OCEANOGRAPHY–THE CHALLENGE

BY

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Britain's awareness of the importance of oceanography has recently become increasingly evident. The Government is reported to be undertaking a major review of how the resources of the sea could help Britain's economy; six major companies (I.C.I., Unilever, B.P., Rio Tinto Zinc, Hawker Siddeley and Costain) have financed a report on the commercial exploitation of oceanography; the Ministry of Technology sponsored a three-day conference at Harwell covering many aspects; an Oceanographic and Fisheries Committee under the Natural Environment Research Council has been formed; and the nation's first research submersible has been completed by a private concern.

As a great maritime nation we have as much to gain in the future from the exploitation of deeps of the sea as we have gained in the past from the domination of its surface. Indeed the need for all advanced nations to play their part becomes increasingly compelling, since failure to do so may have disastrous effects on the survival of mankind, as simple arithmetic can show.

Food

Every 37 years or so the world population is doubling. Only 9 per cent of the world's land surface is cultivated, yet 30 per cent is potentially cultivatable.

Clearly, superhuman efforts on land are needed in our generation if our sons and grandsons are going to live off the food it can produce. Short of enforced population limitation (and there is little likelihood of effective world-wide action being taken until too late), decimation by war or by disease, our great grandsons' generation may face starvation.

Professor Fremlin[1] has pointed out that emigration to other planets is no solution, even if it were possible, since to keep the world population level we would have to be sending out 60 million people a year now, and in 37 years Venus, for instance, about the size of the Earth, would itself be at the same population density. Mercury, Mars and the Moon together have about half the same area. Judging by the castigation it received at the British Association meeting in Leeds, the space programme is going to do nothing whatever towards solving the Earth's problem; in fact it is misguidedly detracting some of the world's best talent from other 'big science' which is needed for the survival of civilization. Dr. J. W. Findlay, Chairman of the American lunar and planetary mission board, admitted the space travel programme was more an adventure than an investment, and compared the attempts on Everest. But the magnificent achievements on Everest and those of Sir Francis Chichester did not cost £3000m/year of the world taxpayer's money, nor did they involve the U.K. in an annual contribution in the shape of the brain drain to the U.S.A., which the Jones Report estimates as about £200m.

Where must we look for food? Charles Darwin claimed there was no part of the world, 'warm mineral springs, the wider expanse and depths of the ocean, and even the surface of perpetual snow' which could not support organic beings. Advances in microbiology have enabled protein to be produced from gas oil, and B.P. has announced it will spend £2m on a plant to be built in France for commercial scale production: so far successful feeding tests have been confined to pigs and poultry. Perhaps synthetic foods may help, but it appears it is mainly the seas that can provide the additional animal protein needed for mankind's survival. Professor Fremlin foresaw that long before the ultimate cessation of life on the Earth in 900 years (when the population could have increased 20 million times, with 120 people per sq. metre living in 2000 storey buildings over land and sea alike!) we might need to resort to using single-celled marine organisms as food: these would be grown under controlled conditions in a sea from which other wild life had been removed. The use of large satellite reflectors in orbit to give extra sunlight, and the hermetical roofing over of the ocean are some of the measures on which he speculated.

But leaving the realms of fantasy, Piccard and Walsh at a depth of nearly seven miles saw a fish like a sole: so Darwin was right. The search for food in the sea has gone far beyond the primitive ways with fish trap and spear, and an American estimate suggests a fourfold increase in the present fish catch of the world might be possible: but new techniques used indiscriminately are certain to upset the balance of nature in the same way as indiscriminate deforestation can create dust bowls. Plankton, the basic marine food, eaten by the Kon Tiki's crew, could when processed supply the protein needs for many times the world's present population, but its concentration in the open seas is generally too low to allow economical harvesting, even if artificial upsurge of water by nuclear power could increase the concentration[2]. In very round figures, 1000 lb of plankton can feed 100 lb of herring, which in turn can feed 10 lb of larger fish, and these could contribute 1 lb to man's body weight. So if man eats herrings he is doing ten times as well in the economy of nature as if he eats salmon—the smaller the fish which man eats, the more people could be fed—always assuming

[1] 'How many people can the world support?' Dr. J. H. Fremlin. *New Scientist*, 29th October, 1964.

[2] 'Food from the Sea'. John D. Isaacs. *International Science and Technology*, April, 1967.

they find the smaller fish palatable. Nature however provides a means for the collection of plankton through certain crustaceans, molluscs and small fish which can be concentrated in estuaries, lagoons and artificial harbours, free of the larger predators which may ultimately have to be exterminated. It has been estimated, though estimates differ greatly, that by such means the yield per acre could be increased more than 20-fold (and Japan has increased its oyster yield 50-fold), to 10 times the food yield from an area of rich cattle grazing. A prime need therefore is for a greatly increased number of marine biologists, for engineers to work with them, and for all the equipment and facilities ashore and afloat which they require. The White Fish Authority, which covers a very complex field in preservation, detection, capture, refrigeration, ship propulsion and fleet management employs only two dozen engineers and naval architects, yet produces £100m worth of product each year.

Minerals

The recent find off the Scillies of part of the gold of Sir Cloudesley Shovell's flagship is insignificant beside the other prizes to be found in vast areas of the Pacific sea bed, if only means can be found to bring them to the surface. Nodules (boulders) containing 50 per cent manganese lie in profusion three miles deep in quantities enough to provide the world's needs for a million years; others have 2 per cent copper, cobalt and nickel. South of Tahiti cobalt lies less than a mile deep, and off California lie phosphorous bearing nodules only a few hundred feet deep. Areas of red clay contain 20 per cent aluminium, and can yield copper in quantities greatly in excess of many land rocks, again enough to last a million years. Already most of the world's bromine is extracted from the sea. Britain now obtains 7 million tons of gravel a year from its coastal waters.

Little wonder that Dr. Taylor Smith[3] thought of the sea as a new El Dorado. 'The present annual value of the biological and mineral resources of the sea is thought to be well over £4000m, of which just half relates to mineral deposits. The sea floor is therefore big business in anyone's language.' It had been said that the direct return on a 20-year investment in oceanography would be more than three times the gain accrued if the same money had been invested at 10 per cent compound interest.

U.S.A.'s Part

The U.S.A. has not allowed the space race to overshadow its intensive research under the seas. Some £120m was federally allocated in 1967 for (non-defence) oceanography, over one third of which is for marine biological resources, and one tenth for wind and wave prediction—so vital to offshore drilling operations. Notable dives have recently been made to over 600 feet by free divers using helium and the saturation technique, the main disadvantage being that decompression to atmospheric pressure may take a day per 100 feet dived. In the 'Sea lab II' project divers remained at nearly 200 feet for 15 days, using trained porpoises in light harness to act as messengers between divers. Sixteen companies including many of the aerospace giants, are spending more than $1m/year on 'ocean engineering' work, and no less than 33 research submarines have been built—*Aluminaut* costing $7m. Some 60 research ships may be built in the next 10 years. Add to this the outlay of the oil companies, and the staggering pace of U.S.A. involvement in the seas is evident, as can be seen from several monthly journals published in U.S.A. on 'ocean engineering'.

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[3] 'The Sea Floor—a new El Dorado?' D. Taylor Smith. Section C, B.A. Meeting, Leeds, 5th September, 1967.

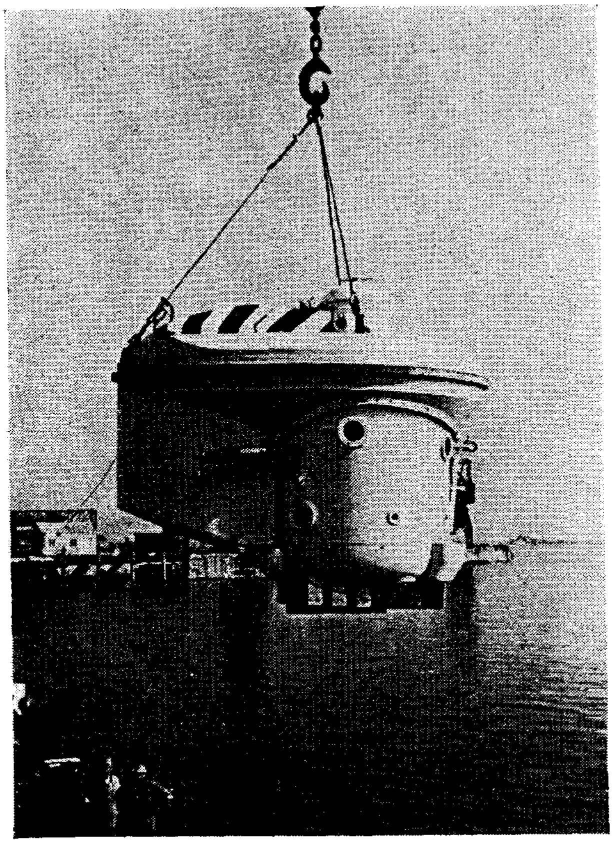

FIG. 1—The Standard Underwater Research Vessel (*Courtesy of Lintott Engineering Ltd.*)

Britain's Part

Britain has indeed made an outstanding contribution towards providing fresh water from the seas by leading the world in desalination techniques: indeed the cultivation of new areas of land must largely depend on correspondingly increased water supplies. Our lead in Hovercraft is equally noteworthy. The work of the Navy's Hydrographic Service, now reinforced with three new *Hecla* Class surveying ships and with further vessels under construction, has led to world wide recognition of Admiralty charts since before the days of Captain Cook. The Navy too has contributed much towards advanced diving techniques. The contributions to physical oceanography have perhaps made up for any lag in the marine biological field. The National Institute of Oceanography, operating the *Discovery* and the *John Murray*, has greatly advanced the study of waves, tides and currents, and of the nature of the sea bed. Substantial outlays have been made on offshore drilling which presents an engineering challenge of the first order, largely met by using American designs of sometimes doubtful reliability: but ultimately the expertise being accumulated may be even more valuable than the products themselves if the world's oil and gas resources become economically exhausted in 30 or so years as has been suggested.[4] Britain indeed has particular problems in that its coastal waters are relatively inhospitable.

The ambitious project by the small team from Imperial College to spend six weeks next summer in a research 'hut' (Kraken) lowered to 100 feet near Oban will be the first serious attempt in the U.K. to carry out free dives of long duration. The leader, Mr. Ray, believes that no amount of remote exploration by wires, sonar, bottles or core drilling can take the place of direct observation and actual work on the sea bed: you just must go down to see for yourself, even if it entails living there to avoid the time-consuming decompression periods required for any dive much over 30 feet. Such a project could be of immense value in servicing the North Sea rigs, where it will be a sad reflection if companies resort to the use of American or foreign equipments as now seems likely.

And equally noteworthy is Britain's first research submersible, S.U.R.V., built as a private venture by the Lintott Engineering Company of Horsham, costing £150,000. It is designed to carry a crew of two and work eventually down to 1000 feet, being leased for investigations and research work.

[4]'Myopia among the Power Men'. C. J. H. Watson. *New Scientist*, 23rd November, 1967.

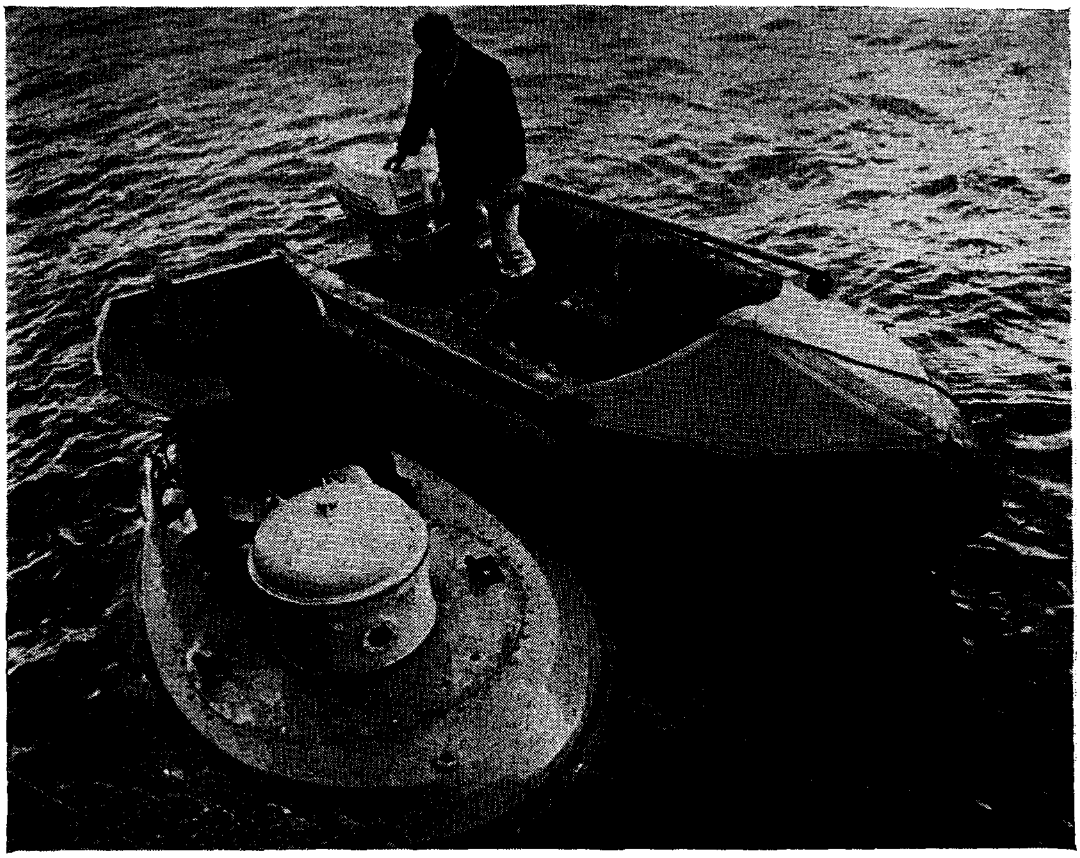

FIG. 2—S.U.R.V. afloat
(*Courtesy of Lintott Engineering Ltd.*)

Going Deeper

Rear Admiral Hushing, U.S. Navy, has outlined[5] some of the problems now being met in working at 9000 feet with water pressures of more than 2 ton/sq in. Naturally effective ways of 'seeing' have to be devised, whether by searchlight, sonar or electromagnetic means, capable of penetrating the fine particles present with any mining or agricultural operation. Little is known about the corrosive effects on metals at these pressures with accelerated erosive forces, and a particular problem arises in allowing for low-cycle high stress fatigue (as opposed to the comparatively low-stress high cycle fatigue in aircraft). High performance electrical generation and conversion devices are needed: and electrical cables must be developed which are not affected by selective compression of gas pockets between insulating layers which can rupture a cable on decompression.

An important question would appear to be the extent to which robots can be used. Professor Thring at the British Association meeting at Leeds outlined[6] an imaginative crawler with highly sophisticated hands which could do anything human hands can do, for unlimited time, with great accuracy and power. Much expertise already exists in this country in the form of remote handling equipment (telechirics) used in the atomic energy world. But bitter experience shows that there are immense problems to be overcome before even simple equipment can be reliable at great depths. Air and sea water differ so greatly in properties such as heat conduction, oxygen content, specific weight, com-

[5]'The impact of high performance science and technology on manpower requirements at the undersea interface'. Rear Admiral W. C. Hushing, USN. Engineering Manpower Commission of Engineering Joint Council report.

[6]'The Next Thirty Years in Engineering'. Professor M. W. Thring. Section G, B.A. Meeting, Leeds, 31st August, 1967.

pressibility, and corrosive effects, that 'ruggedised' versions tested in air can be dangerously useless on the sea bed. (And the unexpected often happens—as with a certain sophisticated diver-to-diver communication equipment operating at an internationally agreed frequency, and costing about £1000: it proved useless due to the deafening crackling of 'snapping shrimps' at that particular frequency.) It appears the Americans initially favour manned observation vessels, with all the accompanying physiological problems for the crews. As Hushing points out, 'Man has done relatively well as a pearl diver, perhaps for the last 2000 years: but when he really moves into the sea, and begins to explore and exploit it and becomes part of it, he has a tremendous transition to make'.

The Challenge—Can Britain Meet It?

Here then lies the challenge to 'big science' and ingenious engineering, with appeal to our traditionally adventurous spirits, and particularly to the young whose interests have been aroused by skin diving and underwater exploration. Biologists, geologists, chemists, physiologists, engineers of all kinds, civil, marine, mechanical, electrical and electronic, and professional seamen and hydrographers—all are involved. The development of instruments and equipment for export would appear to be a most promising field for Britain to pursue. The scope and goals are so great as evidenced by the North Sea Gas developments, that no one country could compete alone, and happily much international co-operation exists through UNESCO and other bodies.

But well under £1m/year is being spent by the Government on 'non-defence' oceanography, not much more than is spent on our canals, much less than the compensation for the recent foot and mouth disease outbreak, and a small proportion of what is spent on meteorology. (Few London bookshops stock a single book on oceanography.) We have hardly started to scratch the continental shelf (except for fish, sand and gravel), let alone the deeps where a completely different and hostile environment exists, perhaps 50 times or more beyond the ambit of conventional submarines. The royalties from the North Sea gas, estimated at £100m–£150m a year, should allow a much greater amount to be devoted to intensifying research and subsidising the engineering development involved.

Does really *effective* machinery exist for the co-ordination of the work of scientists and the increasing number of engineers involved in all the many Government Departments concerned? Is there a realistic national policy looking beyond the needs of the next decade? The Harwell conference revealed 'over the whole range of interests covered, a serious lack of detailed basic information about the sea and sea bed, not only in the deeper oceans but also in estuarine and coastal waters. The heavy demands of modern technology for such data need to be matched by adequate data acquisition and handling systems. There is also a lack of adequate tools for work and exploration in the sea; much of the basic technology already exists but development is dependent on the formulation of agreed objectives. There is a clear call for a well integrated national programme: the lead must come from the Government, but Industry has a major role both in research and development and in manufacture and exploitation'.[7] The question is not whether Britain can afford to meet the challenge but whether we can afford not to.

[7] *Proceedings* of Ministry of Technology Conference, 'The Technology of the Sea and the Sea Bed'. AERE Harwell. 5–7th April, 1967.

RELIABILITY OF SINGLE ELEMENT, SERIES, PARALLEL AND STANDBY COMBINATIONS

A—SINGLE ELEMENT C—TWO ELEMENTS IN PARALLEL

B—TWO ELEMENTS IN SERIES D—TWO ELEMENTS, ONE WORKING, ONE STANDBY

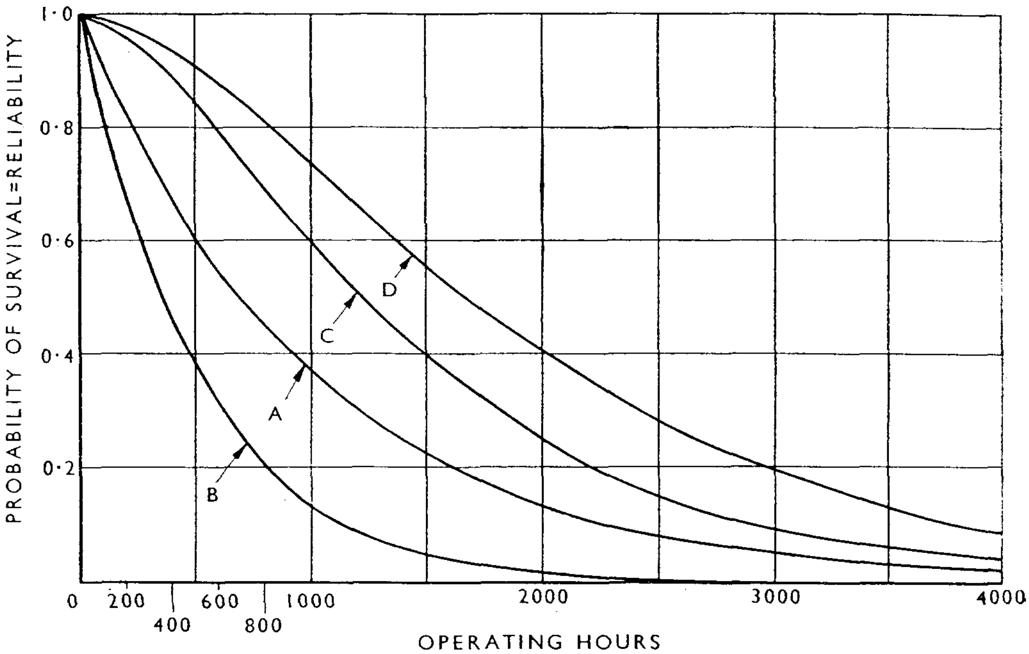

FIG. 6