follows, from now onwards, oxygen analysis will be given in whole numbers and not decimals: readings at 17.30 are 1.7% 28%
- 17.40 R.S. & A.B. with boat come from E.D. are starting to unload some of the ballast.
- 18.30 B.M. rang and told J.H. & C.I. that the boys were going to start unloading some of the ballast and also asked them to send up empty food containers.
- 20.10 A.B. taking dinner down.
- 21.15 Generator topped up. $\frac{1}{2}$ full. While taking dinner down J.H. said any smell in the house may be him as both of them were feeling very unwashed.
- 21.35 T.V. check - they are changing soda lime.

DAY 7. (Cont.)

TIME.

CO₂ O₂

1.8% 28.0%

21.50 at 21.00 hrs. CO₂ was 1.8% O₂ was 28.0% -
'phone at 28.30 as they are going to sleep now,
but wish to top up O₂ again.

21.57 C.I. 'phoned to ask for the big light to be
turned off.

23.30 Called J.H. as requested.

DAY 8.

THURSDAY, 23rd SEPT. 1965.

TIME.

CO₂ O₂

02.10 Generator oil and petrol checked.

07.15 Generator starved. Ran out of petrol - filled
and restarted.

07.30 Mercury spilled in the house. Need flowers of
sulphur. This will have to be obtained from
mainland.
(Packet found on post and delivered 10.45).

07.55 Rang J.H. agreed to keep one "110" for
emergency, but to use the "35 Ats. left in
decanting bottles for lifting the house, via
the hose pipe.

09.20 P.S. & C.N. spoke to C.I.

06.15 hrs.

2.2% 33%

09.30 hrs.

1.7% 39%

10.30 P.S. arrived down at GLAUCUS.

11.00 Generator checked. $\frac{5}{4}$ tank required.

11.20 Basking shark (12 ft.) seen just east of house.

12.00 P.S. reports that conditions were fairly good
and he thinks he has enough material for what he
wants.

13.30 John reported that the analyses are not very
accurate for these high % of oxygen but the
later figures would be more accurate because
he has changed his technique slightly.

1.4% 34%

14.20 B.B.C. Television people arrived, short sound
interview with J.G. Film & synchronised tape
for the television.

14.56 T.V. interviews finished.

15.00 Fort electrical supply changed over to batteries.

15.09 C.I. says bottle O₂ mixture wanted urgently.

17.10 Generator almost empty - topped up.

17.15 Generator stopped - oil topped up.

18.07 Approx. 30 cwt. of ballast now loaded on to the
pontoon, the rest has been unloaded on to the
rocks near to the house. Therefore, when the

TIME.CO₂ 0₂

house is vented it should be buoyant. Telephone communications have ceased altogether, C.N. has just gone in to try and fix it. All the nearly empty B.O.C. bottles have been loaded on the boat for flushing the house.

- 18.20 C.N. has entered the house.
- 18.30 Telephone O.K. now if the aquanauts speak clearly into the earpiece.
- 18.32 Watches synchronised.
- 18.33 C.N. has left the house. It has been decided to switch off all power during the lift and the lift is to be accomplished with the nearly empty B.O.C. cylinders in the boat. C.N. is in position above the house. C.N. is checking the cables for snags. Everything seems to be prepared in the house - will verify in a moment.
- 18.40 Have verified that everything is prepared and lashed down. J.H. is talking to J.L. in the entrance. A buoy has been lashed to the house approx. 3 ft. below the surface - as soon as this appears we shall know that the house is on its way! We hope to be in telephone contact with the house and as soon as the water level drops suddenly, we shall have verbal confirmation of the ascent.
- 18.51 All power turned off; venting operations started.
- 18.55 GIAUCUS shifting.
- 18.56 Air level below porthole. C.I. says he feels like a space man! J. says he feels like a nit-wit!
- 18.58 The bubbles are coming slower; they are now changing air bottles on the surface.
- 18.59 Bubbles started again. GIAUCUS still shifting.
- 19.00 GIAUCUS has surfaced.
- 19.02 GIAUCUS gone down again.
- 19.09 J.M. reports, C.I. suggests free ascent.
- 19.11 J.M. reports gas analysis apparatus floats - says he'll retrieve it before it floats out of the hatch.
- 19.23 A diver is now taking an air cable down again to blow GIAUCUS.
- 19.24 Have agreed with C.I. and J.H. because of low supply of soda lime due to bottles getting wet, if we can't raise GIAUCUS in 2 hrs. we will bring them both out.
- 19.27 Air line to GIAUCUS now being turned on again.
- 20.05 All decide to ring Admiralty for launch.
- 20.07 John has just mentioned the fact his acqualung is empty, he says he'll do a free ascent - has been told to wait for a lung to be delivered.

DAY 8 (Cont.)

TIME.

CO2

O2

- 20.10 Reply from Drake; decompression chamber is now laid on; must deliver the two divers to Drake's Pier.
- 20.17 Spare lung taken down; told to come up as soon as possible.
- 20.22 J.H. & C.I. on their way up; last call from J.H. over and out.
- 20.23 call received from Admiralty; fast launch on its way; and an ambulance will be waiting at Drake's Pier.
- 20.24 J.H. has surfaced. C.I. has followed.
- 20.30 Phoned mainland - H.W. kept him informed of developments.
- 20.35 C.C. takes C.I. & J.H. to meet Navy launch.

Telephoned H.M.S. Drake. C.I. & J.H. both O.K. no side effects but keeping them for another 24 hrs.

DAY 9.

FRIDAY, 24th. SEPT. 1965.

TIME.

- 09.30 All personnel back to fort.
- Start generator - interior lights O.K.
- T.V. O.K.
- Spot light short - probably submerged.

AIR CONDITIONING IN GLAUCUS.

INTRODUCTION.

(a) The Glaucus experiment was designed primarily as an attempt at living underwater cheaply. The reasons for the project were varied, and do not concern us here.

In such a venture, air purity of a fairly high standard must be maintained, as over a long period small amounts of impurities may exert a toxic effect. In addition, as the atmosphere is pressurised, the toxic effects of a substance will increase as its partial pressure. It must be noted that this effect is not confined to gases - aerosols, too, will become more toxic as a larger amount of the suspended material is compressed into a smaller volume of air.

As the Glaucus project was intended to involve as little surface help as possible with the limited funds available, it was decided to use a closed-circuit system. It will be appreciated that such a system involves greater potential hazards than an open-circuit technique, but it also makes it possible for the divers to have greater control over their environment. For instance, oxygen

levels can be altered fairly readily, and ventilation can be increased or decreased as required. In addition, the continual noise of exhaust bubbles is avoided.

In the subsequent account, the air in the chamber itself is referred to as the atmosphere. The term air refers to the mixture of 20.93% oxygen, 0.03% CO₂ and 79.04% inerts carried in steel cylinders.

It was originally intended that we should allow the oxygen level in the atmosphere to fall to about 16% in order to provide a more normal partial pressure at the intended depth of 33 feet of sea water. The CO₂ level was to be kept as low as was practicable, preferably below 1%.

METHODS.

(b) The system consisted of four soda-lime trays, and a pair of oxygen bleed valves connected to 110 cu.ft. steel cylinders. Air was available for flushing the chamber or adding nitrogen, and activated charcoal was spread in the soda-lime trays to absorb organic impurities. The CO₂ and oxygen levels were monitored by means of Lloyds (1955) modification of Haldane's apparatus. Visiting divers were instructed to note any odours in the atmosphere on entering.

The carbon dioxide absorbers consisted of four polystyrene trays, approximately 18" x 30". The position of these is shown in Fig.1. The tray on the table was moved to the floor or on to a pile of other equipment at night, when it was usually about 9" above floor level. No circulatory pumps were used. Indicating soda-lime (B.D.H. Carbosorb) was used as the absorbent, and was stored in 500 g. bottles. Dampened cotton gauze smog masks were worn while the soda-lime was being changed, to avoid inhalation of dust, as during a preliminary "dry" run it was found that bronchial irritation was caused by dust, particularly if the soda-lime was handled carelessly.

The oxygen cylinders were standard B.O.C. medical oxygen cylinders. These could be cracked directly to atmosphere as required, or special bleed valves, provided by Normalair Ltd., could be used. The latter could be set at either 0.65 or 1.54 l./min.

Activated charcoal (B.D.H.) was normally spread thinly in one of the soda-lime trays.

RESULTS & CONCLUSIONS.

(c) 1) CO₂

During the dry run, which lasted from about 10.00 p.m. until about 4.00 p.m. the following day, the CO₂ content rose overnight to about 2.3%. It was then successfully lowered to about 1.2%. This required about 800 g/hr. of soda-lime, a change being performed nearly every 1½ hours (only 2 changes being performed overnight). During the course of this run, J.R.H., who was mainly responsible for the soda-lime changes, developed chest pains, and afterwards a slight bronchial murmur was noted on medical examination. As a result of this experience, smog masks were used on the actual dive, and greater care was taken to avoid raising dust. Although both subjects experienced slight discomfort on deep breathing at some periods during the dive, at no time were these sufficient to cause any anxiety.

The CO₂ absorption during the dive was barely sufficient. Although levels dropped slowly when both divers were asleep (Fig.2), exercise, cold or other divers entering the chamber rapidly raised the levels, on one occasion to

- (c) 2.2%, corresponding to about 36 mm Hg. The levels were normally kept around 1.5%, i.e. between 20 and 30 mm Hg. It was anticipated that high levels might be reached, and a watch was kept on possible subjective symptoms. One observation of interest was made. It was noticed that after a few days breathing appeared to become easier. This agrees with the observations of Schaefer (1963) on submarine personnel subjected to high CO₂ pressures. On returning from a 15 minute dive, however, breathing seemed much more difficult. This dyspnoea appeared to be present for several hours after the dive. However, as already noted, CO₂ levels tended to increase after dives, and it is, therefore, impossible without evidence from quantitative ventilation measurements to comment further on this.

2) OXYGEN.

The oxygen consumption cannot be discussed without reference to tidal pressure changes. As the tidal range resulted in a pressure change of about 10%, it is clear that in order to prevent flooding at high tide, large amounts of gas were needed, this gas being subsequently lost at the next low tide. Gas loss was minimised by allowing the bilges to flood at high tide, but, nevertheless, an estimated 80 cu.ft. were lost at each tide. As the gas leaving the cylinder contained approximately 16% of oxygen, and that entering contained 21%, to a large extent our oxygen requirements were met during tidal adjustments. On occasion oxygen was used to blow back the tide, rather than being bled in continuously.

On the dry run the great difference between night and daytime oxygen consumption was not appreciated, and because of this the oxygen level dropped to 17.9% on one occasion. During the actual run, however, the regulation of oxygen levels proved delightfully simple, and needed very little attention. However, on the last two days, when the oxygen levels were raised, first to 25%, and then to 35 and 40%, the limitations of the gas analyses became apparent - partly through poor technique, and partly through the design of the apparatus, which was intended for use with less than 25 to 30% oxygen, estimations of more than 28% oxygen proved wildly inaccurate. Once the correct technique was arrived at, mainly through trial and error, the greatest accuracy obtained was probably of the order of 1% - 1.5%. Duplicates then agreed to within about 1.5%. Fortunately this accuracy was more than adequate for the purpose, but proved confusing for regulating the oxygen supply.

3) TOXIC EFFECTS AND POLLUTION.

About 1½ Kg of activated charcoal was used over the entire week. Visitors occasionally noted a slight "painty" smell, or other less well-defined odours, but both subjects remained in good health throughout the experiment. Cousteau (1964) has noted that skin infections can occur in man living underwater, and we also noted this. However, this may have been due to the lack of hot water for washing rather than to the absence of ultra-violet light. We experienced none of the other physical or psychological disorders Cousteau's subjects experienced in his experiment "Diogene".

During the last stages of the hyperoxygenation procedure at the end of the week, at an approximate O₂ pressure of 70% ats. both subjects felt slight discomfort on deep breathing, possibly caused by the high oxygen pressure. As it was considered possible that any

congestion of the lungs produced in this way would cause type 2 bends, as described by Walder (1963), both subjects breathed deeply and held their breath a few times before ascent, in order to open up any atelactic areas in the lungs, as described by Buxton (1957). No symptoms of any type of decompression sickness were noted.

Two factors in the environment were quite noticeable. First, the fact that the temperature never rose above 16.2°C., and remained at about 15.4° at floor level, and second, the fact that the air was saturated with water vapour. Whether damp air is as harmful as is popularly supposed is open to question, but certainly a temperature of 16° in an environment where extensive exercise is not only undesirable (because of CO₂ production), but also limited by space, is most unpleasant.

4) GAS ANALYSIS.

In addition to the difficulties encountered when analysing oxygen-rich gas, three further problems arose. First, pressure changes, both those caused by the tide, and those caused by waves, made levelling off very difficult on some occasions. With the standard Haldane, which has one meniscus more to adjust than the Lloyd, analysis could easily have been rendered impossible. Second, the light was very poor, and made accurate work difficult. Fortunately, a large lamp was fitted for use with the television camera, and this ameliorated this difficulty to some extent. Thirdly, accidents happened. As the author is of a pessimistic turn of mind, spare reagents and mercury were available, and also flowers of sulphur to sprinkle on spilt mercury. However, an adequate supply of stopcock grease was not brought, and this caused some inconvenience.

5) DISCUSSION & RECOMMENDATIONS.

The main defect in the system was undoubtedly CO₂ absorption. Although considerable circulation was supplied by convection (as was shown by the fact that if a soda-lime tray was placed at ground level, little reaction took place), this was insufficient.

In any future experiment a circulation system is essential. This, of course, involves the use of a pump, and this is a problem. If an electric motor is used to drive it, care must be taken to avoid contamination of the atmosphere by ozone. Oil fumes must also be avoided - Tufnol bearings might be useful here. Ideally the air flow should be at least 100 l/min./ person. A counterflow system, arranging the older soda-lime absorbers at the inlet end of the system, would conserve soda-lime, which appears to absorb more sluggishly after a time. Fig.3 shows a possible arrangement, incorporating air drying (by refrigeration and condensation) and heating.

It was found more convenient to release oxygen straight from the cylinder than to use the bleed valves. However, such a system would be unsatisfactory for a semi-automatic set-up, where a bleed would be essential. A "basic" bleed, supplemented by additional taps for adjustment and periods of high oxygen consumption might be the best system.

A continuous monitoring system would be desirable. This could be supplied by the circulating pump, and consist of automatic analysers, possibly recording on a chart, and calibrated at intervals by known gas mixtures.

Insulation, heating and drying would add greatly to the comfort and efficiency of the divers. Refrigeration drying would be the best as drying agents such as silica gel could not cope with the enormous amounts of water involved.

Safety precautions will be necessary if a mechanised system is used. To guard against pump failure, soda-lime respirators should be available, and a chemical gas analyser should be available for periodic checking of the automatic system and for emergencies. The Lloyd apparatus is probably the most reliable, but it should be noted that the burette and ground glass cone closing the thermo-barometer space should be open except during analyses, or else pressure changes may cause mercury to be sucked over into the absorption pipettes, or reagents into the burette. A light, powered by batteries, should also be fitted for use in cases of power failure.

DECOMPRESSION.

By the end of the week it could be considered that all tissues were saturated to that depth though most tissues would be saturated after 6 to 8 hours. Thus, it was important that the personnel should not surface when outside the house, as this could produce a bend, the personnel being at a depth of 35 ft. for mean tide level (30 ft. low tide., 40 ft. high tide)., which was equivalent depth of 38 ft. for 15% O₂ and 83.5% inerts. In cautiousness the personnel did not pass more than ten ft. above GLAUCUS so that they were always more than 8 ft. deep, the possibility of bends would be very small.

At the end of the week the O₂ level was raised as shown in Fig.4 such that the equivalent air depth was 25 ft. It was considered safe to surface from this equivalent depth after remaining at a depth of 6 feet for a further 3 hours, though C.I. breathed an 80% O₂, 20% N₂ mixture for an equivalent of 3½ hours i.e. ¼ hr. on, ½ hr. off, ¼ hr. on, 1 hr. off., 1 hr. on, as described by Cousteau (1965) for an ascent from 35 ft. J.H., instead of breathing this mixture, planned to remain at a depth of 6 ft. for 3 hrs, though this was not possible as explained in "Ascent".

Fortunately, both personnel were found to be medically sound, suffering from neither type 1. nor type 2. bends, (the latter being mentioned under "Air Purity".)

However, although the hyperoxygenation procedure before ascent probably accounted for the absence of any symptoms of decompression sickness, it should be borne in mind that the procedures used were, because of the lack of facilities, somewhat arbitrary, and should therefore not be regarded as safe routines for subsequent similar dives. Further tables produced from extensive experiments in the laboratory would have to be used in any deeper experiments.

DIET.

Introduction.

Several peculiarities of the environment must be considered. First, because of the cold, much energy was used purely in keeping warm. In addition, any contamination of the atmosphere had to be avoided. It was also considered that the lack of U.V. radiation might cause a shortage of vitamin D, which would have to be supplied purely from the diet, and in addition, the high CO₂ pressure might affect Ca and PO₄ metabolism, (see Schaeffer, 1963), which is affected by vitamin D.

It has been estimated (Bell, Davidson and Scarborough, 1963) that the average man eliminates about 500 ml/day flatus. Although, even in the enclosed space, this would not be too unpleasant, as the sense of smell adapts rapidly, it could be dangerous, as many of the gases eliminated are poisonous. This demands adequate air purification, and measures to discourage production of flatus.

Fried food has been reported (Bond, Quoted in Skin Diver, 1964), to liberate considerable quantities of acrolein. Although this was not considered important for the depth and duration of the experiment, fried food is not particularly digestible, and so was avoided.

Techniques.

All food was fairly plain and easily digestible, to discourage intestinal fermentation. For the same reason, legumes, which contain large quantities of tryptophan, were omitted from the diet. A high calorie intake was to be maintained by the ample provision of carbohydrate. A level of about 3000 Kcals/day being aimed at. The menus were prepared by Mr. J. Bavin, an experienced hotelier, and the food was cooked by the current ground crew, who delivered it in watertight food containers. As indicated elsewhere, activated charcoal was used to absorb atmospheric contaminants.

Results.

Many practical difficulties were found with the diet. Most of these were encountered by the ground crew, who had to cook the meals under unpleasant conditions, and deliver them under equally unpleasant diving conditions on many occasions. Meals were, therefore, often late, sometimes cold, and occasionally soaked in sea-water. The divers supplying the house sometimes also omitted to bring cutlery. However, the meals were adequate, and usually hot. No pollution problems were encountered, and all divers visiting the house reported the air to smell reasonably sweet. (This was the more remarkable as no hot water was available for washing.)

Recommendations.

It is essential for any more elaborate project that all food is cooked, or at least, heated, in the house itself. This requires an adequate storage space, power for heating and possibly cooking, and a supply of hot water which can be used for washing up and making hot drinks. A simple immersion heater setup, on a slightly larger scale than a domestic kettle, would supply the latter, and it would be possible to make a water-jacket apparatus for heating pre-cooked food. Little trouble, apart from an adequate power supply, is anticipated.

PSYCHOLOGY.

Cousteau, during the Diogene experiment, and the American Navy, in their Sealab 1 experiments, remarked on changes in the psychological condition of their subjects.

Cousteau observed quite severe abnormalities, including intense depression, nightmares, and a recalcitrant attitude towards the surface personnel. He also described a rather vague feeling of "one-ness with the sea", which his divers experienced.

The American Navy noted less severe symptoms, but still noted a dislike for orders from the surface which gradually developed over the experiment.

The authors are inclined to consider that these reports have, perhaps, been coloured by the fact that both these investigations have included psychologists anxious to observe any changes. Although we experienced some differences of opinion with the surface personnel, these differences were perhaps less than experienced between some of the surface crew themselves, and certainly no more than would have been expected under the somewhat arduous conditions. We were also more pre-occupied with the immediate discomforts of cold and damp than with any mental reactions. We did, admittedly, get some exhilaration, as from any novel experience.

In addition to the reason given above for the lack of any notable psychological reaction, there may be two more. Both of us have been diving together for 5 years, and both were determined to stay down for the full week, other factors being favourable. However, it can not be assumed from this result that future experiments of longer duration and harder work, will produce mental disturbances, although this is not considered a major problem to be overcome.

ACKNOWLEDGMENTS.

We wish to thank Royal Naval Physiological Laboratories, (and in particular Dr.E.Elliot), for the use of their library. Also the Navy at Plymouth who made it possible for us to carry out the experiment from their property, and the Diving School at H.M.S.Drake who provided medical observation.

The ground crew should be thanked at this point for the many hours of arduous work they put into the project; also the following firms:-

1. Marconi.
2. Bolson & Son of Poole.
3. British Oxygen Company.
4. Draeger and Normalair.
5. International Paints Ltd.,
6. Millbay Docks.
7. Willoughby's of Millbay Docks.
8. British Road Services.
9. Reynolds Tugs.

as well as those members of the Bournemouth B.S.-A.C. who worked on the project before and after the experiment.

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GLAUCOUS PROJECT 1965

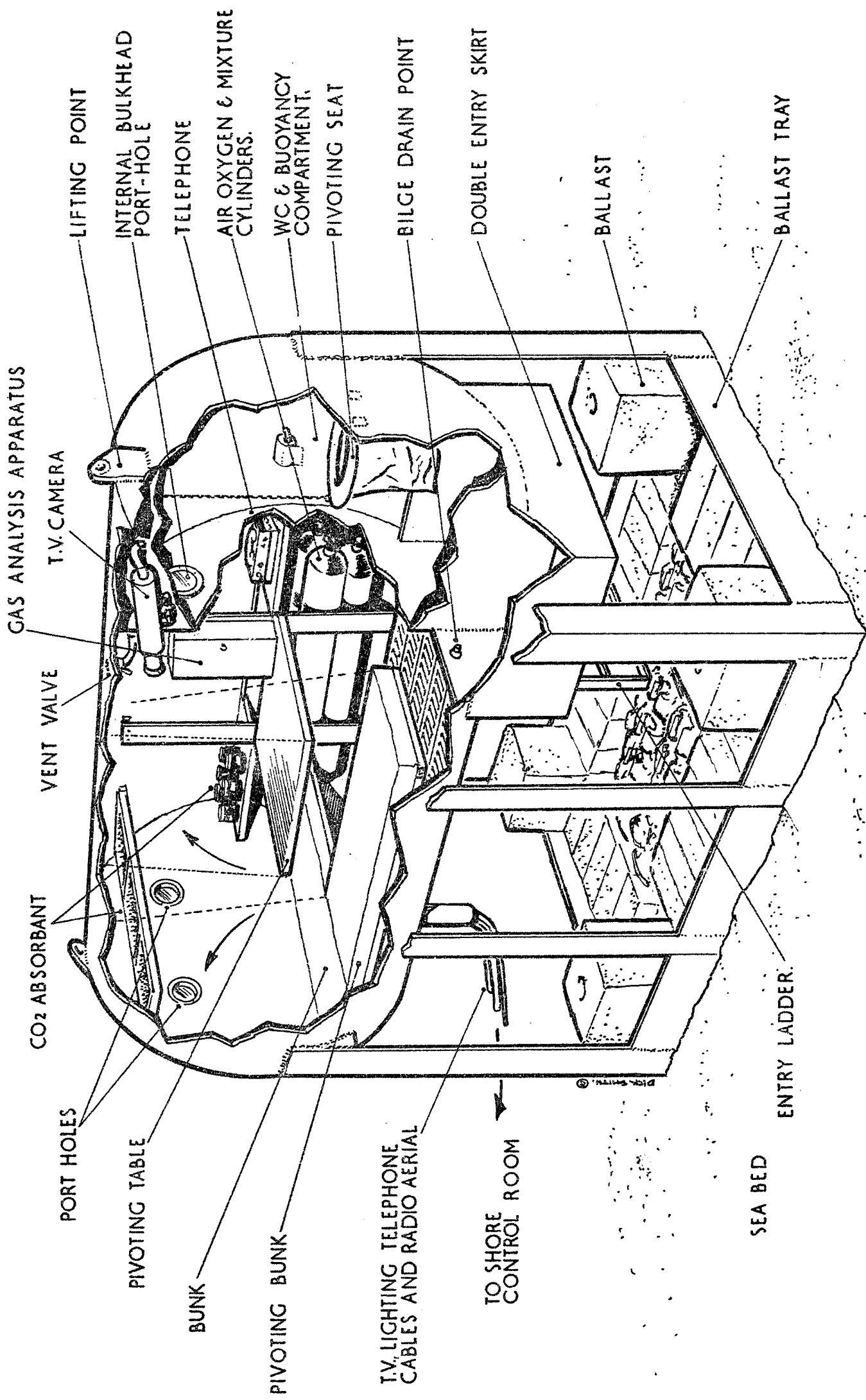


FIGURE 2

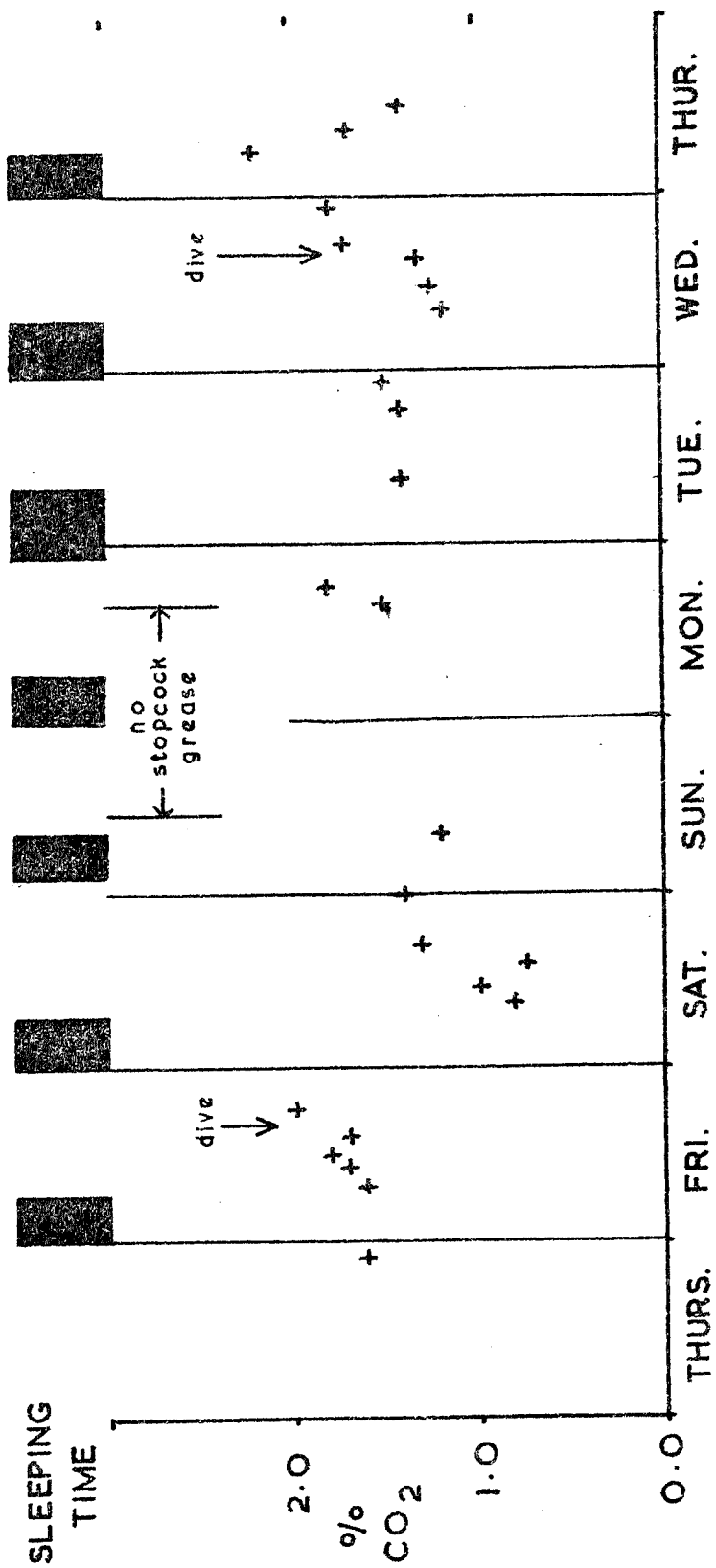


FIGURE 3

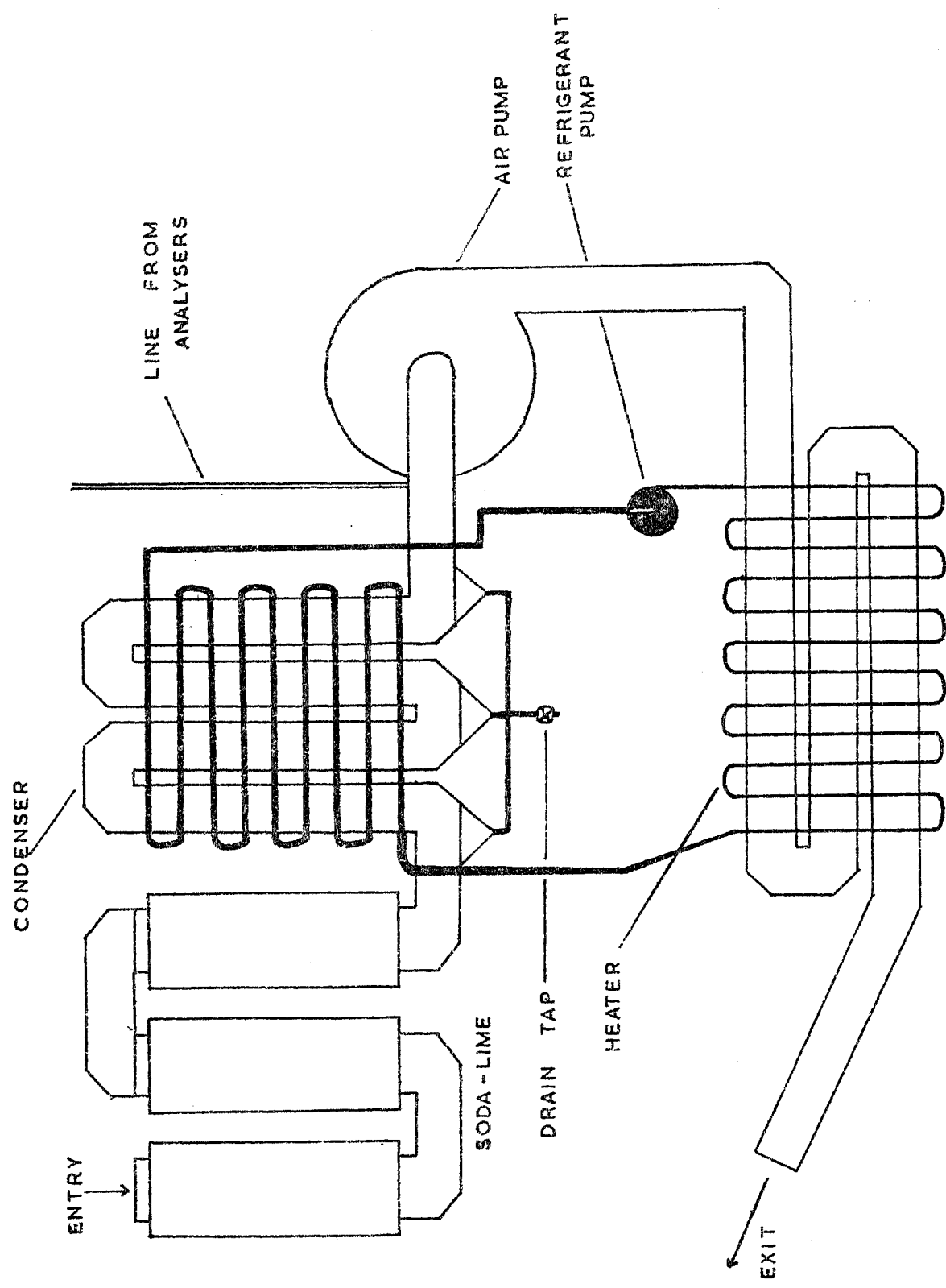


FIGURE 4

