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27.—Historical Development of Diving and its Contribution to Marine Science and Research. By Dr Hermann Heberlein, 'casa Corallo', Breganzona, Switzerland

1. Introduction

One of the first diving attempts in connection with marine exploration was started some 400 km from Edinburgh. On September 8, 1820, the Swiss physician Louis-Theodore Colladon [1] submerged in a diving-bell 10 m deep to the bottom of the sea at Howth, near Dublin (Ireland). During an hour's stay under water he observed and measured the ground. Being a diving doctor, he did not only take an interest in technical dates concerning the diving-bell, but he also kept a diary where he noted the professional divers inside the bell were supplied with additional nourishment as bread and brandy 'in order to regain soonest their lost strength'.

This paved the way for human entry into the sea, and henceforth science and research could be extended from the continents to the submarine field. People became aware of the ocean's importance which covers 71 per cent. of the terrestrial globe. Men invaded the element from where all life on earth seemed to descend.

2. Employment of Diving Equipment and Diving Methods

2.1. Skin Diving

Men are supposed to have always been able not only to swim but to dive, which is proved by mother-of-pearl inlaid works dating from 4500 B.C. that were found in the ruins of Bismaya (Babylonia) [2, 3].

2.2. Diving Equipment

2.2.1. *The Diving-Bell*

Alexander The Great's [4] legendary submergence occurred in 325 B.C. when he was only 31 years old. Aristotele, helped by Diogenes, invented the diving-bell, and both Alexander and Nearchos entered into it. During the course of centuries it developed into a useful and helpful diving apparatus.

Will Philips [5] recovered salvage as early as 1598 from the Spanish fleet which had been defeated by the Earl of Essex on the coast of Spain. Halley [5] spent one hour and a half in 16 metres depth in 1691. Smeaton [5] 1800 used a pneumatic pump to provide fresh air.

2.2.2. *The Diving-tower*

Ernest Bazin [6, 7] employed, after 1850, a diving-tower and reached 100 m depth. Toselli's [8] diving-apparatus *Neptun* goes back to 1884 and proved most helpful in the building of lighthouses and harbour plant. It was used also for natural science investigation. Roberto Galeazzi sen. [9] started constructing his diving-apparatus in

1914. In 1930 he submerged in his own diving-tower to a depth of 235 m. Guided by Roberto Galeazzi jun., after 1950, they descended to 650 m at Capo Corso.

2.2.3. *The Diving-tube*

Collonges **[4]** constructed the first diving-tube in 1855. The father and son construction of Charles and J. Ernest Williamson **[10, 11]** became much more popular. J. Ernest Williamson dealt at the same time with problems of underwater cinematography. Approved scientists such as Townsend and R. W. Miner **[12–14]** collaborated with the 'Williamson Submarine Tube Corporation'.

2.3. Underwater Vehicles

2.3.1. *The submarine*

The Venetian Roberto Valturio **[15]** described and designed an underwater vehicle in 1472. Also Leonardo Da Vinci **[16]** and in particular Borelli **[17]** were engaged in problems of diving-boats before 1734. Wilhelm Bauer **[18]**—around 1850—was not only one of the first who succeeded in navigating his invention beneath the water surface, but he realised also that the submarine would prove useful for research and science. Other pioneers were: Anschütz-Kaempe **[19]**, Simon Lake **[20]** and the Australian Hubert Wilkins **[21]** who all employed submarines for scientific investigation.

2.3.2. *The Bathysphere*

William Beebe's and Otis Barton's **[22, 23]** bathyspheres were built exclusively for research work. In 1934 the two investigators descended to 923 m, a depth never reached before, and in 1948 Barton reached 1372 m with a new bathysphere. Mentioning the team Beebe-Barton, we must not omit the general-assistant, John Tee-Van **[24, 25]**.

2.3.3. *The Bathyscaphe*

The first successful human advance into abysmal depths was pioneered by Auguste Piccard **[26, 27]**. On November 4, 1948, the first submerging experiment took the unmanned bathyscaphe *F.N.R.S.II* down to 1380 m. Subsequently the *Trieste* was built in Italy, and inside this bathyscaphe the Piccards, father and son, let themselves down to 3150 m, in 1953, near the island of Ponza. In 1956 they submerged to 3700 m. Then, on January 23, 1960, Jacques Piccard and Lt. Walsh started from Guam and in the Mariana Trench reached the deepest point of the sea bottom hitherto known (*Challenger*-depth), 10 916 m **[28–30]**. The two French specialists, Willm and Houot **[31]**, took over and transformed *F.N.R.S.II*, and thus made certain of the bathyscaphe's further development.

2.3.4. *The Mesoscaphe*

After Auguste Piccard's death, Jacques Piccard **[27]**, basing his work on designs left by his father, built the first tourist-mesoscaphe for the Swiss National Exhibition (1964) in Lausanne. In 1969 J. Piccard inside the submarine *Ben Franklin* covered a distance of 2800 km. The primary objective of the expedition was to drift submerged with the Gulf Stream for 30½ days, to study the current and its biology **[32]**.

2.3.5. *The Light- or Pocket-submarine (underwater vehicles), 'Underwater Villages'*

The light- or pocket-submarines have only recently been developed [**33, 34**]. The USA, the Soviet Union, Japan, France, etc., were the first nations to construct light-submarines, 'diving-saucers', underwater robots and similar engines which are mostly used for research on the continental shelf. Experimental training of men for prolonged sojourns at 100 and more metres depth was undertaken after 1960. Here we must mention besides Link, Cousteau and Bond the investigating team of Keller-Bühlmann [**35–38**].

2.4. The Scaphander Diver*

2.4.1. *The Scaphander (closed Dress)*

Leonardo Da Vinci was deeply engaged in diving problems [**16**]. A model of his diving-suit was already equipped with facial protection and air-valves. The scaphander and similar diving-suits and equipment were built and perfected for many different tasks by Freminet [**39**], Cavolini [**40**], Drieberg [**5**], Paulin [**41**] and others. In 1844 Milne-Edwards undertook his first scientific work on the sea bottom. He gave an order to Colonel Paulin to produce a diving-apparatus with diving-suits for his research work. Repeatedly he spent half an hour in five to ten metres depth and investigated on the unknown sea bottom near Torre dell'Isola, a few kilometres from Palermo. Mentioning Milne-Edwards, De Quatrefages [**42**] and Henri de Lacaze-Duthier [**43**], we must not omit the name of Anton Dohrn [**44**]. Not only had he the idea of using the progress of modern diving for the work of the Zoological Station at Naples, but he personally participated in active submarine research. Anton Dohrn's special merit was that he made available his new knowledge to everybody. It was only natural that Reinhard Dohrn should carry on his famous father's work. Unfortunately he had—1910—a diving accident caused by a technical defect [**45**]. The inland investigator, Emile Yung, [**46, 47**] brought forward submarine investigations of special interest.

From a scaphander, in the bay of Banyuls and Port Vendres, the scientists François, Guital, Pruvot [**43**] did excellent marine exploration as early as 1880. Three years later, Berthold and Weisman [**40**] employed the scaphander for scientific work in the Gulf of Naples. Hermann Fol, after thorough studies in the Lake of Geneva [**48, 49**], dived with Edward Sarasin near Nizza, in the Mediterranean. Southwell [**50**] dived in 1906–12 along the oyster-banks of Ceylon, and in 1908 H. Blegvad [**51–53**] investigated the oyster-banks in the Arctic water of Lomfjord, employing the scaphander in use at that time. In the salt-springs of Austria's Tennen-Mountains A. v. Mörk dived in 1913 [**50**], and near Hanstholm, Denmark, during the erection of a pier in 1923, P. L. Kramp [**54**].

A very great explorer was the Swedish zoologist Torsten Gislèn [**55, 56**]. He recognised the importance of documentary underwater photography and used it, together with Odquist, for his scientific work.

* *Scaphander*. This term was used for the first time by M. de la Chapelle, in 1775, in his book: *Traité de la construction théorique et prarique du Scaphandre* . . . Later on, French and German scientists (see H. Stelzner: *Tauchtechnik*, Coleman, Lübeck, 1943, pp. 69, 71) took over the word 'scaphander' for this type of swimming apparatus. It is meant for a diver who is equipped with a round copper helmet with a sight window and a closed dry diving-suit + lead shoes + a communication string (signal) towards the surface + an air supply through a tube (air pump on ships).

Before 1935 it was E. A. Martel [**50**] who explored the source of the Vaucluse in Southern France in connection with paleontologic works, using diving-apparatus.

Erich Wasmund [**57–59**] from Kiel made himself a name beyond national boundaries by his personal submarine research. He wrote a report on the stony ground in the bay of Kiel, where he worked in −6 to −10 m, despite very bad water conditions.

2.4.2. *The Self-contained Scaphander (Closed-Dress)*

In this special domain we must mention above all Stelzner and Bräutigam [**60**] of the Dräger-works, and Davis [**10**] of Siebe, Gorman & Co., whose work between 1910 and 1915 showed the best results.

2.4.3. *The Diver-helmet*

Whereas in the Mediterranean, marine explorers between 1844 and 1935 dived mainly with scaphanders (closed-dress), in the Caribbean, at the beginning of the twentieth century, the diver-helmet (without dress) was brought into prominence.

In 1905 and 1907, Jacob Reighard [**61–63**] worked on the warning coloration in coral-reef fishes. The director of the Tortugas Institute, Mayer (who later on changed his name to Mayor) [**64–66**] supervised this work. Mayer also delivered the funeral oration for Alexander Agassiz who died in 1910 during a scientific expedition. Ernest Cotton [**67**], a railway engineer from Marathon, Florida, and W. S. Dunn had a decisive part in the further development and improvement of the diver-helmet.

W. H. Longley [**68–72**], the head of the Tortugas Institute after Mayor, began to work under water in 1915, equipped with a diver-helmet. He quickly recognised the importance of underwater photography and succeeded in a few years in bringing back from his submergences the first colour photographs of immense scientific value (after 1917). After 1923, Longley, together with Bartsch, devoted himself to underwater cinematography.

E. W. Gudger [**67**] assessed accurately the difference in the use of the scaphander (closed-dress) and the diving-helmet which was easy to handle, of great help and not too expensive. Lewis R. Cary [**67**] and Bowman [**50**] also worked under water. In the North-American lakes Edward F. Ricketts [**50**] did limnologic research work which became well known because it was published jointly with the Nobel Prize winner John Steinbeck [**73**]. J. F. Curtis [**74**], L. W. Vaughan, Boschma, Yonge, Hart, Verwey, Kitching and Macan [**50**] undertook their submarine work in the years between 1923 and 1934.

A shipwreck drove Gilbert C. Klingel [**75**] to the Inagua Island south of the Bahamas, shortly before World War II. Equipped with his diving-helmet he explored the underwater world at his leisure.

The Swiss zoologist Hans Mislin [**76**], with the help of Max Manger, manufactured personally all his diving equipment. The two scientists explored between 1942 and 1944 the lakes of Biel, Sils and Lago Maggiore and the rivers Maggia and Melezza.

2.5. Autonomous Divers

2.5.1. *The Underwater Wanderer*

Marine science and research got a fresh impulse through autonomous diving. As its father and pioneer we must consider Yves le Prieur [**77**]. As early as 1905 he

dived in Indo-China. The first absolutely autonomous submergence took place on August 6, 1926. With Fernez at first, and later by himself, Le Prieur created his own compressed-air respirator, but he also designed and manufactured masks and waterproof cases for his photo- and movie-cameras. He built a cage for protection against sharks and constructed an underwater harpoon. In 1935 he founded a diving school and three years later he took his first colour underwater films.

2.5.2. *The Modern Autonomous 'Skin-diver'*

Step by step the sticking to-the-ground underwater wanderer developed into the lightly floating independent 'skin-diver'. One of the first books on modern, autonomous diving was written by Guy Gilpatric **[78]**. Jacques-Yves Cousteau **[79–83]** foresaw plainly the immense possibilities of modern diving. In partnership with Philippe Tailliez **[84–86]** and F. Dumas **[87]**, and in collaboration with the inventor Gagnan, he created an easy, handy and very safe compressed-air respirator.

A quite different personality is Hans Hass **[88–95]**. While still a student he learnt modern diving from Gilpatric in 1937 on the French Riviera. Later, when he was an experienced biologist, he explored the underwater world. His encounters with sharks, above all, brought completely new knowledge to the zoologists and altered fundamentally their attitude towards these 'cannibals'.

Conrad Limbaugh **[96–101]** must be mentioned as one of the most important personalities who connected in a most helpful way the advantages of modern diving with marine research and science. His proposal to Boyd Walker to teach diving with 'aqualungs' to his students and thus give them first-hand pictorial instruction fell on fertile ground. Walt Disney himself consulted Limbaugh about natural science and the study of sharks for his new style of film. Jacques Pittard **[102]**, a natural scientist from Geneva, discovered lake-dwellings in 1936 in the community of Chens in the Lake of Geneva which dated probably from the Bronze Age. Divers, equipped with 'Le-Prieur aqualungs' fixed signal-panels at the place of discovery, in 2, 5 and 7 m depth. Additionally aerial photographs were taken.

Also in the thirties—1937—Hugh Bradner **[103–104]** learnt diving from the physical scientist, E. Thomas. Later, as professor at Berkeley and La Jolla, he was engaged mainly on seismic oceanology. The Genoese Giuseppe (Duilio) Marcante **[105–107]** began diving as an underwater hunter. In 1952 he was one of the founder members of the 'Centro Subacqueo di Nervi' that he still directs. It was not long before Marcante saw the possibility and importance of collaboration between sport-divers and marine science.

Ruper Riedl **[108, 109, 40]** began to dive in 1947 after taking his degree in zoology, as this offered him the best possibility of making full use of marine research. He also worked with an underwater camera.

2.5.3. *Variations of Autonomous Diving*

In 1936–37 the brothers Ivan and Dusan Kuščer **[110–112]**, a physicist and a geologist, and Marko Zalokar **[113]** started diving with a divers-helmet. They made all their own equipment and used a special hand-pump with a tube about 25 m long. In this way they worked in the limpid water of the Adriatic Sea. Their Viennese mother accompanied her sons under water when she was almost 70.

Nowadays, in certain cases, the compressed-air bottles are replaced by a fresh-air supply from a light compressor placed on a buoy.

2.6. Photography, Film and Television

2.6.1. *Underwater Photography*

Wilhelm Baur [**114, 115**] was one of the first who tried (1856) to photograph the sea bottom out of his 'Brandtaucher'. In the same year Thompson [**6**] tried to make use of underwater photography to explore the sea bed near Weymouth. Ernest Bazin [**7**] constructed diving-tubes in 1865 which he used also for taking underwater photographs. One of the first written references to underwater photography goes back to 1871. In appreciation of Joselli's [**116**] merits as a scientist, the 'Ruballino Society' let him use the steamer *Sardinia*; from this base Joselli employed a camera connected under water with a diving-bell. In 1888 E. G. Carey [**117**] submerged with a diving-bell and took underwater photographs with the aid of three electric arc-lamps. Very great services to the success of underwater photography and its application to marine science and exploration were rendered by Louis Boutan [**43, 118–122**] who worked after 1890. He devoted himself to experimental photography on the sea floor, using all his strength and showing inflexible energy and ability. Lacaze-Duthier sustained Boutan's new-styled investigations, and Boutan's brother, the engineer A. Boutan, assisted him with the design and construction of underwater cameras. The underwater lighting is said to have been conceived by the engineer Cahufour.

At about the same period as Boutan—1891—Paul Regnard [**123**], a professor at the Sorbonne, was also engaged in underwater photography. Just before the turn of the century, in 1898 and 1899, J. E. Romborsts [**124**] and C. L. Bristol [**61–63**] photographed under water. Etienne Peau [**125, 126**] was also an excellent underwater photographer. B. Wandolleck [**18, 127**] seems to have written only about his impressions on underwater photography, and we cannot find whether de Casparis' [**50**] 'Thalassiuscope' was ever employed.

Another milestone in the domain of underwater photography was established by W. H. Longley [**68–72**], who worked in close collaboration with Mayor [**64–66, 128**]. During the period from June to August 1917, Longley's main objective was to achieve underwater colour photographs. It is quite amazing that in 1916 a 'Submarine Photo Co., Miami, Florida' [**128**] already existed in connection with the excellent underwater photographs of 'Longley and Company'. Torsten Gislèn experimented with a wooden case when he photographed under water, and collaborating with him Gustaf Odquist [**55**] achieved really good underwater photographs. In 1930 U. V. Bogaerde [**129**] took photographs under very bad weather conditions in Falmouth harbour.

Erich Wasmund [**57**] began to deal with underwater photography in 1937, and we must not omit the name of J. B. Collins [**130**]. Since World War II the greatest progress in underwater photography combined with diving is due to the work of specialists like J. Y. Cousteau [**79–83**], Hans Hass [**88–95**] and Dimitri Rebikoff [**131**].

2.6.2. *Underwater Cinematography*

J. Ernest Williamson, in association with his father [**11, 132**] started his underwater film experiments in the years 1913–14. His brother George M. Williamson was called

in to collaborate. In February 1914 J. Williamson was ready to begin his main work in the clear waters around the Bermudas. The Williamsons collaborated also with such scientists as G. Englehart, R. W. Miner **[12–14]** and Townsend. The best films for the Williamsons, however, were taken by Harold A. C. Sintzenisch **[133]**, in 25 m depth without the use of artificial light.

Paul Bartsch **[68–72, 134]** worked for the Marine Biological Station of the Carnegie Institution on Tortugas. When, around 1920, he showed his first underwater films, many of the spectators were seasick!

Floyd Crosby **[135]** worked as an underwater cameraman with Beebe during the Haiti Expedition. After 1930, the Universum-Film-Aktiengesellschaft (UFA) produced films like 'Mass Migration of Fishes' and 'Sea Animals in the Adriatic Sea'. Le Prieur's **[77]** experiments with his self-made underwater camera were also extremely interesting.

A short time before World War II, E.R.F. Johnson **[136–137]** was deeply engaged in the problems of underwater cinematography. After the war, H. J. Hodges **[130]** made excellent underwater films in the Mediterranean under conditions of very good visibility. W. D. Chesterman was largely responsibile for the construction of the camera. Cousteau, Hass and Rebikoff are again distinguished by their contributions towards the increase and development of underwater cinematography in the post-war years.

2.6.3. *Underwater Television*

To complete this report we must mention underwater television, although the camera is not usually held by a diver **[138–146]**.

Underwater television was first employed with success on the occasion of the atom bomb test at the Bikini Islands in 1947. In 1951 it proved a positive help in searching for the sunken submarine *Affray* in the English Channel, and again it was underwater television that gave good results in localising the crash site of the 'Comet' aircraft in the Mediterranean, near Elba, in 1954. The use of underwater television in modern swimming-research laboratories is steadily increasing.

2.6.4. *Variations of Underwater Photography and Cinematography*

Explorers who did not submerge or even enter into the water have experimented with photography as an aid to underwater research. In 1856 M. Thomsen **[6]** lowered his underwater case into the sea in Weymouth Bay, whereas W. Saville-Kent **[147]**, before the turn of the century, tried to photograph the 'secrets of the sea' through the water. After 1897, R. W. Shufeldt **[124]** specialised in photographing fishes. Jacob Reighard **[61–63]** used different methods to take his photographs: (1) through the water surface; (2) standing in water up to his waist and letting down a waterproof camera beneath the surface; (3) using the 'Reighard water-glass' in order to photograph into the water; and (4) using a boat with a glass floor through which he photographed the underwater world.

Lucien Rudax **[148]** walked along the seashore and photographed what the low-tide had surrendered. The zoologist Ipswitch Ward **[149]** built himself a waterproof room with a glass wall, and around this building he dug out a pool. Leon Gaumont also 'worked' in a similar manner **[150]**. He managed to take quite good photographs

of diving otters and other water animals. Rudolf Lorenz [**151**] constructed his underwater camera with patent D.R.P. No. 281 383 dated March 7, 1914. The civil-engineer H. Hartmann [**133**] put his underwater camera of 680 kg weight into action from the coal barge *Vestal*. According to Ewing, Johnson [**136**] must have built an underwater camera which, in 1935, was employed in 3500 m depth. Such a deep-sea camera had also been designed by Harvey [**136**]. The engineer Rudolf Hofman worked in the bay of Keil and in the Lake of Constance from 1936 [**152**]. In 1938 Maurice Ewing, Allyn Vine and J. L. Worzel [**136**] began to photograph the sea bottom without themselves diving.

2.7. Coordinated Diving

2.7.1. *Guidance at Sight*

A profitable collaboration developed between Roy Waldo Miner [**12–14**] and J. E. Williamson [**11, 132**]. Miner, from a diving-cabin, guided the divers by giving sight signals.

2.7.2. *Guidance over the Telephone*

Francis P. Shepard [**153–155**] worked with the former Navy diver and natural scientist Frank Haymaker, who coordinated his submergences exactly according to Shepard's instructions. Both were in continual contact over a telephone.

2.7.3. *Various*

C. G. J. Petersen [**156**] entrusted professional divers with the exploration of oyster-banks in 1908. His collaborators R. Spärk and H. Blegvad [**156**] also employed divers to resolve their scientific problems. The geologist L. van Laczy [**50**] in 1925 described the observations of a professional diver in the tropical waters of East India. The Swedish zoologist Torsten Gislèn [**55, 56**] had professional divers, auxiliary crew and equipment at his disposal for scientific work. Lilian Lyle [**50**] was engaged in 1926 in exploring and counting the algae underwater growth on hulls, near Scapa Flow, in 12 to 21·5 m depth. A wealthy Arabian lent a pearl-fishing boat complete with crew to the head of a Danish expedition, Mortensen [**50**], to enable him to work at Banda, previous to 1930.

2.8. Various

2.8.1. *Women as Diving Explorers*

Quite remarkably, women also did active submarine exploration. Before World War I it was Poldi Führich [**50**]. In Beebe's *The Arcturus Adventures* we read about Ruth Rose [**157**]. Ten years later—1935—Miss Powell [**50**] dived in England to explore flooded caverns. Underwater biological research of the greatest importance was done by Eugenie Clark [**158**].

2.8.2. *Marine Archaeology*

Diving after sunken ships and the recovery of treasure is as old as the hills. It may be truly said that the Mediterranean is the world's greatest museum. However, marine archaeological research and science have developed only in the second part of the nineteenth century. A bibliography [**159–164**] of underwater archaeology already totals several thousand volumes.

2.8.3. *Underwater Painting and other Transmission Methods*

During the years 1768–71, 1772–75, 1776–80, Captain James Cook **[165–168]** undertook his epoch-making expeditions across the oceans. He died in hand-to-hand fighting at Hawaii, on February 14, 1779. For his third expedition he invited a painter with a biological degree—Johann Wäber from Bern (who subsequently called himself John Webber). He was expected to deliver drawings and paintings of people and landscapes of materials collected from the sea.

Alexander the Great **[4]** wrote his messages on hard tables when he dived in the sea in Southern Persia. Longley **[68–72]** used tables covered with wax, on which he scratched his notes under water. Mayor **[64–66, 128]** wrote, after 1920, with a soft pencil on a white table, and Miner **[12–14]** painted the underwater world from nature by Olsen in 1924 through the Williamson tube.

William Beebe **[169–171]** introduced the telephone for making himself understood. Zarh Pritchard **[135]** worked out original underwater paintings for Beebe. Yonge **[50]** wrote with a pencil on rough opal glasss, and Wasmund **[50]** used a common slate which he brought with him in a specially manufactured cotton-bag fastened round his neck. Exploring coral reefs, the Baronet Eugen von Ransonnet Villez **[172–173]** used a diving-bell constructed according to his own design and employed particularly near Ceylon. In this bell the scientist could draw under water what he observed. The results were the very first underwater reproductions from nature. Ernst Haeckel **[174]** visited the coral reefs near Tur in the southern part of the Sinai peninsula in March 1873. Divers brought living corals from the sea bed for Haeckel to elaborate scientifically. The German doctor and natural scientist C. B. Klunzinger **[175]** lived for almost ten years in the Egyptian town Koseir on the Red Sea. He also employed divers to find corals and fishes and marked with a bar the exact place where he hoped to find the material.

2.8.4. *Glass-bottomed Boats*

Towards the end of the nineteenth century, certain marine stations such as Naples, Rovigno **[176–178]** began to employ glass-bottomed boats for the exploration of the coast.

2.8.5. *The Diving-sledge*

The Dräger-works **[60]** thought of building a diver-sledge. Max Valentiner dealt mainly with the problem before and after World War I.

2.8.6. *The Underwater Elevator*

In 1944 Hans Mislin **[76]** and Max Manger constructed an underwater elevator which was first experimented with in the Lago Maggiore.

2.8.7. *The Underwater Torpille*

Hoping to improve his underwater photographs and films, the specialist Dimitri Rebikoff **[131]** created a tubular torpille and the 'Pégase' after 1950.

2.8.8. *'RUM' and 'FLIP', Modern Submarine Research Apparatus*

RUM was a remote-controlled underwater tank **[34]** (Remote Underwater Manipulator) equipped with several underwater television cameras for sea-bottom exploration.

The exploration tube-ship FLIP (Floating Instrument Platform) is, as its name indicates, a tubular ship more than 100 m long which can be turned from the horizontal to a vertical position to provide uninterrupted sampling from the sea down to 100 m depth.

3. Conclusion

Underwater houses, underwater vehicles, RUM, FLIP etc., are present-day constructions for the exploration of the sea. Today or tomorrow they will be completed or replaced. But men will always be behind these inventions, to go on exploring the secrets of the underwater world.

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