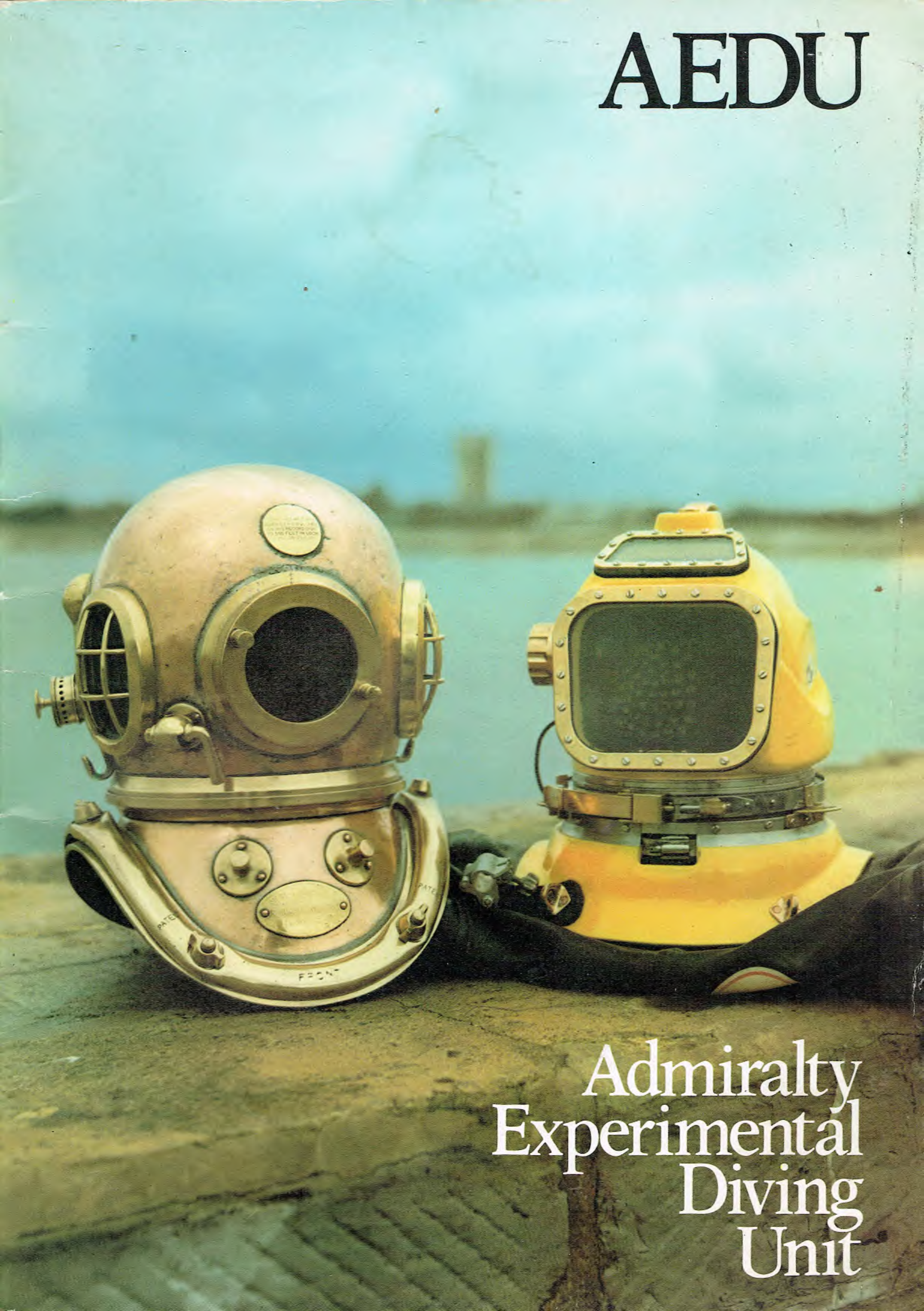
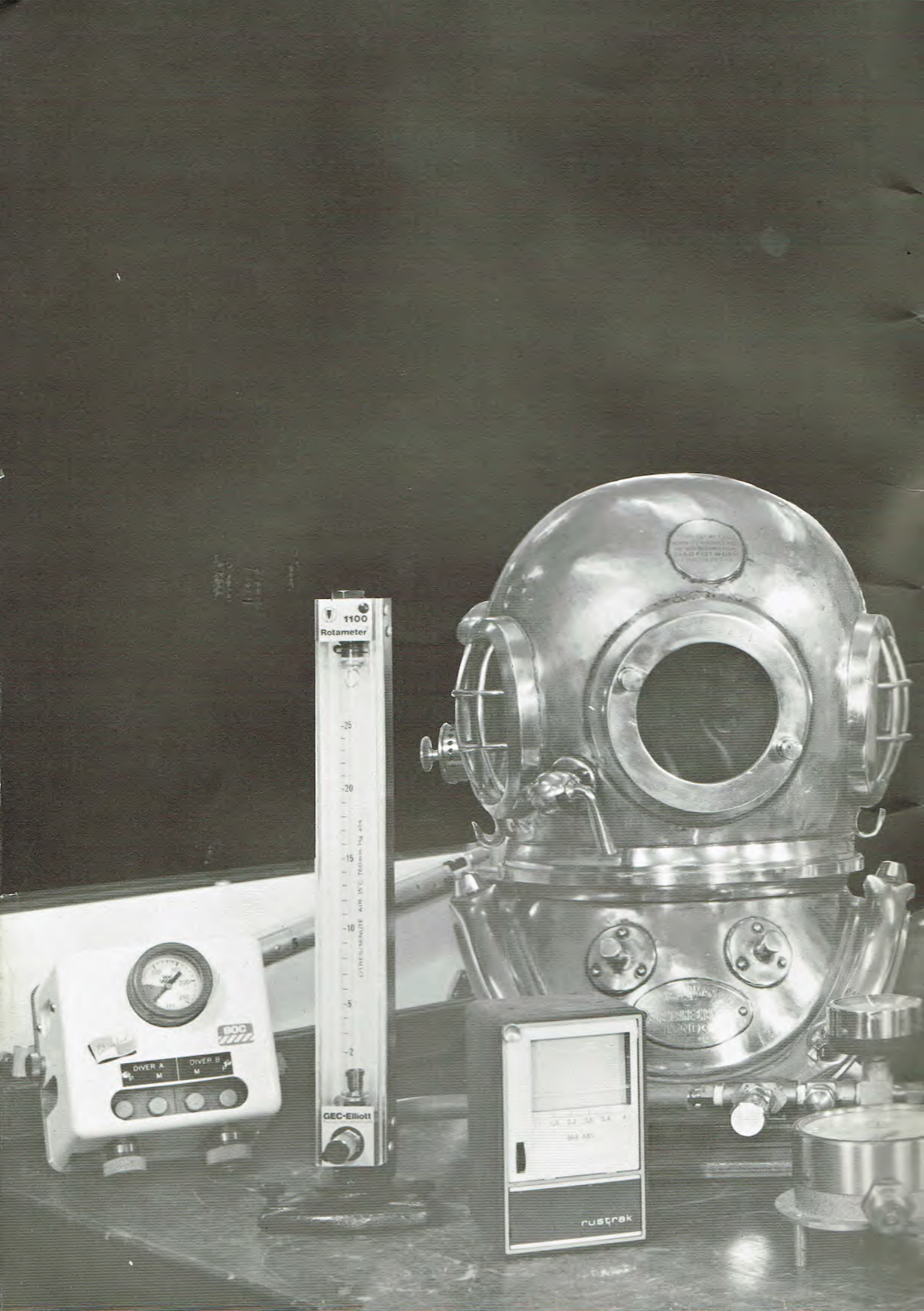
AEDU



Admiralty Experimental Diving Unit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Admiralty Experimental Diving Unit

AEDU

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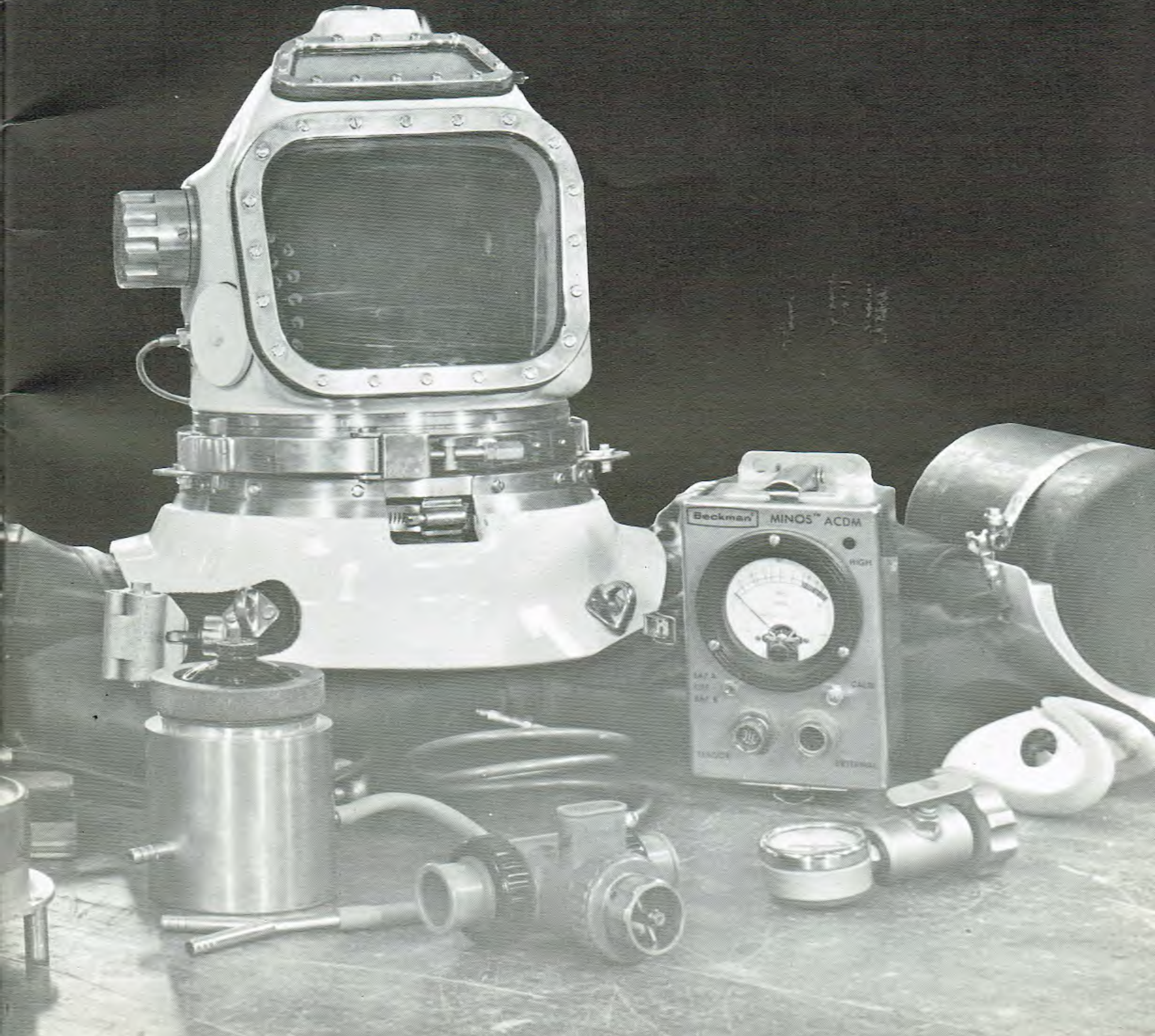


Background to AEDU

The Admiralty Diving Committee was formed in 1943 to meet the problems posed by port clearance parties and by submarines. They in turn recommended the formation of the Admiralty Experimental Diving Unit. This was staffed by naval uniformed and scientific personnel and doctors who began work in the factory of Siebe Gorman & Co. Ltd., the diving equipment firm.

The organisation was wisely kept in being when the war ended and, after an intermediate move to Brixham, settled at HMS VERNON in 1945 under the Superintendent of Diving.

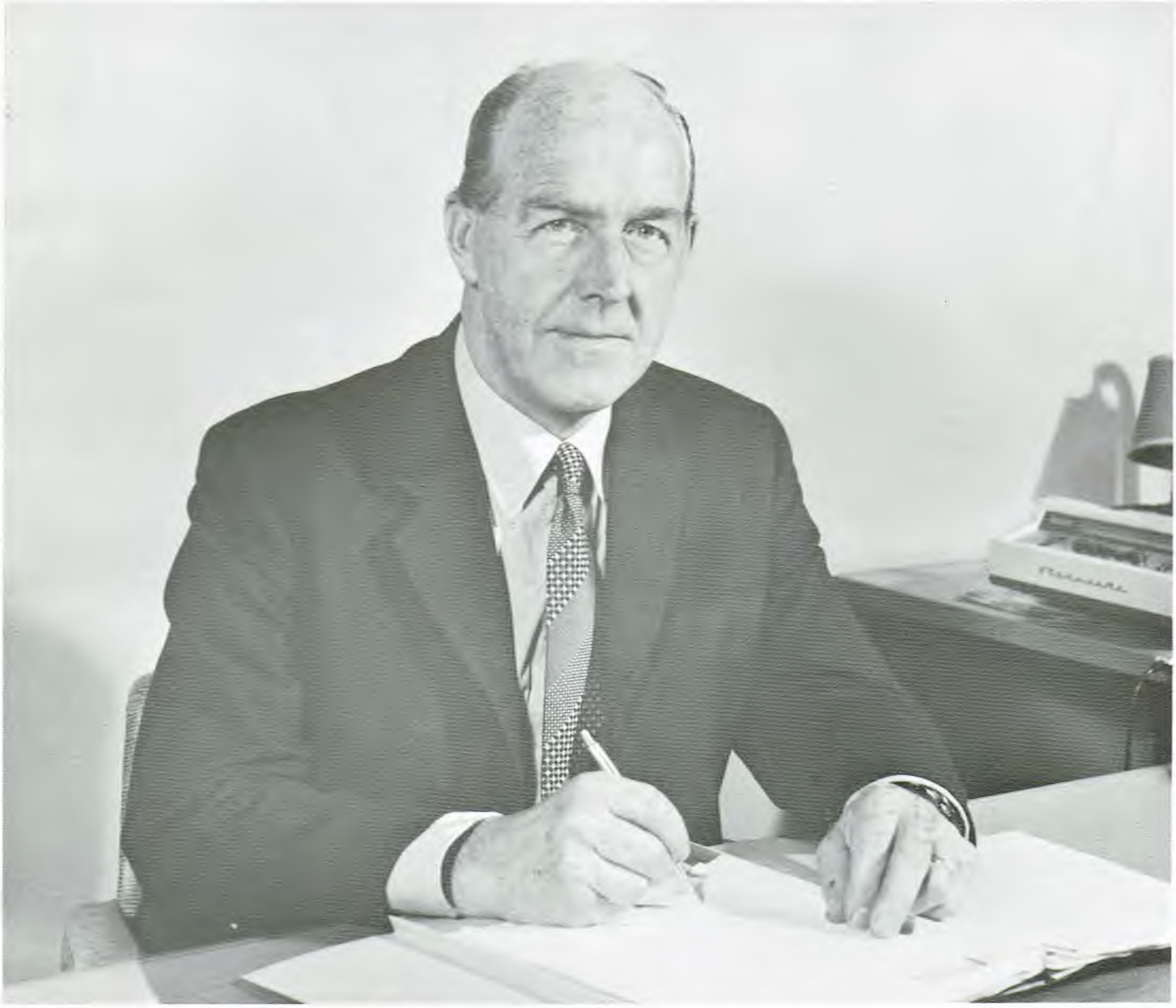
Following re-organisation in 1967 in the departments of the Director General Weapons (Naval) the AEDU was rationalised to bring the diving techniques and equipment research and development performed by the AEDU under the control of the Director of the Admiralty Underwater Weapons Establishment at Portland.

The Unit continues to be located within the boundaries of HMS VERNON but is an outstation of AUWE. The staff consists of civilian and uniformed personnel under the direction of the Officer in Charge, a senior principal scientific officer.

The Superintendent of Diving is also located in AEDU.

"Human Torpedo under way"—a 1944 photograph.

Meet our officer in charge



K R HAIGH, MSc, C. Eng, FIMechE, FIEE, MIERE.

Mr K R Haigh joined the Royal Navy Scientific Service during 1952 and was employed on the design and development of anti-submarine equipment. Later he was engaged on oceanographic research and spent considerable time at sea in research vessels all over the world. Between 1968 and 1970 he was an exchange scientist at the US Naval Oceanographic Office. During this period he was a member of the six-man crew of the submersible "BEN FRANKLIN" during the Gulf Stream Drift Mission which took place in 1969. On his return from America he was appointed to AUWE, Portland, and in 1972 became the Officer in Charge AEDU. He is a past Chairman of the Council of the Society for Underwater Technology and in recognition of his service to SUT he has been elected an Honorary Vice-President. He sits on many national and international committees concerned with diving and underwater matters, among which are the Advisory Board of the Fort William Underwater Training Centre and the UK Health and Safety Executive inter-departmental working party on the rationalisation of diving legislation. A particular interest is the safety of underwater electrical equipment for which a code of practice is currently being prepared. He has written many papers on underwater matters and holds several patents in the field.

Responsibilities

The Admiralty Experimental Diving Unit is responsible for research into all aspects of diving material, the development of diving systems and equipment, breathing sets and associated gear, inclusive of physical safety.

The activities cover:

Life support systems including divers' breathing units, clothing and suits, the standardisation, supply storage and test of breathing gases and associated equipment, as well as breathing units for fire-fighting, damage control and submarine escape purposes.

Diving systems including the provision of divers' tools for use in underwater ship husbandry and seabed tasks, compression chambers, diver monitoring, navigation and tracking sub systems with particular reference to the physical and general comfort of the divers.

The formulation and carrying out of a deep diving experimental programme covering other than the physiological aspects which are the responsibility of RNPL.

Evaluation of commercial and foreign diving equipment.

Advice and assistance to other Government departments with diving interests.

Inter-departmental and industrial co-operation

A very large proportion of the work undertaken in AEDU is entirely military unclassified and is directly applicable to commercial diving. This is particularly so in the case of saturation diving where the RN technique is no different from that of the commercial world; many of the divers operating in the North Sea are ex-RN personnel.

The expertise available has been utilised by the following Government departments:

Department of Energy

Currently four joint projects are under way in the diving field. These cover breathing apparatus with an associated integrated diving suit, development of underwater tools and studies on the safety of electrical equipment underwater. These projects have been jointly funded, with AEDU retaining the technical control of the contracts.

Arrangements have been made for the Petroleum Engineering Department to use the services and facilities of AEDU for the inspection of diving equipment involved in any accident being investigated under current legislation. The Chief Diving Inspector recently appointed is an ex-member of the AEDU staff.

Health & Safety Executive

The AEDU has for many years provided the technical expertise required for the examination of diving equipment as called for by the Health & Safety Executive and its predecessor, the Factory Inspectorate.

Training Service Agency

The AEDU, together with the Superintendent of Diving, provided a very strong input to the Task Group and Working Party set up to study diver training and are now both represented on the Advisory Board to the Fort William Underwater Training Centre management.

Facilities

In order to carry out its responsibilities in research and technical support to diving, extensive facilities are available in the AEDU'S main building. These include laboratories for equipment tests and trials which necessitate such items as a breathing machine, O_2, CO_2 analysers, freezing equipment and ovens: a facility for testing oils and greases used with various HP gas mixtures: a small compression chamber for items to be pressure tested to 305 metres: a range of flow recording instruments, and various bench testing equipments to enable full performance parameters to be achieved.

In addition there is a laboratory for the production of prototype items with facilities for rubber dipping, fibre glass and harness work, suit-making and general fabric work. A trials tank capable of being chilled to freezing or heated to tropical temperatures is situated on the ground floor and is normally used for initial testing of equipment. A fully equipped engineering workshop and stores together with domestic and workshop facilities for a trials team of divers completes the ground floor of the building.

Main offices and conference room are accommodated on the first floor.

Drawing office and bookwriting facilities, together with the electronic laboratory and further offices complete the second floor of the building.

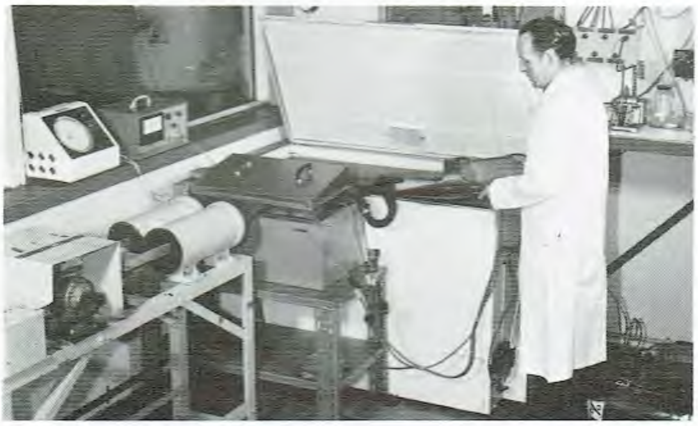
Other main facilities include a 10 metre diameter 20 metres deep trials tank and a hyperbaric chamber system in which wet or dry saturation dives can be simulated to 300 metres. This Deep Trials Unit is situated in the grounds of the Royal Naval Physiological Laboratory at Alverstoke, Gosport, Hants.

Environmental Trial of a Deep Diving Breathing Apparatus.

Main Laboratory.

An instrumented Windak Mk. 5C undergoing evaluation on the diver. The parameters being measured are oxygen uptake/carbon dioxide production from a diver swimming against a known weight.

Interior small tank facility.



AEDU trials tank

Anyone visiting HMS VERNON or its neighbourhood at any time since 1917 cannot have avoided seeing that dominating feature, the Mining Tank, now the AEDU's Diving Trials Tank. With its grey, steel clad working platform towering 94 ft high over the VERNON walls, it resembles a giant water storage tank, which of course it is—55 feet of captive fresh water in a riveted steel cylinder supported by a steel gantry, topped by a rectangular work-top with all "mod cons".

Originally supplied by the USA in World War I to help resolve married failures in the North Sea mine barrage, the tank served the Royal Navy mine designers well until the concentration of underwater weapons work at Portland in 1959. Many generations of mines were proved and improved by trial launches into the tank, coming to rest on the "mat" to be observed through the ports on the various deck levels. In 1943 and 1944 the newly captured Italian oscillating mine was put through its paces in the tank, sinking on launch until its electrically adjusted displacement plunger gave it buoyancy to rise again, only to gently sink from 2 metres depth and oscillate between this datum and 5 metres until the batteries ran down; a nasty fish to meet in the placid channels of the tideless sea.

When the tank passed into the administrative care of the Officer in Charge AEDU, a major refit was put in hand, the now little needed mine rails were removed, though a set was preserved on a portable base and stowed away. Changing rooms and shower facilities were built in, and a diving compression chamber with two compartments was incorporated. New lighting has been installed and the tank can now provide excellent trial service for any underwater equipment which requires the chance to operate in water down to 50 ft.

What are the "vital statistics"? The diagram gives a slightly compressed impression of the installation. Briefly, a column of sea water 55 ft high and 30 ft diameter is housed in a white painted tank. The water is constantly filtered and has a visibility of about 30 ft. The top 10 ft can be heated by steam injection. High pressure air is available at 4,000 psi and the compression chamber has a maximum depth of 200 ft.

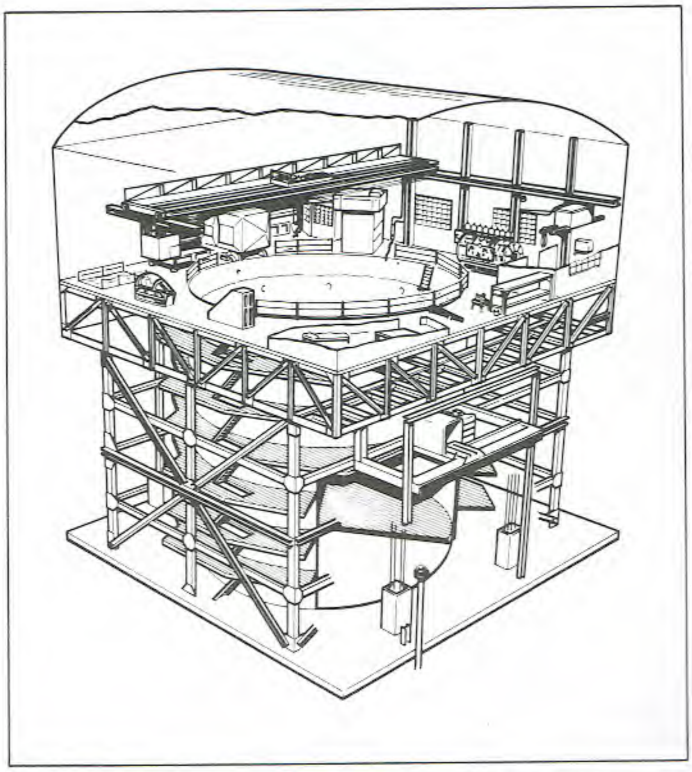
A moving platform, "the mat", covers the whole base area and can be moved and lowered under control to any depth, or to the bottom. Alternatively, equipment may be lowered, launched, dropped, or fired into the water, observed or filmed on its performance either from outside through the ports or by diver swimming with the apparatus.

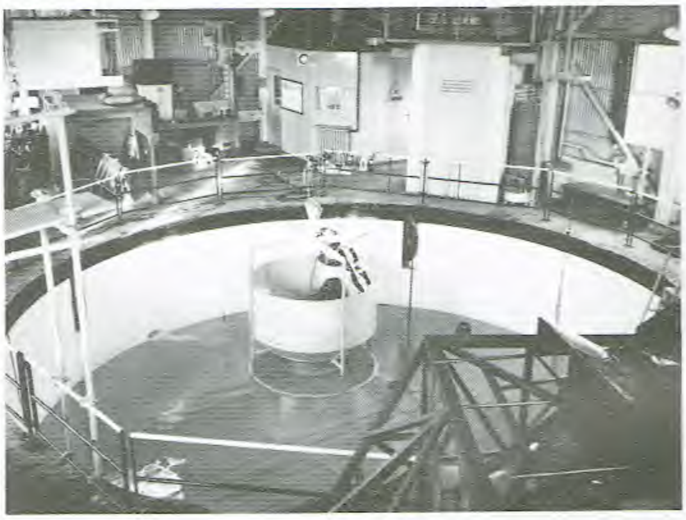
External lights are available on the ports at choice and the scuttles are spaced every 10 ft on each of the six floor levels. Staff divers, underwater photography and closed circuit television are available, and any additional instrumentation can be imported by the user.

A six-person lift makes access easy and a 2-ton travelling crane raises heavy equipment through an access hatch, from ground or lorry level.

The tank is available for use by all concerns and has been loaned to a number of industrial concerns engaged on Government contract. Industrial companies may hire the facility to prove or test their own products.

Applications for use should be made to the Officer in Charge AEDU, C/O HMS VERNON, PORTSMOUTH, PO1 3ER.





Layout of interior working area.
Submersible Compression Chamber Training Module.

Aircrew underwater escape training

A "staple diet" of recent years is the routine training of fixed wing and helicopter aircrew in ditching drill. A mock-up cockpit and "chopper" cabin have been installed, and realism is added by a gearing which turns the cabin over on entry to simulate the helicopter motion on entering the water. This training was extended to include RAF Search and Rescue crews. Its value has been proved over and over and now courses have been programmed to include North Sea oil company staff who regularly use helicopters for visiting oil rigs in the North Sea.

The aim of the course is to give confidence, overcome fear and demonstrate that properly trained aircrew can make their escape from the most difficult of situations.

Helicopter aircrew are briefed fully on the danger of disorientation and have to escape from the module in a variety of situations. It is important that they should remain strapped into their respective seats until all movement ceased and then make their escape. This takes approximately 10 seconds to accomplish. Divers are in a position within the module to assist in the event of an emergency.

The tank can be darkened to simulate moonlight conditions. By the end of 1975 over 17,000 persons had completed the Underwater Escape Training Course.

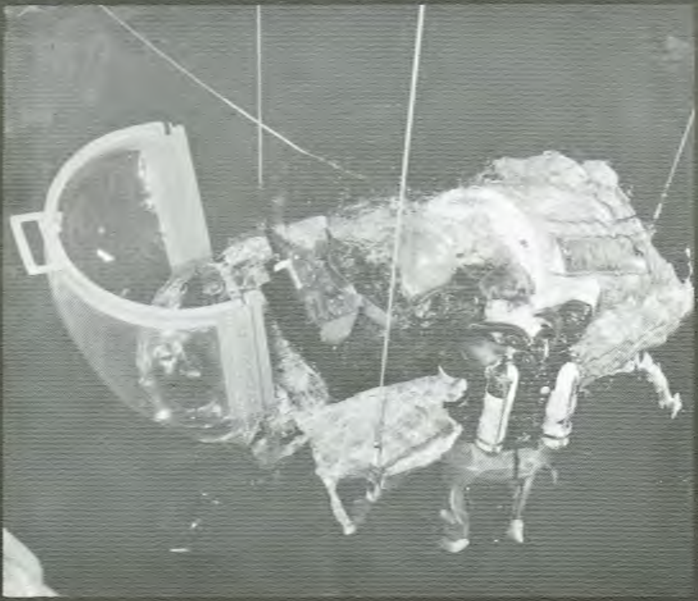
Application for training in helicopter underwater escape training should be made to:

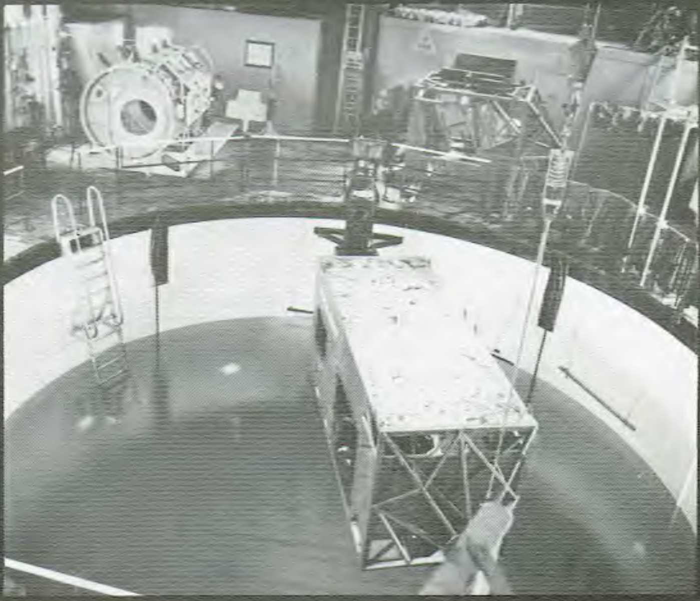
The Officer in Charge, Royal Naval Safety Equipment & Survival School, MOD (Navy) Establishment, Seafield Park, Hillhead, Fareham, PO14 2DJ

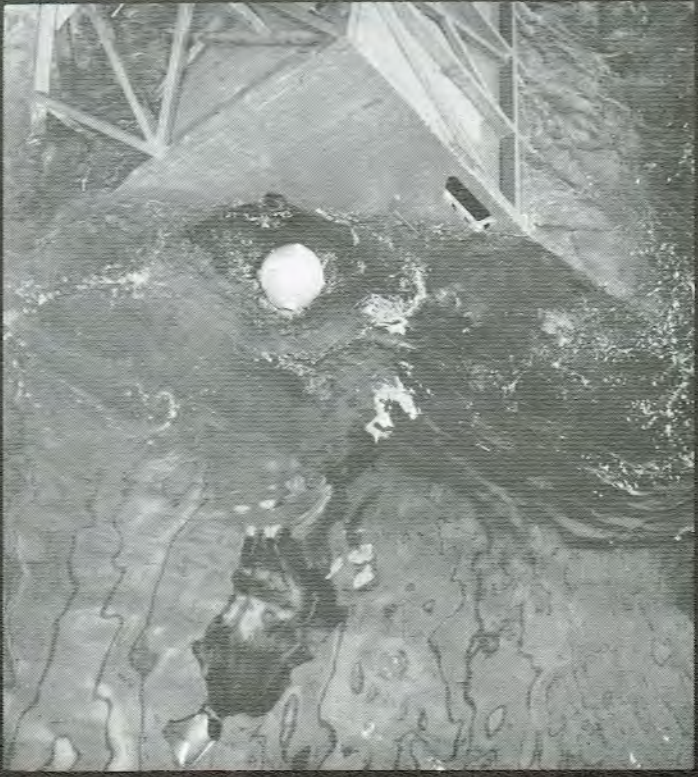
or

Petroleum Training Association North Sea, "Mayfield", Hoby, Melton Mowbray, Leicestershire.

1. "Dunker" ready to roll. *2. Point of escape.*
3. Pilot leaving the cockpit. *4. Fixed wing trainer.*







Deep trials unit statistics

Depth Capability
300 metres (986 ft of sea water).

Chambers

Diving Chamber
23′ 6″ vertically, 10′ diameter. Water depth 10-12 ft. Water temperature control 32°-86°F. Bacteriological and sediment filtering. Safety platform to surface divers in an emergency. Swim ergometer and weight-lifting Divers' gas supply panel. Full atmosphere conditioning.

Compression
13′ long 6′ diameter. Fitted with bunks, heating, cooling.

Chamber (Deck Decompression Chamber)
Full atmosphere conditioning.

2 in No Manlocks
6′ x 6″. 1 Manlock is normally kept at the surface to send assistance to the divers, if required, and the other is used for ablutions.

2 in No Handlocks (Medical Locks)
18″ x 12″. 1 Handlock is used exclusively for meals.

Three divers can be operated with reasonable comfort and complete safety at any one time both from the living and operational aspects. During dive sessions two of the divers are operative in the water while the third acts as attendant from the dry section of the diving chamber. By changing round at regular intervals the full value from three divers is achieved.

Control
Depth is controlled to less than $\frac{1}{2}$ metre by master gauges which are calibrated before each trial series. Rate of ascent/descent is controllable between rates 0-300 metres/Min.

Gas supply to divers and/or any oxy/helium mixture. The CO_2 content of the chambers is maintained at less than 0.05% of 1 Atmosphere and any prescribed PO_2 can be adhered to although from the fire risk aspect this is never allowed to increase above 25% of 1 Atmosphere.

Monitoring
All chambers are continuously monitored for PO_2, CO_2 humidity and temperature. EEG, ECG and other physiological parameters can be recorded if required.

Closed Circuit TV Coverage
of diving and compression chambers is continuously available.

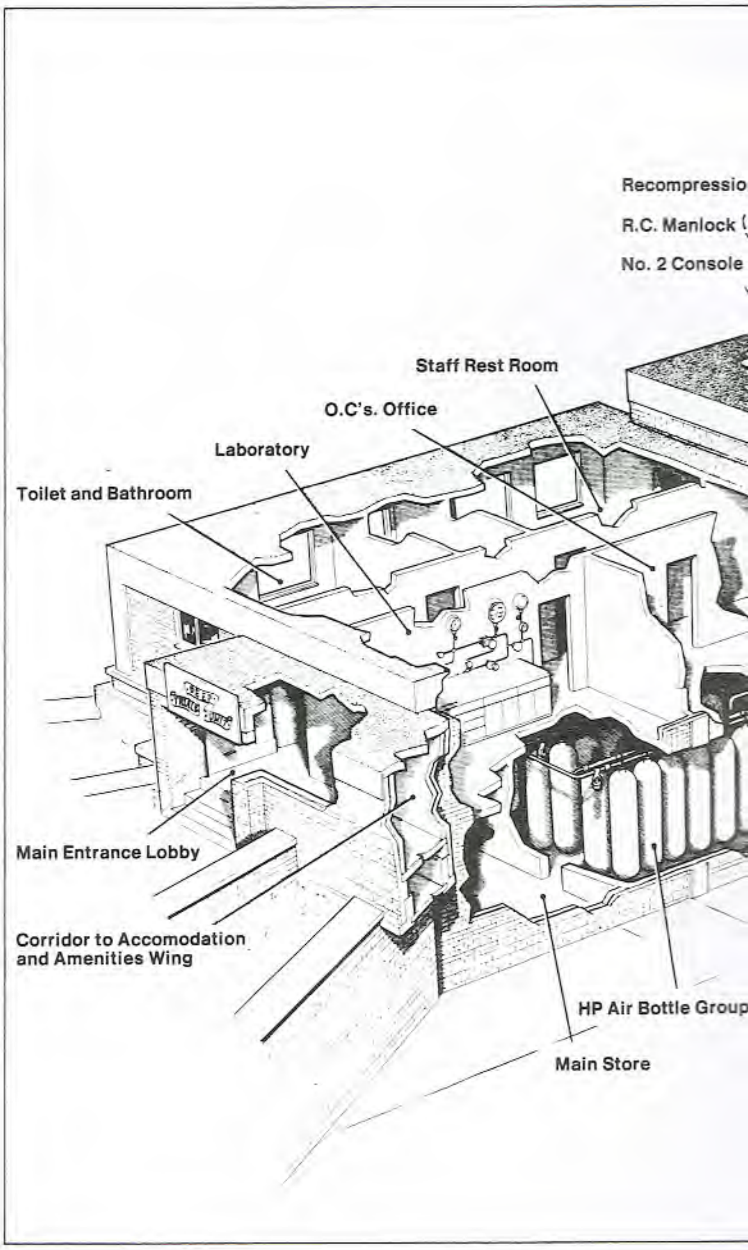
Communications
Two-way communication is available between the control and all chambers. Helium voice unscrambling is installed and functions to the maximum depth. An underwater speaker directs the divers whilst on task.

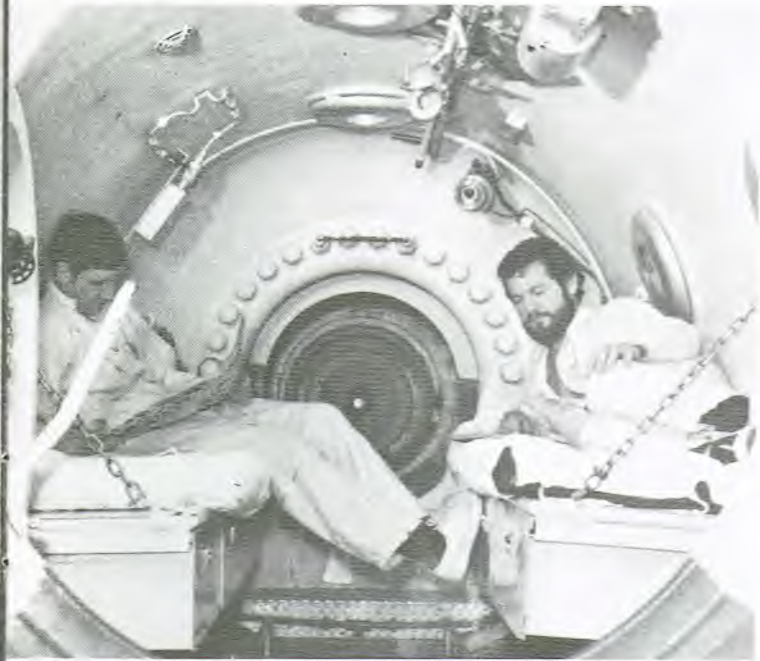
Access Doors
Five, 2′ 6″ diameter, two-way quick acting doors provide access to the chambers and locks. One overhead conventional strong-backed eliptical (3′ 11″ x 2′ 9″) hatch is used for loading equipment into the diving chamber using a $\frac{1}{2}$ ton lift and traverse.

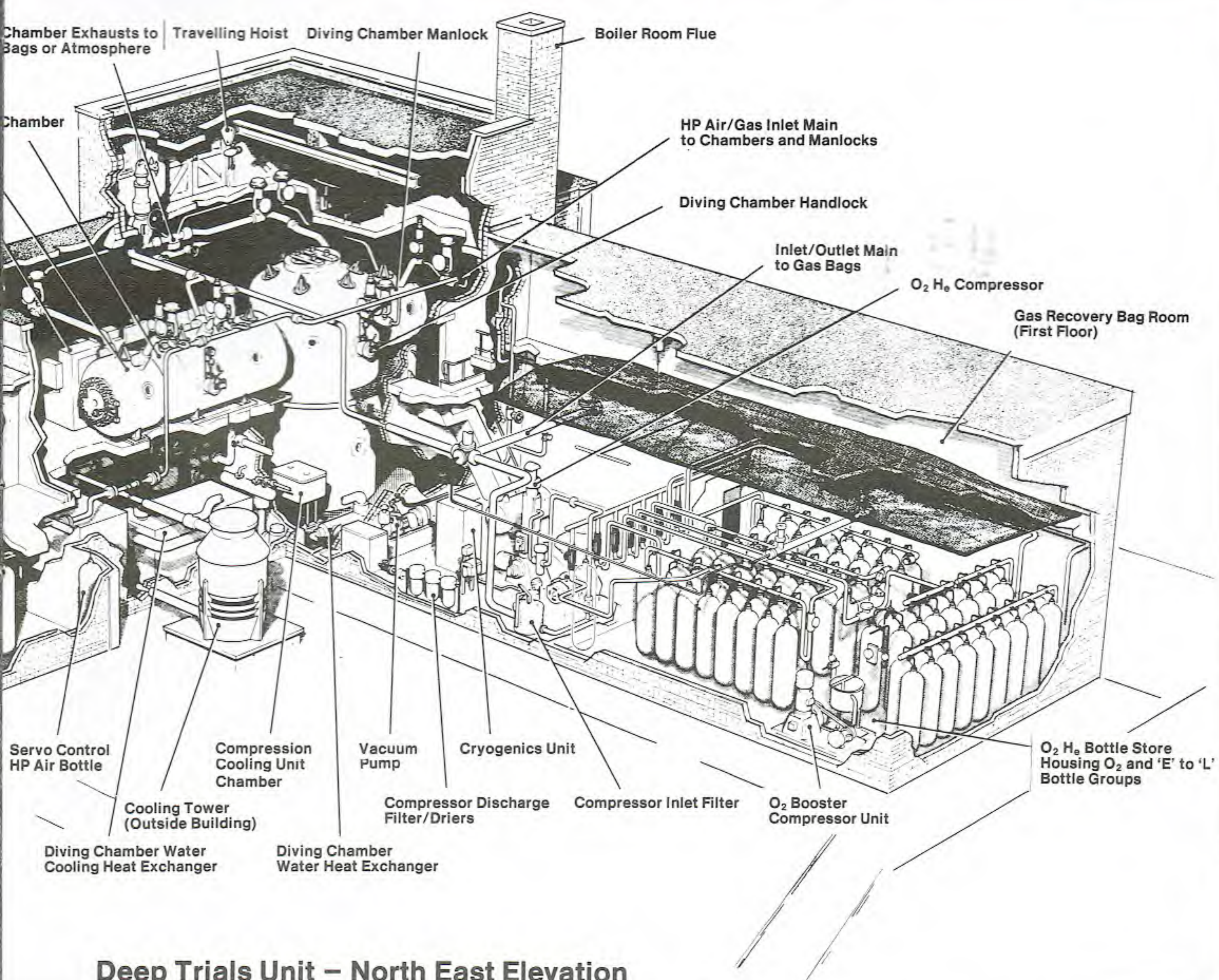
Entertainment
For dives involving long decompression times, radio and live TV programmes are available to the divers.

Domestic Support
Full house-keeping facilities available to support up to 12 divers outside the pressure complex.

The control consul during recent deep trials.
Interior of the living chamber.
NE elevation drawing of deep trials unit.







Deep Trials Unit – North East Elevation

Diver ship maintenance

Diver Ship Maintenance has gradually evolved, largely by the expertise of divers themselves who from time to time have been able to make emergency repairs to ships in the absence of dry docking facilities. Traditionally, the clearing of fouled screws and blocked inlets has been done for many years but the increased mobility given to divers by self-contained equipment made it obvious that there was very much more that they could do. Some of the earliest efforts were devoted to the exchange of sonar domes underwater, and now an appropriate dome exchange outfit for use by divers is an integral part of each new hull outfit.

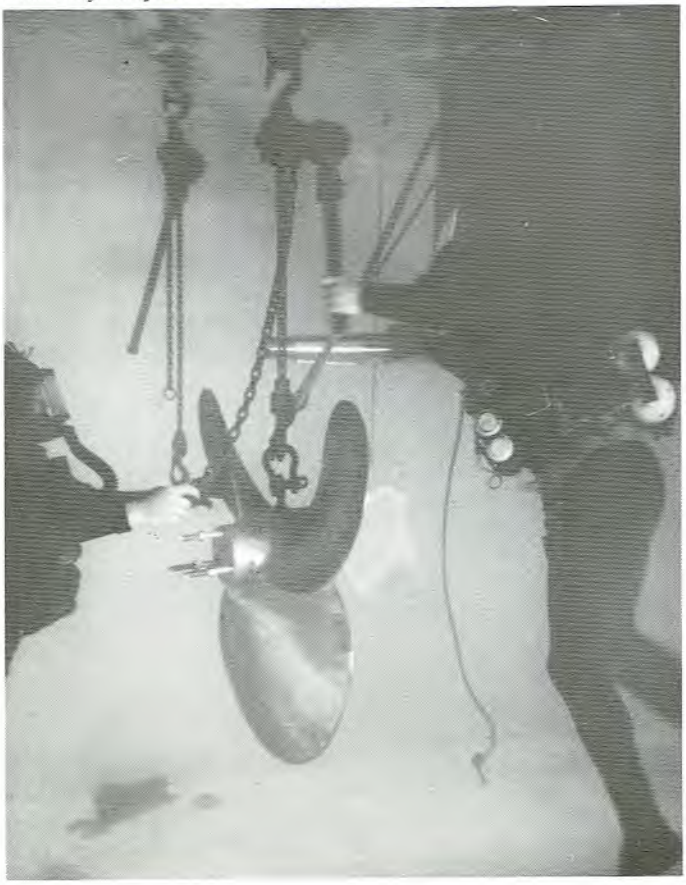
Submarine propeller changing came next and is now a well-established technique which can be carried out by local diving teams. AEDU has continued experimental work to expand the range of underwater tasks to include the exchange of the much larger propellers on destroyers and frigates. Special pneumatic tools modified to ensure that no seawater enters the mechanism have been provided to assist in this work.

A variety of hand power tools is used to assist in numerous lesser jobs carried out by divers. These tasks include propellor changing on coastal minesweepers, transducer exchanges, removing welded rope guards to clear fouled propellers, roll damping fin changes, the fitting of blanks on inlets to enable work to be done inboard, cleaning and dressing propellers, cleaning sonar domes, replacement of stabiliser fairings on frigates, replacement of damaged logs and inspection and reporting prior to dry docking.

Research has also been carried out on underwater painting using pressurised brushing techniques. The paint with a water displacing agent was used for localised repairs of damaged paint work.

Propellor change.

Neutrally buoyant hull scrubbing brush.

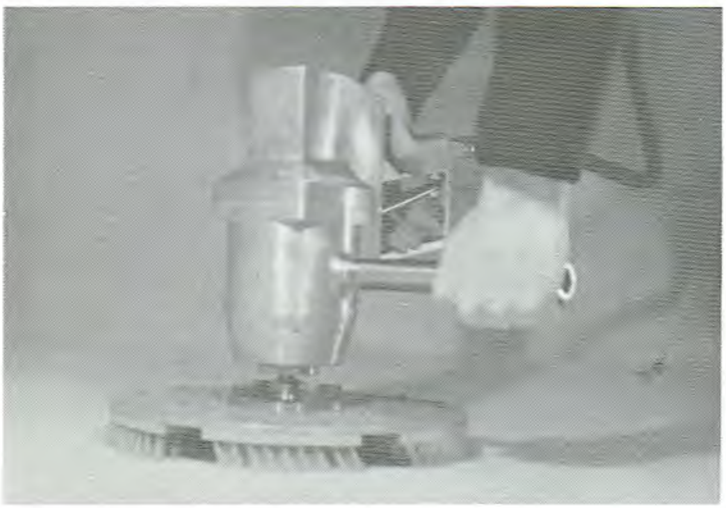


Dressing a propellor with u/w grinder.

Underwater tools

Hydraulic power tools have the advantage of operating with a non-compressible working fluid, which allows their operation at greater depths, unlike pneumatic tools which are limited to approximately 50 metres by increasing gas supply and back pressure. Power tools operated in conventional manner using hydraulic oil as the working fluid have the advantage of long life and efficient operation but the disadvantage that a supply and return umbilical to the tool is required and should the hydraulic oil leak and contaminate any of the diving equipment or chamber system then a possible fire risk could arise.

Submersible electro-hydraulic power unit with tools manufactured by J & S Pumps Ltd.



Underwater air driven scrubber.
Underwater hydraulic drill.
Seawater-driven hydraulic tool.

Seawater driven hydraulic tool

If seawater is used then this danger is removed and as a bonus the hydraulic system is simplified since no return line is required for the motors and many sealing problems are removed. This also results in a smaller and more easily handled unit. Development of a range of underwater tools operated on seawater is now in progress. The work is under MOD(N) sponsorship and is being carried out by the National Engineering Laboratory (NEL). The object is to produce a low cost system with a relatively short design life accepting regular replacement of heavy-wear components.

Accident investigation

A necessary and important part of AEDU's work involves the testing of equipment following a diving accident. This service is carried out on request, and normally without charge, for both service and civilian authorities. The Health and Safety Executive, the Department of Energy and local Police Forces are among those who have taken advantage of the service.

The Unit carries out a thorough examination of the equipment, issues a report and provides the services of an expert witness if required for any subsequent Inquest or fatal accident Inquiry. This applies to anywhere in the United Kingdom and to date court appearances have been made in places as far afield as Anglesey and Lerwick in the Shetlands.

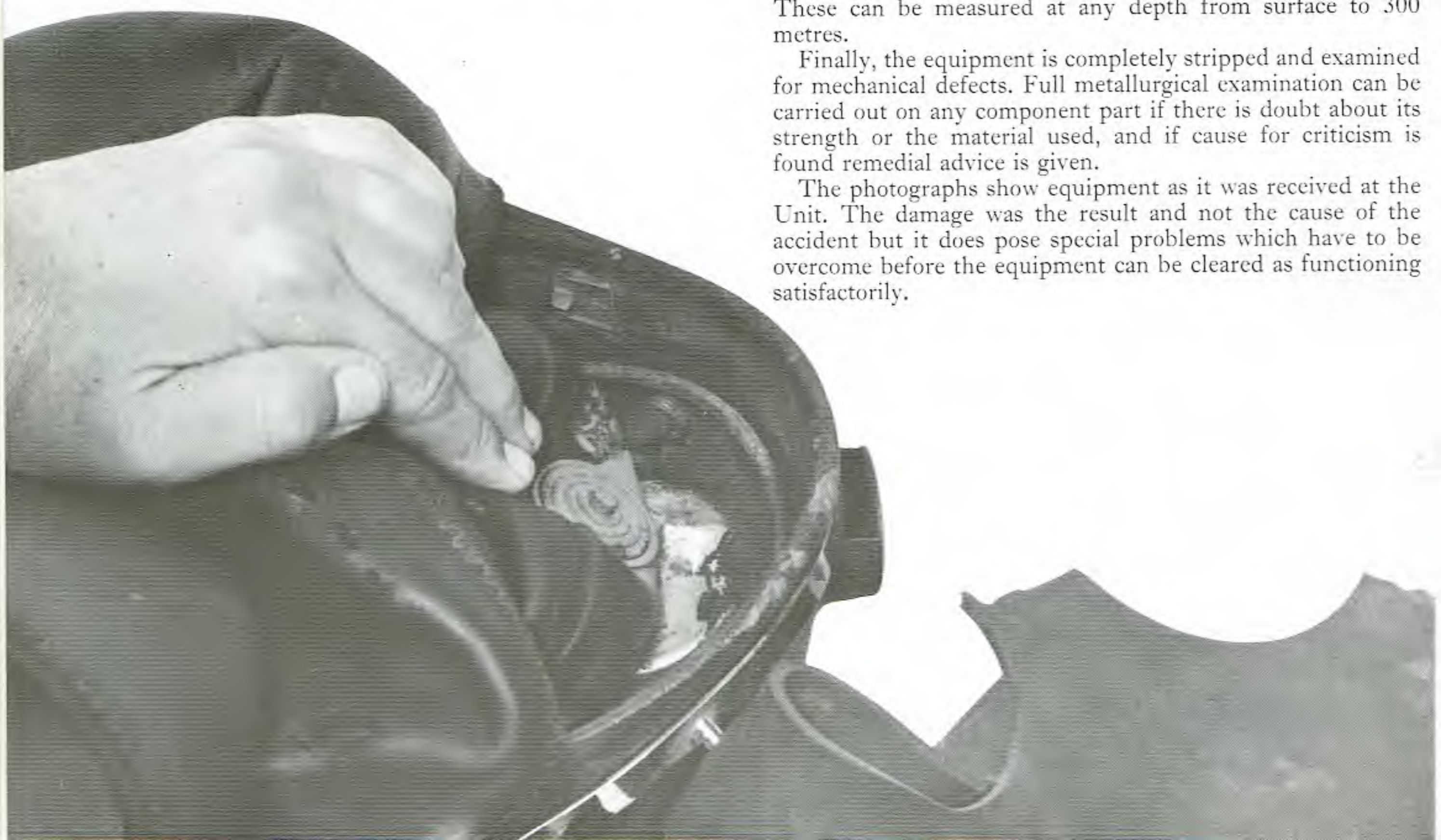
On receipt of the equipment a visual check is carried out. External damage is noted together with control valve positions and the general condition of the article. Air or breathing gas pressures are noted. Samples are analysed either in the AEDU or another laboratory and the results checked against the appropriate British Standard.

At this stage the equipment is given a subjective test by being dived by one of a team of experienced divers. The person chosen is usually familiar with the particular apparatus and will judge its performance. The actual conditions appertaining at the time of the accident, including depth and temperature, can be closely simulated.

Bench testing where appropriate then follows. Results obtained include breathing resistance and flow measurement. These can be measured at any depth from surface to 300 metres.

Finally, the equipment is completely stripped and examined for mechanical defects. Full metallurgical examination can be carried out on any component part if there is doubt about its strength or the material used, and if cause for criticism is found remedial advice is given.

The photographs show equipment as it was received at the Unit. The damage was the result and not the cause of the accident but it does pose special problems which have to be overcome before the equipment can be cleared as functioning satisfactorily.



Search and rescue divers' buoyancy aid (SARBA)

SAR divers wearing lightweight self-contained underwater breathing apparatus are required to jump from helicopters in order to rescue air crew from ditched aircraft or extricate injured survivors from their parachute and harness. Recovering aircrew from sinking aircraft involves the divers in the risk of being dragged down below the surface. A diver may be taken down to depth and then be faced with the problem of getting himself and a survivor to the surface as quickly as possible, so a special purpose divers' buoyancy aid was devised at the AEDU to assist both a negatively buoyant diver and survivor to the surface. The means of achieving such a rescue was developed and agreed upon together with Fleet Air Arm personnel and involved the SAR diver wearing the SARDBA at all times.

As a standard piece of flying/diving equipment the device consists of three separate buoyancy chambers and a hook and lanyard for attaching to the survivor. One buoyancy chamber is in the shape of an underarm life ring and raises the survivor to the surface, another buoyancy chamber is spherical and raises the diver to the surface at exactly the same rate, both of these are detachable from the diver. A third inflatable stole supports the diver on the surface should his breathing apparatus be exhausted after the rescue.

The diver has located the pilot and has attached the buoyancy bag.

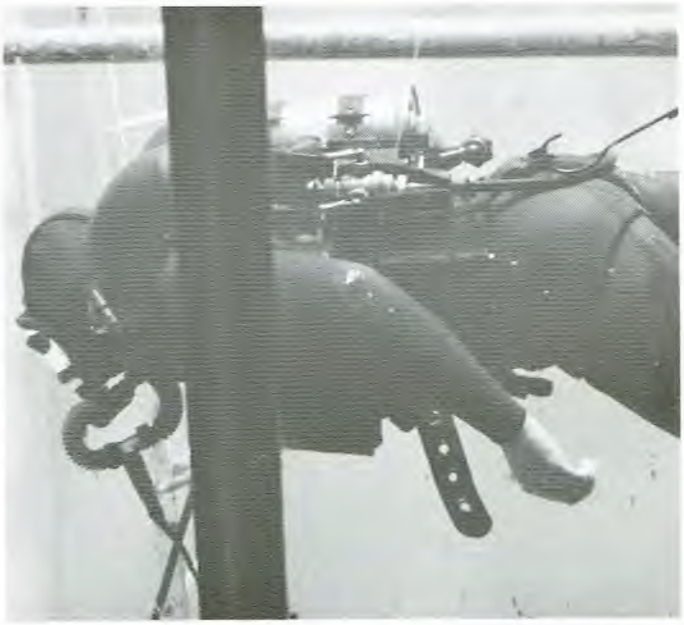
A sequence of three photographs that show SARDBA in use. The diver with harness entering the water for a simulated rescue of a downed airman.

The airman breaks surface and the diver has secured the harness.

Deep diving breathing apparatus

An instrumented Windak Mk 4C undergoing evaluation on the diver. The parameters being measured are Oxygen uptake/Carbon Dioxide production from a diver swimming against a known weight.

Prototype Venturi Assisted Semi-Closed Circuit B/A for Deep Diving.



Standard diving equipment was in use for early deep dives although for oxy/helium dives in the late 1940s injector recirculation was fitted to economise on gas. The injector used at that time achieved a recirculation ratio of 9:1. Use of this equipment was continued for some years until 1959-1960 when very lightweight surface demand diving equipment (SDDE) was in use with surface supply. It was quickly realised that a happy marriage could be achieved between this lightweight equipment and a submersible decompression chamber (SDC) which was in use at that time from HMS RECLAIM. In 1961 deep diving was carried out using swimmers equipped with SDDE, working from the SDC lowered to the working depth.

The SDDE was initially standard equipment simply used with oxy/helium gas on open circuit. Development continued and by 1965 dives to 183 metres (600 ft) for up to one hour on the bottom were achieved using a specially produced servo-operated demand valve and modified reducer. Restricting bottom time to one hour or less meant that the open circuit breathing apparatus with its high gas consumption rate could be accepted. The advent of a requirement for saturation diving with resultant increased diving time available, in the water and increased depth capability, has necessitated development of breathing apparatus which will be much more economical in its use of breathing mixture.

An Admiralty patent taken out in the early 1950s described a constant mass flow device to provide a constant mass of breathing mixture to a diver's breathing apparatus irrespective of diving depth. This device has been incorportated in the majority of semi-closed circuit breathing apparatus, both self-contained and umbilical supplied, produced throughout the world. The system is very foolproof and robust providing a high degree of safety, and the basic principle has therefore endured and in modified form is the means of supply of breathing gas to the WINDAK Mk. 4C Semi-Closed Circuit Breathing Apparatus. This equipment has been developed as a joint venture between MOD and WINDAK Ltd. The apparatus has been produced to the requirements of divers, to reduce maintenance, decrease preparation and set-up time and improve comfort in the water; it has completed 164 man/hours at 250 meters or deeper, in the water at the Deep Trials Unit. The set is primarily designed to be swum by a finned diver on a gas supply umbilical, but may also be used with boots.

To improve communication and comfort and provide a stable base on which to mount navigation aids and other instrumentation, a hard helmet equipment is under development. This breathing apparatus incorporates the best of constant mass flow supply, new developments in venturi design which have achieved recirculation ratios up to 37:1 and improvements in suit and gas heating design.

A "push-pull" breathing apparatus specifically for use from a submersible compression chamber, which will cycle breathing gas on closed circuit between the diving chamber and the diver's breathing apparatus, is also under development in collaboration with the Department of Energy.

The pumps are being developed by Normalair Garrett Ltd and the diver mounted controls by Windak Ltd.

Diver heating

It is vital to maintain the diver in a state of thermal safety. The means of achieving this can be quite different for different environments. There is for example a distinct division between the deep diver in cold water breathing helium and the shallow diver breathing oxygen/nitrogen mixtures. Cold shallow dives are those not exceeding a depth of approximately 20 metres in water temperatures down to —2°C with a surface air temperature down to —34°C. A deep dive implies a dive deeper than 60 meters involving breathing oxy/helium with all its attendant insulation and respiratory heat loss problems. The minimum water temperature in this range is not likely to be as low as the shallow case, but the heat loss problems are more severe.

Research has concentrated on two approaches for diver heating. The first is closed circuit water heating and the second, low voltage DC electric heating.

The options for closed circuit water heating are, diver mounted back pack utilising storage type heater/heat exchange unit and circulating pump, or bell mounted hot water supply with concentric supply and return umbilical to the diver. The latter is less cumbersome but relatively inefficient.

The most efficient method of heating the diver is to turn electrical power into heat at the diver. Thus the main effort has been directed towards designing an electric heated suit which can supply a maximum of 1.2 kw at 28 volt DC. This amount of heat would only be necessary at the 300 meters level where the heat lost from the diver is greatest.

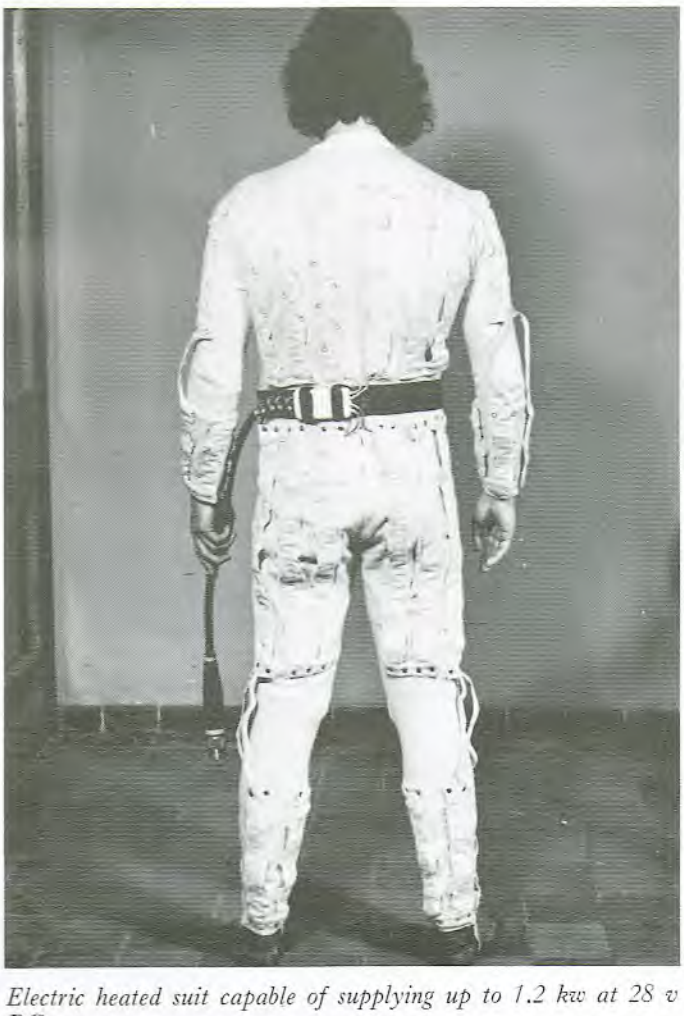
Prime considerations have been given to diver safety and comfort. The safety aspect is covered by an electronic sensor unit which continuously monitors the umbilical supply to the diver. If a fault occurs or the umbilical is disconnected then the unit will automatically switch the power off, in less than 1/10 thousandths of a second, thereby completely protecting the diver.

Other work has been directed to the development of a heater working on a storage principle. The unit is charged up by an electric resistance heater, the heat being retained in a material which has a very high latent heat of fusion. Heat can then be extracted by flowing water through cooling coils surrounding the unit. This heater has an energy density of 270 kWh/m^3 and in an effort to improve this figure AUWE is investigating the use of other thermal energy sources.

Respiratory heat loss becomes significant the deeper the diver descends. At about 180 meters the amount of heat exhaled exceeds metabolic heat produced; therefore additional heating is required for the breathing gas. Methods undergoing research are; the use of heat pipes for transfer of exhaled heat back to the inhale gas and electric gas heating by impulsing the power to meet the divers breathing pattern.

Other systems are direct heat exchangers using hot water or electric heaters. A more exotic type of heat producing system being researched is a high frequency supply via a flexible wave guide but this is some way off.

Research at AUWE has resulted in a small self contained heater unit for divers, capable of supplying 1.5 kwh.



Electric heated suit capable of supplying up to 1.2 kw at 28 v DC.

Closed circuit water heated suit. Heat is controlled by varying the water flow.

Saturation diving systems–A proj

In 1948 HMS RECLAIM was commissioned as the Royal Navy's number one diving ship; she is still operational and frequently makes news headlines by carrying out useful or important diving missions (the recent recovery of a RN Sea-King helicopter in the English Channel). This diving system is quite old and currently limited to short duration dives down to 140 metres.

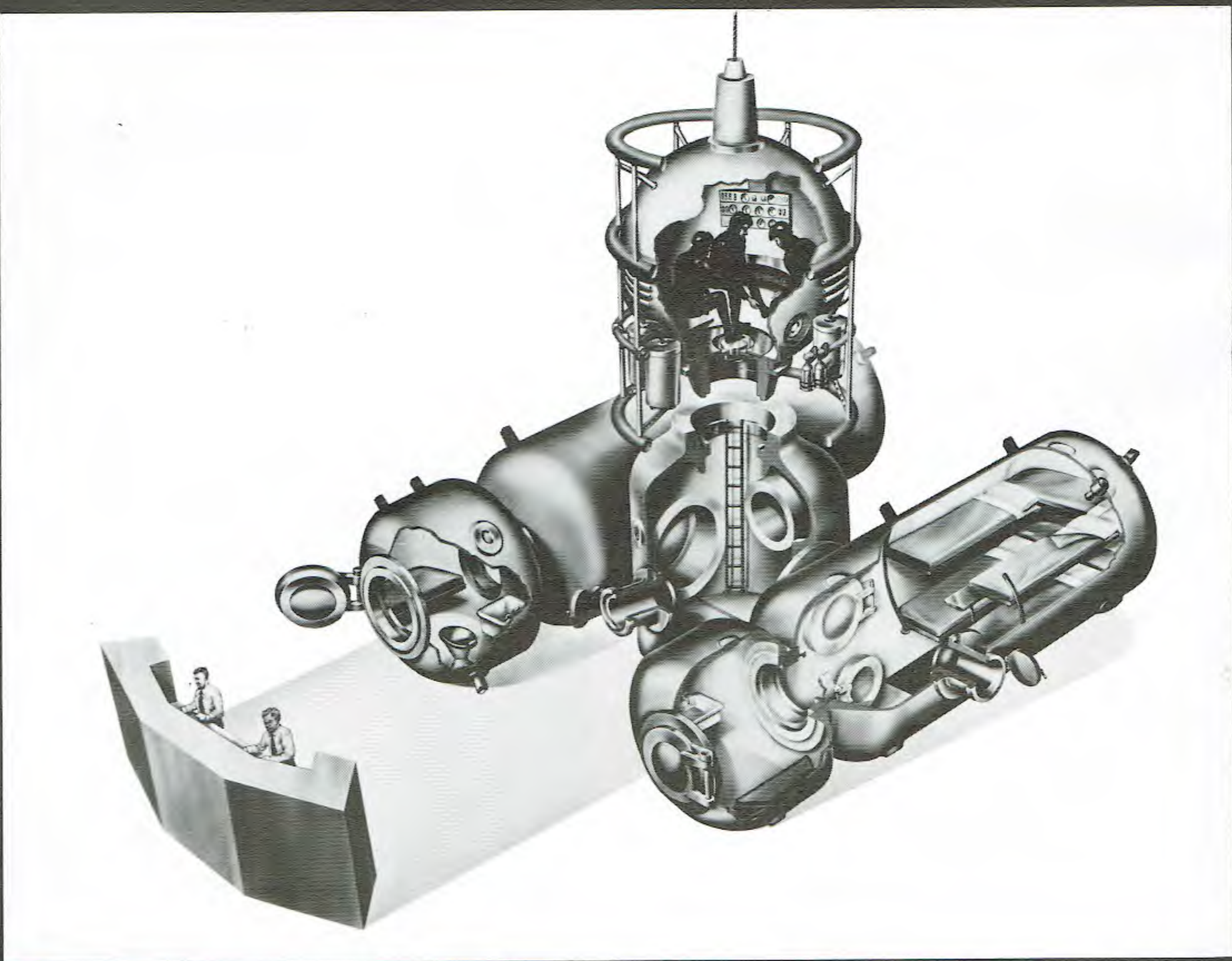
A 300 Metre RN Saturation Diving System

AEDU in conjunction with other MOD departments and by contract with industry, have now designed a complete new saturation diving system (SDS) for an operational depth of 300 metres (a depth rating which covers over 95% of our UK continental shelf).

This system is designed around a shipborne compression chamber complex with autonomous central control, a self-contained gas plant, advance diving chamber handling gear and substantial back-up medical monitoring and computer data logging equipment. The chamber complex mounted below decks consists of five chambers formed from 2.2 metre diameter cylinders; two of which are fitted as day/night decompression chambers with seating, bunks, tables, etc; two smaller sections which serve as entrance locks and house wash/toilet facilities; and the fifth section which forms a central connecting chamber with shower, bath and recreational facilities. This chamber can transport three men (two divers plus one attendant) to and from the work site in the sea; it is a 2.5 metres diameter sphere packed with equipment for continuous long term diving activities. (See artist's impression).

The system is operated from a central control console below deck and supports up to 12 divers to 300 metres—24 hrs/day—7 days/week, for long periods. In fact, this design permits continuous relay teams of divers to be employed for a virtually indefinite period. The system includes a substantial gas plant with large bulk storage at high pressure of helium and oxygen, gas mixing and helium purification on-board.

Diving operations at these depths require accurate station-keeping by the ship and this is attained using dynamic positioning, controlled from the ship-borne computer data, collected by acoustic and other position indicating devices. This computer is also utilised to collect numerous other data from the system and the divers, besides aiding individual diver navigation. Other ship facilities include the diving equipment store, breathing apparatus preparation laboratory, gas analysis laboratory, hospital-type sick-bay, helicopter landing platform, heavy lift equipment, manned and unmanned search submersibles.



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The AEDU Deep Trials Unit has been used over the last four years to establish a RN Saturation Diving procedure and proving the decompression tables prepared by the Royal Naval Physiological Laboratory at Alverstoke, to a depth of 300 metres. This compares with work done in other countries to ascertain that working dives to this depth at sea is now practical.

Further developments and experiments in the UK and abroad indicate that diving to 600 metres may soon become a working proposition. Current development in geological surveys and the search for mineral deposits, indicates that a requirement to operate just over the edge of the continental shelf to depths of about 600 metres will very soon be a real requirement. Whilst requirements to operate beyond 600 metres may arise in the not too distant future, the present state of the art of diving equipment and of physiological research, indicate that diving much beyond 600 metres will require further basic physiological research and involve much higher capital equipment cost with attendant logistic problems of bulk gas handling.

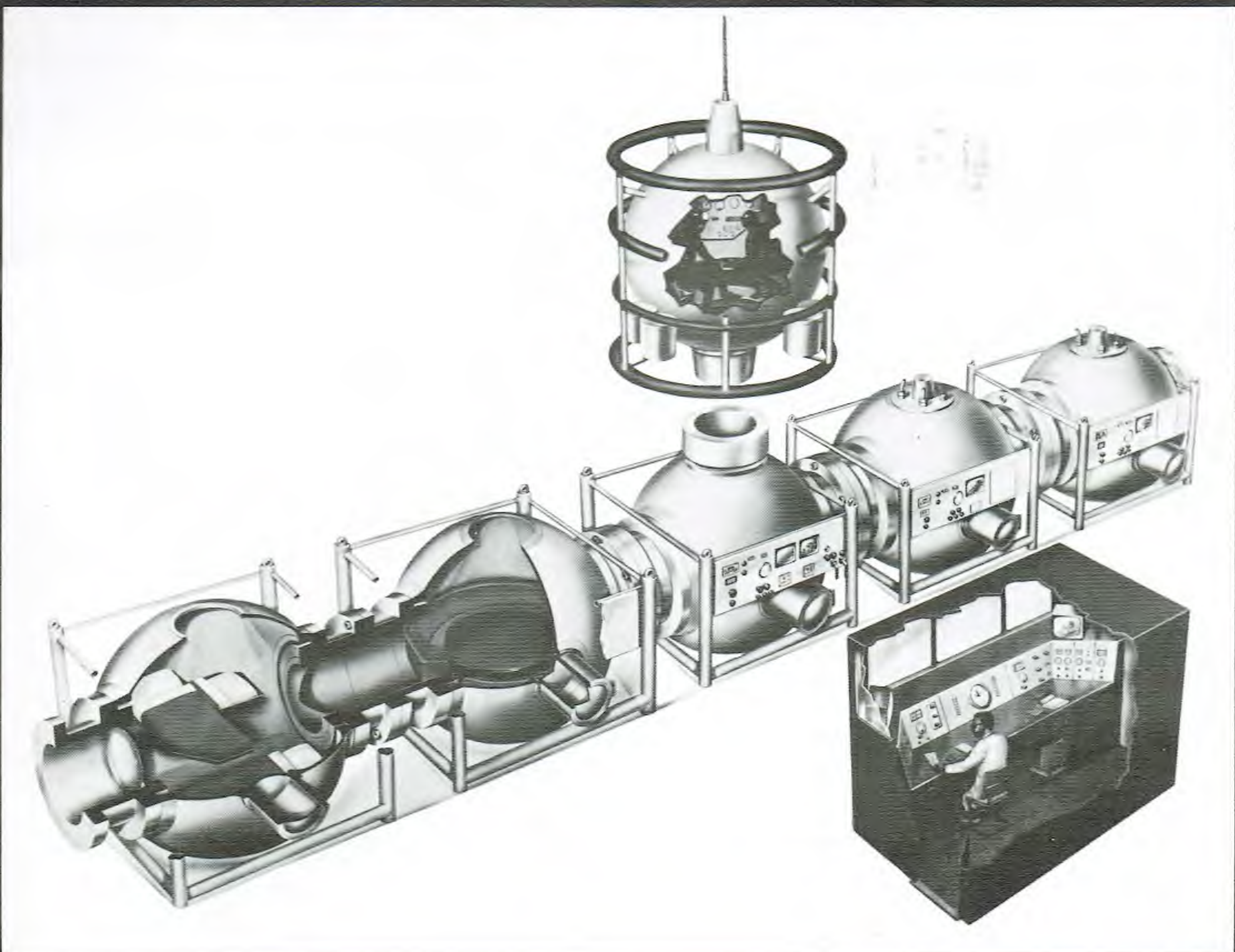
We therefore see a real requirement for considering a 600 metre saturation diving system now and deferring hardware procurement of equipment to dive beyond 600 metres for the time being. A new hyperbaric research facility designed for 2000-3000 metres is being considered.

AEDU—600 Metre Modular Diving System (600-MDS)

AEDU in conjunction with industry, is now examining the feasibility of a new Saturation Diving System to operate teams of divers to 600 metres. This design concept is based on one standard decompression chamber built as a self-contained module. This module is a spherical pressure vessel with standard doors, service pads, mounting, etc. built into a basic framework which contains the essential operating control system and life support package. The internal fittings can be varied to provide bunks for 3/4 men, or table and seating for 3/4 men, or wash/shower/toilet facilities as required. (See artist's impression).

By coupling say, three of these modules together, we have a saturation diving chamber complex with a rest section, living section and wash/toilet section for a 3/4 man team. By adding one extra rest chamber and one extra living chamber we extend the complex to five modules and enlarge the total habitat for 6/8 men (i.e. two teams). To complete the chamber complex we mate a diving chamber to transport the divers to and from the work site in the sea. The system is then connected up to a central control cabin, served with a typical diving system gas plant and diving chamber handling gear.

The whole system is based on assembling a number of basic modules to form a diving complex. The system can be dismantled and re-built elsewhere or re-built to meet differing requirements on the same site. The site can be a fully operational ship, a floating platform, an oil rig at sea or a shore-based research/training facility. The basic design is simple; it utilises considerable learning from AEDU'S many years of research in deep diving and the design study on the Royal Navy's SDS. It is readily adaptable for military, commercial, research or training requirements; and is likely to be very cost effective by comparison with individually designed diving systems.



Research

Electrical Safety
Much of the research work undertaken at AEDU has an electrical/electronic content. This is deliberate policy, based on the premise that given reliable safety protection circuits, electrical power utilisation control and distribution will be as readily accepted by the underwater worker as it is by his land based counterpart.

Indeed it is difficult to visualise how diving operations can expand in scope and complexity without the increased use of electrical power.

In pursuit of this policy work continues on research into fail safe and intrinsically safe methods of electrical supply. Work sponsored by AEDU has shown that line insulation monitors can be designed to "crowbar" a supply, (thus eliminating the source) in less time than it takes for the diver to register the sensation of shock, and in many times less than the time for heart fibrillation or other damaging effects of shock to occur.

The design criteria for this equipment is well known, requiring only the force of safety legislation demanding its use, to make it a viable commercial proposition.

Power in diving chambers is presently at low voltage d.c., being safer than the equivalent voltage at normal power frequency. This procedure often poses excessive volt drop problems with associated heavy and bulky supply cables.

High frequency (>50 KHz) offers considerable safety advantages over d.c. so enabling higher voltages to be used, reducing this volt drop problem. Work will shortly be put in hand to research a high frequency, high power source.

As the results of this work proceed, they will be incorporated into specifications, and codes of practice as guidance to equipment manufacturer and user.

Electrical Laboratory
To expand the "in-house" facilities the electronics laboratory has been re-equipped to provide a capability in both the linear and digital fields. Small size and low power consumption are mandatory in any diver carried equipment. To this end, much circuitary is implemented in CMOS technology. To miniaturise further, as the future may well require, a custom-built thick film technology will have to be employed.

Medical Monitoring
It is firmly believed that as the divers' life support packages become more complex, to meet the needs of deeper diving, it will be vital to monitor his physiological condition during an operational dive. This will give advance warning of any short fall in the diver or in his equipment performance.

Parameters such as heart rate, respiration rate, body and gas temperatures should be continuously monitored. To do this on separate cores would make the umbilical cable unacceptably large.

Work through AEDU has produced a multiplex system by which all this data is time multiplexed on a single fibre optic core.

The photograph shows the prototype diver's unit, together with the surface de-multiplex unit.

Work is continuing on this, and on the refinement of the associated sensors, which will be fully integrated into the diving dress and helmet. Communications is clearly a candidate for a further fibre optic link.

Communications
Improvement of diver communications is a field actively investigated in AEDU. Strong links between the defence organisation and commercial and civil users have been established. There are several problems in the communications field unique to the underwater hyperbaric situation. Breathing gas containing a high helium content distorts the human voice. While this problem has largely been overcome in the use of the electronic speech processor, other problems still remain. The dynamic qualities of microphones and loudspeakers operating in the dense gas environment produced under high pressure, in chambers, is an example.

Communication in divers' helmets is aggravated by the high ambient noise of exhaust gas, whilst the acoustic properties of a helmet are hardly conducive to high quality sound reproduction. These problems, and the need to engineer a "hands off" communications equipment, demand the production of a suitable voice-operated switch.

In the free swim mode clearly a "wireless/sonar" communications link is vital, whilst for the tethered diver a rugged and reliable hard wire link is preferable. The many facets of frequency selection, range, endurance and secuirty of speech all have to be considered.

Diver Homing and Navigation
Again, in the free swim mode the sometimes nil visibility and hostile environment demand pin point navigation, and the ability to home into or return to a pre-marked target.

Miniature diver carried sonar sets, and locating pingers to a large degree solve the location problem while digital displays of depth, time elapsed and navigation data help in diver orientation. In both these areas some work has been done, and much yet remain.

Self preservation figures high on the divers' list of priorities. No matter how advanced the technology, unless the equipment is well designed, rugged and reliable, and it works, it will never be fully accepted by the diving fraternity.

Other Research Items

The range of work encompasses several branches of engineering, and in company with other MOD departments, many disciplines including physiology, psychology and underwater medicine. The range of topics covered can be obtained from the following list of tasks in hand, some of which are covered by extra-mural contracts:

Development of divers' heated suits both electrical and hot water closed circuit operated.

Development of self-contained diver heater units, both battery-powered and thermal operated.

Studies of the use of heat pipes for distribution of heat around a diver's body.

Study of heat pumps for the extraction of heat from the water surrounding the diver.

Study of methods of heating the inspired breathing mixture.

Study and development of a compressor/depressor breathing system for saturation diving.

Study and development of venturi-assisted breathing apparatus for saturation diving.

Development of a very small oxygen breathing equipment.

Development of electronic instrumentation for the detection of gas bubbles in the blood stream.

Prototype divers unit.

Testing communications units.

Study of the application of sonar techniques to quantify gas bubbles in the blood stream during decompression.

Feasibility study on self-contained diver navigation system.

Further development of helium speech unscramblers.

Feasibility study on multi-purpose diver communication system.

Feasibility study on the use of open circuit seawater hydraulic tool system.

Investigation into the application of arc plasma technology underwater.

Studies on in-water survey and maintenance of ships.

Research into non-compressible materials suitable for wet suit construction.

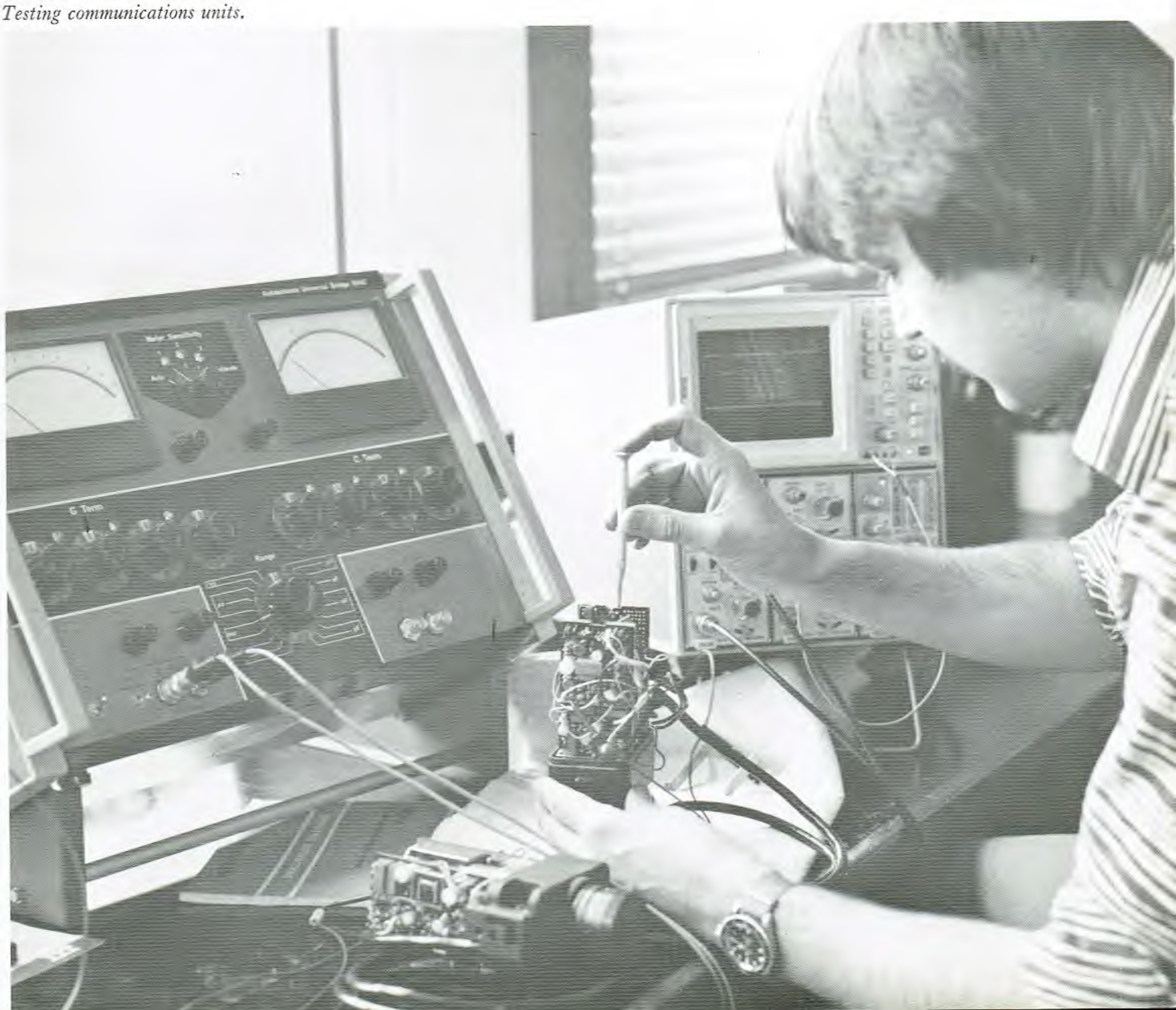
Feasibility study of a centralised computer system for a seagoing diving system.

Design and detail of saturation diving system with the necessary environmental control, medical monitoring, underwater search facilities and ship installation details.

Feasibility study of a 600 metres modular diving system.

Development of breathing gas standards and cleansing of equipment.

Investigation into underwater gas generators for buoyancy purposes.



Evaluation

DTV

The DTV or Diver Transport Vehicle is a two-man wet submersible which was manufactured commercially. At present a number of modifications both on the mechanical side and the electrical side are being carried out to improve the overall performance of the vehicle for its particular military application.

Basically the DTV was designed to carry two divers sitting side by side, and a quantity of cargo. The vehicle is approximately 5.8 m in length, 1.4 m wide (over the hydroplanes 2.4 m) and weighs about 900 kg. It has an operational depth capability in excess of 30 m, the vehicle alone can be submerged to a considerably greater depth. It is battery powered, and has a top speed in excess of 5 knots.

Life support for the pilot and co-pilot consists of a built-in breathing supply or BIBS. However, there is room in the cockpit to enable the crew to wear personal breathing apparatus. The existing BIBS is an air system, but there is a possibility of incorporating a mixture breathing system at a later date.

The "teardrop" shape of the vehicle has proved to be hydrodynamically very good. The basic frame is aluminium over which is a skin of glass-reinforced polyester resin.

Further studies will be undertaken in AEDU to examine different control systems, batteries, increased carrying capabilities, buoyancy systems, instrumentation and navigation.

"JIM"

"JIM", the atmospheric diving suit is presently undergoing a series of evaluation trials by AEDU and RNPL, the object of which is to determine the usefulness of deep diving equipment of this nature for observations and inspection, salvage and recovery and to assist in the event of a submarine accident.

The body of "JIM" is manufactured from magnesium, and the limbs in aluminium alloy, the latter constructed in such a way, that in water they are approximately neutrally buoyant, and allow considerable freedom of movement. JIM'S eyes of which there are four, offer the operator a fairly wide field of view. The controls for life support are housed inside the shell and there are two separate but identical systems which can be cross-connected, therefore allowing various permutations should any particular component fail. Oxygen is metered in to maintain an air atmosphere to provide an endurance of approximately 24 hours.

In the water, and weighed correctly at about 30 kilos, JIM can walk forwards, sideways and backwards; he can fall forwards or backwards to pick up tools, and do a task at seabed level. He can roll along the seabed, walk into a one knot current, walk in fairly thick mud, and climb a gradient of about 45°.

Trials at AUWE Portland have proved that JIM at a depth of 457 metres can perform various tasks such as undoing and doing up nuts and bolts, shackles and quick-release connections.

At sea JIM can be deployed from a parent vessel, and then controlled from a gemini, it can be lifted or lowered as the operator requires.

Work continues on manipulator improvement, designing and buoyancy control system, and in the various methods of examining improved manuoevrability.

The DTV during recent trials.

"JIM" demonstrating his ability to assist in submarine rescue.

Careers in Diving

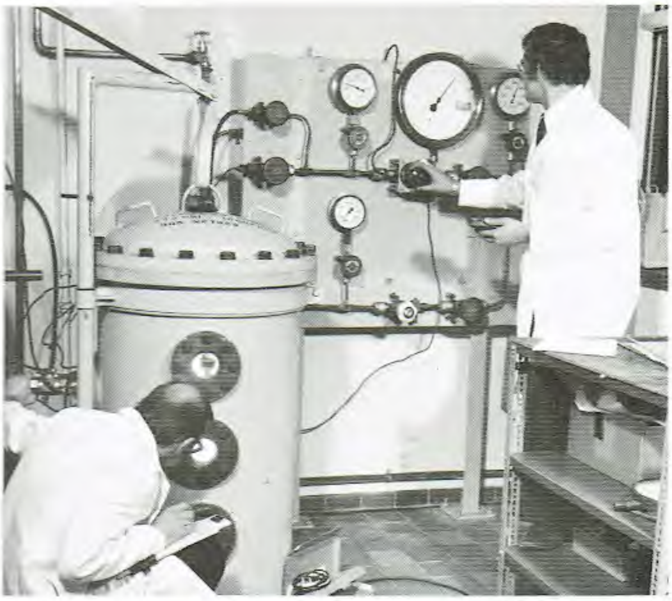
Science Group
The Science Group is responsible for initiating, directing and carrying out the greater part of all research and development within the Civil Service. It has eight grades ranging from Assistant Scientific Officer, with duties mainly of a support nature, to Chief Scientific Officer. Grades above this, for example those held by Directors of the large R & D Establishments, are within the "Open Structure" of the Higher Civil Service at Under Secretary level and above. Graduates are normally recruited to the second, third or fourth of the eight grades, respectively Scientific Officer, Higher Scientific Officer and Senior Scientific Officer.

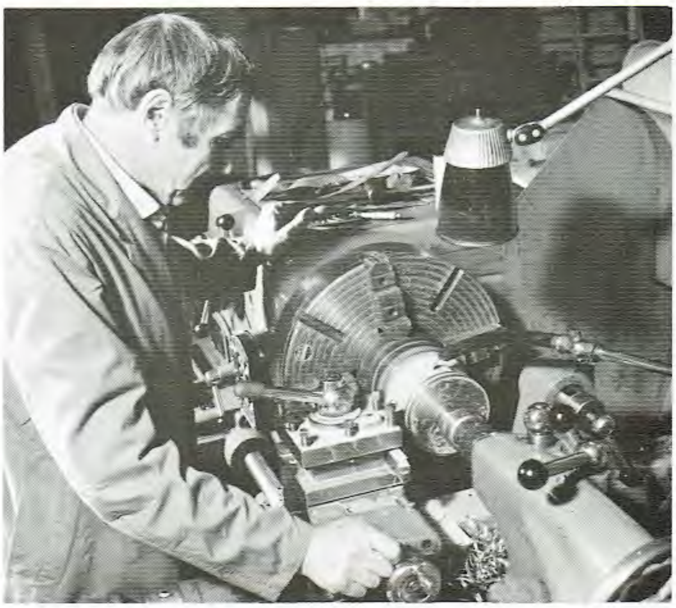
Scientific Officer
Entry into this grade is normally limited to those under 27 years of age and the qualification required is a degree, HND, HNC or equivalent, in a scientific, engineering or mathematical subject.

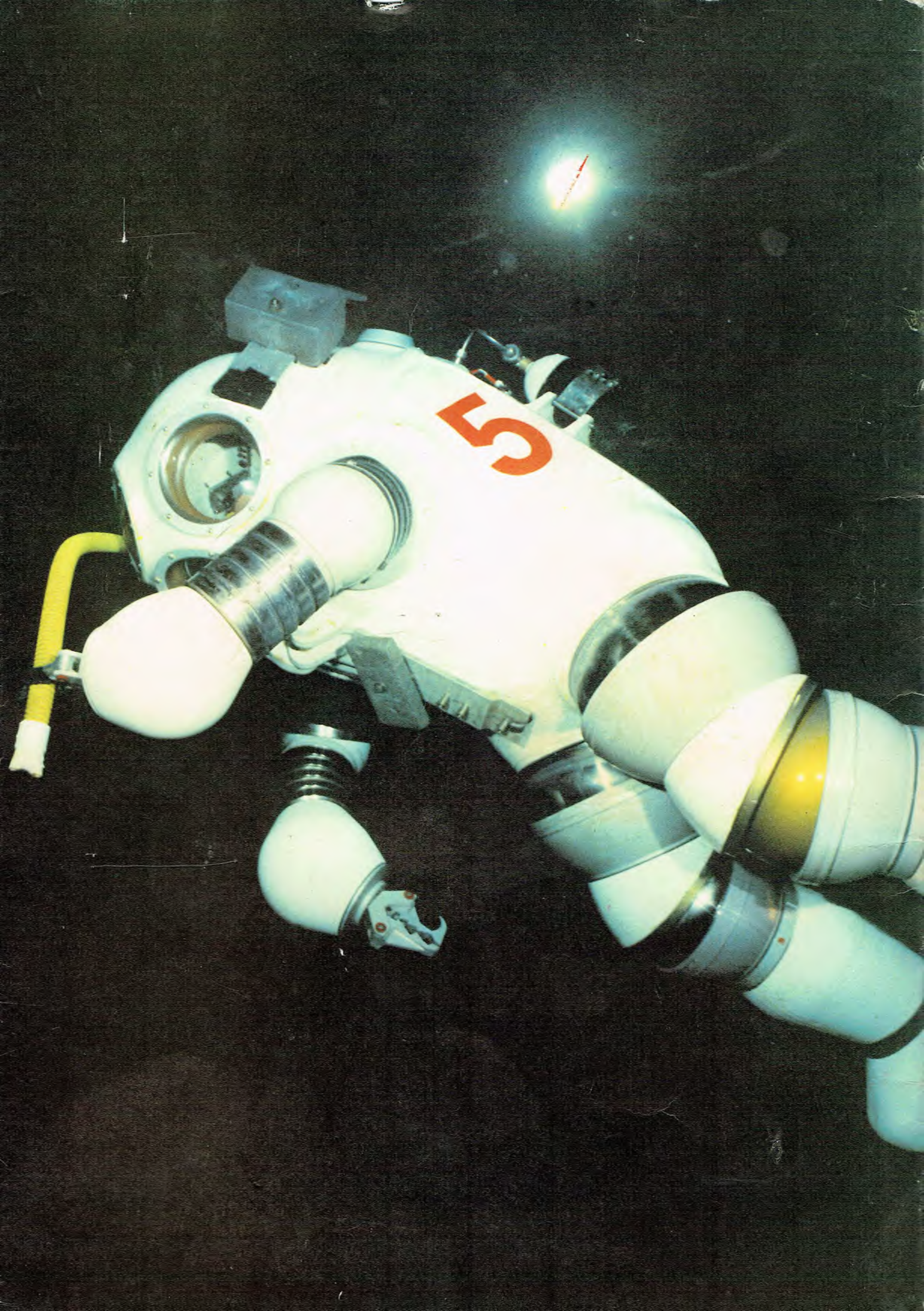
Higher Scientific Officer
Candidates for entry into this grade must normally be under 30 years of age with qualifications as for Scientific Officer (above) but they must also have undertaken postgraduate research work or had other relevant experience since qualifying. Those candidates with a 1st or 2nd class honours degree or equivalent must have at least 2 years' relevant postgraduate experience and other caniddates at least 5 years' appropriate experience after qualifying.

Senior Scientific Officer
Candidates for entry into this grade should normally be at least 25 and under 32 years of age with a 1st and 2nd class honours degree, or equivalent, in a scientific subject (including engineering and mathematics) and must have at least 4 years' appropriate postgraduate or other approved experience.

Higher Grades
Although there is occasional recruitment to the higher grades, entry to these is normally by promotion. The four grades above Senior Scientific Officer are: Principal Scientific Officer, Senior Principal Scientific Officer, Deputy Chief Scientific Officer, and Chief Scientific Officer.



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