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THE AQUALUNG : AN AID IN UNDERWATER EXPLORATION

By F. B. SALVADORI*

THE human body is not naturally adapted to life under water. The cave paintings do not give us any indication of the early men having made any attempt at underwater exploration. But, as soon as man reached the first steps in civilization he showed a desire to know the goings-on under the surface of the water. History shows that free-diving, viz., diving without the aid of any kind of apparatus or equipment, played an important part in the Hellenic world where it was first developed for sponge fishing ; even today, the divers of these coasts hold the record in the Mediterranean and in other seas for this type of fishing ! In the same way coral was fished centuries ago both in the Mediterranean and the Extreme Orient. Together with these two more or less contemporary forms of fishing, we have information of the fishing of pearls and varied types of shells for different ends. Even in Homer's Iliad the art of diving is held in honour. Those divers who attained celebrity and glory belong to the Greco-Roman period, some were even deified, for instance Glaucos together with Neptune. Scyllias and Cyana were famous for their bellicose underwater operations against the Persian army at Cape Artemisium.

More historical information on the employment of frogmen in battle comes from the pen of Thucydides in several episodes of the war between Sparta and Athens.

But if history has recorded these and numerous other accounts of man's free-diving, it gave us very little regarding experiments with breathing apparatus ; perhaps the oldest account is that of Aristotle, if the interpretation given to one of his passages is correct : 'The divers have even built themselves instruments by which they can remain longer in the water breathing the air that is to be found above the surface, as nature has given a trunk to the elephant which it uses for an analogous purpose.'

Whereas little is known about diving operations in the Occident during the middle ages, numerous instances of divers being employed for war and fishing purposes are recorded from the Orient.

Only with Leonardo da Vinci do the first drawings of underwater equipment appear ; however, viewed in the light of modern experience, these could not have been used for any kind of underwater work ; rather, they are more of the imagination. All the same, based on these, numerous immersion equipments were made, but the insufficient knowledge of that epoch regarding pressure etc., obstructed a solution to the various problems involved in diving. Perhaps, one of the first and most simple instruments invented was the diving bell by Borelli of Italy in the 17th Century : 'a submerged metal bell that did not touch the bottom, under which the diver could

*Dr. Francesco Bashchieri-Salvadori is the Curator of Fishes, Zoological Gardens, Rome. He was the scientific director of the Italian National Underwater Expedition to the Red Sea areas in 1953. He came to India during the close of 1958 as F.A.O. underwater expert to survey the Pearl and Chank beds of the Gulf of Mannar.

return to breathe without the necessity of returning to the surface.' Evolution in this field became ever more rapid and trials followed in quick succession, till, at the end of the 18th Century, the first practical apparatus could be used.

Finally in 1819, with Augustus Siebe, a definite apparatus fed from the surface by a pump came into being. Following this, in 1844, the first series of scientific dives in history took place—the great naturalist Milne Edwards dived repeatedly with the Paulin apparatus along the coast of Sicily.

In 1855-60, Benois Rouquayrol and Auguste Denayrouze built the first diving apparatus using compressed air. This prototype was the basis on which the modern aqualung, with subsequent modifications, was constructed.

The major development of underwater activity and inventions of better equipments could be put in a chronological order as follows :

(*a*) for bellicose purposes during World War II with oxygen apparatus, used first by the Italian Navy assault parties, then by the British, Japanese and Americans ;

(*b*) immediately after the war until today for sport and industrial purposes, *i.e.*, underwater spear-gun hunting, industrial fishing and salvaging ;

(*c*) and finally in the most recent years for scientific and general research purposes with the aqualung.

While for sport and some industrial purposes free-diving with mask and fins alone is sufficient, for research and salvage operations, one or other of the breathing apparatus is essential to allow the diver to descend to greater depths and remain there for greater duration. The modern equipment varies from the old type of surface-fed diving bells : from the most simple and practical method consisting of a rubber mask fed either by pump or by cylinders of compressed air from the surface, but allowing the diver more flexibility and independence of movement, to the most modern of all, the oxygen apparatus and the aqualung. The last two permit the diver complete freedom of movement for his underwater work. Each apparatus however serves its own purpose depending on the conditions, depth, duration and type of work in which the diver-specialist will be engaged, not forgetting the importance of the various economical factors.

There is, I think, no need to describe the surface-fed apparatus as they are by now well known to all ; a brief description however of the oxygen and air apparatus and some of their defects and merits might be of use to those who intend to carry out diving operations using them.

The oxygen apparatus is also called 'closed circuit-respirator' because, the breathing channels of the diver together with the cavities of the apparatus form a closed circuit. This mainly consists of (*a*) lung-sack in rubber or rubberised canvas, (*b*) a metal purifying-filter, (*c*) metal cylinder containing compressed oxygen, (*d*) mouthpiece and mask, and (*e*) corrugated tube connecting the lung-sack to mouthpiece. The lung-sack has the function of distributing respiratory gas at hydrostatic pressure. The purifying filter contains grains of alkaline substances, usually calcium soda, to absorb the carbon-dioxide ; if this is not absorbed as and when formed, it would rapidly reach toxic concentrations. The oxygen in the lung-sack, consumed by breathing, becomes renewed either by a system of continuous flow from the cylinder or as and when the diver breathes. This apparatus is commonly called the Davis Apparatus because it was Davis who, at the beginning of this century, made the necessary modifications to pre-existing types that enabled the apparatus to be used with such success as a means of escape from submarines. It is also used for speleological explorations. Compared to the air-apparatus, the closed-circuit-respirator presents the advantage of possessing fewer impediments and a higher autonomy of immersion. On the contrary it offers less possibilities of immersion at greater depths because, as is well known, oxygen at a pressure of about 2 kg. per sq. cm., can become toxic, and even at depths of 10 metres the apparatus may present considerable dangers to the human system.

As regards underwater scientific research, the explorer has to cover greater depths and therefore the air-apparatus, for the time being, the only type that permits several minutes stay at a depth of 60-70 meters with minimum risk if used rationally, is undoubtedly the most advisable form of equipment. Although present manufacturers are constructing the air apparatus or the Aqualung under different patents, all are working more or less on the same principle, i.e., the possibility of supplying air by means of a regulator from the reserve cylinder carried by the diver on his back to the diver's lungs only on demand following inhalation by him.

This apparatus notwithstanding its simple design and ample possibilities for work at greater depths, can at the same time present equal dangers if used imprudently; one of the most common dangers being what is known as the 'bends'. The 'bends' are liable to happen, when, after a long stay at great depths the diver returns to the surface too rapidly, a certain amount of inert gases like nitrogen dissolved in the blood stream during stay under pressure liberate in the form of bubbles causing osteo-muscular pains, disturbed breathing, paralysis and even death. The only sure way of avoiding such a condition is to adhere strictly to the Decompression Rules, i.e., the practice of halting during return to the surface at the stipulated depths and for the specified time, as indicated by the Decompression Tables (these tables are printed now-a-days by the Navy in most countries and by the Institutes of scientific research on the physiology and pathology of the human body in immersion).

Another more serious danger presented by the aqualung when the diver surpasses the depth limit of security, say 60-70 meters, is what is called 'rapture of the deep'. This phenomenon which manifests itself as a perfect state of drunkenness, causes a change in the diver's intellect, thereby inducing him to perform awkward impulsive actions at times without the minimum reflection. Dangerous because, such a state of mind may lead the diver to strip off his mask and mouthpiece or even to continue on the downward journey, unaware of his reflex actions in his new state of exhilaration. The cause of this 'rapture of the deep' is not yet clear. There are various hypotheses, but for the moment, none is altogether convincing.

Although I have only mentioned about breathing apparatus and their evolution, there are other types of equipment essential for underwater research: Equipment like the spear-gun for the capture and collection of biological specimens. Underwater camera for photographic recording of life underwater. Depth meter for recording the depth at which the studies are made, and water-proof wrist watch to note the time of immersion. Modern science has contributed all these to enable the researcher to make a thorough study of underwater life through direct observations.

By means of these underwater equipments, particularly the aqualung and the underwater camera, the biologists as well as the hobbyist can explore, document and study the various forms of underwater life. The social behaviour of fish, fish locomotion, their breeding grounds, the pattern of distribution of life under water and the type of the sea bed are some of the more important studies for which the biologist finds the aqualung and similar underwater equipments most indispensable. During my short stay in India, I was able to have a general idea of the underwater life in Gulf of Mannar area. Though I was particularly concerned with the study of the chank and pearl beds off Tuticorin, India, yet, my general observations of the flora and fauna of these beds remind me of the Red-Sea areas which I visited in 1953 with the Italian National Underwater Expedition. Broadly, the pattern of distribution of life underwater in the Red-Sea areas stands parallel to that of the Indian waters ; especially so in the case of the coral beds of the Gulf of Mannar. It may be stated that there is much scope for detailed scientific studies of the underwater flora and fauna of the Indian waters because, these areas are not explored so far. Intensive underwater explorations, both for scientific as well as sportive purposes, have resulted in the depletion of stocks of numerous species of fishes in the Mediterranean Sea and hence, one is bound to come across many larger species in unexploited areas like the Indian waters.

One could derive endless pleasure and a mine of information watching the underwater life—the brilliantly coloured fishes that swim about, the graceful movements of the scorpion fish, the parrot fish amidst the coral beds, the corals themselves with a diversity of exciting formations and colours like the brain coral and the stag-horn coral, the sandy bottom with innumerable star fishes, red sponges, brilliantly coloured sea anemones, the hydroids and the various types of marine plants are some of the typical 'treasures' of the sea. Only through photography can these be brought to the surface. Modern methods in underwater filming and television have enabled the scientists, who are unable to withstand immersion, to study the ocean beds and the mysteries of underwater life.

As we have seen the first official underwater research was carried out by Milne Edwards in 1844, but it is only in the last few years that a serious attempt has been made to employ underwater equipment in a field other than industry or sport. The possibilities in this new field are as vast as the sea itself. The institutions that conduct underwater research with positive results are few. The notable among these are L' Office Francaise de Rechérches Sous-marins, founded by Commandant Yves Cousteau in 1952 at Marseille, the Scripps Institute of Oceanography at La Jolla in California, Instituto Internazionale di Studi Liguri at Bordighera, L' Institute de Rechérches Sous-marins at Cannes, the Internationales Institut fur Submarine Forschung at Vaduz in Liechtenstein, and Il Centro-Italiano Ricercatori Subacquei at Genova. Looking into the past and over the horizon of the future, it is doubtless that other institutions will spring up in countries where a desire exists to elevate and augment their own scientific advancement.