SUBMARINE NAVIGATION

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SUBMARINE WARFARE

PAST, PRESENT AND FUTURE

By HERBERT C. FYFE

With an Introduction by Admiral the Hon Sir Edmund Robert Freemantle G.C B., and a chapter on "The Probable Future of Submarine Boat Construction," by Sir Edward J. Reed, M.P.

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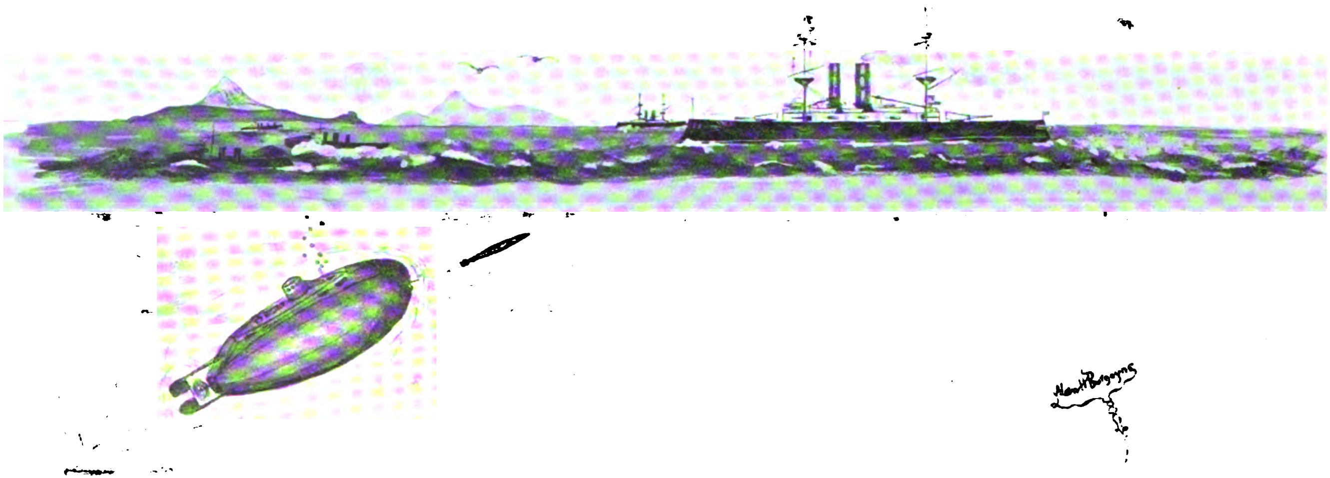

A SUBMARINE IN ACTION

SUBMARINE NAVIGATION

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PAST AND PRESENT

BY

ALAN H. BURGOYNE, F.R.G.S.

ILLUSTRATED

VOLUME I

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1903

NOTE

In the preparation of the present history of a new subject, I have had occasion to enlist the services of many eminent authorities for whose valuable assistance I am deeply grateful. My acknowledgments are especially due to Admiral Sir John Hopkins, G.C.B., Colonel Vittorio Cuniberti, Chief Constructor to the Italian Navy, Mr. P. W. D'Alton, Mem.Inst.C.E., Major C. Field, R.M.L.I., Fred. T. Jane, E. B. Frost, Capt. Cable, Lieut. Spear, U.S.N. and Mr. Simon Lake of 'Argonaut' fame, whose advice in their various departments has been of inestimable value in the compilation.

For most of the information of the 'Holland' boats I have to thank Messrs. Vickers, Sons and Maxim, and the various members of the Holland Company, New York, U.S.A.

Similar aid has been given me by the representative journals of Europe and Great Britain, amongst which I should like to mention the *Engineer*, *Graphic*, and *Navy and Army Illustrated*. My best thanks are due also to Messrs. Clive R. Fenn and Herbert C. Fyfe, for their kind services in reading through my proofs.

A.H.B.

ASCOT.
March, 1903.

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PART I

IN any retrospect of the events of the last century, one is at once struck by the vast changes that have been effected in the short space of a hundred years. Steam is almost absolutely under the control of man, having been broken in, as it were, to work his will, and now lately electricity, a far greater and more fickle power, is also slowly being subdued and will shortly be counted another servant of humanity. With steam subjected the steamship was not long in making its appearance. Countries became threaded and crossed in every direction by iron rails and land locomotion was much simplified. With electricity, however, little has as yet been done. It has proved a power far from easy to control—a power which has many times turned the tables on its masters. Its faculty of unexpected action is well known, but it is the 'boxing up' of that power that is found so difficult. The increased knowledge of electric force has more than anything else made submarine navigation prominent in recent years. Replacing the steam engine, which, as one might conjecture, is scarcely suitable for developing power when travelling beneath the surface of the sea, although it has been tried singly and in conjunction with electricity, the electric motor is an ideal engine for the submarine. There is no combustion requiring large supplies of oxygen (a valuable commodity in a small inclosed space)

B

to support it, and the motor also is not nearly so ponderous a machine as the steam engine, taking power for power. We, as a nation, are very conservative, and have ever been the last to adopt anything new, as witness the screw propeller, breech-loading guns, etc., preferring rather to let our possible enemies experiment for us, until a stage is reached when it is essential that we should follow. Then, and not till then, do we begin to build, panic-stricken as a rule lest matters have been allowed to go too far. A proof of this is found in the Naval Defence Act of 1888, when seventy ships were suddenly voted for at an expenditure of over £21,000,000. I do not mean by this that we are in as bad a way with reference to submarine boats as we were then with the Navy. Far from it; we have, however, always this truth to face. France and America are building submarine boats in great numbers, whilst Germany and Russia have long been conducting experiments secretly with models and private craft. Until two years ago we had done nothing. In an article in the first number of the 'Empire Review,'[1] Rear-Admiral FitzGerald says:

Extract from 'Empire Review'

'There is one engine of destruction—or rather proposed engine of destruction—concerning which I desire to make a few remarks; and that is the submarine boat. Personally, I do not believe in the submarine boat *at present* as a serious factor in naval warfare. That, however, is a very small matter, as a great many people do believe in her, and both the French and Americans are building several. There seems to be an insuperable difficulty in the matter of securing stability, and especially longitudinal stability, in a totally immersed body. It is said that the weight of one man moving forward or aft in a submarine boat completely deranges the longitudinal stability, and thus, of course, causes her to steer erratically in the vertical direction, which would be very awkward if she were near the top and did not want to appear, or near the bottom and did not want to stick in the mud. But who shall say that science and French and American ingenuity will not overcome this apparently insuperable difficulty, and bring us face to face with a most formidable engine of naval warfare, of which we shall have none?

1 'Empire Review,' February 1st, 1901. 'Our Naval Strength,' by Rear-Admiral FitzGerald.

SUBMARINE NAVIGATION

'It seems a little risky to hold our hand altogether. We are said to be 'watching'; and no doubt it will be very convenient if we allow others to spend their time and money on experiments, and then just cut in at the right moment when the submarine boat has established itself as a practical engine of warfare, and build as many as we want with the 'unrivalled resources' which we are so fond of talking about. But it should be remembered that secrets are better kept abroad than they are in England and that a new mechanical industry always takes some time to develop and to train the special workmen essential for its prosecution.'

The following is an extract from the 'Times':[1]

Extract from 'Times'

'Our Navy it is true has always been rather slow to adopt appliances and engines of warfare which have found favour with other Powers. Slow and sure is a good maxim, but sure and ready is a better. We must not be caught napping, and when a particular weapon has found favour with a nation as shrewd as the Americans and another as ingenious as the French, it behoves us not to neglect it ourselves. Further consideration and experiment may show that it is not a weapon suited to our notions and methods of naval warfare. But such a conclusion can only be established by experiments conducted under our own supervision and subject to conditions which leave no factor of the problem unaccounted for. For this reason we shall be surprised and disappointed if, when the Navy estimates are presented, it is found that the Admiralty have neglected to provide the Navy with a few submarine boats of the best type yet produced, to be employed in the experimental study of the whole problem.'

These two extracts are sufficient to show that at last the presence of the submarine boat in foreign navies is being felt in England, and it is as well it should be so, for it is obviously absurd to sit down quietly, and without experiment to say, 'These vessels can never be of any use to us.' The moment a novelty such as the 'Gustave Zédé' is known to have undergone trials in Toulon or Cherbourg Harbour, as the case may be, frantic articles appear asserting that the ironclad is doomed, whilst others equally fantastic deny the possibility of the new vessel ever proving of use. Which of the two types is the

1 'Times,' January 11th, 1901.

most harmful it is difficult to say, but the appearance of such articles immediately proves to readers who have a knowledge of the subject, the author's ignorance thereof. The submarine boat *cannot* drive the battleship from the sea in its present stage, and for years to come preponderance in ships of the line will mean superiority in sea-power.

Likewise to ignore the submarine altogether is not only a foolish procedure, but one that in time would become fatal, for the submarine boat has arrived, and what is more, will remain, improving as time goes on and as science places new powers and inventions into the hands of engineers. They have a present value—an almost unknown value, it is true—yet undoubtedly they will have to be reckoned with in future naval wars. Their effect on blockades I will comment on in a later chapter, but their utility does not end there.

We must always bear in mind that the torpedo boat did not begin with the destroyer, nor did the life of the ironclad open with a 'Duncan.' All vessels of to-day are but the evolution of time, for who on looking at the old 'Warrior,' the first of the British ironclads, would have prophesied the 'Majestic'? And had anyone when looking at the first torpedo boat, with a speed of 15½ knots,[1] been so foolish as to hint that in twenty-five years a vessel of similar type would accomplish over 35 knots in the same time,[2] he would in all probability have been taken for a maniac. So it was with Sauvage, the Frenchman who first mooted the idea of the screw-propeller, and so it always will be. Our minds are made for to-day and for to-day only—the things of to-morrow are beyond us. And of all nations England suffers most in this respect, for inventors have long ago discovered that the British shop is the last place to take their wares and consequently other nations—possibly our future enemies, for who is not with us is against us, and which of the great Powers can we really call 'friend'?—gain, and we lose. Thanks to the tenacity and bull-dog perseverance of our race we can as a rule come out 'top,' but it is better to be already there than always to have

1 The first torpedo boat was built for Norway in 1873—length 57 ft., beam 7 ft. 6 in., draft 3 ft., speed 15.6 knots.

2 The 'Viper' was built in 1899—length 210 ft., beam 21 ft., draft 7 ft. She displaced 312¼ tons, and on a preliminary trial accomplished 37.113 knots. Ran on Renouquet Rocks in 1901.

an up-hill fight to wage, even if we win every time. The sooner these truths are understood by the man in the street, the better it will be for us. The mind of the British public is noted for its plasticity when once it has been roused from its usual lethargic insularity, and, when the tide of thought of a nation is turned into one channel, its will is law. This forcing the hand of incompetent administrators has saved us many times before, but it scarcely seems worth while waiting until the masses are stirred to life, before acting. A little more judicious foresight and a lesser fear of the Treasury would save all Naval Defence Acts and most of the Supplementary Votes. No invention of merit should be rejected without fair trial, and inventors sending in plans or models ought, unless their ideas are obviously absurd, to be given a chance of proving the merits of their invention. Because the submarine boat does not appeal to the English mind, it is no reason why England should not possess them, given of course an efficient type. How an efficient type can be discovered without experiments I cannot conceive. 'History is experience, and as such underlies progress just as the cognate idea, experiment, underlies scientific advance.' [1] These are the words of one of the world's greatest naval students; they are almost a platitude if carefully considered. A medical student cannot set up as a specialist without first having been through a course at the hospitals, and in the same way our constructors cannot be expected to build a perfect submarine boat on the spur of the moment, without first having studied their principles by the aid of exhaustive experiments.

I have almost come to an end of this preamble, and will say a few words about the principle on which these articles are being compiled. The works published on the subject are very few in number and nearly all of them foreign, and a great deal of my matter has been drawn from the service publications.

I will in the first two or three numbers of this work give, in as much detail as possible, a history of submarine navigation from its commencement up to the present time, whilst the last part will be devoted to a discussion on the utility of the sub-

1 'Distinguishing Qualities of Ships of War,' A. T. Mahan; Scripps-McRae Newspaper League, November, 1898.

marine boat in modern warfare and some account of the theory of the submarine. Technicalities have been avoided as much as possible, as it is my intention to present to my readers a work which the least initiated can easily comprehend.

Although submarine navigation (taking navigation in the strictest sense of the word) was not attempted until 1620, several inventors are known to have made descents beneath the surface of the sea for the purpose of exploration. Aristotle
B.C. 332 tells us of the diving-bells of Alexander the Great, which were
Alexander The Great used with some success in the siege of Tyre, 332 B.C. Nothing is known of their mode of descent or manner of sustaining life.[1]

A.D. 1150 Bohaddin — An Arabian historian named Bohaddin, living about 1150 A.D., relates that a diver entered Ptolemais during a siege by means of a submarine apparatus.

1538 Toledo — In 1538 an invention for descending into the sea was heard of at Toledo, an invention in which Charles V. is said to have interested himself, whilst, forty-two years later, an Englishman, William Bourne, invented a plunging apparatus.

1580 W. Bourne — William Bourne's invention resembled that of Symons in outward form, but the means employed for submersion were different. Bourne submerged his vessel by contracting its sides by means of a number of hand vices, and thus reduced its volume.

1605 M. Pegelius — Twenty-five years afterwards Magnus Pegelius launched a similar construction, which, we are told, was a marvel of its time. None of these early experiments, however, can be considered, when referring to submarine navigation. They could not navigate, being suspended, for the most part, from vessels as with the diving-bells of to-day.

1620 C. Van Drebel — The honour of having constructed the first submarine boat undoubtedly belongs to Cornelius Van Drebel, a Dutch physician. His first experiment was made in 1620, when he built and launched a navigable submersible boat, and so successful did it prove that he had two others constructed on the same plans, in the larger of which James I., of whom Van Drebel was an intimate friend, made a lengthy trip. These

1 'On procure aux plongeurs la possibilité de respirer en les renfermant dans une cuve ou une marmite d'airan qui reste ouverte en bas.' ('La Navigation Sousmarin,' par Maurice Gaget.)

early craft were built of wood and rendered watertight by stretching greased leather all over the hull.

CORNELIUS VAN DREBEL

The following is from a description of the largest. 'She carried twelve rowers besides passengers, and made a journey of several hours at a depth of from 12 to 15 feet. The holes of the oars were made to hold the water by leather joints.' [1] Drebel accounted his chief secret to be 'the composition of a liquid that would speedily restore to the troubled air such a proportion of vital parts as would make it again for a good while fit for respiration.' [2] The composition of this liquid for enabling air to be used again was never made public. [3] The following extract from a pamphlet issued in France in 1680 [4] is interesting, as being a possible explanation of this wonderful elixir of life.

1 'New Experiments, Physico Mechanicall, touching the spring of air,' etc., by Robert Boyle, Oxford, 1660.
2 Dr. Keiffer.
3 Chambers' 'Encyclopædia.'
4 'Manière de respirer sous l'eau.' (L'Abbé de Hautefeuille.)

'Le secret de Drebel devait être la machine que j'ai imaginée et qui consiste en un soufflet à deux soupapes et deux tuyaux aboutissant à la surface de l'eau, l'un apportant de l'air et l'autre le renvoyant. En parlant d'une essense volatile qui retablissait les parties nitreuses consumées par la respiration, Drebel voulait évidemment déguiser son invention et empêcher qu'on le decouvrît.'

Van Drebel died in 1634 without having completed his experiments, leaving behind him no document relative to his work on the subject.

1632 R. Norwood In April, 1632, a Richard Norwood took out a patent for a submarine invention in which he proposed the 'making and using engines or instruments for diving and for raising or bringing out of the sea and other deep water any goods lost or cast away by shipwreck or otherwise.' He was therefore the first to patent an idea relative to submarine navigation.

1634 Mersenne and Fournier In this year two priests of the order of Minimes, Fathers Mersenne and Fournier, wrote a small work entitled 'Questions Théologiques, Physiques, Morales et Mathematiques,' in which is given a description of a submarine boat. Father Mersenne's judicious observations are well worthy of notice. It was he who first proposed a metallic hull for submarine craft, and he likewise points out that all vessels of this nature should be pisciform. The two extremities ought also to be spindle-shaped to allow of progress being equally easy in either direction.

His invention (although it never went further than designs) was destined to blow in the sides of ships, and to this end large cannon, or 'colombiades,' were to be placed on either broadside, a lid-covering preventing the entry of water. At the moment of firing, the cannon was placed with its muzzle tight against the opening, and the lid withdrawn. The shot having been fired, the lid fell into place automatically with the recoil of the gun.

1640 J. Barrié In 1640 a Frenchman of Pradine, named Jean Barrié, was granted a letter patent by the King of France, 'par laquelle Sa Majesté lui accordait le privilège, pendant 12 années, de retirer et pescher au fond de la mer, avec son vaisseau ou patache allant dans l'eau, toutes et chacune les marchandises et autres choses qui s'y trouverent.' (La Navigation Sous-marine. M. Delpeuch). This vessel was in all probability nothing but a diving bell.

In 1648, Bishop Wilkins published some very whimsical projects, and devoted a whole chapter of his 'Mathematicall Magick' to a dissertation 'concerning the possibility of framing an Ark for submarine navigation.' 1648 Wilkins

He here recites the difficulties of the scheme, but evidently considers them not insurmountable; and afterwards he enlarges upon its advantages in privacy, security from pirates, storms, ice, etc., in naval warfare, philosophical experiments, discoveries, etc. He does not, however, give any description of vessels.

A French engineer, named de Son, constructed a submarine boat at Rotterdam in the year 1654. This craft resembled that of Van Drebel in many respects, but was larger and was propelled by a paddle-wheel instead of oars. Its length was 72 feet, beam 8 feet, and depth 12 feet. The results of these experiments have remained completely ignored. 1654 De Son

Borelli can be credited with having employed the acme of simplicity for the submersion of his boat. He fixed a number of leather bottles into the hull—the bottles inside and their mouths open to the water. To sink he had only to allow the water to enter these bottles, and to rise again he squeezed the water out of them and bound the neck up, so that they could not refill, and thus reduced the volume of the vessel, which at once ascended. 1680 Borelli

On November 25th, of the year 1685, the King of France received a communication containing the invention of an Italian Jesuit, by name, Joseph M. Ciminius, a Neapolitan priest. His invention provided the means for men and ships to rise and sink at will to the bottom of the sea, fully armed and with all the limbs free to stop, move, sit down, walk about and run for the space of seven hours and even for a whole day. 1685 J. M. Ciminius

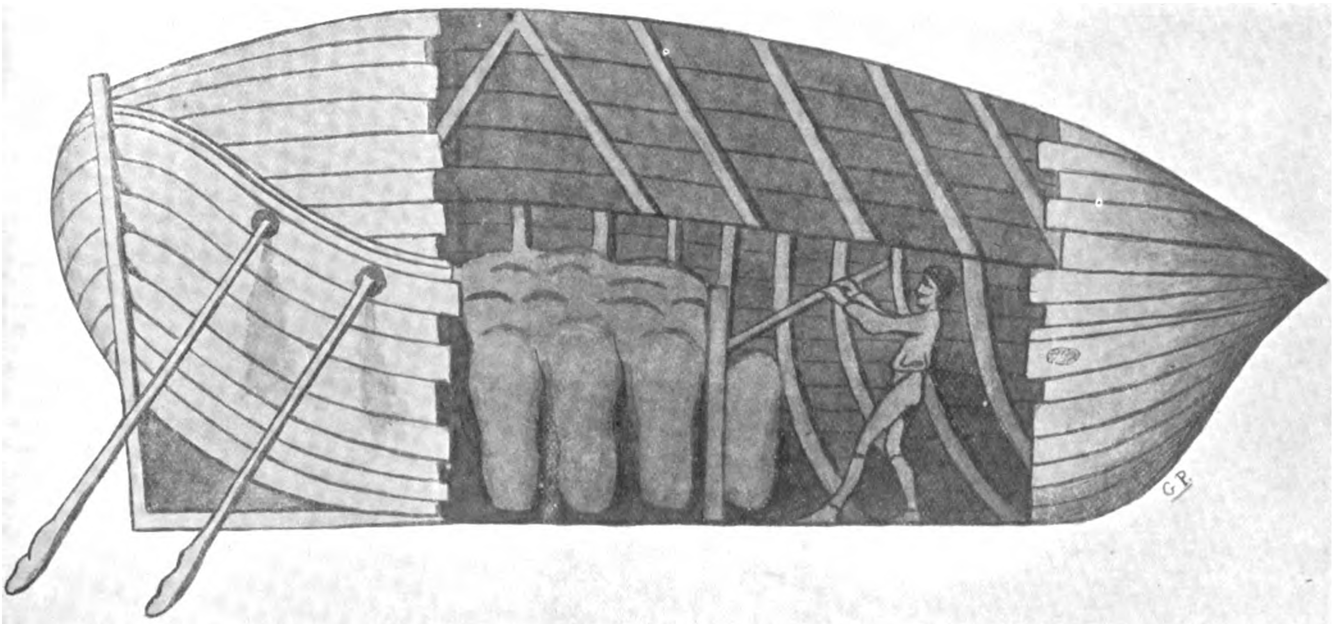
This gentleman (Roger Doligny) also wrote to the King and proposed a machine by which one might go beneath the surface and sink to the bottom. With a vessel fitted therewith one might destroy all the armaments of one's enemies and 1688 R. Doligny enter or leave at will any hostile port, destroying therein all shipping, merchandise, or obstructions and aiding a landing party if necessary,—'et généralement faire tous les mouvements d'un poisson et se condiure partout aù ou jugera à propos.' . . . . . .

1691 J. Holland — In the Patents of Inventions, volume 1 (1600-1700) is a reference to one John Holland, who patented an engine connected with submarine navigation. By a curious coincidence the vessel of a present day John Holland is accepted as the most advanced type of submarine. This year also a Sir Stephen Evance patented a submarine boat. (Sir S. Evance)

1694 S. Winball — An Englishman, Samuel Winball, patented a strange diving contrivance in the year 1694. Nothing is known of its character.

1715 J. Lethbridge — In 1715, John Lethbridge invented and built a submarine boat which he described as the first diving machine not communicating with the outer air. His primary experiments were made with a disused sugar barrel, in which he at one time managed to remain submerged for over half an hour. He subsequently had a vessel of copper made, 6 feet long by 2 feet 6 inches in diameter at its widest, which was at the top, the apparatus being cone-shaped. The diameter at the bottom was only 1 foot 6 inches. It was entered from the top and the cover hermetically sealed; five hundred pounds of ballast were taken aboard and the machine then sank; if the occupant desired to re-ascend he had but to detach fifteen pounds thereof. Vision was obtained through a 4 inch glass window fitted with 1½ inch of glass, whilst as in many other later vessels, two jointed arms were fixed in the sides, by means of which objects on the ground might be collected and brought to the surface. (1733) In 1733 one of these apparati was used in the harbour of Marseilles to endeavour to obtain some specie from a vessel that had sunk there. Thirteen years previously, in 1720, a like quaint machine had been made use of in a series of futile attempts to secure part of the gold supposed to have been sunk with the Spanish galleons in Vigo Bay during the action between the British and combined French and Spanish Fleets.

A long interval went by before another attempt at submarine navigation was ventured upon. In the 'Gentleman's



I. SYMON'S SUBMARINE BOAT

Magazine,' 1747, is an article on the submarine boat constructed by a man called Symons or Simons, with which experiments had been conducted in the Thames. It took the form of a galley with a dome-shaped roof, and was immersed in the same manner as the invention of Borelli, by the augmentation of volume produced by filling leather bottles. Propulsion was obtained by the aid of four pairs of oars, which were worked in joints of greased leather. The 'Graphic' gave a picture of it, the oldest known illustration of any submarine boat (Fig. I.). This boat was made of wood and rendered water-tight in the same way as that of Van Drebel. 1747 Symons

In the short accounts which I have given above of the earliest attempts at submarine navigation, one notices immediately the lack of mechanical power necessary to carry out the cognate idea, or, to put it in another form, theory was in advance of the practical scientific knowledge of the day. The principles of these early inventors differed little from those held by our constructors of to-day. They all recognized the possibility of navigation between two waters, and also that their ideas controverted no law of Nature. Having thus something to work upon, these daring men (for, considering the means at their disposal, they required great self-confidence to carry on such experiments) constructed their various craft. The success of Van Drebel is miraculous if we bear in mind the absurdly limited resources of the time, and there seems no reason whatever to doubt the statement that James I. did descend in one of the Dutchman's boats and remained under water between three and four hours—a voyage no sovereign who valued his life would undertake without unbounded confidence in the inventor even in the present day. I doubt if there are many living people who would care to risk a trip on the 'Holland,' so great is the horror (a horror amounting almost to superstition) of being drowned like a rat. The boats of Van Drebel conclude an era in the history of submarine navigation, the era of wood. With the 'Turtle' commences that long list of submarine boats that may not even yet be half completed, the metallic-hulled submarine boats.

J. Day, a Yarmouth mechanician, 1763, made 'a small submarine boat,' which he tested with some success in Plymouth Harbour in 1774. His second descent, however, 1763 J. Day cost him his life, for he never came to the surface again, and all attempts at finding him proved unavailing.[1]

1773 D. Bushnell

David Bushnell was an American engineer, and to him belongs the honour of having invented the first submarine craft which really navigated under serious conditions and gave incontestably valuable results. He first produced the safety weight, a weight which in case of accident might be released from the vessel's hull and thus lighten the vessel, causing it to rise to the surface.

His little boat, which occupied four years to make, took the form of a turtle, and he consequently named his invention after that chelonian. The shape, if not conducive to great speed, at least favoured stability. The 'Turtle' could only hold one man with a sufficient supply of air for half an hour's submersion. At the lower extremity of the hull was placed the safety weight, a mass of lead, which also acted as ballast. The mode of propulsion employed has been the subject of some dispute, and it would be better for me to fully describe in detail the two methods with which Bushnell is credited with supplying his little vessel.

Figs. II. and III. (probably authentic designs) show roughly the form of the 'Turtle.' Propulsion was obtained by the oars AA, fixed in the sides of the boat by watertight joints. Steering was effected by a rudder, or rather paddle, at the back, B, the operator sitting on the seat, C. The immersion tank is shown at D, and the pipe by which it is filled at E. The little conning-tower, F, was just large enough for the head of the occupant, and was fitted with look-out windows. G represents the lead-ballast and safety weight, whilst at H was a bomb or detachable charge of powder, with which it was intended to blow in the bottoms of the enemy's ships.

Figs. IV. and V. give us quite a different picture of Bushnell's invention. These designs are probably quite recent, and are nothing but the reflections of a vivid imagination. Two reasons support the theory that they are not correct. Firstly, the presence of screw-propellers, which we know were not invented till some thirty years later, and secondly, in one

1 There is some doubt about the size of Day's boat, as in one case it is described as being 'of 50 tons burthen,' which would scarcely be as small as most other accounts lead one to imagine.

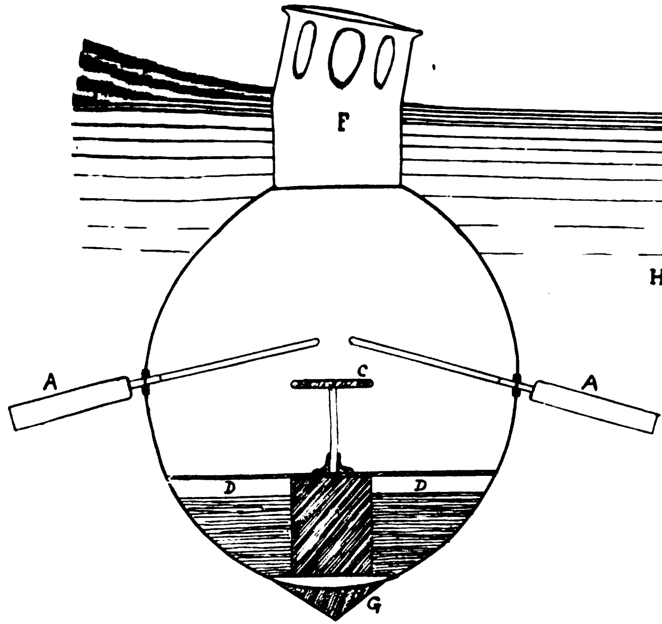


Fig 2.

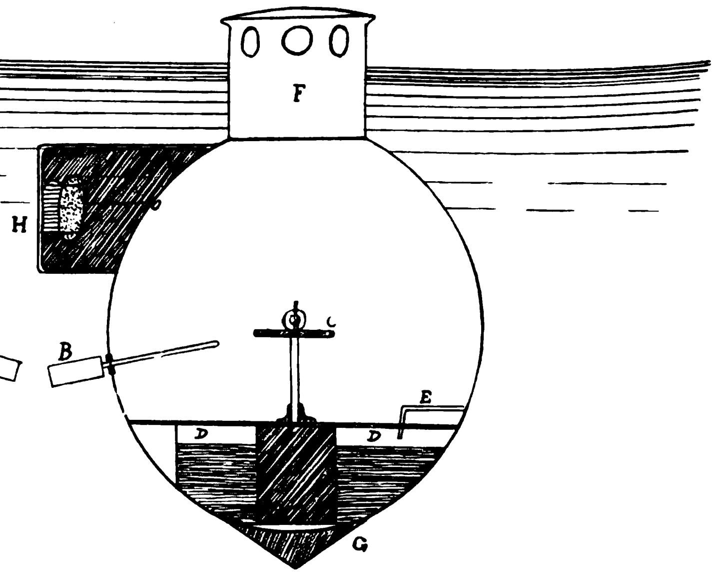
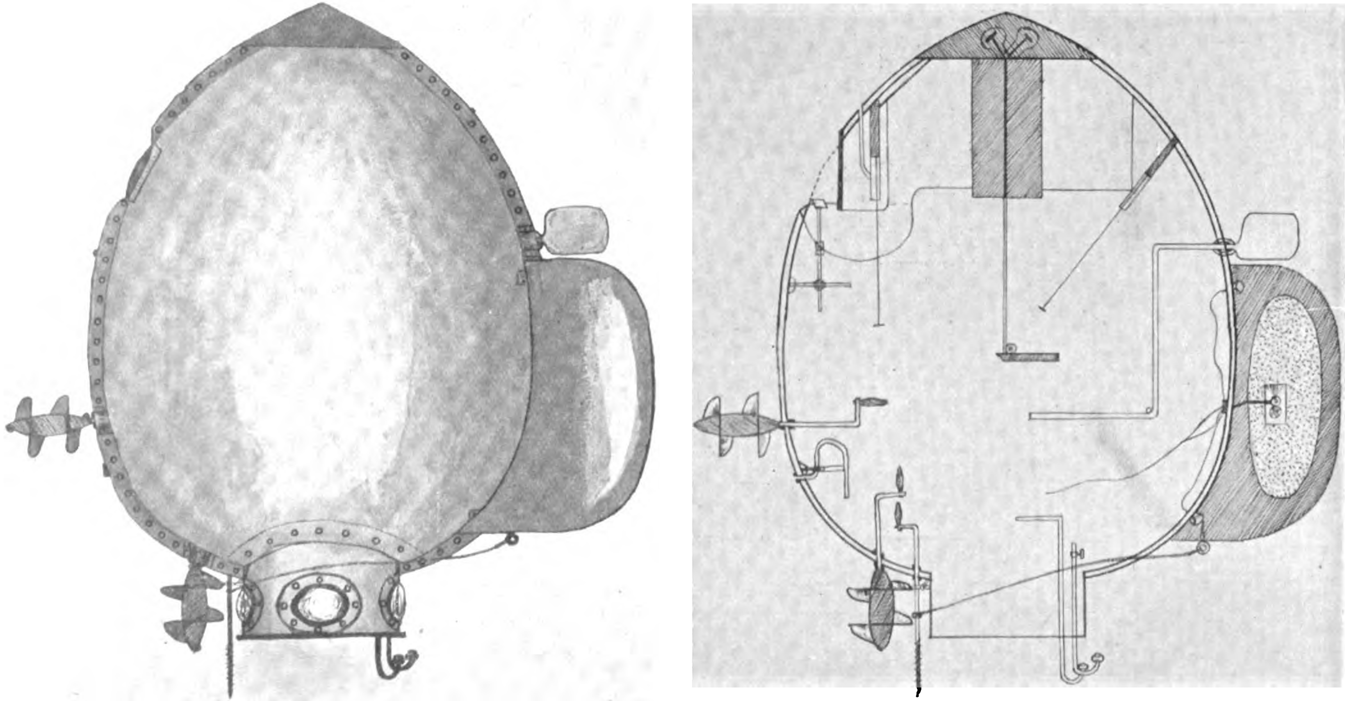


Fig 3.

'TORTUE'



IV.-V.

of the plans (not given here), is a picture of a man dressed in a very stylish modern suit, sitting on the seat of the boat. The weird and absolutely incomprehensible pumps and tubes fixed in the hull also lend it an air of mystery which is suspicious. I cannot leave this interesting invention without recounting the attempt to blow up an English frigate in New York Harbour during the American War of Independence.

In 1776, having obtained the permission of General Parsons to make use of his submarine against the English Fleet, anchored to the north of Staten Island, David Bushnell instructed Sergeant Ezra Lee in the working of his little craft. After several trial trips, the sergeant tried one calm night to attack one of the blockading ships, 'Eagle,' a 64-gun frigate. He was towed as close as possible by two rowing-boats, and manœuvred so as to sink just under his enemy. He could not fix his torpedo, however, as the English ship was sheathed with copper, and his boat did not offer enough downward resistance for him to pierce a hole in it. Carried along by the current, the sergeant soon lost sight of his adversary, whilst the torpedo floated about on the surface of the water, blowing up an hour later with a terrific explosion, to the great terror of the English, to whom this type of warfare was unknown.

Bushnell, although deceived in his hopes, lived to the ripe old age of ninety.

Seven years after Bushnell's first experiments a Frenchman, 1780
by name Sillon de Valmer, sent the proposal of a submarine S. de Valmer
boat to the Minister of the Marine, in which he stated he would construct a vessel which could not only navigate with perfect ease on the surface, but could also sink to the bottom and move between two waters. The vessel was to be barrel-shaped, terminated at each end by a pointed cone. To De Valmer therefore belongs the honour of having first proposed this shape now so general in all modern vessels in a more or less modified form.

In the bows of his vessel was to be placed a small conning-tower which would communicate with the interior. The dimensions of this tower were to be, diameter, 3-4 feet, and height, 7 feet, whilst the boat on which it was to be supported would have a length of 54 feet, a beam of 16 feet, and 12 feet

6 inches depth, the whole having a displacement of 8,000 cubic feet.

Propulsion was to be obtained by means of oars placed on each side, and having the palettes hinged on either side of the stock in such a manner that they would close up when pushing the oar forward at the end of each stroke.

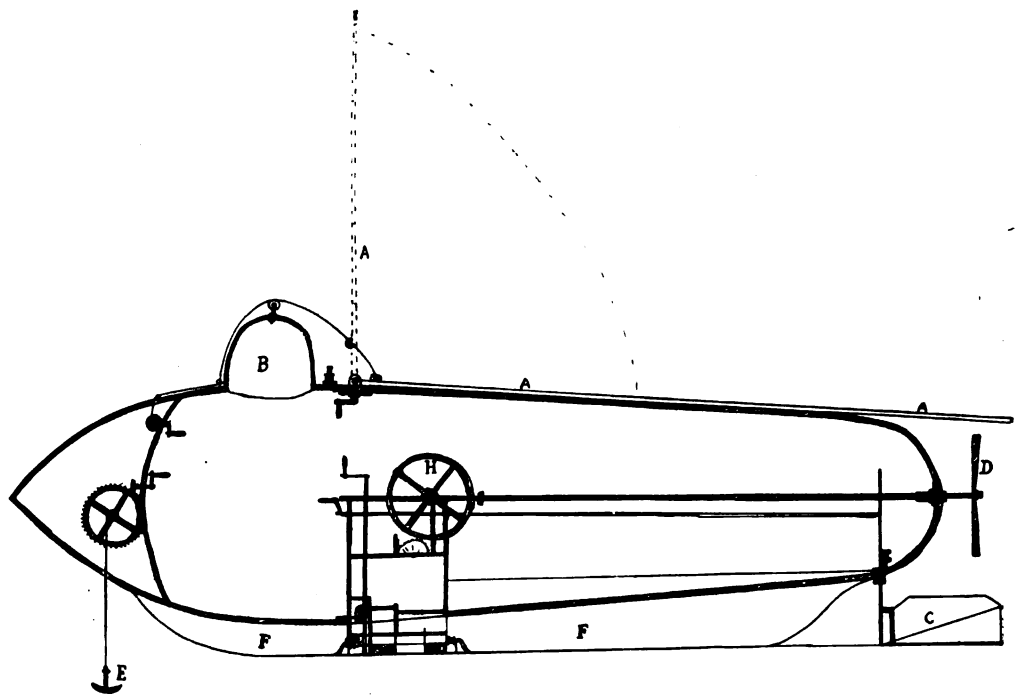
This method has been reproduced in later vessels, notably the 'Goubet II.' Although purely theoretical the proposals of Mr. de Valmer are well worthy of notice, as being sound and practicable. His ideas, like those of many other inventors, were many, many years in advance of the mechanical resources of the day, and I fear even had his theory been put into practice, his invention, owing to this cause alone, would have proved a failure.

Beaugenet Another French inventor offered to build a submarine boat with which one might go into the centre of London without a single Englishman being a whit the wiser. This boat, which required only five or six men as crew, was to be armed with cannon.[1]

1795 Armand-Maizière In March of this year, Mr. Armand-Maizière placed before the Committee of Public Safety the plans of a steam submarine vessel, which was to be worked by a number of oars vibrating on the principle of a bird's wing. Not only were these oars destined to aid the boat in her forward progress, but others similar were placed so as to aid in submerging the ship. The following is translated from Mr. Delpeuch's volume: 'This (the steam engine) was made up of a cylinder in which was to be placed,—"a piston actuated by the vapour of water generated in a strongly-bound wooden boiler. The water will be heated by a stove. By means of couplings the movement of the piston will be transmitted to one or more rows of oars fitted with palettes beating the water,"—these palettes, which Mr. Armand-Maizière compared in his plans to the wings of a bird, were to be animated by a backwards and forwards movement and not by the transmitted motion of a complete circle.' The inventor adds, 'there are two sorts of wings (ailes), so placed that one lot are for propelling the vessel and the other to make it submerge.'

As Mr. Delpeuch remarks, it was nearly a century before

1 'La Navigation Sous-marine.'—M. Delpeuch.



VI

'NAUTILUS'

inventors again supplied their submarines with separate motors to aid in submerging them.

1796 J. Fabre

Jules Fabre, a professor of chemistry and mathematics at Aix University, wrote a treatise entitled 'Mémoire sur la navigation au-dessous de la surface de l'eau et sur l'usage qu'on peut faire pour ruiner la Marine Anglaise.' The vessel he proposes was to have a hull shaped like a peach stone, or 'similar to two boats stuck one on top of the other.' His ideas were laid before the Minister of the Marine by Citizen Le Tourneur, a member of the Executive Committee on July 5th, 1796.

1800 R. Fulton

The celebrated American engineer, Robert Fulton, besides being one of the inventors of the steamship, was also greatly attracted by the possibilities offered by submarine navigation. He offered his plans to the French Government in 1797, and a Commission appointed to examine them gave a favourable report; the Minister of the Marine, however, was absolutely hostile to the innovation. Fulton then made a model of his submarine, and this again was received with favour by the Commission elected to report upon it. But, after a long delay, and in spite of the favourable opinions expressed by the various examining Committees, the Minister of the Marine told Fulton that his plans were rejected. The same ill-luck awaited him at the hands of the Dutch Government, yet even these two rebuffs did not daunt him in his endeavours. Three years later he applied to the first Consul, Bonaparte, who, after due consideration, appointed three eminent men, Laplace, Monge, and Volney, to examine his plans, and also gave him 10,000 francs to carry out experiments. Fulton built his submarine boat in 1800. He named it the 'Nautilus.'

The 'Nautilus'

The 'Nautilus' (Fig. VI.) was a cigar-shaped boat, about seven feet in diameter. The hull, as with the 'Turtle,' was of copper, but supported by iron ribs. A novel feature was the collapsible mast and sail, A, for use on the surface, which, when submerged, folded compactly and fitted into the deck. At the forward end projected a small conning-tower, B, through which the occupant kept watch and steered. The steering was effected by a rudder, C, and the propulsion when submerged (and on the surface as well when a favourable wind was lacking), by a wheel D, fixed in the centre of the elliptically-shaped stern. This was rotated by a hand-winch, H. The length of the 'Nautilus' was 21 feet, 4 inches. A small anchor, E, was suspended from the bows, and a keel, F, for aiding the stability, ran the whole length of the hull.

Trials of 'Nautilus'

The 'Nautilus' was completed in May, 1801, and made her first trials in the Seine, opposite the Invalides. Fulton and one sailor formed the crew, and with nothing but a candle to light the interior they remained submerged twenty minutes. On coming to the surface they found that the current had carried them some considerable distance down the river; so again sinking beneath the surface, Fulton steered his vessel to the point of departure. After several trials, the 'Nautilus' was despatched to Brest, and there Fulton (who had had several alterations made in his boat as the results of the first experiments, amongst them being the insertion into the hull of a sheet of plate-glass, to get a little light from without), accompanied by three others, descended on June 3rd, 1801. Having arrived at a depth of 25 feet, he accomplished various evolutions in different directions for over an hour. On the 26th of the same month he sailed out of the harbour, and then quite suddenly lowered his mast and disappeared from view, giving an instance of the despatch with which this feat could be accomplished. He then, on the same day, succeeded in blowing up an old hulk placed at his disposal by the Government.

On the 7th August, having introduced air at high pressure into the 'Nautilus,' Fulton remained submerged five hours without suffering the slightest inconvenience. But the proverbial nine days, during which his invention was the wonder of all, had passed before his experiments were completed, and just as his efforts were being crowned with all the success he had ever hoped for, he found that he no longer interested the Powers that were, and consequently his project failed, and he remains another victim of that short-sighted apathy concerning anything novel so common to all administrations.

'And what did Fulton ask?[1] A reward for each vessel that he destroyed; the reimbursement of the price of his ship, that is to say, 40,000 fr., including the 10,000 fr. advanced him by the Minister of the Marine, and lastly a patent giving him-

1 Translated from an article in 'Le Yacht.'

self and his crew the quality of belligerents, so that, if they were captured, they would not be hanged as pirates.

'Curious as it may seem, it was this last question of the patent that raised the most difficulty. The Minister of the Marine, Admiral Pléville le Pelley, wrote saying: 'It seems impossible to serve a commission for belligerency to men who employ such a method of destroying the fleets of the enemy.' Caffarelli, maritime préfet at Brest, said the same thing: 'A very strong reason has decided the Admiral and myself to refuse (to let Fulton operate against an English frigate); it is that this type of warfare carries with it the objection that those who undertake it and those against whom it is made will all be lost. This cannot be called a gallant death.'

'Lieutenant Duboc, who has written the history of the 'Nautilus,' says on this count: 'It is curious noticing how, a century ago, the morality of war had progressed, or rather 'fallen;' for all nations gave themselves up to the study of the submarine boat.'

Whatever the cause, Fulton was rebuffed. His submarine boat, giving birth to an order of things worthy of the great genius of Bonaparte, was completely ignored. He consequently gave himself up to the study of steam navigation, and made a celebrated experiment on the Seine in 1803. Napoleon had no greater confidence in the steamship than he had in the submarine boat and torpedo. Fulton, embittered by his ill-success, went over to England, where he was just as unsuccessful, and so he passed on to America, where steam propulsion rapidly developed to the astonishment of old Europe.'

The 'Mute'

Fulton had not completely given up his study of submarine boats, and in 1814 he produced the 'Mute,' a huge vessel capable of holding a hundred men. The 'Mute' was 80 feet, 6 inches long, 21 feet wide, and 14 feet deep. This submarine boat was armoured on the top with iron sheets, beneath which was a wood lining almost a foot in thickness. The name was given it on account of the silent engine which propelled it. The trials were unsuccessful, and, in fact, never completed, for before he could finish them Fulton died.

Outline of Fulton's Life

Although this work deals solely with the history of submarines, I feel it would not be out of place to say a few words about this great engineer relative to his inventions. Fulton was born at Little Britain, Pennsylvania, in 1765. At the age of seventeen he adopted the profession of a portrait and landscape painter; but he also, even then, devoted a considerable portion of his time to mechanical pursuits. At the age of twenty-two he came to England to finish his education in art under the able supervision of West, a fellow-countryman. Here he made the acquaintance of the Duke of Bridgewater, Earl of Stanhope, and Watt, by all of whom he was persuaded to devote more of his attention to mechanical engineering.

Proposes Steam Propulsion

In 1793 he conceived the design of propelling vessels by steam but did not at that time find a suitable opportunity of putting his views into practice. He devoted a great deal of time to the question of the supersession of canal-locks by planes of double incline, and for these the British Government gave him

Patented Flax-Spinning Machine

a patent in 1794. In the same year he obtained patents for flax-spinning and rope-twisting machines, and various other mechanical inventions bearing chiefly upon the construction of canals, on which latter subject he published a treatise. In

Moves to Paris

1797 he removed to Paris, and remained for seven years in the house of the American Minister in Paris, Joel Barlow, carrying on his scientific studies. The same year he offered his plans of the 'Nautilus' (described above) to the Minister of the Marine. Shortly after he projected the first panorama ever exhibited in Paris, and made important experiments on submarine explosives. These experiments were further continued in America, but although Congress voted 5,000 dollars for prosecuting them, his plans were finally declared

His first Steam boat

impracticable. It was also at Paris that he first succeeded after repeated trials in propelling a boat through the water by the aid of steam. In 1806 he returned to America and repeated the experiment on a larger scale and with more decided success. In 1809 he took up his first patent; but his rights were disputed, and, after protracted legislation, a compromise was effected. In 1814, Fulton constructed the first United States

His Death

war steamer, and he was engaged upon an improvement of his submarine torpedo when he died on February 24th, 1815.

This is but a short outline of an exceedingly active life. Fulton, as can be seen by the above account, was a many-sided man; there is a great gap between flax-twisting machines and submarine torpedo boats yet he set his hand to both and reaped from each venture an extraordinary success for the period. One cannot help feeling keen sympathy for a man so full of genius when one reads of how that genius was thwarted at every turn and of the scandalous way in which his efforts were received by the world at large.

An Englishman, Hodgman, is said to have made experiments with a submarine boat in this year; and six years later, Klinger, a German, tried a vessel of his invention, the results of both trials being equally unknown. 1801 Hodgman 1807 Klinger

Klinger's—or, as he should more properly be called, Klingert's—invention resembled a gigantic diving bell, weighted at the lower end and fitted with a hydrostatic piston worked by a screw and winch.

In this year also two brothers, by name Couëssin, presented a project for a submarine boat to Napoleon. They had already some renown as mechanicians, and in consequence the Emperor took a lively interest in their designs and gave an order for a submarine boat to be laid down. This vessel was named 'Le Nautile.' 'Le Nautile' had much in common with the 'Mute' of Fulton. It was shaped something like an enormous barrel; the hull was of wood of tremendous thickness, and bound with iron. The flat ends of this barrel-like body were terminated by two cones which served as immersion reservoirs. The length was 28 feet.[1] 1809 Couëssin

The Couëssins supplied their vessel with two modes of propulsion; a triangular folding sail on a collapsible mast fixed in the deck (as with Fulton's 'Nautilus') for surface sailing, and oars for use when submerged. With these a speed of 1½ knots could be obtained. A fresh supply of air was obtained from the surface by two supple leather pipes kept on the surface by buoyant floats. During one of the trials a serious accident occurred, the results of which were almost fatal. A large quantity of water got into one of these aeration tubes and overcoming the reserve buoyancy, 'Le Nautile' sank. Luckily the crew managed to cut off the flow of water from the two tubes, and, having expelled that which had entered, the submarine boat was again brought to the surface. The official trials of this vessel took place in 1810, before a commission

1 This did not include the two cones at each end.

composed of Carnot, Monge, Biot, and Savé, who gave a favourable report of the invention, in spite of the accident above described. 'Le Nautile,' however, was soon forgotten, and the gallant efforts of the brothers Couëssin lost in the oblivion of time.

1821 Captain Johnson

An eccentric American, Captain Johnson, experimented in 1821 with a submarine boat one hundred feet long. He thought with this to go and release Napoleon from St. Helena, but as we know Napoleon stayed in the island to the end of his days, Johnson's project must have been a failure.

1823 Shuldham

Two years later Shuldham, also an American officer, constructed a submarine boat capable of diving to the depth of 30 feet. 'This officer, to whom great mechanical talent is imputed, had probably other objects than submarine warfare in view; for to destroy vessels and yet be in a position to fear no harm from them, it is sufficient to dive to a depth of twelve or fifteen feet.' [1]

1825 Montgery

Montgery, a captain in the French Navy, struck out on quite original lines when he introduced his ship 'L'Invisible.' He had a tremendous opinion of himself as an inventor, and a portion of his perhaps rather optimistic and exaggerated description of his boat would be interesting:

'Quelles que soient la grandeur de la forme d'un navire, on pourrait l'installer de manière à le faire plonger et marcher sous l'eau; et si l'on était pressé par le temps ou gêné par les ressources naturelles, on transformerait avec avantage en corsaire sous-marin un petit bâtiment d'une centaine de tonneaux; car, ne fût il armé que d'une seule colombiade et n'eût il qu'une marche fort médiocre sous l'eau, il affronterait sans danger toutes les flottes actuelles de l'Europe et d'Amérique. Son grand défaut serait de ne pouvoir joindre l'ennemi dans certains circonstances.

'La partie supérieure de 'l'Invisible' est à peu près semblable à la carène, mais sensiblement aplatie, afin de faciliter les manœuvres lorsqu'on navigue à la surface de l'eau; elle est percée de deux écoutilles (hatchways) qui laissent passer les hommes de service—et garnie de verre lenticulaires destinés à eclairer l'entrepont ('tween-decks).

'Le beaupré (bowsprit) rentre à volonté dans le navire; les

1 Montgery.

mâts sont à charnières; lorsqu'on veut plonger, on loge tous le gréement (rigging) dans une rainure (groove) pratiquée par le milieu du tillac (deck). L'intérieur du bâtiment est divisé en deux parties par un plancher horizontal; la partie inférieure elle même est divisée en compartiments qui servent à loger; les uns, les munitions; les autres, le volume d'eau dont le poids détermine les submersions. Pour plonger, il suffit d'ouvrir des robinets; lorsque, ensuite, on veut émerger, on expulse, au moyen de pompes foulantes (force-pumps), l'eau qu'on avait introduite à l'effet d'affectuer la descente. Quant aux mouvements dans le sens horizontal, ils s'obtiennent par le moyen d'une roue logée à la poupe et de pales (paddle-boards) fonctionnant sur chacun des flancs du navire.'

Montgery proposed arming his boat with four colombiades, a powerful ejector-pump with which to hurl forth explosive compositions, a hundred torpedoes, a like number of rockets, and large quantities of small arms for the crew. Montgery's ideas never took practical form, and, had they done, it seems likely that the inventor would have lost his life. Nevertheless, although Montgery claimed the impossible for his vessel, yet some of his theories were undoubtedly sound and have been followed in various degrees in later constructions.

1826
Boisseroles

It is said that Johnson, the would-be saviour of Napoleon (who unfortunately died before the energetic inventor had a chance of making an attempt at the rescue contemplated), proposed to the Spanish Government to sink the French war-vessels in the harbour of Cadiz by means of a submarine boat of his design. Whether this is really so or not, another inventor, General Boisseroles, without doubt made such a proposition in 1826. He planned to construct a submarine gunboat which would sweep the bay of Cadiz of ships of the enemy, and so enthusiastic was he about his invention that a Naval Engineer, Marestier, was appointed to examine the designs of the gallant general. M. Delpeuch[1] gives a voluminous extract from the report sent in after the examination, which although interesting, would take up too much space here. Suffice it to say the plans were found to have but little worth, being inferior reproductions of a vessel similar

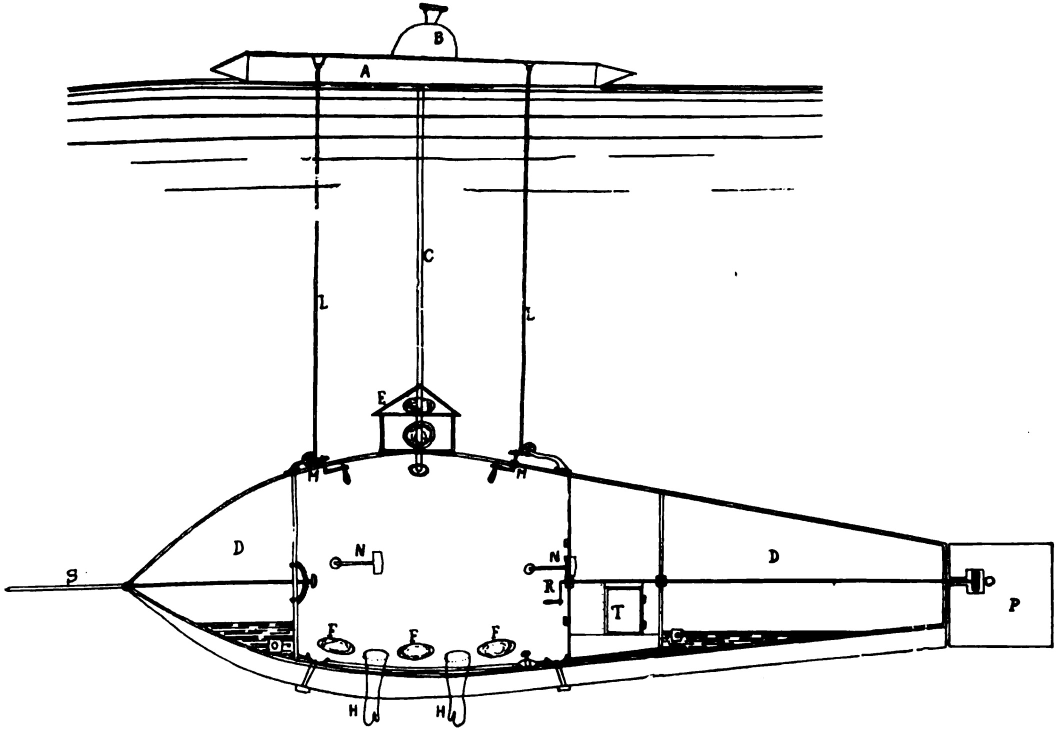
1 'La Navigation Sous-marine.'—M. Delpeuch.

to that of the Coëssin brothers, whilst the motive power was of a very mediocre description.

1827 Castera In 1827, Castera, a well-known authority on submarine navigation, and also a magistrate of France, took out the first patent for a submarine boat. His invention differed from those that preceded it in that he did not intend it for warlike uses, but as a lifeboat. On the opposite page is a plan of his ship, which was suspended from a surface float, A. This float supported a funnel, B, by which fresh air descended into the vessel by the tube, C. The boat itself was divided into three compartments, of which the two at either extremity, D D, acted as ballast tanks. The centre one was largest, being about half as large again as the other two combined. This was the habitable portion of the boat. In it was contained all the mechanism required for working it when submerged, and also the stopcocks and pumps for regulating the quantity of water in the tanks.

In the centre of the upper portion was placed a small conning-tower or lookout house, E, fitted with thick lenses as windows. The aeration tubes were fixed on either side of this little conning-tower and were of great length, allowing the boat to descend to some considerable depth. In the bottom were inserted several portholes, F F F, fitted with strong glasses, and a pair of leather gloves, H H, for picking objects off the bottom of the sea or river in which the vessel happened to be navigating.

The required elevation was obtained by winding in or letting out the cords, L L, by the winches, M M, fixed fore and aft of the conning-tower. Propulsion was effected in two ways: either by the oars or palettes, N, or by the wheel, O, placed in the stern in a recess in the rudder, P. This wheel was rotated by a hand-wheel, R. In the bows was fixed a plane, S, for preserving the horizontal stability, worked from the inner compartments; and lastly, at T, was a door by which the divers could descend from the boat and carry out works at the bottom of the water. The keel running along underneath the boat was, besides acting as a keel, a detachable safety weight. Castera's vessel was, taking all things together, a model of great ingenuity. The surface-float can be pardoned in that he did not intend to use his invention as a war vessel. The



VII. CASTERA'S SUBMARINE BOAT

only dangers to which Castera's boat was liable were the entry of water into the air funnel and the severing of the suspensory cords. The leather gloves are distinctly novel, though likely to become a danger when a depth was reached at which the leather could no longer withstand the pressure.

In a little brochure which Castera had printed, entitled 'Essai sur la Navigation Sous-Marine,' he gives the designs of several submarine vessels. The second of these is little different from that given in the illustration, a few minor details only having received alteration. The most curious is of a submarine trolley, the body of the vessel being balanced on a framework swung between two large pairs of wheels. These wheels were to be rotated internally by a system of levers. This design is especially interesting as being a true prototype of Mr. Lake's wonderful marine-explorer, the 'Argonaut.'

A Spaniard, named Cervo, made a descent in 1831 in a spherical submarine boat made of wood, and never came up again. The pressure of water was probably too great. 1831 Cervo

We hear of M. Villeroi for the first time in 1832, when he designed and constructed a small submarine boat of the following dimensions: length, 10 feet; beam, 3 feet; height, 3½ feet. With this tiny craft he made several more or less successful experiments, and there exists a witnessed paper stating that the inventor and one man descended beneath the surface and remained submerged for twenty minutes, from 3.15 to 3.35 p.m. on August 12th, 1832. He then again came to the surface, and re-submerging, navigated and performed various evolutions beneath the surface for the space of 10 minutes. Again coming to the surface he lifted the hatch, after having been enclosed for 55 minutes. Villeroi repeated his experiments in 1835 before a number of naval officers including the renowned British Admiral, Sydney Smith. At this trial a newspaper correspondent of the 'Réformateur,' M. de Liancourt, and the inventor remained beneath the surface for two hours. A committee was appointed to appraise the value of the invention, and on this committee was M. Gustave Zédé as secretary, and it is probable that his subsequent great interest in submarine boats was primarily aroused by the invention of Villeroi. 1832 Villeroi

1834 Dr. Petit — In 1834, a French doctor of Amiens, Dr. Jean-Baptiste Petit, had a small vessel about 12 feet in length constructed. This little submarine was propelled by two oars, and was fitted with a small conning-tower on which was placed a seat for navigation on the surface. On August 15th the inventor made some trials in a dock at St. Valery-sur-Somme, before a large concourse of people, and after making a tour of the basin, seated on the outside, came to the wharf to take on board the ballast necessary for submergence. This accomplished, he waved adieu to the spectators and disappeared, but although the watchers on the bank waited long, he never came up again. Next morning at low tide his submarine boat was found lying in the mud, and the inventor suffocated within, another sacrifice at the altar of science.

1840 D'Aubusson — In this year a French nobleman, the Marquis de la Feuillade d'Aubusson, projected a submarine ship of 76 feet in length. It was to resemble an ordinary vessel in form, being flat on the deck. The propulsion, the most novel point in the designs, was obtained by alternating cylinders.

The following extract may not be devoid of interest:

'Les bateaux sous-marins essayés jusqu'à présent pouvait bien monter et descendre dans le fluide, mais leur vitesse sous l'eau étant à peu pres nulle il fallait les remorquer avec des embarcations ordinaires ce qui est impossible en présence de l'ennemi; aussi, dans l'état actuel, ils ne peuvent servir à la guerre. Mais, si ces bateaux étaient mus par des moyens cachées sous l'eau, par des hommes dont on n'exigerait qu'un travail modéré qu'ils pussent soutenir huit heures sur vingt-quatre; si ces bateaux pouvaient parcourir sous l'eau près de 2,500 toises [1] à l'heure, comme on le démonstrera par le calcul et les lois de la résistance des fluides; si ces bateaux contenait assez d'air pur que les hommes qu'ils porteraient pussent rester sept à huit heures sous l'eau enfin, s'ils portaient des torpèdes, petites machines infernales inventées par Fulton; si des hommes revêtus de l'appareil du plongeur, et qui tireraient des bateaux l'air necessaire pour respirer, de sorte qu'ils pussent appliquer ces torpèdes sous la carène d'un vaisseau ennemi, il est évident que l'on pourrait incendier, sans danger, les flottes

1 Toise = 1 fathom = 6.39459 ft. Therefore '2,500 toises à l'heure' would be a little over 3¼ miles (strictly, 3.277 miles) an hour.

et les ports d'un ennemi; que les guerres maritimes deviendrait impossibles, et qu'aucune nation ne pourrait s'arroger l'empire des mers.'

The ideas expounded above are very sound, and it is a pity d'Aubusson did not carry his project into execution, as then we should have had a chance of judging whether he was also a practical man. In all probability, however, although everything had been worked out to his entire satisfaction, the marquis would have found that he had omitted an important item. One has only to look at the trials of the modern submarine craft for instances of misplaced faith. That he greatly advanced the knowledge of submarine navigation is undoubted, and his studies came when they were most necessary, in fact just in time to save the question of submarine boats from becoming extinct, for since 1840 no two years have elapsed without one or more attempts to solve the interesting problem being brought forward, and the evolution of the 'Morse' and 'Holland' can be traced to have begun with the projected vessel of the Marquis d'Aubusson.

1842 Payerne and Bouet

Dr. Payerne commenced experimenting with diving-bells in 1842, and it was he who finally perfected them. The incident that led to Dr. Payerne inventing a submarine boat is worthy of note. Paisley, one of the most famous engineers of the day, had been employing a diving-bell, suspended from the frigate 'Success' in his attempts to raise the 'Royal George.'[1] This bell was supplied with air by an indiarubber tube. Payerne had been allowed to descend many times in this bell, and once with Paisley reached a depth of 14 fathoms. As an experiment he had placed in the bell two air cases with air compressed to eleven atmospheres, his idea being to dispense with the surface tube. His success was such that in 1843 he invented a diving-bell containing its own reservoirs of air, which required only a sustaining rope from above.

Three years later he produced his first submarine boat, a vessel provided with every type of mining instrument and also a diving chamber. This was so arranged that, when wishing to descend from the boat, the pressure of the air in this chamber

[1] The 'Royal George' went down off Spithead in 1782 with Admiral Kempenfelt on board. She was being careened to stop a leak, and the broadside guns became loose; rushing to the downward side they increased the slant of the vessel until at last she capsized.

was raised until it slightly exceeded the pressure of the column of water without.[1] The door was then opened, and the diver had only to step straight on to the bottom. This invention of Payerne proved of immense value to the French naval authorities in clearing the harbours of Brest and Cherbourg of the submerged rocks which at low tide were likely to be a danger to navigation. Dr. Payerne was nobly backed up financially by a certain M. Bouet, who recognized the ability of the inventor.

1846 In 1846, these two constructed a vessel of 35 feet in length. It was shaped something like a barrel, one end (the stern) being hemispherical in shape. To the forward end was added a pointed cone 9 feet 6 inches in length. The hull was strongly built up on a number of hoops which added greatly to the vessel's power of resistance. Three rows of convex top-lights, nine in a row, were fitted in copper sockets along the upper portion, being so arranged as to reflect all light into the interior; five others were placed round the hull on the water line (the line at which the vessel floated when light), but these were flat, and could be used as windows. A propeller, fixed in the stern between two rudders, provided a means of propulsion, the shaft being revolved by hand.

This boat, known as the 'hydrostat' of Payerne, did not come up to the expectations of its inventor, who turned it shortly afterwards into a simple diving-bell, in which capacity it rendered good service in the construction of the breakwater at Cherbourg and the harbour works at Brest. It was also later employed in destroying a bridge at Paris. Payerne approached the subject of submarine navigation from a scientific point of view, and was not one of those men who desired fame by risking his life in an impossible machine. He never claimed for his inventions that they would change modern warfare completely, nor had he any other desire than to benefit the world at large by any knowledge he culled from his experiments.

1851 L. D. Phillips I will not stay long over the two inventions of the American shoemaker, Lodner D. Phillips. They were both 40 feet in length, but the first had a diameter of 5 feet and carried a

1 This principle has been utilized since, notably by Simon Lake in his 'Argonaut.'

spar-torpedo, whilst the second was only 4 feet in diameter. They both took the form of a very pointed cigar, and submersion was obtained by the filling of tanks, running fore and aft. Phillips died on board one of his little vessels on Lake Erie, crushed to death by sinking to a depth too great for his boat to support the pressure of water. His papers were subsequently found by Mr. Bachford, who presented them to the Admiralty in 1870. Their utility was questionable and the matter has dropped into oblivion.

During this same year a Frenchman, Alexandre, made some futile attempts to solve the interesting question. His experiments were carried out in New York Harbour. Alexandre

Bigard, another inventor who interested himself in the subject, was equally unsuccessful with his invention. Bigard

Le Batteaux produced a marvellous and useless machine in 1852; it resembled a huge barrel bound with thick iron rings. His idea was to descend to great depths and examine the hulks of sunken vessels, and bring up anything of value. The result of his experiments has never become known, and considering the means with which he intended experimenting, ignorance on this point is probably not to be lamented. 1852 Le Batteaux

We now come to the most persistent inventor to be found in the whole history of submarine navigation; I refer to Wilhelm Bauer. Bauer was a turner by trade, and carried on his business at Dillingen, and the Germans have right on their side in boasting that their country bred the man who did more in searching a solution of the submarine navigation problem than any other inventor. Bauer [1] was born in 1822 at Dillingen in Bavaria; at twenty years of age he joined the army, serving in the Light Horse for seven years. During the war between Germany and Denmark Bauer was struck by the amount of damage caused by the Danish fleet on the German sea-border, and it was to prevent these raids that first caused him to turn his mind to submarine navigation. Casting aside all other occupations, he threw himself heart and soul into the subject he had newly adopted and which appealed to him so strongly. He is said to have been haunted by his new conception day and night, but could not put his ideas into practical shape until he one day saw a dolphin gambolling in the sea. W. Bauer His History Germany

[1] Extract from 'Die Gartenlaube,' 1869.

He was attracted by its antics, and whilst watching, it suddenly occurred to him to base his plans on the shape of this amphibian. His friends teased him sorely over this fancy of his, endeavouring to persuade him how useless the form he had adopted would be. Bauer, however, clung to his idea, and in 1850 he had his first submarine built at Kiel.

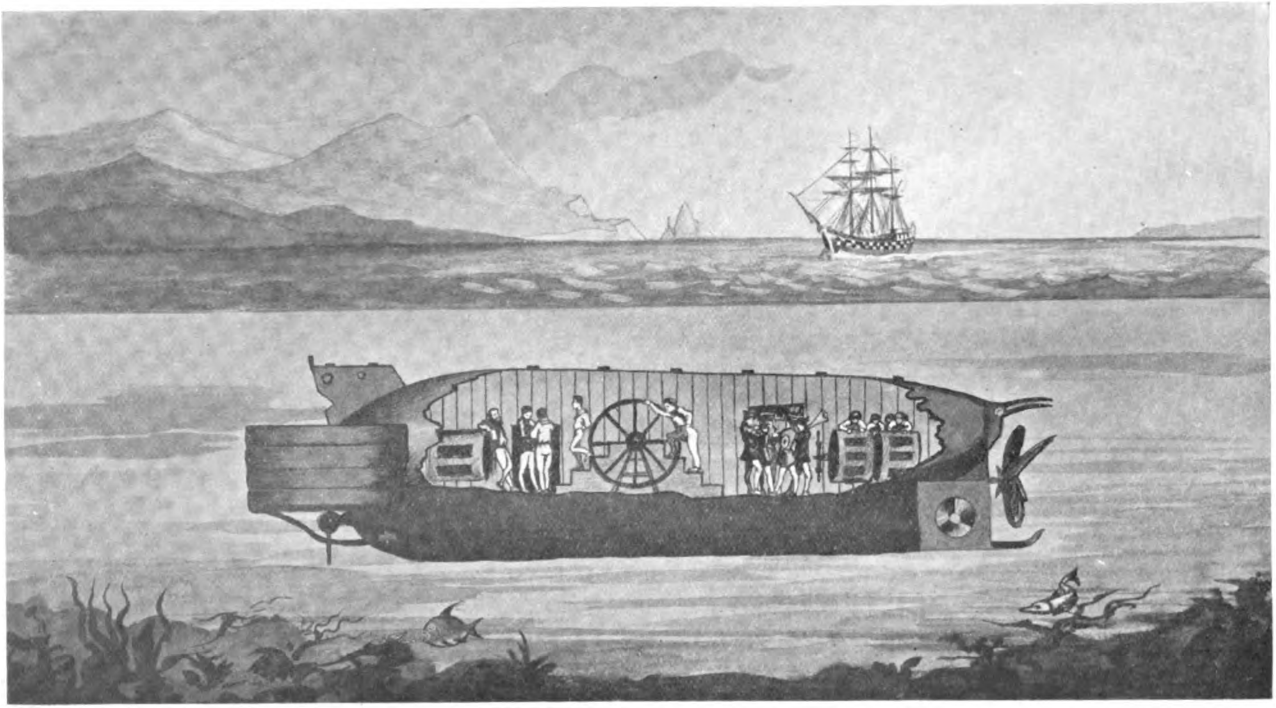
The first Submarine

This vessel he called 'Der Brandtauscher,' and it cost over £550, most of which was paid by the army of Slesvig-Holstein, whilst he was also aided by several admirals and civilian friends. He was unfortunately persuaded to alter certain details in the construction of his vessel by Dr. G. Karsten, a professor of science at Kiel, who disagreed altogther with his principles. This man Karsten did a great deal of harm to Bauer by writing pernicious articles about him and his inventions. Owing partly to this cause, and partly to the fact that Bauer's knowledge of the subject had scarcely reached that stage when an extensive experiment could be successful or even warranted, 'Der Brandtauscher' proved a failure. It sank in Kiel harbour in 1851, but happily with no one on board, and although attempts were made for years to refloat it, they were not attended with success, and so Bauer's first submarine is still where it sank, provided the ravages of time have not destroyed it. This little misadventure made not the slightest difference to Bauer, who at once essayed his luck again, this time trying the Government of Austria; here he was received evasively and by no means encouraged, the Austrians feeling but little interest in the new class of vessel.

Austria

The way in which he eventually received attention touches on the romantic. A lady of wealth and standing, a *persona grata* at court, was attracted by his peculiar personality and pleaded his cause to the authorities, not without success, for Bauer was called to Trieste and presented to the Emperor, who ordered the Admiralty to appoint an examining committee to sit over the plans of the inventor.

This commission gave a favourable report, the result of which was the voting of 31,800 francs by the Naval Defence Committee, 21,200 francs by the Bourse of Trieste, 31,800 francs by the Minister of Commerce at Vienna, and 21,200 by the Austrian Lloyd Company, in all 106,000 francs, or £4,240 for the construction of one of his ships. When all matters



VIII. THE 'DIABLE MARIN'

had presumably been settled, Von Baumgarten, Minister of Commerce, took it into his head that Bauer's principles were absolutely wrong and contrary to all laws of nature. This decision, in direct opposition to the one arrived at by the Commission appointed by the Emperor, soon became the cause of a public controversy, and to save unpleasant results Bauer and his invention were dropped, and the matter buried in ministerial forgetfulness.

Disheartened a little at this last check, Bauer turned his back on Europe, and, coming to England, pleaded his cause before Prince Albert, begging him to take interest in his invention and to back him up in his experiments. The Prince Consort lent a sympathetic ear to the tale of the cast-out inventor; taking him under his protection, His Royal Highness supplied the exiled scientist with funds for several years. Bauer designed a war corvette and a submarine boat in the designer's loft of 'Palmerston and Scott Russel,' being aided in his task, which took seven months, by Charles Fox and the great engineer Brunel. It is said that Bauer was unfairly treated whilst here, in that copies of his plans were made.[1] A vessel was built after the plans of Bauer, but modifications by Lord Palmerston, Pausmore, and Scott Russel were introduced, the result being a disastrous failure, for at one of the trials the boat sank and drowned a large number of people. After an ineffectual attempt to persuade the American Government to adopt his inventions, Bauer, as a last resource, went to Russia. Germany would not receive him, and indeed a pamphlet was issued warning all good patriots not to assist Bauer in any way, as he had offered to the foreign nations that which should have belonged solely to Germany. This unjust treatment would have certainly driven most men to thoughts of suicide, or at least have made them give up all ideas of submarine navigation. Not so with Bauer, however; he was of different calibre, and failures seemed only to encourage his ardour.

England

Russia

Le 'Diable Marin'

Bauer's Russian submarine boat (Fig. VIII.) was built at the Leuchtemberg Works, St. Petersburg, in May, 1855, and

1 There is probably some truth in this statement, for Scott Russel afterwards built an unsuccessful submarine boat greatly resembling those of Bauer in many details.

was received by the Russian Admiralty on November 2nd of the same year. He called it 'Le Diable Marin.'

After a great deal of delay it was transported from St Petersburg to Cronstadt, where the trials were to take place. On arrival at its destination Bauer discovered a mistake in his calculations, the repairing of which cost 16,700 roubles.[1]

On May 26th, 1856, this marine monster was eventually launched in front of the breakwater at Cronstadt, and at once started on its trials.

The following is a description of Bauer's invention:[2]

The Russian submarine, 'Le Diable Marin,' resembled a dolphin in outward shape. It had a length of 15 m. 80 (52 feet),[3] a beam of 3 m. 80 (12 ft. 5 in.), and a depth of 3 m. 35 (11 ft.). The framework of the hull was of iron, and the hull was credited with the power of resisting a 45 m. 50 (150 ft.) column of water. The exterior consisted of sheets 0 m. 61 (2 ft.) in breadth and 3 m. 05 (10 ft.) in length, having a thickness of 15 mm. (.6 of an inch); these sheets were clamped together, and given additional strength by being fastened to the keel by iron corner-pieces, having a thickness of 180 mm. (7 in.). In the bows was a hatchway for entrance and exit.

That the weight might be the more easily distributed, the forward part of the ship was 6 inches less in height than the middle portion. Two port-holes were let into the hatchway fitted with thick glass. These glasses were 50 mm. (2 in.) thick, and 250 mm. (10 in.) in diameter, and let into metallic sockets.

Propulsion was obtained by means of a propeller in the stern; this propeller was protected by four iron braces. The motive power consisted of four wheels 2 m. 13 (7 ft.) in diameter, worked on the system of the treadmill. The axle was 88 mm. (3.46 in.) in diameter, and was fitted with accelerating gear at its after end. The least satisfactory detail in Bauer's inventions is the lack of efficient propulsive engines.

Stability and submersion were obtained by four cylinders. Of these, three were large, having a length of 3 m. 05 (10 ft.)

1 A rouble is worth 2s. 10d. The price paid for Bauer's mistake came, therefore, to £2,365 16s. 8d.

2 'Die Unterseische Schiff-fahrt,' by Louis Hauff, Munich, 1859.

3 The English equivalents are only given approximately.

and a diameter of 1 m. 40 (4 ft. 6 in.); they could hold 22,500 kilograms [1] of water, sufficient to sink the boat completely.

The fourth cylinder was smaller, and was used for maintaining the stability of the boat. It had a length of 1 m. 52 (5 ft.), and a diameter of 350 mm. (13.78 in.).

Pumps were used for forcing the water into the cylinders, and longitudinal stability was obtained by reducing or augmenting the volume of water carried as ballast.

In the bows was fixed a large mine, containing 500 lb. of powder and other combustible matter; on either side of this mine protruded a thick indiarubber glove, to allow of fixing it to the keel of the vessel to be attacked. A door by which divers might descend to the bottom of the water was also provided, and this is not unnatural when one considers that Bauer's very first submarine was intended for industrial purposes.

Large tubes over 30 feet in length, and pierced by little holes, were placed along the top of the boat, and from these a continual rain fell, the falling water purifying to a large extent the vitiated air.

On May 26th, 1856, Bauer tried his boat for the first time. Trials
At three o'clock in the morning, in a thick black fog, Bauer standing on the bows of his vessel, appeared off Cronstadt, and hailed the sentinel with the official password. The man, frightened to death at this marine apparition, ran away as hard as he could, dropping his rifle instead of giving the alarm with it. The same result happened with all the sentries, and, the coast clear, Bauer forced his way into the Port Imperial.

The serious trials began later, 'Le Diable Marin' being manned by Bauer, Lieutenant Fedorowitch, another junior officer, ten men, and a mechanic.

Having reduced the flotability to practically nil, Bauer let 5 litres of water into the small regulating cylinder, and the vessel slowly sank from sight, to the great surprise of the crew, who kept their eyes glued to the darkening port-hole. After this first immersion, Bauer ejected double the quantity of water he had allowed in, and 'Le Diable Marin' rushed to the surface, the reappearance of the sun being hailed by the crew with cries of 'Staba Bochu.'[2] The crew soon overcame

1 One kilogram = 2.2 lb.; therefore 22,500 kilograms = 49,500 lb.
2 'Staba Bochu' = 'Praise be to God.'

all nervousness, however, and forgot their Slavonic 'Allah! Allah!' in the interest of the vessel that contained them. During the next few days, confident now in the courage of his crew, Bauer went through an exhaustive series of trials, turning, diving, rising, speed ahead and astern, all which evolutions were carried out satisfactorily. On June 12th, having descended to a depth of 17 feet, he remained submerged whilst he wrote letters to his mother, King Maximilian of Bavaria, and the Grand-Duke Constantine.

Experiments were then made to discover what effects submersion had on the compass, and a scientist, Lenz, who with a *confrère* Fritsch had made several descents, discovered that at three different depths no deviation from the magnetic line was noticeable.

Bauer also made a trial of the vitality of man in an inclosed space, the amount of air he consumed, and the contamination such air could contain without damaging the health.

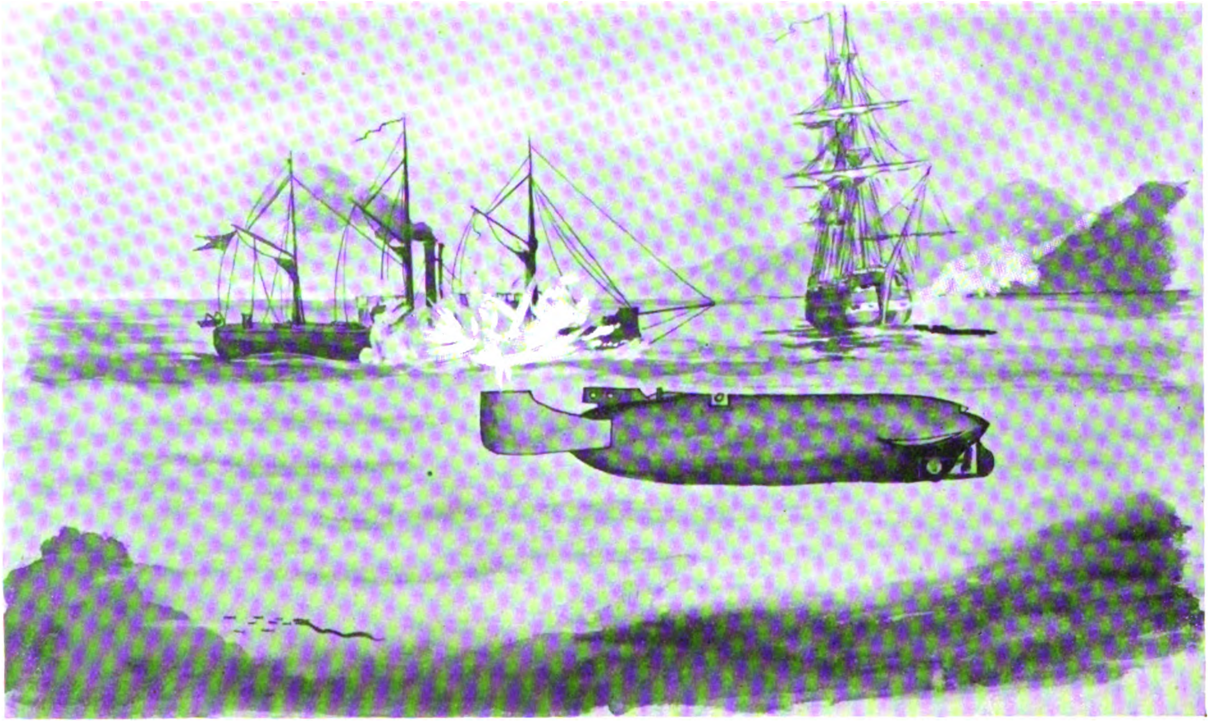
Bauer noticed that the voices of people on the surface could be distinguished beneath the water, and, on making experiments, discovered that the blow of a hammer on a sheet of iron could be heard at a great distance when submerged, water making an excellent conductor.

At the coronation of Alexander II.,[1] Bauer remained submerged during the whole ceremony with a band of four musicians, who, when the first gun of the royal salute was fired from the flagship in the harbour, played the Russian imperial hymn, accompanied by the voices of the whole crew. The boat remained submerged for four hours on this occasion (Fig. VIII.).

In spite of all his successes, Bauer was not appreciated in Russia, and the Russian Admiralty detested him as a tiresome innovator. Lieutenant Fedorowitch remained Bauer's firm friend through all his troubles.

It was not that the Russians were disinclined to adopt the submarine boat! They wanted it very much, but they were not prepared to have the inventor as part of the bargain, and consequently they tried to draw all the knowledge of Fedorowitch. This they found impossible; so a commission was appointed to plan trials to be carried out, at all of which

1 Alexander II. was crowned at Moscow on September 6th, 1856.



IX. BAUER'S COAST DEFENCE SUBMARINE

Fedorowitch was to take the helm. The submarine boat was to pass under a ship anchored in shallow water. Bauer, knowing nothing of this lack of depth, allowed his vessel to go too near the bottom, the result being that the propeller was caught up in a mass of seaweed, and, despite the endeavours of the whole crew, it could not be freed. Bauer's ill-luck seemed to dog him everywhere, as he was only 40 feet from his goal when the accident occurred. Seeing that all efforts were unavailing, the inventor drove out the whole of the water, and let drop the safety weights at the bottom of the boat. The bows at once rose to the surface with a jerk, but the propeller still remained entangled. Lieutenant Fedorowitch at once opened the hatchway and got out, and was picked up by the boat of the examining commission. Bauer remained below lightening his vessel, until an inrush of water warned him that he had not a moment to lose if he did not wish to be drowned.

This almost fatal accident terminated Bauer's one hundred and thirty-fourth and last attempt at submarine navigation in Russia. He managed to refloat his boat after four weeks' work, but it was again lost off Ochda, ten versts from the iand, and there it is to this day, if it has survived the action of the sea-water. In 1858, Bauer, after making four requests, was given permission to leave the country, which he did immediately.

Another Design

Besides the vessels already mentioned Bauer designed a vessel which was intended to destroy its opponents by fire.[1] In form it resembled his 'Diable Marin,' except that in the bows instead of a mine there projected a large cup, which contained some explosive matter. This cup was guided under the hull of the ship and the charge ignited, the result being (according to Bauer) the destruction of the ship attacked. This vessel was to be utilized for coast defence only. Its dimensions are unknown, but it was to be supplied with engines of 100 I.H.P. For the construction of his vessel Bauer required 100,000 thalers,[2] but all his efforts could not raise more than 40,000. So the project fell through.

Bauer, having reached the end of his resources and wearied his patrons, was at last obliged to abandon his pet hobby, and from this date he slowly sank out of men's minds. His

1 See illustration on opposite page. 2 Thaler = 3s.

splendid energy and dogged determination are certainly monuments in the history of the evolution of the submarine boat. It must be remembered that in no respect was he to blame for the fact that his inventions did not arouse more sympathy or were not more successful. The spiritlessness and the perversity of the time are answerable for his relative failure. He undoubtedly advanced the science of submarine navigation many steps, and he proved conclusively that to live under water in comfort was not impossible.

1854 Marié-Davy

The submarine boat of M. Marié-Davy, a Professor of Chemistry at the Montpellier University, Hérault, contained in its propulsive machinery a distinctly novel feature. The propeller was to be rotated by the action of an electro-magnetic engine. His vessel in outward form was cigar-shaped, but flattened at the after end where were placed two rudders, one vertical and the other horizontal. The propeller was inside both of these, next the hull.

In the bows was fixed a three-pronged auger, which by a simple coupling motion could, when in contact with the hull of a hostile vessel, be rapidly revolved by the electric engine. The engine was placed in the after half of the vessel and that the weight might be the more evenly distributed, the batteries were to be put into position well forward. In the roof, besides a man-hole, was fixed a large ventilator, presumably for use when on the surface. The propeller was to have been four-bladed, and was expected to give the vessel a speed of 4-5 miles an hour.

M. Marié-Davy has the distinction at least of being the first to propose electric power for a submarine boat, and as the initiator of a new era in submarine propulsion, his designs deserve to be chronicled.

Cambrez-Bassompierre

M. Cambrez-Bassompierre was a native of Liège, Belgium, and his proposition was for a submarine boat propelled by oars, whilst he also had some novel method of preserving the longitudinal stability. His ideas were expressed very vaguely however, and no conclusions can be drawn from our knowledge thereof.

Anon

The last invention of the year 1854 of which we have any knowledge was that of a young workman, in a prison at Ajaccio. M. Delpeuch, from whose work I have extracted my information on this boat, shows an egg-shaped vessel, with a large four-bladed propeller in the bows, and a queer spear-like rudder at the after end. A recess in the lower section of this freak contains a mass of ballast attached by a rope to a winch, evidently for use as an anchor. The young prisoner also designed a species of torpedo.

1855 Picot Guéraud

Mr. Picot-Guéraud, of Belleville, proposed a submarine vessel for cutting the wires of contact mines, etc.

Scott Russel

Scott Russel's vessel, as I mentioned previously, was almost a counterpart of Bauer's 'Diable Marin.' It was intended for the Siege of Sebastopol. This vessel, which at its trials sank, drowning the crew, cost the Government £7,000, and cannot, therefore, be considered a success.

Babbage

Babbage, an Englishman, presented a model to the Admiralty. A vessel was built after the same plan; it had a length of 46 feet, a beam of 4 feet 6 inches, and a depth of 3 feet 1 inch. It was open underneath like a diving-bell, and was divided into four compartments which could be filled or emptied at will by means of force pumps. Air for breathing was contained in three circular reservoirs, whilst propulsion was obtained by a propeller turned by hand. It carried a crew of six, and was intended, as in the case of Scott-Russel's design, to aid in the siege of Sebastopol. Its trials were unsatisfactory, and in due course it reached the scrap-heap.

Spiridinoff

A Russian officer, Spirindoff, presented plans of submarine boats to his Government, use at Sebastopol being still the object in view. It resembled in many respects the hydrostat of Dr. Payerne, but was propelled by the suction and propulsion of water. This invention never went further than the plan stage.

Vilcoq and Deschamps

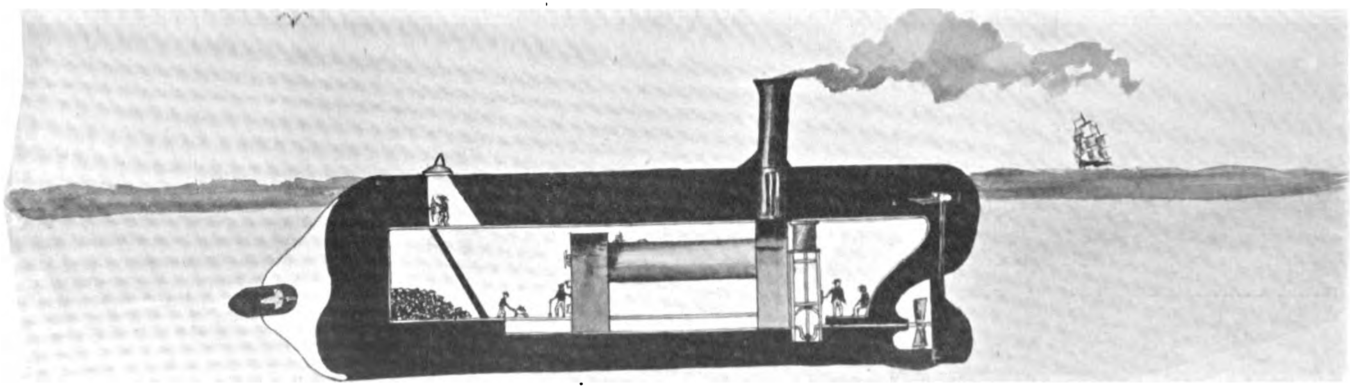
These two gentlemen invented a small submarine boat which presented one or two novel features. The steersman encased himself in an indiarubber suit and stood out of the upper deck. Gloves of the same material were also provided for fixing torpedoes, picking up objects, etc. The vessel was so small, however, that little came of the experiments made of it.

J. Nasmyth

In the same year, 1855, James Nasmyth proposed his submerged mortar. He had already made his name prominent by the invention of the steam hammer, and, as was only to be expected, a project from so great an engineer attracted considerable attention. Nasmyth's vessel was not intended for submarine navigation, and, indeed, could not sink beneath the surface. In shape it resembled an ordinary vessel, but was provided with a ram-shaped beak (Fig. X.). This contained a bomb filled with high explosives, which was to be discharged at the side of the vessel to be attacked. Immunity from danger was secured by the extraordinary thickness of the hull. The latter, constructed of wood, had a depth of 10 feet, and would certainly have been impenetrable to the ordnance of the day. This wonderful vessel was driven by a steam-engine, the steam being supplied by a single high pressure boiler. The propeller was fitted in a recess forward of the rudder, which was worked from the conning-tower. This conning-tower was in the extreme bows and accommodated one man. It contained a wheel for steering and lookout glasses in a dome above, besides the usual accessories, engine signals, etc.

The interior of this vessel was not subdivided in any way whatsoever, there being one large roomy space containing the boiler, engine, living room, etc.; coal was stored forward. A ladder communicated with the conning-tower, and the whole design displayed a surprising simplicity. The length of the ship over all was 70 feet, and the breadth about 20 feet, the wood employed in its construction was poplar on account of its incombustibility and elasticity. The speed obtained on trial was over ten miles an hour, and the crew required to work the vessel numbered four. No account is obtainable relative to the experiments to which Nasmyth's invention was subjected, but even if they proved comparatively successful, the steady advance in the power of artillery would soon have caused all such vessels to become obsolete. Had he brought out his idea ten years earlier some advantage would doubtless have resulted, but now that iron was entering into the construction of vessels of all classes, Nasmyth could scarcely expect the Government to adopt as a warship a vessel built entirely of wood.

It is remarkable to what extent the war with Russia affected the invention and construction of submarine boats. It acted as a magnet to the inventive geniuses of the day, and is an instance of the far-reaching effect a war can have upon long standing institutions. It is said that at present there is not



X. NASMYTH'S FLOATING MORTAR

E

a submarine boat which can be called perfect—and it is true. But at the same time it is safe to assume that a war would soon add those touches of perfection to the article complete and perfect in theory, but crude in practice. In no other year do we find so many men seeking the solution of that fascinating problem which even yet is still to seek. Bauer, Scott-Russel, Vilcoq and Deschamp, Babbage, Spiridinoff, and Nasmyth, all names to conjure with and not one of them was successful. Yet each in turn did something to bring us nearer to the goal; each design showed a certain advance in submarine navigation, and even if their principles had already been known for long they reiterated and proved their truth more fully.

The next two attempts at submarine navigation of which we hear are fantastic, and may be passed over with but slight notice. The first of these was the hydroscaphe of Althabegöity. He took out a patent for it in 1856, but it never went past the model stage. It was in shape like a filbert or hazel-nut, and was composed of two hulls, each having an elliptical form on one side and flattened on the other, joined together. A rudder was fitted to each end, which were both alike, and no information was given as to the boat's motive power. Its length was 82 feet and its breadth 40 feet.

1856 Althabegöity

From the centre of the hull rose a conical tower supporting a huge four-bladed propeller. This propeller was intended to sustain the boat at an even depth. Behind this propeller shaft was a wide tube containing two ladders, by which the occupants might descend or ascend from the interior. The sustaining screw was fitted into a floating box, whilst the exit tube rose several feet above the surface of the water.

In the bows was fixed a flexible tube which was attached to a floating bowl. This tube was doubtless for keeping up a good supply of fresh air. Immersion was obtained by the introduction of water into the lower compartment of the boat. Althabegöity intended to construct his ship of wood, and was sanguine of its success. It was to be fitted with two small propellers, one at either end, but, as previously stated, the power by which they were to be worked was not given.

W. Newton

The second submarine boat, which was more valuable as a curiosity than for its utility, was that of William E. Newton. He had no warlike purposes in mind when he designed his vessel. His intention was really little more than an aid for divers, there being no provision made for men in the interior of his vessel. It was egg-shaped, with very pointed ends, and propelled by a many-bladed screw. On each side was a fin on which two divers took their places, and all being ready, the little vessel was allowed to sink, the divers being clothed in the ordinary diving costume. When at the bottom they detached the tools necessary for any work on which they were engaged from the hull of their mechanical help-mate, and, when they had completed all that they desired, the water was expelled from the tanks, and the little vessel leapt to the surface again with its two passengers seated outside. The idea is charming—in theory. In practice it seemed to drop out of people's minds very quickly, and, from this fact, its success or otherwise can be pretty correctly gauged. William Newton was not a one-subject inventor; he tried his hand at every imaginable thing connected with the sea, above or below, but failure was the invariable result of his persistence.[1]

1857 Scheltema-Beduin

The next invention hails from the far Indies and is the conception of Paulus Scheltema-Beduin of Batavia, Java. This inventor offered to build a submarine vessel for the French Government, but his offer was declined. It is a misfortune that but little is known of the invention, for, coming from so distant a clime, remote from the progress of mechanics and engineering, details of the plans would have been of especial interest.

Hubault

M. Hubault, a towns-fellow of the ill-fated Dr. Petit, sent to the Minister of the Marine an oblong submarine boat, very similar in outward appearance to the Nicolas-Tesla submarine of 1899 (a small vessel to be driven by wireless telegraphy).

M. Hubault's vessel was suspended from the surface by a float, through one of the two bent tubes in which fresh air would be drawn for the two men forming the crew, the other tube serving as a ventilation for drawing off the vitiated atmosphere. Four thick lenses, placed two on each side, were provided as look-out glasses, and from the bows projected

1 He invented a sort of canvas bag which was intended to raise sunken ships. These bags were to be attached to the side of the vessel to be raised, and filled with gas, when they would act as balloons and rise at once to the surface with the vessel. This project was also a failure.

a searchlight from which a powerful beam might be thrown on objects immediately ahead. The propeller was to be rotated by a hand winch connected by a multiplying cog-gearing to the propeller shaft. Two rudders fixed astern served for steering in the two senses of the vertical and horizontal.

M. Hubault's design had little originality about it, the method of suspending his vessel from the surface by tubes being merely a copy of Castera's invention thirty years previously.

Of the inventors of 1859 who deserve most notice, Mr. Conseil of Havre stands easily first. He had not only the untiring energy of the true enthusiast, but also the practical ideas of the scientist. His first plans, formulated in 1857, provided for a small vessel of only 5m. 33 in length, 1m. 33 in beam, and a depth of 1m. 50. A Commission appointed to judge the value of this little boat condemned it as being incomplete in detail. Not to be discouraged, he set to work to remedy the defects in his initial design.

1859 Conseil

Conseil's second submarine boat contained no new feature. In form and design is resembled the hydrostat of Dr. Payerne, and it took after the invention of Vilcoq and Deschamp in that the steersman was encased in a leather suit which projected from the top of the vessel. The propeller was turned by hand, but in the trials that took place in the Seine between St. Michel's Bridge and the lock de la Monnaie, before a Commission appointed by the Minister of the Marine to examine the invention, the speed on the surface never exceeded 1½ knots per hour, whilst submerged, the boat went whither the current willed.

The dimensions of the new vessel were: length, 9 metres; beam, 1 metre 66; depth, 2 metres; and weight, 3 tons. The method of placing the vertical rudders was different in this second design, there being two pairs, one forward and one aft. Propulsion was, as in the first vessel, by means of hand winches of the pattern later adopted in the little 'Davids' of the American Civil War. In the trials mentioned above six men worked the propeller, and for thirty-five minutes remained submerged. The Commission condemned the invention.

Conseil, in no way discouraged, laid down the plans of a third vessel to be propelled this time by a turbine motor. He had perceived how inadequate was the human power to impart a sufficient speed to a submerged vessel. He also increased the dimensions of his boat and doubled its displacement. Length, 12 metres; beam, 2 metres; depth, 2 metres 33. He eventually, owing to the continued ill-success of his vessels as submarine boats, decided to convert them into semi-submarines,—surface vessels with the minimum of freeboard,—hoping by this means to have an efficient life-boat, possessing complete immunity from the attacks of waves.

Van Elven

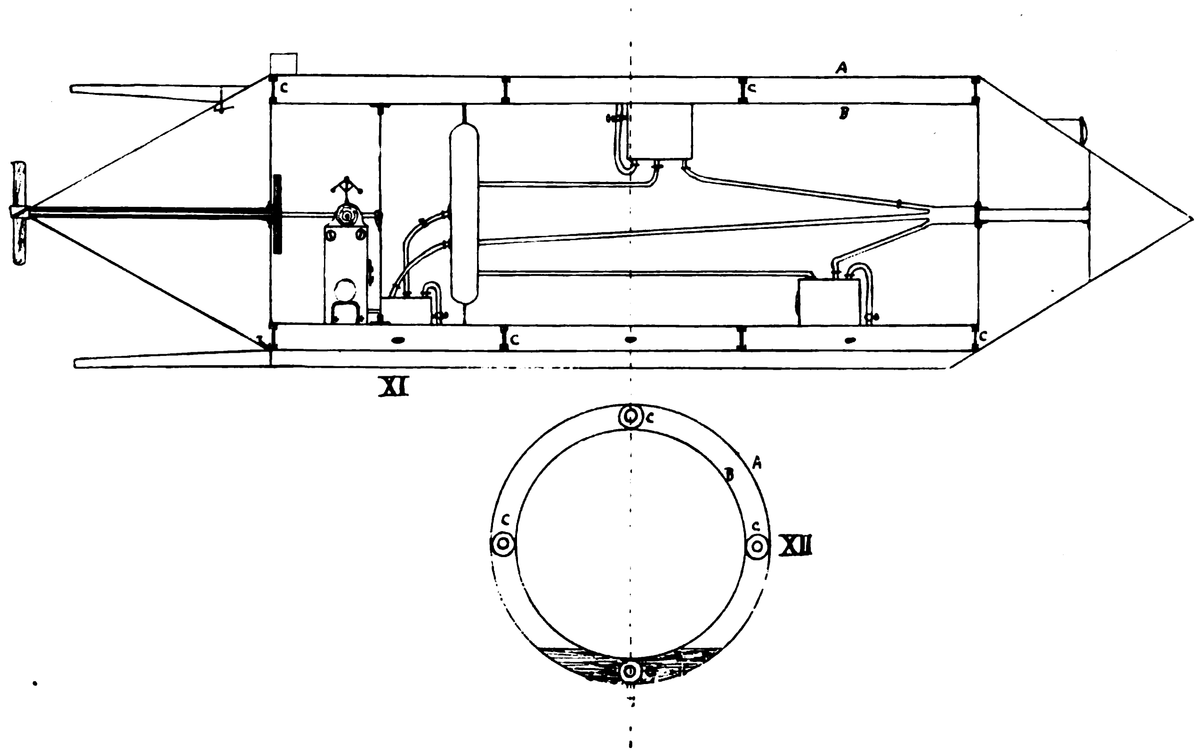
Tétar van Elven, a Dutchman, of Amsterdam, was the first to propose the use of an optical tube,—the forerunner of the 'cleptoscope.' His submersible was to be heavily armoured on its deck and driven by steam from a high pressure boiler. Its weapon consisted of a steam turned auger, and its complement of twenty men.

The optical tube was of two looking-glasses placed at either end of a tube at an angle of 45 degrees. This remarkable invention could be revolved so as to view the whole horizon.

Masson

A French gentleman of Evreux, Mr. J. M. Masson, also proposed a submarine boat in 1859. Its dimensions were to be as follows: length, 8m. 50; diameter, 2m. 60. In shape it resembled a thick pencil, or a rocket, being cylindrical in body, with a sharp cone-shaped beak affixed to the forward end, the stern having a hemispherical form. Forward, in the top was a manhole, and still further forward, just at the joint of the cone and main body, was fixed a long tube which, during submersion, might be projected above the surface for the purpose of renewing the air within the hull. The most remarkable feature of the fittings was a carbonic acid engine, the first of the type ever proposed for a submarine boat. This engine, or contrivance, was not for the propulsion of the vessel, however, but for the emptying of the water-tanks. Propulsion was by hand as in most other cases we have cited up to the present.

Mr. Masson's invention is decidedly ingenious and one well worthy of study. From the experiments just noted it will be seen that the submarine boat was slowly emerging from the stage of theory to that of the practical, and the trials of



THE SUBMARINE BOAT OF O. RIOU

Bourgois and Brun's vessel in the two following years was a result of the failures of their predecessors,—failures that brought out weak points capable of remedy.

Olivier Riou invented two submarines, one propelled by steam (see Fig. XI.), the other by electricity. They had a length of 42 feet, and a diameter of 12 feet. Steam for the first was generated by the heat of either in combustion, whilst the electrical power for the second was obtained by batteries. 1861 O. Riou

There was one novel feature in both these vessels, and that was the construction of the hull. This was double (Fig. XII.), being made of two concentric cylinders, A B, one inside the other. The two hulls were not fixed immovably to one another, but were on rollers C C C, so that if the outer hull rolled to the right, the inner rolled to the left, and thus it was estimated the stability would be absolute, in that the motion of the one being inverse to that of the other would tend to counterbalance the effect of each, and that the vessel would remain steady. The intervening space between the two hulls served another purpose, however, namely, that of submersion tanks. It was divided up so that part of it could be filled at a time, according to the depth of submersion required.

The inside cylinder, B, swung on an axle, C C, which extended from end to end, the after portion containing the propeller shaft. Nothing is known of the trials of these two boats, but had they been worthy of note, records would doubtless have been made of them.

The next inventor of a submarine boat was a Spaniard, Narciso Monturiol, who gave the name of 'El Ictineo' to his invention. It was very like Bauer's boats, and was tried over sixty times.[1] These multitudinous experiments took place mostly at Barcelona, and were not altogether unsuccessful. We are told that 'it manœuvred several metres beneath the sea with the same facility as on the surface. If oxygen were lacking a machine supplied it as soon as its absence made itself felt, and for five hours a crew of ten men remained beneath the surface without communication with the air above. Nor is this all; the vessel is armed with cannon, and made as excellent markmanship with this arm as would be possible on the earth or on board another ship; the blows are directed N. Monturiol

1 'Espagne Contemporaine,' 1862.

upwards against the vulnerable parts of armoured ships. The 'Ictineo,' is, besides this, armed with a powerful auger worked by steam, and capable of piercing the hulls of vessels. The invention is worthy of the notice of both sailors and soldiers.'

Such an invention should indeed have altered the world's history, yet, strange as it may seem, 'El Ictineo,' with all its perfection, effected nothing and was presently forgotten, as had been all its predecessors. The steam-turned auger is a distinctly novel mode of attacking vessels, and 'El Ictineo' must have resembled a gigantic sword-fish.

In the original plans of 'El Ictineo,' which I have seen, no sign of a powerful auger is visible, nor is any mention of such an instrument made.

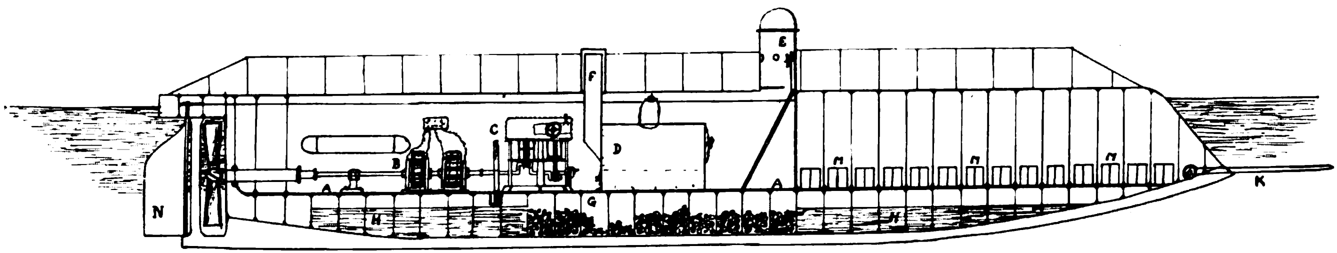
1862 Villeroi

In 1862, at the request of the Government of the United States, a French Engineer planned and built a cigar-shaped submarine boat. The following account of a trial of this vessel is from an article given in 'The Navigator,' a service paper published at that date:

'At four o'clock, when the tide was at its highest, M. Villeroi boarded his invention and moved slowly away from the shore. The vessel first made a run of half an hour on the surface of the water, and then dived in 16 to 20 feet of water, and the occupant picked up some stones and collected a few shells from the bottom. He afterwards manœuvred in all directions during this submersion, so as to puzzle a crowd of small boats which had encircled him from the beginning of the trial. Then, rising again to the surface, he performed various evolutions on the surface, and after this last trial, which had lasted in all for an hour and a quarter, he opened the manhole and shewed himself to the people, who welcomed him with lively interest and approbation.'

M. Villeroi's submarine boat had a length of 35 feet, and a diameter of 3 feet, 9 inches. It was built in twelve sections, of which the two end ones were conical. At the after end was a propeller having a diameter of 3 feet, 2 inches; it was four-bladed, and was worked by a hand-crank. Submersion was obtained by the introduction of water into large gutta-percha tubes; it could be expelled by pumps. Rows of port-holes fitted with thick glass ran along each side and at the top,

1 'Tarière' in the original.



XIII

ALSTITT'S TWIN PROPULSION SUBMARINE

whilst a conning-tower in the bows was fitted with look-out glasses for steering; steering was effected by a rudder beneath the propeller, and stability was obtained by lateral and horizontal planes fitted in the last three sections of the vessel. Although the trials, if we may judge from the extract given above, were satisfactory, yet nothing more was heard of Villeroi's submarine cigar.

In 1863 appeared the first submarine fitted with two means of propulsion, steam and electricity; it was designed by an engineer called Alstitt, and built at Mobile, United States of America, in 1863. The hull (Fig. XIII.) was divided horizontally by a deck, A, of thick sheet iron. Beneath this deck were two water-tanks, H H, placed fore and aft and minutely subdivided, whilst the middle space, G, was utilised as coal bunkers. 1863 Alstitt

The stern compartment above the deck contained the motor, B, for use when submerged, and a little forward of this, the steam engine, C. The boiler, D, was situated almost in the centre of the vessel, the funnel F being placed in a small tower, which during submersion could be hermetically closed. The rest of the space (except right forward where the accumulators were situated M M) formed the living room of the crew. A small conning-tower, E, to which access was gained by a ladder, was fixed in the deck; strong look-out glasses were placed around it so that a good all-round view might be obtained. The funnel was telescopic, and when after running on the surface it was necessary to dive, it was drawn in, the cover put on, the fires put out, all pressure of steam blown off, and the steam engine disconnected. The motor was then geared on and the dive made with the aid of a horizontal rudder, K, fixed in the bows. For ordinary steering, the rudder, N, in the stern was used. The forward compartments, besides containing the accumulators and electrical appliances, had also cases filled with large quantities of air in a compressed state, and stores for the crew.

The armament was composed of large water-tight cases of powder; these were arranged along each side of the vessel, to which they were attached by iron chains connected with the interior. They were so constructed that they rose to the surface, the buoyancy being sufficient to sustain the weight of powder. When they were in contact with the ship to be destroyed, ignition was obtained by an electric spark. If the vessel to be attacked happened to be in motion, the submarine boat would scatter several contaet mines in its path, which could be collected again if they did not take effect.

The feeble point about this boat is the horizontal rudder forward, which could never be expected to work satisfactorily. The outward form of the vessel is not one that lends itself readily to submarine navigation, but whatever the faults of A'stitt's boat, he was undoubtedly the pioneer of the mixed propulsion type, the latest development of which is to be found in the 'Narval' and 'Holland.'

Bourgois and Brun

We now come to the perhaps best known attempt to solve the problem of submarine navigation, that of Captain Bourgois and Engineer Brun. I have by me a work dealing exclusively with their inventions,[1] and cannot do better than translate a few extracts direct from the original.

'The submarine boat, of which the plan is on the opposite page (Fig. XIV.) has a length of 41 metres (134.52 feet)[2] from the extreme tip of the stem to the stern post (*étambot*) and the rudder shaft. Counting from the point of the projectile to the back of the rudder, this length will be increased to 46 metres (150.92 feet).'

'The beam is 6 metres (19.685 feet), and the total height from the top of the conning-tower P to the bottom of the keel 4 metres 20 (13.7182 feet).

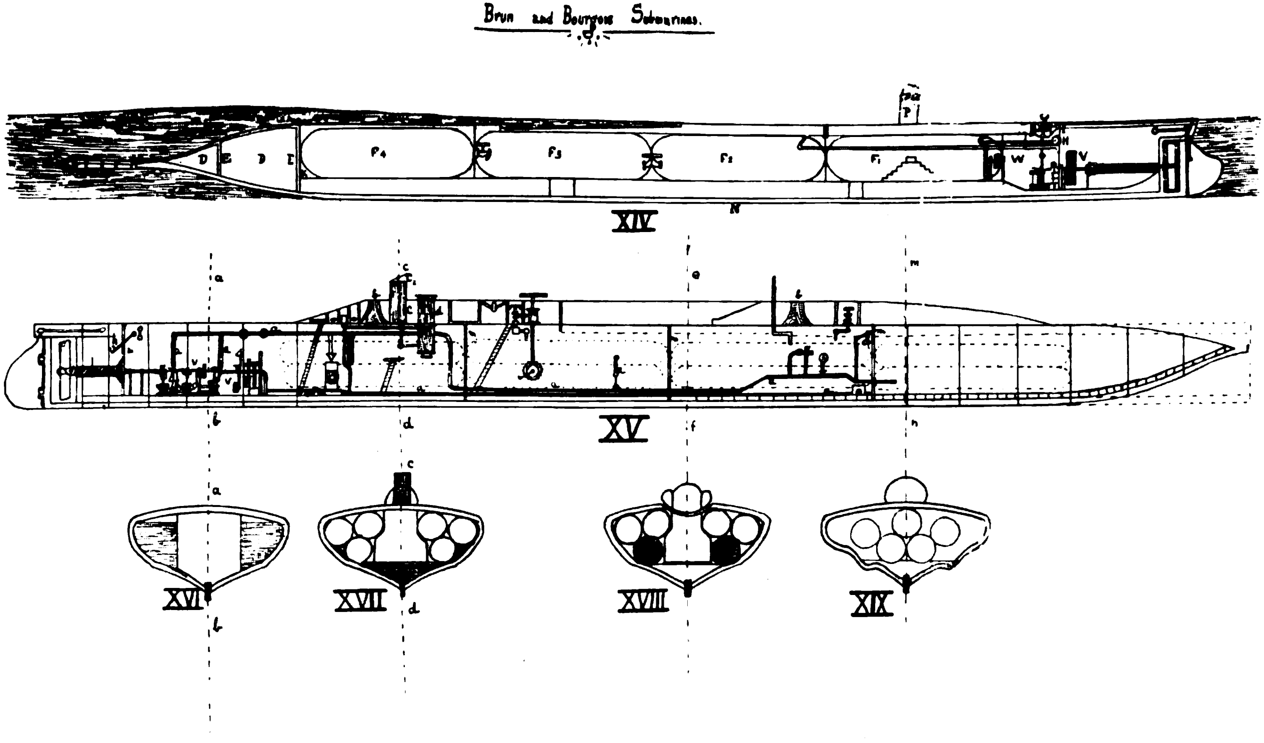
The letter N indicates approximately the point of centre of gravity and the centre of the keel, situated on the same vertical.

'In the interior of the boat the height forward is 2 metres (6.5618 feet), and aft at the maximum of space 2 metres 40 (7.8738 feet).

'This vessel will be constructed of strong metal in the same way as all iron ships. A very heavy iron keel will serve the double purpose of being a solid base upon which to build up the hull and ballast for preserving stability. This keel will

1 'De la navigation sous-marin appliqué à la Défense des Ports. Le plongeur, bateau sous-marin de MM. Brun Ingenieur, de la marine, et Bourgois, Capitaine de vaisseau. Extrait de la Revue Maritime et Coloniale, Paris, 1877.'

2 For convenience I am giving the English equivalents to all measurements.



XIV.-XIX. BOURGOIS AND BRUN'S SUBMARINE BOAT

be prolonged at the forward end first up to the stern, and then further as a spur, serving the purpose of bomb pole, circular and bound in iron. This mast, with a length of 3 metres (9.8427 feet), and a diameter of 0 metre 30 (11.811 inches) will carry the steel projectile, conical and hollow; it is intended to explode against the hull of an enemy's ship.

'One can understand that the dimensions of this pole and the fishes [1] of iron would give it sufficient strength to support the first shock of an onslaught at a speed of nine knots; and that the explosion of the projectile, in destroying everything surrounding it would completely disengage the submarine boat from the vessel attacked. If experience showed that the resistance of the pole to the shock was insufficient, it could be easily remedied by augmenting the power of the fishes or even the size of the iron pole on which the wooden tabling [2] is fitted.

'When the ship is navigating on the surface, to get into position of attack, the axis of the spur will be parallel to the surface of the water at a depth of 1 metre 50 (4.9213 feet). And the blow will thus take place 1 metre 50 beneath the water-line of the enemy, that is to say *below* the armour belt of ironclad ships.[3]

'At the moment of attack, nothing of the submarine would be visible but the conning-tower P, 1 metre (3.2809 feet) high by 0 metre 65 (2 feet 1.591 inches) in diameter, armoured in front, furnished with a door opening towards the stern and pierced with holes fitted with movable covers, and by which the captain might watch the enemy's ship and direct the attack.

'An examination of the plan given will suffice to give a sufficiently accurate idea of the shape of the boat and the

1 The word given is 'jumelle,' which in naval parlance means a 'fish' or 'support'; thus, 'les jumelles de mâts et de vergues' would indicate the 'ratlines,' 'shrouds,' or 'mast stays.'

2 Tabling—the letting of one timber into another by alternate projections.

3 In case of the English deeping the armour of their ships, it will be easy to lower the position of the spur down to the level of the keel, and even to sink the vessel a little more during the attack. Besides, the submarine must direct its attacks more especially against the large vessels. (Note: We must always remember that ironclads spoken of by Bourgois and Brun were of the earliest type, and devoid of watertight subdivisions such as those of to-day possess.—AUTHOR).

nature of its fittings. We will, therefore, only add the following few explanatory remarks:

'The stability of the vessel will be guaranteed in the first place by the iron keel, situated immediately beneath the centre of the hull; in the second place by the low position of the centre of gravity of the engines and defensive and offensive armaments, and lastly by the presence of about ninety tons of iron ballast under the deck of the interior and between the timbers of the flooring.

'In case of necessity one can make the vessel rise rapidly to the surface by throwing the ballast out of the traps L L, after having taken the precaution to increase the pressure of air in the chamber above to that of the ambient water.

'An inspection of the installations and form of the forward end will show clearly also that no grave accident to the vessel can result from the explosion of the projectile.

'Indeed, the tangents, leading from the point of the explosion to the surface of hull, form such slight angles that the chances of the explosion doing harm are very remote.

'Besides this, the slightness of the angle at which the shock will reach the armoured part of the hull, after having its power lessened by the resistance of the water, would cause that to ricochet and strike when split up. Even if the outer skin be ruptured, the narrow iron partitions, besides the absorbent matters placed in the forward compartments, would soon counterbalance the force of the shock and prevent the damage reaching the interior of the vessel.

'Again, if the narrow compartments are filled with a substance having the same density as water, the longitudinal stability of the vessel will undergo no change in the event of a breach being made at that point.

'We almost think that the precautions we have indicated above are very exaggerated; but it seems preferable to us to err rather in an excess of prudence than an excess of rashness, in the first experiments which are undertaken.

'The air reservoirs F 1, F 2, etc., will be of cast steel, with two rows of cross rivets, and lined inside with an air-tight glazing. They are to resist a trial of twenty atmospheres pressure from an hydraulic press and a pressure of compressed air of at least fifteen atmospheres, conditions already fulfilled by air reservoirs of the same type as also by high pressure boilers, which have permitted engines to work safely at a pressure of twelve atmospheres.

'The volume of each of the large reservoirs, F 1, F 2, etc., which have a cylindro-spherical form, like high pressure boilers, is about 19 metres cubes 5 (688.6785 cubic feet). Each of the little reservoirs (of which there are two, placed on each side of F 4), which have the shape of a cone terminated by two hemispheres, has a volume of 5 metres cubes (176.58 cubic feet).

'The seven forward reservoirs communicate with one another. The two reservoirs, F 2, and the two reservoirs, F 1 (in the plan only the one reservoir is shown, there are in every case two, side by side), communicated directly by tubes with a central reservoir, H, which distributes the compressed air to the slide-boxes of the engine, by one of the methods in general use with high pressure machines. These dispositions give four independent groups of reservoirs, and permit one to hold in reserve, for the moment of attack, a good supply of air at the maximum pressure.

'At K in the bows and W in the stern are water compartments so arranged that the simple turning on or off of water cocks will fill or empty them.

'Besides this, each compartment is furnished with a hand pump, by which the compartments can be emptied without the aid of compressed air. The forward compartment can contain about 16 metres cubes (565.07 cubic feet) of water besides the air reservoirs. The compartments in the stern can each hold about 8 metres cubes (282.53 cubic feet).

'The iron ballast will be placed in such a fashion that the axis of the boat, taken to be exactly in a line with the propulsion of the propeller, will be horizontal, with 15 tons of water in the forward compartment and a like amount in the two in the stern. The quantity of this ballast (*i.e.*, the iron ballast) should be such that, with the latter amount of water (30 tons in all), the vessel will be entirely submerged, with the exception, of course, of the conning-tower P, which has a volume of 0 metre cubic 350. This is the position of the vessel navigating just on the surface, as is shown on the plan.'

It is not worth my while giving a translation of the whole description; for one thing, space is too limited, and for another, trivialities on which the inventors comment in full are unnecessary in a work of this description. I will give roughly, however, a few of the dimensions which occur here and there, and which, with the plan before us, will have a certain amount of interest.

The air cylinders were to have a diameter of 0 metre 36 (14.173 inches), and their pistons a stroke of 0 metre 36. The screw placed as in ordinary steamships has the following dimensions: Diameter = 2 metres (6.5618 feet). Thrust = 4 metres (13.124 feet). It was to have six blades with distance between each of 0 metre 30 (11.811 inches).

The vitiated air, after being used for respiration, is expelled by the pump X, situated above the reservoir H. The rudder is manœuvred in the ordinary way by lines attached to a wheel. If the engines are placed *hors de combat* through some accident the screw can still be worked by a hand winch, V. For mooring purposes a small casting anchor of 200 kilos would be carried.

Provisions for twelve men for forty-eight hours were to be stored, besides several oars, and pots of grease for the engines. By the day, light could be obtained by lenticular glasses placed in the upper part of the hull; by night one or two lights would be allowed in the ship, in spite of the amount of oxygen they would require for their combustion. Each man would be furnished with a lifebelt in case of accident, when there would be some chance of his being saved.

The submarine boat described above would have a total displacement of 350 tons, of which the hull would take half. The following is a roughly-compiled table of weights:

	Tons.
Hull	175
Air reservoirs	30
Water reservoirs	6
Water (carried)	30
Engines	10
Armaments	9
Ballast	90
Total	350

The engines were to be of 84 horse-power, with which 9 knot speed was expected; this would, of course, have diminished as the pressure of air decreased. This submarine was never built, so we will proceed at once to a description of 'Le Plongeur,' which was experimented with in the years 1863, 1864 and 1865.

The construction of the 'Plongeur' was commenced in June, 1860, at Rochefort, to the plans of M. Charles Brun. The plans adjoined (XV.-XIX) are from 'l'Art Naval,'[1] and will help my readers to understand more fully the form and fittings of this submarine boat.[2] The 'Plongeur' was built entirely of sheet iron. Its shape was that of a flattened spindle, the hull presenting a smooth continuous surface to the water. It had the following dimensions:

	M.		Feet.
Length between perpendiculars . . .	42.50	=	139.44
Beam, outside measurement	6	=	19.685
Depth, including keel	3	=	9.8427
Depth from conning-tower to keel . .	4.35	=	14.272

	Tons.
Weight of hull	135
" engines and air reservoirs	59
" water introduced for immersion . . .	33
" equipment and complement	13.85
" iron ballast	212.35
Total	453.20

Height of centre of gravity on the keel	1m. 395 = 4.5604 ft.
Height of centre of hull	0m. 772 = 30.316 in.
Distance from centre of hull to centre of gravity	0m. 623 = 24.41 in.
Surface of mid-ship frame submerged	13m. cubes = 459.12 cubic feet.

[1] 'L'Art Naval,' Vice-Admiral, Paris, 1867.

[2] I have seen the original model of the 'Plongeur' in the Naval Museum at the Louvre, Paris. It was placed there after the 1867 Paris Exhibition.

The bows of the 'Plongeur' terminated in a point, but there were no fittings for a torpedo attached, as it was thought better to reserve the study of modes of offence until the certainty of submarine navigation had been assured. The 'dorsal fin' of the boat ran along a third of its length, starting from a small conning-tower of 1m. 50 (4.9209 feet) in height placed near the stern. It had a diameter of 0.60 (23.622 inches), and was fitted with port-lights for navigation on the surface.

In the centre of the vessel this fin was flattened and a recess was made to receive a small lifeboat (see XVIII.). Connecting water-tight doors gave communication between the submarine boat and the little safety craft attached to it.

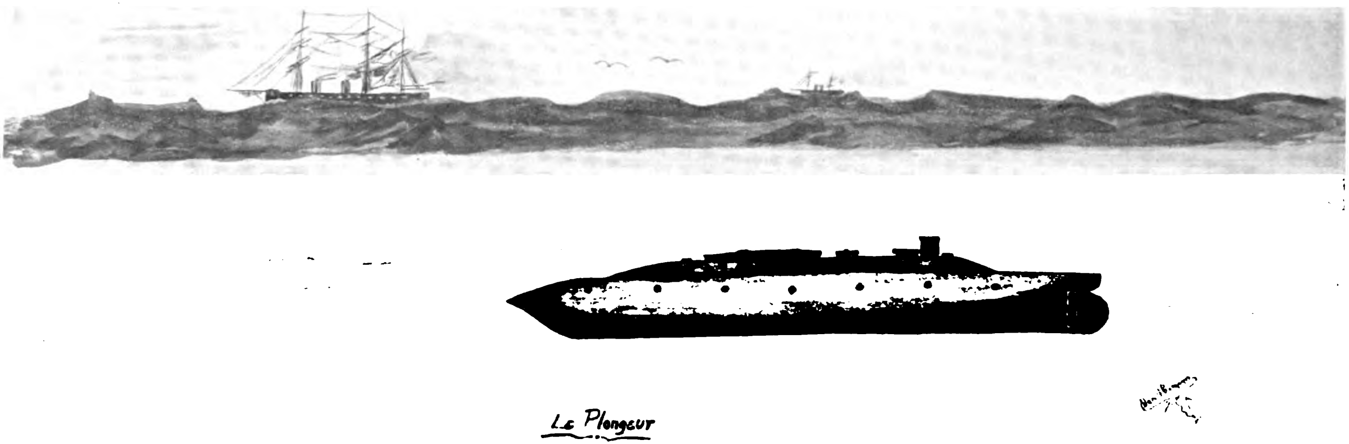
The air reservoirs were made of sheet-steel of 8mm. thickness (.3149 of an inch). They had a length of 7m. 25 (23.782 feet), and a diameter of 1m. 12 (3.6746 feet), and weighed in all, 45 tons. The volume of the five forward reservoirs was 30 metres cubes (1,059.5 cubic feet), and of the other eighteen reservoirs 117 metres cubes (4,132.03 cubic feet). The volume of the water reservoirs was 56 metres cubes (1,977.73 cubic feet), but this was found to be more than was ever required.

The engines, situated in the stern, occupied a space of 3 metres long by 1 metre wide. They consisted of two groups of compound double cylinder engines, and were connected in pairs to the same crank. The interior diameter of the cylinders was 0m. 32 (12.599 inches), this being also the length of the stroke. The engines, besides rotating the propeller, worked the pumps.

Besides the vertical rudder, the 'Plongeur' had two horizontal rudders, placed symmetrically on each side of the stern. They were joined in the interior by a bar, which, manœuvred by hand, gave the required inclination.

The lifeboat had a length of 8 metres (26.247 feet), a beam of 1m. 70 (5.5775 feet, and a depth of hold of 1m. 10 (3.6089). It was sufficiently roomy to hold the twelve men forming the crew of the 'Plongeur,' and was fitted with air tanks at each end, which rendered it unsinkable.

The 'Plongeur' was launched on April 16th, 1863. On June 8th following, the first engine trial took place, the vessel being moored by four cables; eight reservoirs with a pressure



XX.

of 12 atmospheres and a capacity of 48 metres cubes, 84 (1,725.13 cubic feet) were used. In 17 minutes the pressure sank to 1.5 atmospheres, and the power developed from 68 to 6, I.-h.-p.; whilst the effective pressure on the pistons became reduced to 0.84 atmospheres, although at the beginning it had been 5.25 The total number of revolutions registered was 1,599.

On June 10th, a trip was taken on the river between Rochefort and Charente, over a course of 5,750 metres. The vessel was submerged to a draught of 2m. 52 (8.2678 feet). A slight accident prevented the pressure in the reservoirs being greater than 10.75 atmospheres. The wind was adverse going, but favourable for returning, and the water was slightly ruffled. The outward journey took an hour, and required the air of 11 reservoirs; the homeward journey took 62 minutes, 12 reservoirs being used. The engines averaged 36 revolutions to the minute, and the speed obtained was 3 knots. This would have been much greater had not a cord become entangled in the propeller. This experiment proved that the vessel steered well in every direction.

The next experiments undertaken were those of submersion. These took place in a basin at Rochefort, 130 metres long, and a depth of 6m. 40. To avoid fatal accident in these experiments, experiments almost without precedent, a large pipe was fixed into the top of the boat. This pipe contained ladders, and was large enough for a man to go up or down, and the top showed well above the surface of the water. A trap door, shutting from inside the boat, placed it in the condition of being without this means of escape, which was only to be used in case of emergency. As it happened this escape proved its value at the first experiment, for on submerging, one of the lenses broke, and the water, after being held for some moments by the pressure of the air, rushed in and threatened destruction to the whole crew, who quickly escaped to the surface. The watchers on the bank knew that something had gone wrong by the appearance of a huge column of water spouted into the air. The basin was quickly emptied and the 'Plongeur' dried, and although this incident caused some apprehension amongst the spectators, it in no way shook the confidence of the personnel of the boat.

The window being mended, new experiments were commenced on September 5th, this time to test the efficacy of the lifeboat. This trial was quite successful, the little boat with its occupants leaping off the 'Plongeur' as soon as the screws were loosed. On the 7th more experiments of immersion and emersion took place, and so satisfactory did they prove that the safety-funnel was removed and the hole by which it was fixed in the boat blocked up. On September 12th the effect of the propeller when in motion, on the longitudinal stability of the boat, was experimented with. By February, 1864, all the basin trials having been carried out and proved eminently successful, the 'Plongeur' commenced its deep sea trials. The small despatch boat, 'Vigie,' was placed at the disposal of the Commission to follow the trials. After several inconclusive experiments, from February 14-16th, a really interesting trial took place on the 18th. The crew consisted of an officer, Doré, and twelve men, and having closed their vessel, they let sufficient water into the reservoirs to sink the boat; unfortunately they misjudged the quantity, and, despite the endeavours of the crew, the 'Plongeur' slowly settled down, until, after a minute, she touched the bottom. The donkey-engine (which had been fitted after the first experiments) was utilized to drive out some of the water, and the 'Plongeur,' or rather the stern half of her, ascended to the surface. The bows remained submerged several feet, but a speedy altering of ballast brought the ship to a level keel. A second trial was more successful, and the vessel rose to the surface horizontally. The 19th proved rough, but February 21st was again fine, and a trial of speed when submerged was made. A course of 965 metres (1,053.3 yards) was chosen, between the Moullières and Fontenelles buoys at the mouth of the Charente, and the 'Plongeur' accomplished this distance at a speed of 5 knots, and finished up by grounding on the point off Fort Vaseux, where she had to remain until the following day.

It is not worth while running through all the details of the multitudinous trials to which the 'Plongeur' was subjected. Not once did the vessel manage to navigate between two waters, although in a canal during one experiment, she glided over the soft mud of the bottom and thus deceived the occupants into thinking they had found the long sought-for equilibrium. But whatever the results of these experiments, Bourgeois and Brun advanced submarine navigation many steps, and proved two things conclusively: (1) the facility of navigating on a level with the surface of the water, and the invisibility of the same; and (2) the facility of sliding over muddy or sandy bottoms in depths not exceeding 35 feet.

1863-64

The American Civil War of 1864 of course stimulated to an unprecedented extent the inventive genius of the day. The Campaign proved a veritable magnet for novel ideas, and afforded the long looked-for opportunity of achieving fame to many an inventor whose plans might otherwise have never seen the light. The leading characteristic of 'getting there' before anybody else was true of the American in this instance as in numerous others; for it was an American scientist who wrestled with the idea of submarine navigation as a respectable asset in war, and emerged triumphantly. It was on the 'other side' that the first of the submarine boats to prove of real utility in warfare was designed and built.

A French Design

At the very commencement of the Secession War trials were made in this direction; a cigar-shaped vessel was ordered from a French engineer, who received the substantial payment of £10,000, while in addition to this handsome sum he was to have received £5,000 for every hostile ship destroyed by his invention.

When, however, the vessel was ready for its trials, the 'inventor' was inconveniently missing, and as might have been anticipated under the circumstances, the submarine proved a complete failure.

There are but few details to hand concerning this submarine boat, but in all probability it resembled the invention of Villeroi.[1] The length was 35 feet, and the diameter 6 feet, the hull being of sheet-iron. The crew, consisting of sixteen oarsmen, who worked the oars placed eight on each side, and an officer who attended to steering and a torpedo, were supplied with air by a machine which doled out oxygen in small quantities, whilst the vitiated atmosphere was expelled by another engine. Immersion, we are told, was obtained by the introduction of water, whilst a small conning-tower enabled the direction to be corrected from time to time. Rows of

1 See page 42.

glasses allowed a certain amount of light to penetrate into the interior. The armament consisted of a spar torpedo worked on rollers from the conning-tower.

Attempt on 'Ironsides'

Despite this ill success, several submarine boats were constructed, and one of these made an attempt to blow up the battleship 'Ironsides.' This vessel (Fig. XXI.) was more of the nature of a 'submersible' than a 'submarine,' in that it always remained on a level with the surface of the water. The following account of the attack on the Federal ship may be of interest.[1] During the operations against Charleston, the vessel most feared by the confederates was the 'Ironsides;' so well trained was her crew, and so perfect their shooting, that the attacks on the forts were most dangerous; several attempts were made to destroy this vessel with torpedoes, but without effective results.

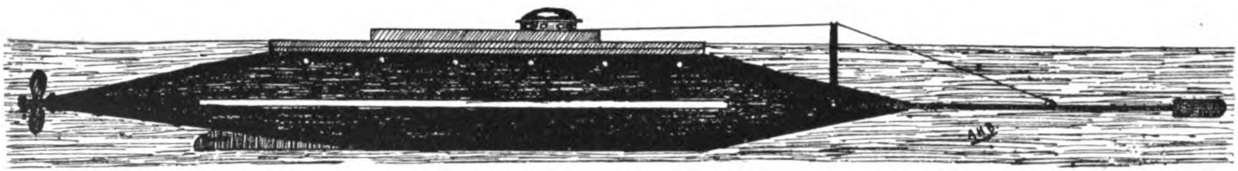
Nevertheless, on the night of October 5th, 1863, the attempt proved almost successful. A torpedo boat, very novel for the period, was placed in commission at Charleston and put under the command of Lieut. W. T. Glassell, of the Confederate Navy, who received orders to attack and destroy as many ironclads as possible. Glassell was assisted by Captain Stoney (chief officer), J. H. Tombs (engineer), and Charles Scemps and Joseph Albes as assistants. The vessel belonged to a class known as the 'Davids,' shaped like a cigar, and propelled by a small engine and propeller; its length was 50 feet and its diameter 9 feet.

Offensive power was supplied by torpedoes carried at the end of a spar of 15 feet in length, fixed in the nose of the boat.

Just previous to the attack the little vessel lay anchored off Moris Island;. 9.15 in the evening was the time chosen to make the attempt, as being the hour when the deck was most deserted.

A little object, resembling a pleasure boat, was suddenly descried by the sentinels, floating on the water close at hand. The officer of the watch, Howard, ordered his men to fire; simultaneously with this order the vessel received a terrible shock, the result of the explosion of the torpedo, which threw a gigantic column of water into the air, flooding the deck

1 'Naval History of the Civil War.' Admiral Porter, U.S.N. 1887.



XXI. THE TORPEDO BOAT WHICH ATTACKED THE 'IRONSIDES'

and the engine room. Ensign Howard, mortally wounded by a rifle shot fired from the torpedo boat, died five days later.

The proximity of the 'David,' and the small target it presented (scarcely 9 feet by 6), prevented the big guns from being used; a heavy fire of musketry was, however, poured into the escaping torpedo boat until it was lost to sight. Two monitors were rapidly despatched in pursuit of the hardy little assailant, but although two ships' cutters were launched to aid in the search, no trace of the boat could be found. Happily the 'Ironsides' was in no way damaged, and her escape was undoubtedly due to the misjudgment of the distance between the torpedo and the hull of the ironclad.

Lieut. Glassell was subsequently picked up at sea by a tramp steamer; he explained that the explosion had injured the torpedo boat, and that he and the other two officers had been obliged to abandon her and seek safety by swimming.

This attack showed that a new element of naval warfare had come into being, and a stern watch was kept to prevent the recurrence of an attack which so nearly proved disastrous.

The 'North,' with all its enormous resources, did not possess a single torpedo boat. If the fleet blockading Charleston had included twenty of these vessels they would have broken down opposing obstacles with far greater speed than they could have been made, and the way to Charleston would have been thrown open.

The Confederates had not the slightest intention of abandoning the idea of possessing torpedo and submarine boats, and wisely. Convinced of the value of the new arm, the South equipped another but more perfect vessel of the 'David' type. The first trials, however, were productive of such little satisfaction that the officers at length began to lose faith in them.

On January 14th, 1864, the Minister for the Navy Department wrote to Vice-Admiral Dahlgren, commanding the fleet blockading Charleston, to the effect that the Confederates had launched a new vessel capable of destroying his whole fleet; the alarming information had reached the Navy Department from an apparently authentic source, and he (the Minister) considered this intelligence so serious that he thought it his duty to acquaint him with it at once. Nevertheless Dahlgren could not believe that any attempt would be made against the exterior line of the blockade, but only against the ironclads in the interior; he warned all the officers, however, to take every precaution to prevent an attack. Despite these warnings, the Confederates managed to take one of their boats over the bar, and on the night of February 17th, the 'Housatonic,' a fine newly built ship, anchored off the harbour in a most favourable position for a torpedo attack, was destroyed under the following circumstances: towards 8.45 p.m. the officer of the watch, Lieut. Crosby, descried a suspicious object about a hundred yards away making for the ship.

Attack on 'Housatonic'

All the officers in the squadron had a general idea as to the form of the 'Davids,' and also what they looked like on the water. The Commander-in-Chief had received a printed notice on the subject, descriptive of these novel infernal machines, and containing hints as to the best way in which they could be avoided. He attached more importance to torpedo boats than was generally considered necessary at that date, and considered them the most serious difficulty in the taking of Charleston, and the greatest menace to the safety of his fleet. He gave out that the whole line of blockade would in all probability be attacked by these new engines of naval warfare, and warned his officers to guard against them with all the means at their command.

When this suspicious object was seen by the watch-officer, it resembled a flat plank moving on the water immediately in the direction of the ship. In two minutes from the time when it was first sighted it had reached the side. The anchor-chains were allowed to run through the hawse holes, the engines were set in motion and all hands called up on deck; but unfortunately these steps were taken too late. The submarine boat hit the 'Housatonic' a little forward of the main mast, in close proximity to the magazine. The steersman evidently knew the plans of his enemy in every particular, and manœuvred to explode the torpedo at the most vulnerable part. The pivot guns were turned towards the attacker, but could not be depressed sufficiently to harm it.

For the space of a minute the 'David' rested touching the side of the doomed ship, its commander coolly waiting for the correct moment to fire. He had not to wait long; the moment came, and the vessel, leaping violently in the air, partly by the force of the explosion, and partly by the huge wave thrown up, commenced at once to settle down by the stern with a heavy list to port.

The torpedo must have driven an extremely large hole in the 'Housatonic' to cause so rapid a finale to the attack. Naturally the greatest consternation reigned on board the vessel. Nothing could be more demoralising to a crew than to be torpedoed without being able to strike a blow in self defence. A hundred pounds of powder would be dangerous to a powerful ironclad, and its effect therefore on a wooden vessel can be better imagined than described.

The men climbed hurriedly up the rigging as the hull sank beneath them, an absolute panic took possession of all. Captain Pickering had been badly injured by the explosion, discipline was of course lost, and a general *sauve-qui-peut* ensued.

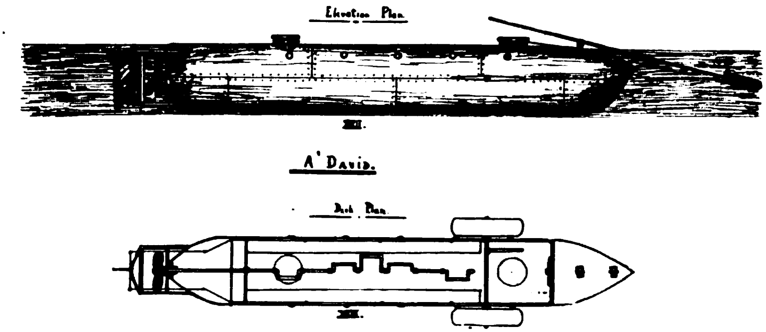
Boats were despatched from the 'Canaladiagua,' and a number of the crew were saved by this means.

Fate of the 'David'

But what of the author of this disaster? Not a trace could anywhere be found of the hardy attackers, and it was generally believed that they escaped during the confusion; when, however, about three years later divers were sent down to the 'Housatonic,' the dreadful truth was discovered. Fixed in the hole that it had itself created, sucked in by the enormous inrush of water, was the ill-fated submarine, its crew of nine all being drowned like rats.

They could scarcely have hoped for any other termination to such a venture, desperate as it must be regarded from every point of view. In earlier trials in the smooth water of the harbour the same vessel had already drowned three crews, and better luck in the open sea could scarcely have been anticipated. On trial the speed obtained had been five knots.

In form the 'Davids' resembled ordinary surface launches covered in, and made of boiler-plates. The small illustrations in the text will give some idea as to how the motive power was obtained. The vessels always had a tendency to dive, and it is to this cause which must be attributed the terrible and sinister list of fatalities which figure in the records of these craft. During the attack on the 'Housatonic' the manholes had foolishly been left open, and in consequence the water entered as soon as the sinking ship dragged its aggressor beneath the surface. Had they been closed it is quite possible the buoyancy of the little vessel would have been sufficient to



THE TORPEDO BOAT WHICH SANK THE 'HOUSATONIC'

withstand the suction of the water entering the breach, and in that case the submarine boat might have risen to the surface and the crew have escaped.

Trials of 'David'

The 'David' was originally intended to tow a torpedo, and it carried a spar torpedo for the first time when it attacked the 'Housatonic.' Its trials are worthy of note. It was first manned by Lieut. Paine and eight volunteers, but whilst cruising in front of Charleston, the wash of a passing steamer upset the equilibrium, and all except Paine perished, and he only escaped because at the moment he happened to be looking out of one of the manholes. The vessel was raised and repaired, and again Lieut. Paine took command, but while anchored off Fort Sumter it sank for the second time, the lieutenant and two men managing to escape.

Paine had had enough after this second adventure, but Aunley, one of the constructors of the boat, willingly took command, and with eight volunteers started on a trip up the Cooper river. They had not proceeded far when, for some unknown reason, it sank in very deep water, all nine of the crew being drowned. Yet again was it raised; this time to be taken against the 'Housatonic' by Lieut. Dixon of the 21st Regiment, of which essay we already know the result. The persistence with which this vessel was repeatedly raised and utilised, and the stolid indifference to a retrospect of disaster speaks volumes for the indomitable pluck and heroism of the Confederate sailors, and the splendid vigour they displayed in fighting for their cause, and for a regime which was fated to perish. But these attempts could not save them. There is one dominating fact to be considered here as elsewhere. The naval power must always have a battle fleet in being as main factor. Any other forms of vessel are auxiliaries forming but additions to it; torpedo boats and submarines will take their place with ships of the line, but the day is yet far distant, even if it is ever to dawn, when they can be considered in the light of adequate substitutes.

The original 'David'—the prototype of the one that sank the 'Housatonic'—was designed by one Barriens, and was sold in July, 1901, as scrap iron. This vessel was built in 1861, but was tipped into a canal the following year by her constructors, to prevent her falling into the hands of the Federals. She was pulled out and placed on the shore beneath the old Spanish Fort about 4 miles from New Orleans, where she had remained up to the time of the sale,—a relic of great historical value. Her length was 35 feet.

The following account of the attack on the 'Ironsides' by a torpedo-boat (Fig. XXI.) is extracted from Barnes' 'Torpedoes and Torpedo Warfare,' 1869:—

'The first attempt to use the torpedo boat was that upon the "Ironsides," off Charleston, on the night of the 5th of October, 1863. The circumstances of this affair are interesting in view of the novelty of this application of torpedoes to actual warfare, and may be thus briefly summed up.

'At about 9 o'clock a small object was descried by the sentinels, approaching the ship from seaward; being taken for a boat, it was hailed in the usual manner. A rifle-shot from the now rapidly approaching craft was the only reply, and the officer of the deck fell mortally wounded. At the same instant, a tremendous explosion alongside shook the huge hull of the "Ironsides" to its centre—an immense column of water deluged her decks, and for a moment there was considerable confusion and alarm, during which the torpedo boat drifted out of sight.

'Boats were sent in pursuit, but nothing could be seen of their daring assailant. Two men were, however, discovered floating by the aid of life-preservers—one of them was the captain of the torpedo boat. He stated that the explosion filled his craft nearly full of water, and, thinking she was sinking, abandoned her. She had left Charleston that evening soon after dark, and steamed down outside the fleet, when the vessel was turned round and steered directly for the "Ironsides." Four men constituted her crew, and her torpedo contained sixty pounds of powder.

'The subsequent history of the vessel is, that, deserted by all but one of her crew, she drifted for an hour helplessly in the tide without motive power. Her engineer, after being in the water for some time, found himself near her, and succeeded in getting on board, lighting her fires anew, and navigating her safely back to Charleston. Here she remained until the close of the war, occasionally venturing out to attack our fleet.

'Upon the occupation of Charleston she was found there with eight others similarly constructed, and was brought into the Naval Academy, where she is preserved as one of the relics of the war. These vessels were built of boiler iron, and were of the shape known as "cigar-shape." They presented but a very small target above the surface, but were usually clumsy and dangerous craft in a seaway. Under full steam they could attain a speed of seven knots per hour.

'The name "David" was given to the first of this form of craft, likening her to the "David" of Holy Writ, who, with a sling, slew Goliath. This name, like that of the "Monitor," became familiar to our people, and was used as a generic title for all such craft.'

W. Wood

The 'Stromboli'

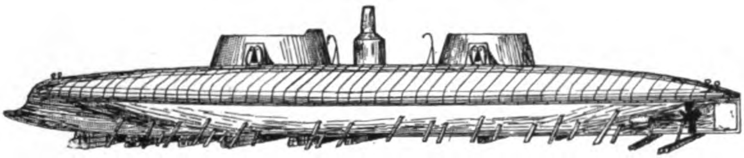
In October, 1864, experiments were made by the Federals on the Hudson river with a novel type of vessel called the 'Stromboli.' It was built at Fairhaven to the plans of a celebrated engineer, William Wood, and had a length of 84 feet, beam 20 feet, and depth 23 feet. The 'Stromboli' was not a true submarine, but as by the introduction of water it could be almost completely immersed, it enters into the same class. The speed with 150 revolutions was 10 miles an hour and the first trials gave great satisfaction.

The armament consisted of a spar torpedo containing 220 lbs. of powder, the spar on which this was fixed having a length of 30 feet. The charge was exploded by electricity.

The 'Stromboli' was commissioned by John Lay (the inventor of the Lay torpedo), and on November 16th, 1864, the vessel was ordered to attack the Confederate ironclads in Hampton Roads. She reached her destination on December 6th, and what occurred subsequently is not known.

The 'Keokuk'

It would not be out of place here to mention the submersible monitors which made their appearance between 1860-64. Of these, the most curious was indubitably the 'Keokuk,' of which



XXIV. AMERICAN SUBMERSIBLE MONITOR 'KEOKUK'

an illustration taken from an old American lithograph is appended. The design representing this weird vessel on the stocks, gives us an excellent idea of the form of the hull. The principal dimensions are as follows:[1]

Length without ram	160 ft.
Length with ram	164 ft. 6 in.
Beam, extreme	36 ft.
Depth	14 ft.
Draught	8 ft. 6 in.
I.H.P.	500
Armament	2—11 in. M.L.
Diameter of propellers . .	7 ft. 6 in.
Number " " . .	2

The engines consisted of four cylinders having a diameter of 22 inches, and having a stroke of 20 inches. Besides those propulsive engines were two for ventilation, one for submersion, and two small auxiliaries.

1 'L'Art Naval,' Vice-Admiral Paris, 1862.

The hull was of iron, supported from end to end by three carlines.[1] Fore and aft were divisions which, whilst acting as water-tight compartments in case of an accident, served also as submersion tanks. These could be filled in forty minutes and emptied in fifteen. When submerged to the utmost the turrets and funnel alone showed above water. The shot fired by the 11-inch guns weighed 180 lbs.; the turrets were immovable, but had three port-holes, so that a very fair arc of fire could be obtained. The rudder was protected by a flat iron plate, and the deck could be opened up to renew the air in the hull. The crew numbered one hundred.

The following is a brief account of the work performed by the 'Keokuk' during the Civil War.[2] On April 7th, 1863, the 'Keokuk' with other ironclads[3] under Admiral Dupont, was ordered to attack Fort Sumter. In approaching the fort, the 'Keokuk' had to stand in closer than she had intended, to avoid a collision with the 'Nahant.'[4] A storm of projectiles struck her; she was hulled ninety times in thirty minutes, and some of the shots went clean through her.[5] Her 2-inch plates proved of very little avail, and her turrets were several times pierced. Her commander was forced to withdraw from the action, it being quite impossible for him to continue to fight with his ship riddled like a sieve. Despite the shambles to which his vessel had been reduced, not a man of the crew was killed.

The forts received little damage, although they were bombarded for over an hour; the monitors themselves, with the exception of the 'Keokuk,' were but little hurt. The 'Keokuk' went down in the following night, and blood-stained clothes were washed ashore from her showing that she had suffered severely.

1865 In 1865, a queer looking ship was placed under the command of James Rivers, just before the taking of Richmond. Ex-

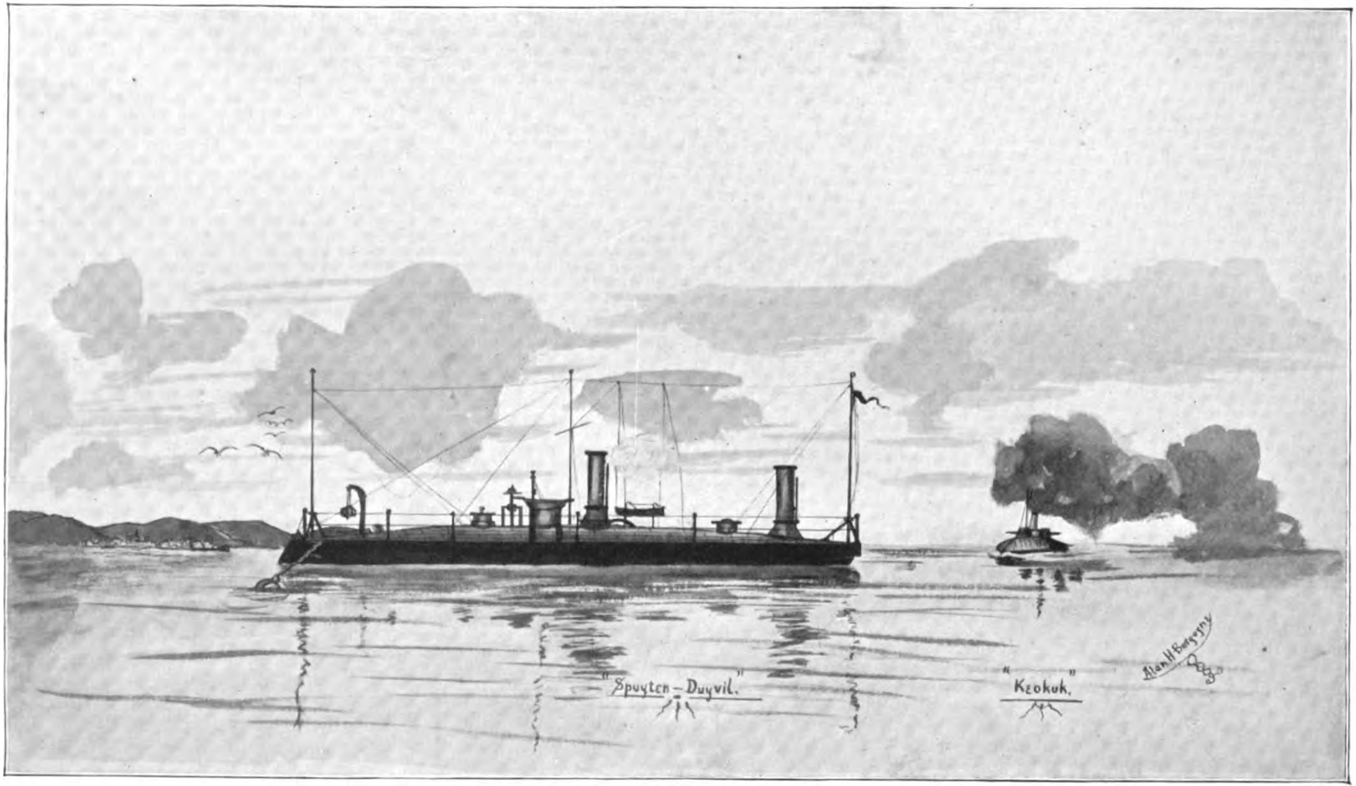
1 'Carlingues'—'carlines' or 'carlings;' longitudinal steps or supports.

2 'Ironclads in Action,' vol. i., by H. W. Wilson, 1895.

3 The 'Keokuk' was protected by 2 in. of armour, and had also a ¾ in. inner skin of iron.

4 The Northerners say she came within 550 yds. of the port, and General Beauregard, in 'Battles and Leaders,' says she approached as close as 300 yds.

5 H. W. Wilson.



XXV.

ternally it appeared to be a complicated Chinese puzzle of funnels, masts, and turrets. It was scarcely a submarine boat,[1] and yet it could not be called a surface vessel. It was built at the Mallory shipbuilding yard, Mystic, Connecticut, to the plans of William Wood (the designer of the 'Stromboli'), and John Lay, and when launched received the name 'Spuyten-Duyvil.' Its hull, which was constructed of wood, covered with an iron sheeting an inch in thickness, had a length of 82 feet 6 inches, extreme beam 20 feet 6 inches, and depth 10 feet.

W. Wood and J. Lay

'Spuyten-Duyvil'

The conning-tower, placed exactly in the centre of the deck, had a diameter of 5 feet. The load draught, under natural conditions, was 7 feet; but when a quantity of water had been introduced into the hull it became two feet more. In this position the speed was only four miles an hour, but when light the vessel could go nine. The crew consisted of nine in all, including the commander.

Introduction and expulsion of ballast water was contrived by force-pumps. The armament consisted of a spar torpedo, worked in a similar manner to that of the 'Alarm.'[2] When submerged to the utmost scarcely a foot of the deck showed above the surface.

Winan

In 1864, also, appeared the 'Winan' semi-submarine boat. It was launched on the Thames, and was in form very similar to the 'Plongeur' of Bourgois and Brun. The length was 250 feet.[3] Propulsion was obtained by a steam engine driving two propellers, one at each end of the vessel; the forward one was to cut its way ahead, the stern one to drive the vessel into the vacuum created by the one in the bows[4] The inventor said that the behaviour of his vessel at sea was all that could be desired. Nothing is known of the experiments carried out, however, and in all probability the boat never went beyond the trial stage.

1866 Raeber

The invention of Raeber of Newark, close to New York,

1 See Fig. XXV.

2 See Admiral Porter, 1374.

3 G. L. Pesce, 'La Navigation Sousmarine,' Paris, 1897.

4 This principle is employed on the Russian Ice-breaker, 'Ermack,' built by Messrs. Walker in 1898.

enters into that category of submarines not designed for offensive purposes.[1]

His First Design

It took the form of a cigar, flattened on the bottom, and was made of thin iron sheets strengthened by thick corner pieces. Its length was 30 feet, and depth and beam 7 feet 6 inches. On the surface, when light, it showed only 18 inches above the water, with a deck about 8 feet long by 3 feet wide.

It presented many exceedingly novel features, features that have been copied again and again in many later designs.

The most important of all these innovations was the movable screw. This was, I think, the first time this type of propeller had been practically used;[2] the best known modern instances are the propeller of the 'Goubet' and the twin screws of the 'Baker' submarine boat.

This propeller was three-bladed, and had a diameter of 3 feet; it was encased in a network shield to prevent obstruction. The change of direction of the propeller was of course limited, but it could work almost at right angles to the hull on either the port or starboard side. On either side of the hull, about 2 feet forward of the screw, were placed two horizontal rudders to preserve equilibrium when submerged.

The interior was divided into three compartments, of which the centre one contained the machinery and formed the living space of the crew, consisting of six to eight men. The two other divisions, situated forward and right aft, served as tanks for taking in water ballast; the amount of this could be regulated by force-pumps, two of which were carried, and the whole of the water could be expelled if necessary with the aid of compressed air carried in cylinders at a high pressure. The tanks could easily be emptied of all the water in twenty seconds, but to fill them took about ten seconds longer.

The air to form the breathable atmosphere for the crew

1 There seems to be some doubt as to whether the invention described above was really due to Raeber. In 'Les Bateaux sous-marins,' by F. Forest and H. Noalhat, a boat very similar in every detail to the one I describe is credited to one Merriam. I am taking G. L. Pesce, however, as my authority in this instance, for where Forest and Noalhat comment but casually on the vessel (although they give several descriptive designs), Pesce has devoted several pages to the subject, which makes me think his information more reliable.

2 The movable propeller had been proposed by Shorter as early as 1800, and sixteen years later by Millington, whilst in 1839 George Hunt constructed a working model of one.

was also carried compressed in cylinders. A small pump was used for expelling the vitiated air.

Propulsion was obtained by two hand winches geared on to the shaft of the propeller, and in fine weather two men were quite enough to work the screw. With three men on each side a speed of 4.4 knots per hour was obtained. In the centre was fixed a small conning-tower, and into this opening the captain had to place his head, a movable seat being situated conveniently beneath him; from this vantage point he could watch external movements and transmit orders to the men below. As in rough weather the altitude of this small look-out did not permit him much vision, rolls of wire were provided by which the vessel could hold communication either with the land or else with a ship on the surface. Two or three miles of this wire were carried.

The vessel could either be used as a diving-bell or as a submarine torpedo boat. Considering its mode of propulsion and means of communication with the shore it would scarcely have succeeded in any offensive undertakings; but as a mining vessel or an aid to foundation laying it might have proved of value.

His Second Design

Raeber is also credited with designing another and larger vessel, this time undoubtedly for warlike purposes.

It was to have a length of 75 feet, and the flat bottom was to be abolished, stability being assured by two keels. The upper portion would be armoured with 2 inches of iron. The air and water reservoirs would run the whole length of the vessel. An iron spar would be fitted forward, to the end of which a torpedo was to be attached. This spar could be drawn in and the torpedo placed in a protecting recess in the hull when not in use, but for warlike purposes the spar would project from 18 to 20 feet.

Propulsion was obtained either by hand winches, as in the smaller vessel, or by compressed air; the speed was expected to be 6 knots.

Raeber affirmed that such a vessel would be able to sink 80 feet, and stay at that depth several hours without the crew being inconvenienced; but nothing further was heard of the invention, and it is very doubtful if it ever went past the plan stage.

1867 S. Hallet — Amongst the various scientific exhibits at the Paris Exhibition in 1867 was a model of a submarine boat designed by Samuel Hallet, of New York. It had a great resemblance to the one invented by Dr. Payerne.

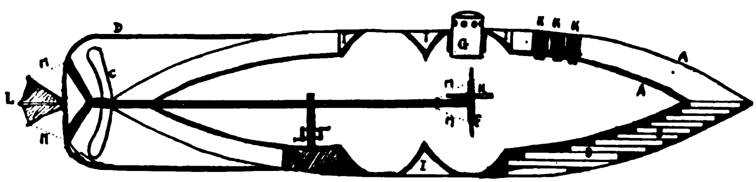
1868 Alexandrowski — In this year a submarine boat was launched from Winan's shipbuilding yard on the banks of the Neva, close to St. Petersburg. Its plans were by M. Alexandrowski, and had a displacement of over 600 tons.[1] After several trials, not altogether unsuccessful, it was crushed through descending to too great a depth. It was, however, refloated, and now serves as a pontoon.

1869 O. Vogel — In this year a submersible boat was designed by a German, Otto Vogel, the plans being accepted as satisfactory by the Prussian Government.

Under ordinary circumstances it would navigate on the surface, the top part of the hull showing above water. This was thickly armoured, and through gun-ports in it heavy ordnance could be fired in all directions. It was considered the equal of a first-class ironclad in defensive and offensive powers.

When submerged, a submarine gun, of which no details are known, and torpedoes, were to be used for offensive purposes.

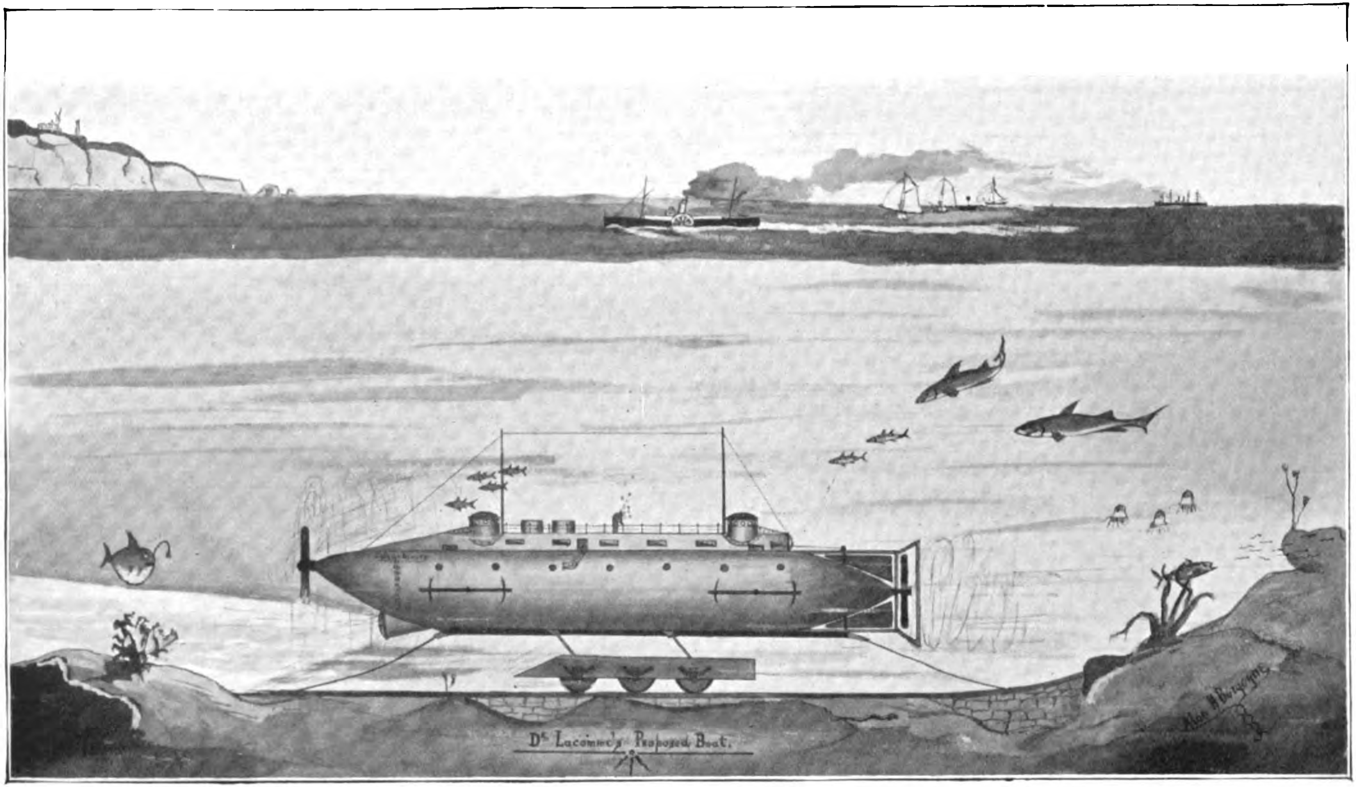
Dr. Barbour — Barbour, an American doctor, proposed a vessel 23 feet long by 3 feet wide, with a depth of 5 feet 4 inches.



XXVI. DR. BARBOUR

The elevation plan above gives a good idea of the shape. The hull was double, the space between the two envelopes, A A, being filled with tubes of air, B B B, the interstices being filled in with blocks of wood, making the whole a compact mass. The outer envelope of the hull was of copper, on account of its non-corrosive properties.

1 Drzewiecki.



XXVII. DR. LACOMME'S SUBMARINE RAILWAY

The propeller, C, protected from floating obstacles by the shield, D, was rotated by means of two oscillating motors situated at E. The motive power was to be supplied either by carbonic acid gas or ammonia. The propeller shaft was hollow, and through it passed the rudder ropes, M M, fixed to the outside edge of the rudder, where the leverage would be greatest. The rudder, L, resembled a double fish's tail. The steering wheel, F, was placed directly under the conning-tower, G. This, too, was telescopic, and its altitude could thus be altered at will.

Two horizontal rudders, H H, were placed in a line with the steering-wheel, one on each side of the vessel. The spaces, I I, were used for ballast chambers and could be filled or emptied of water at will. K K K represent cartridges filled with nitro-glycerine; these were in tin cases having a large reserve of buoyancy, such that, when released directly under the vessel to be attacked, they would rise, and being connected by a wire with the submarine boat, could be ignited on contact. Room was provided for two men. I have no information as to whether this vessel was ever built, and if so, what success she attained on trial.

This same year yet another doctor brought forward designs for a submarine receptacle. I use the term 'receptacle' advisedly, for the fact is, it is very hard to know exactly what to call the invention of Dr. J. Lacomme. He can lay claim to proposing the most original of all submarine inventions; it was nothing more nor less than an under-water tramway. Dr. Lacomme

The project was placed before Napoleon III. Yet, despite the patronage of royalty, a submarine cross-channel railway is still in the future, and, indeed, is likely to remain so.

The lines were to be laid across the channel on very much the same principle as railways on land are constructed. On these lines would be placed a heavy truck or carrier, to which the passenger car would be attached by cables.

The car resembled the submarine boat of Bourgeois and Brun, and was made of iron; it was driven by two propellers placed as in the first Winan submarine, fore and aft. The motive power was to be compressed air.

The vessel would always have a certain margin of flotability to allow of its detaching itself from the truck and ascending to the surface. The weight of the truck alone kept the boat submerged, but when the two were attached to each other, the force with which the truck rested on the lines was so little as to almost do away with the natural friction. From this it would result that the motive power need not be very great.

Brakes were to be fitted in case of a sudden incline, and a powerful searchlight placed in the bows would light the way, whilst an electric wire would keep the boat continually in communication with the stations at each end. A large safety float, capable of reaching to the surface when at the greatest depth, was fitted to the upper part of the hull. This float was intended in the event of an accident preventing forward motion, and the detaching machinery failing to act, to renew the air in the interior of the hull until help—which would have been wired for—arrived.

In the stern was placed a diving chamber, from which divers could descend and remove obstacles and repair the line, and perform any other work that would be found necessary in so queer a locality. The following extract from the inventor's 'Mémoires' may be interesting:

'Par la combinaison de mon projet, on peut transporter des poids immenses avec très peu de force motrice. On peut, au besoin, sortir de l'eau sans que celle-ci puisse penétrer dans l'intérieur du bateau.

'Obtenir, en cas de nécessité et pour un temps indéterminé, l'air exterieure par l'intermédiare d'un flotteur qui, au moment désiré, monte rapidement à la surface de l'eau. Ce flotteur peut servir aussi à renouveler l'air emmagasiné dans les réservoirs; ou peut également communiquer et recevoir des dépêches télégraphiques pendant que le bâteau est en motion, éclairer la voie ferrée ainsi que l'interieur du bateau, par lumière électrique (dans le vide), et sans production d'acide carbonique.

'Voyager rapidement dans l'onde tranquille à l'abri des vents et des tempêtes, brouillards et mal de mer (tant redoubtés par de nombreux passagers).

'Enfin, on peut, en quelques seconds, ramener le bateau sous-marin à la surface de l'eau, où il peut naviguer et rentrez dans le port comme un steamer ordinaire. Le chariot (ou plate-forme) se trouverait dans ce dernier cas, abandonné sur la voie ferrée jusqu'à ce qu'il soit ramené à la station par un bateau remorqueur.'[1]

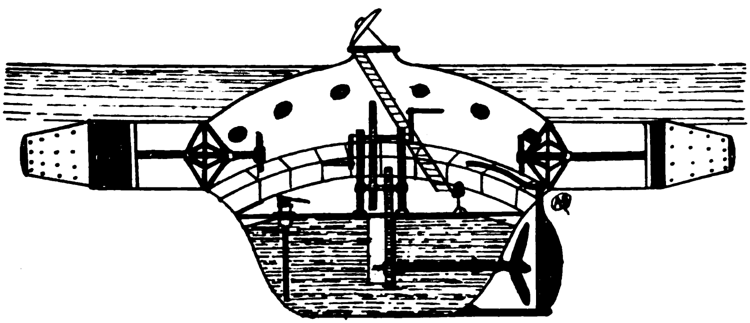
This project never seems to have been received very seriously, but considering the peculiarity of conception it is well worthy of notice as a curiosity. There are undoubtedly possibilities attached to the idea, and the submarine ferryboat of M. Goubet is nothing but an evolution of the invention of Dr. Lacomme.

1 A full account of Lacomme's invention is to be found in the 'Foreign and British Mechanic and Scientific Instructor' for 1869, and also in the 'Mechanic's Magazine' for 1872.

PART II

THE invention of André Constantin was the outcome of close scientific study during the dark days of the siege of Paris. 1870 A. Constantin

This inventor, a retired lieutenant in the Navy, was the first to think of obtaining longitudinal stability by reduction and augmentation of volume. The appended sketch (Fig. XXVIII.) gives one a good idea of the general outline of this quaint vessel. It is taken from a contemporary journal.[1]



XXVIII. INVENTION OF ANDRE CONSTANTIN, 1872

The length was 6 metres (19.685 feet), but with the pistons included 11 metres (36.09 feet), the diameter 5 metres (16.404 feet). The following description is extracted from the same source as the illustration. The bows and stern were terminated by two cylinders; each of these was furnished with a piston which could slide by means of a powerful hand-screw the whole length of the cylinder. Only the exterior surface of these pistons is in direct contact with the water, the piston head being rendered water-tight. It is quite easily seen that

1 'Journal de Havre,' 1874.

the volume of water surrounding the boat must vary according to the positions of the pistons, although the weight of the vessel will always remain the same. The boat by a judicious management of the ballast water could descend or rise at will and stop at any desired depth. Small windows are fitted in the hull by which light could penetrate into the interior allowing of vision both ahead and astern so that any obstacles that might be encountered could easily be avoided. Openings in the hull were fitted with india-rubber sleeves terminating in the form of gloves [1] and furnished with gripping instruments with which it was possible to seize exterior objects, and even to destroy vessels by affixing explosives to their hulls. Navigation in every direction was made possible by two rudders, one horizontal and the other vertical. An ordinary mariner's compass would be carried to set the course by. The vertical rudder permitted horizontal evolutions; the horizontal rudder was utilized for rectifying the longitudinal stability. As the powers of this last rudder were limited, in case of necessity one of the cylinders could be slightly altered either fore or aft, to produce the desired stability by reduction or augmentation of volume either in the bow or the stern.

The motive power was obtained either by hand, when a winch was revolved, or else by an engine worked by compressed air; the power was transmitted to the propeller and propeller-shaft (which were situated far below the engine) by means of cogged wheels. The interior contained compressed breathing air tanks for the crew, an air pump for keeping the supply regular and ejecting the vitiated atmosphere, and a water pump for keeping the boat dry in case of leakage. The inventor asserts that the only weak point in the construction has been overcome. Water is so destructive in its effect on anything it touches that in time the pistons might leak. To obviate this possibility, he was going to fix accordeon-shaped ducts of leather or india-rubber, about which the water would be allowed to circulate freely, whilst the interior would be safe from its deleterious contact so conducive to leakage

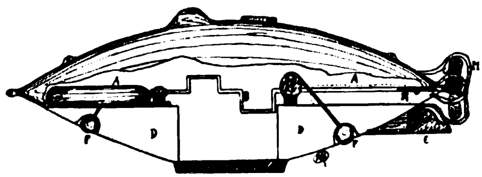
However ably the inventor defended the perfection of his vessel, she could never have been anything but a mediocre

1 Similar to those of 'Castera.'

navigator. The shape and projecting cylinders would both be detrimental to speed, and its depth when compared to its length, places it almost in the category of buoys. Actually the sole point of practical interest in this vessel is the inventor's employment of water as the means of securing longitudinal stability.

We now come to a somewhat ingenious design which had a Transatlantic source. 1872 Halstead

The plans of this invention had been offered to the French Government who refused it, as early as 1866, and it was not until 1872 that the United States bought them and had a model constructed. His vessel (Fig. XXIX.) was 30 feet long by 8 feet 6 inches in diameter; the inventor, Halstead, an American, called it the 'Intelligent Whale,' probably from a certain resemblance it bore to the gigantic mammal. 'Intelligent Whale'



XXIX. THE 'INTELLIGENT WHALE'

The interior of the vessel contained two compressed air cylinders, A A, for the use of the crew which was to number thirteen, six of whom would be required to work the winch B, which revolved the propeller C. This propeller was guarded from damage by a crinoline M. Fore and aft were situated two submersion tanks D D. Steering in the vertical plan was effected by the rudder E, and horizontally by the rudders N N.

Two doors were fitted in the bottom, and by these divers were to descend to the bottom. Before doing this, however, the vessel was anchored by dropping the weights F F, and the submarine would then remain suspended in the water as far from the bottom as the length of chain which had been let out with the weights. The speed to be obtained was estimated at 4 knots an hour.

But however excellent the invention seemed in theory, in practice it proved disastrous, the first experiment resulted in melancholy failure. It must be pointed out however, that the hopes of the inventor were shattered partly owing to wrong execution of orders. By some means or other the manhole had not been properly closed and on descending the water poured into the interior. But for Halstead's forethought in attaching his vessel by ropes to a ship on the surface, he and his assistants would have met an untimely end. Luckily they were pulled up in time, but the accident proved fatal to the scheme. The mishap so vividly impressed the examining commission that Halstead was not asked to make a second trial.[1]

1874 Admiral Porter 'Alarm'

Another of those vessels which could be submerged to a certain extent before going into action was the torpedo-ram 'Alarm' (see opposite page) built in 1874 at Brooklyn, New York.[2] She had a length of 173 feet,[3] beam 27 feet 6 inches, draught 12 feet, and had an immense under-water prow or ram, 32 feet long, projecting from the bow. Within this iron armour, was the torpedo machinery. This consisted of a cylindrical iron 'spar,' 35 feet long, carrying a torpedo attached to its outer end, and capable of being run out under the water, a distance of 25 feet ahead of the prow. Electric wires led from the torpedo along the spar, through grooves cut for that purpose, to a firing pedestal on deck. The 'Alarm' was designed to fight bows on.

The 'Mallory Propeller'

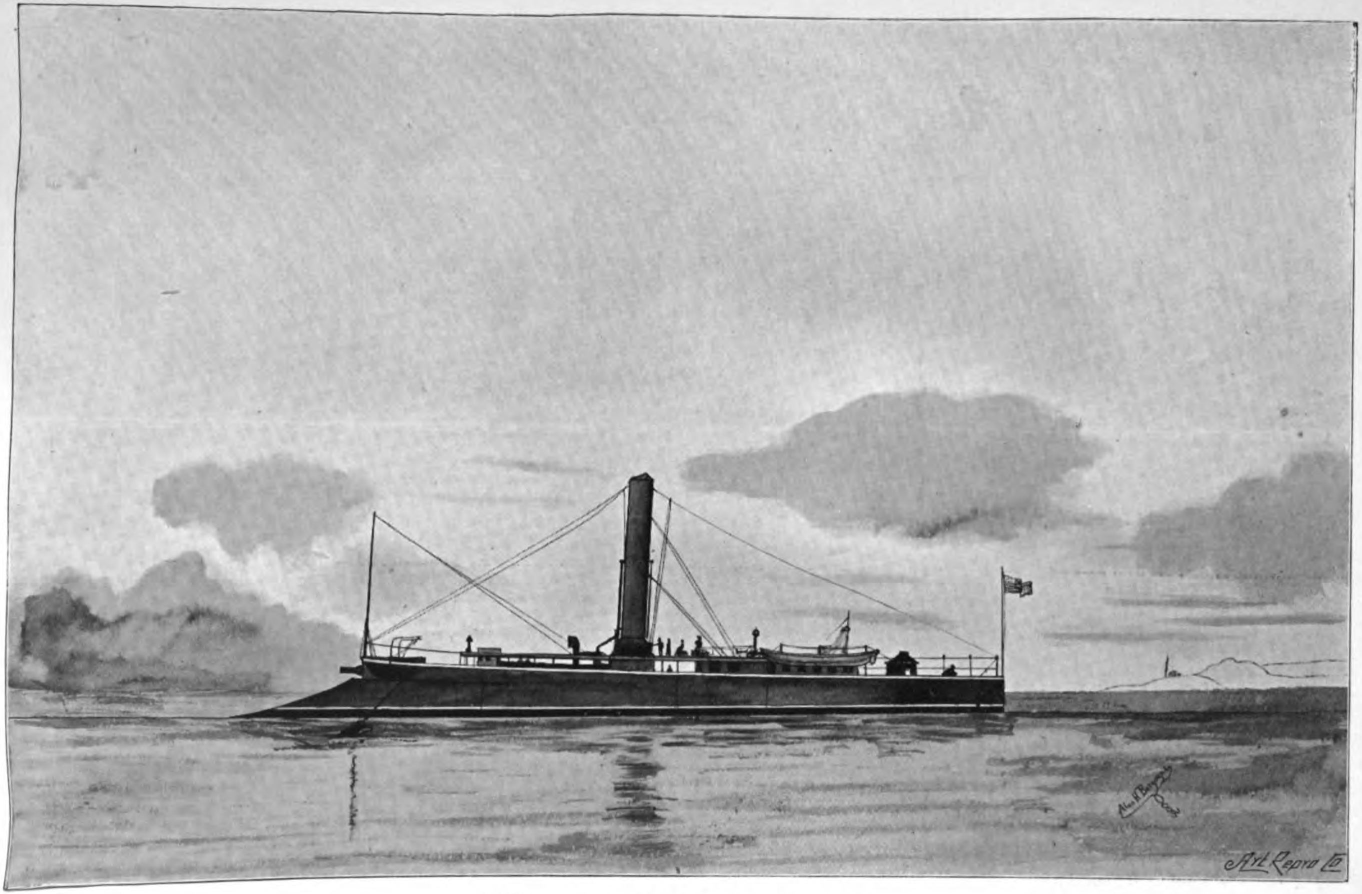
Remarkable turning and manœuvring powers were obtained by adopting the 'Mallory Propeller,' an ingenious invention by which the screw might be quickly moved so that its full force was exerted in a direction at right angles to the vessel's length, causing the latter to turn almost on a fixed pivot. The armament, in addition to the ram and torpedo, consisted of one heavy gun mounted in the bow, for firing directly ahead, and a number of Hotchkiss and Gatling machine guns.[4] In action it was intended that, simultaneously with ramming a

1 According to the 'Engineer,' July 17th, 1896, the 'Intelligent Whale' did drown one crew during a trial on the Hudson. This vessel can still be seen rusting away in a disused corner of Brooklyn Dockyard.

2 'Scribner's Magazine,' 1887; Article by Lieut. W. S. Hughes, U.S.N.

3 W. Laird Clowes gives the 'Alarm' a length of 158 ft. in his Naval Pocket Book for 1899.

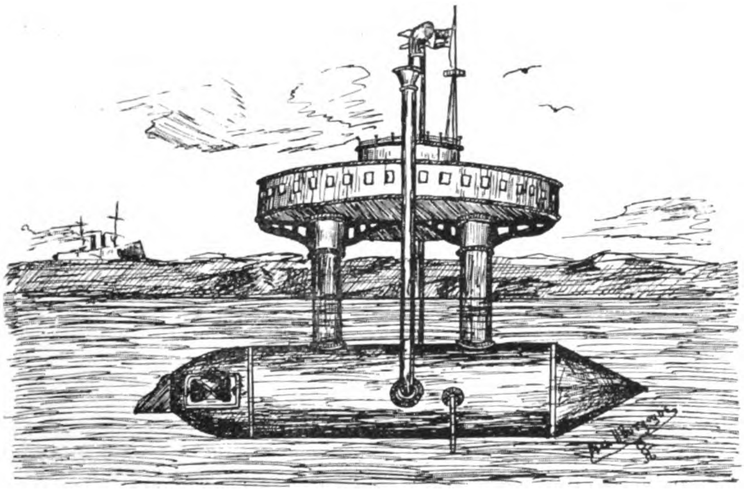
4 H. Buchard in his 'Torpilles et Torpilleurs des Nations Etrangers' (Paris, 1889), says that the armament of the 'Alarm' consisted of 1-38 c/m (15 in. M.L.), 4 Gatlings and 3 spar torpedoes, one on each quarter, besides the one in the bow.



XXX. U.S. TORPEDO RAM 'ALARM'

hostile ship, the gun should be fired and the torpedo exploded. The 'Alarm' displaced 800 tons, I.H.P. 600, 10 knots speed. By the introduction of water she could sink almost eighteen inches below the ordinary water-line. The 'Alarm' was the invention of Admiral Porter, U.S.N.

An Italian is next in the field in bringing before the public notice a means of submarine progression and certainly the idea of Donati Tommasi (Fig. XXXI.) is original if a trifle eccentric. It was not, in point of fact, a real submarine which was conceived by the Peninsular scientist but a bizarre combination—an air-ship and submarine boat in one, and styled a 1876 D. Tommasi



XXXI. D. TOMMASI'S 'HEMI-PLONGEUR'

'Hemi-Plongeur.' From the body of the submarine boat proper, in which all the propulsive engines, etc., were contained sprang two stout columns, on which was to be built a circular platform. This platform would be held a good distance from the waves by the buoyancy of the submarine boat to which it was attached.

The submarine boat [1] is divided into three compartments. The middle one contains the propulsive engines and the others the merchandise.

1 Translated from a description by the inventor.

The lower portion encloses a reservoir destined to contain either air or water. A pump worked by the propelling machinery allows of it being filled with water if it should be necessary. When it is desired to sink beneath the surface, water is allowed to enter the reservoir. It is emptied again when one wishes to rise. A screw placed in the stern is rotated by the engine thus giving forward motion to the boat. Two tubes, one to act as smoke-stack and the other as a ventilator for the stokers, go up one on each side of the submarine, and project a few metres above the platform.

There was an extra possibility here as well; it would even be feasible to do without this ventilation tube by utilising the two columns which join the plunger and the platform, and which are used to ventilate the engine room. These columns are of such a size as to allow of merchandise being passed down from the deck to be stored away in the hold of the plunger.

It is unnecessary to proceed further with this description which is infantile in its minute explanation of insignificant details. No dimensions are given, but in conclusion Donati Tommasi who throughout was confident of the potentialities of his fanciful creation points out how his system might advantageously be applied to ships of war by placing turrets in the centre platform.

1877 Drzewiecki No. I

In this year, Drzewiecki, a Russian engineer, constructed a small submarine analogous to the first Holland boat.

It had something in its favour; it was a little craft, 4 metres (13.124 feet) long,[1] and propelled by a screw worked by the feet with pedals, on the same principle as a bicycle, the power being transmitted by cogs. The hull was of steel, the lower part forming a ballast tank which could be filled or emptied according to whether it was desired to sink or rise. In the centre rose a small conning-tower through which the occupant who constituted the whole crew could obtain a glimpse of the horizon.

On each side of this minute conning-tower was a leather glove as in the vessel of Castera,[2] by which means explosives could be affixed to the keels of vessels of the enemy; the

1 F. Forest gives the length as 5 metres.

2 See Part I.; also A. Constantin's invention.

torpedoes were to be carried outside within easy reach of the gloves. These were enclosed in two boxes strung together and fitted with india-rubber suction caps [1] to ensure adherence to the hull of the ship attacked. A small pump was employed to keep up a supply of fresh air and to expel the foul atmosphere, the pump being attached to the propeller shaft. This embryo submarine boat attracted the attention of the Russian Government, who ordered Drzewiecki to construct an improved and larger vessel, which commission was carried out at St. Petersburg in 1879. This boat will be described in due course. It exhibited an immense advance on the first, and indeed it was hard to believe it had sprung from the same source.

A scientific paper [2] published in 1895 a resumé of the history of submarine boats and amongst other accounts appeared the following:

'In 1877 we investigated an invention having for its main object the fixing and firing of torpedoes under water. This was a submarine vessel, which could at pleasure be moved on or under water. It was the invention of Mr. Jos. Jones, a shipbuilder, of Liverpool, and a gentleman of experience in naval matters, and who was known for his advanced and practical views upon certain questions connected with naval warfare. Mr. Jones' vessel could be made to descend to any required depth in the water—as shown by a working model—to remain stationary at any depth, to move forwards or backwards in a straight line at any level, to go deeper, or to rise to the surface. By the arrangements proposed she would be as much under control as any torpedo boat. Mr. Jones' object was to be able to start out of sight of the enemy, and, moving along under water, to lodge a torpedo under the bottom of an enemy's ship. In the model which we examined, Mr. Jones certainly made out his case, but of course between a model and a perfected apparatus there is a wide gulf, which we fear Mr. Jones was unable to bridge, as we never heard any more of the invention. It, however, was a step in the right direction, and if it had proved successful it would have marked a new era in submarine warfare.'

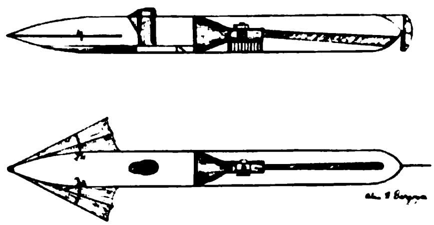
J. Jones

1 'Ventouses en caoutchouc.'
2 'Invention.'

It is unfortunate that we have no details concerning this boat, but even the above account, incomplete as it is, is not devoid of interest.

A. Olivier

Extremely novel features will be found in the design for which Mr. A. A. Olivier took out a patent on May 19th, 1877. (Figs. XXXII.-XXXIII.). The hull was cigar-shaped [1] with a curved deck on which was placed (about a third of the way from the bow to the stern) a glass conning-tower. On each side of the vessel and below the natural water-line were two wings which could be spread out or folded at will by a simple manipulation of cranks in the hull. When folded they fitted into a specially made recess in the hull. The forward part was attached to the stem-point, the after part to the hull a little forward of the conning-tower.



XXXII-XXXIII

These wings could be raised or lowered from either end thus producing the effect of horizontal rudders; the elevation of the vessel was decided by this means.

This curious ship was to be propelled by the gases generated from the ignition of high explosives, the massed vapours escaping through a tube at the stern. Distinctly out of the common is this mode of obtaining propulsion but its value is almost entirely counteracted by the fear of the premature explosion of the powder or other propellant employed as fuel. Comment on Olivier's invention with the few details available concerning it is next door to impossible. I will therefore pass quickly on to the next invention upon which we have data.

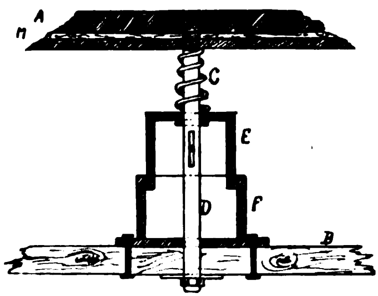
E. Thompson

This gentleman draughted the plans for a submersible vessel [2]

1 'Fish-shaped' according to other statements.
2 Patent, July 24th, 1877.

which, although similar in outward form to the surface ship, was to be fitted with tubular frames placed all round the hull from the gunwale downwards, the stability (according to the inventor) being thus increased. By filling this tubular structure with water, the vessel may be submerged to any depth up to the top of the towers, which were to be erected on deck, and in case of war vessels, fitted with cannon. The idea strikes one as fantastic.

Two inventors Messrs. T. H. Watson and S. J. Woodhouse patented a design for an armoured submarine boat on March 7th, 1878. The outer shell of the hull was in compartments, those fore and aft containing water, the outflow and inflow into which could be regulated by pumps. The middle compartments were used as reservoirs for compressed air. 1878 Watson and Woodhouse



XXXIV

In the centre of the deck rose a conical dome sheathed with armour plating. This armour plating was attached to the hull in a very novel manner and the appended sketch shews well the idea of the inventors.

Between the outer skin A, and the wooden backing B, were arranged a number of spiral springs C, coiled in the fastening pins D. These bolts were screwed into A, and had attached to them flanged metal caps E, fitting within flanged sockets F, which was in turn bolted to the backing B. The bolt D, was further secured to the cap E, by a transverse bar working in a slot in the bolt. The socket F, was to be filled with a packing of cork, india-rubber, etc., which would be compressed by a blow on the armour plate, and assist the spring C, in restoring the plate to its original position. The flexibility would be further increased by a layer of india-rubber M, between the inner and outer skins.

The internal surface of the dome is to be covered with lattice work, and at the top are inlet and outlet holes which are closed when the vessel is submerged. To close the perforations in the dome a sliding shield is used. A meter and pressure gauge would be employed to register the amount of air in the vessel, and to ensure the proper distribution of air throughout the vessel valves are provided, a pressure gauge being used to determine the pressure in each compartment. To ascertain the amount of air consumed since the last take in, an outlet meter was used. In connection with this outlet meter was a blower to exhaust the impure air. When the vessel was below water the impure air was to be utilized for the combustion of the fuel, on which also nitre was thrown. An apparatus was provided for producing air chemically.

The waste steam, air and water were to be discharged by a pipe situated just above the propeller. A manometer was used for registering the depth when navigating in deep water, but if the depth of submersion did not exceed the height of the vessel's hull a special instrument was used. For egress from and ingress to the vessel two revolving drums were provided, semicircular in form and containing two water-tight compartments.

There was a careful elaboration here and evidence of much thought which prompts respect. The armament consisted of two guns for vertical fire placed fore and aft of the dome and having each a water-tight gun compartment, and one gun forward. This weapon was to be used for destroying torpedoes, or any obstructions to the onward course. Any water entering the gun-ports during the firing of the weapon was carried at once by the pipes to the ballast tanks. Port-lights were fitted for the steersman who stood in a compartment beneath the forward gun-room. A ram was also fitted to the bows.

The vessel possessed three decks and was driven by a single screw, the motive power undetermined. And yet despite the labour expended on the design it must be admitted that this submarine boat showed very little real ingenuity and would almost certainly have been a failure. The most interesting feature concerning it is undubitably the armour plates cushioned on springs and india-rubber, though the efficacy of such a system is doubtful.

We have not yet concluded the record of the 'seventies' for on August 12th, 1878, J. R. Surman protected plans for a submarine boat. Very few facts are obtainable about this vessel, but from the data at hand, it could not have been of any marked scientific importance. It was cigar-shaped and was suspended from the surface by a floating air-bag, through which the air, by which the propulsive engines were to be driven, would be drawn. The submersion of the vessel could be regulated, by the inflating and exhausting of the external bag. The vessel was divided into three divisions. The floating forward chamber, taking up a third of the whole ship, contained compressed air, which after being used as a motive power was breathed by the occupants. A feature of special interest in this invention was the floating glass for observing the course to be steered. In this we see the beginning of the periscope of to-day. The single propeller was rotated by an air engine, and the vertical rudder was placed immediately abaft the screw. J. Surman

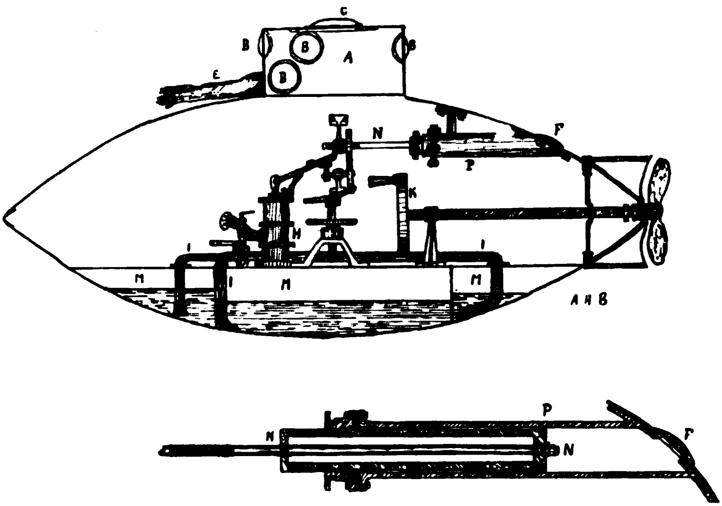
In this same year (1878) George William Garrett built his first submarine, taking out a patent for the design. It was a small vessel, being in length less than 14 feet; the diameter was only 5 feet at the widest part. W. Garrett No. I

With a plan of this vessel before us (Figs. XXXV.-XXXVI) it is unnecessary to enter into any very long description.

A is the conning-tower fitted with the glasses B B, and a manhole C, whilst leather gloves E, similar to those of Drzewiecki were fitted in the front.

The water ballast tanks are situated in the bottom of the boat M M, and these were filled until the floatability became practically nil. The desired depth was then obtained by manipulating the piston N, in the cylinder P. The water entered at the hole F, which was covered with gauze to prevent obstacles from entering and choking the mechanism. The water ballast could be evenly distributed between the three tanks by means of a hand pump H, and the tubes I I I. Propulsion was obtained by manual power, the flywheel K, being rotated. Four rudders were fitted, two horizontal and the like number vertical.

All the trials made with this boat took place in one of the Liverpool Docks, and Mr. Garrett remained under water for considerable periods. This was a really serious essay to solve the great problem, and Mr. Garrett's scheme stands out prominently among the numerous abortive plans fated from the outset to come to nothing through lack of idea furthered by faulty execution.



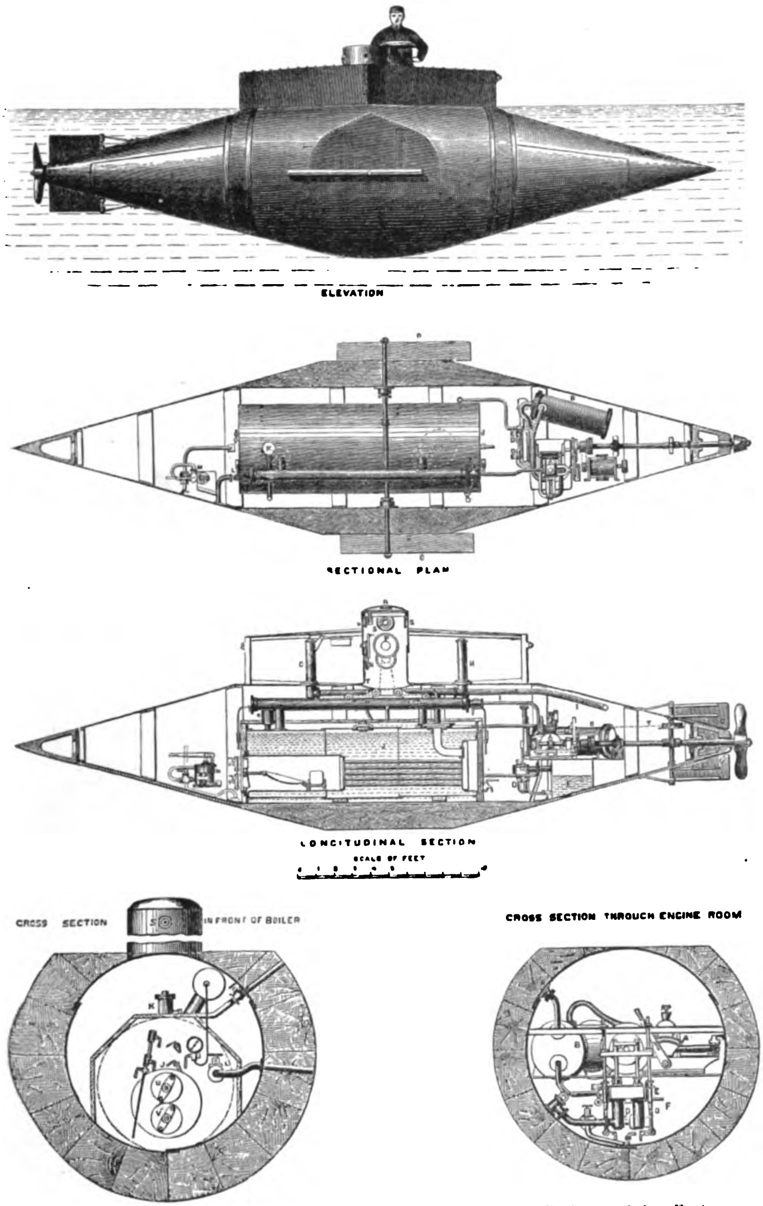
XXXV-XXXVI. REV. GARRETT'S FIRST SUBMARINE

1879 W. Garrett No. II

In the autumn of 1879 this inventor commissioned Messrs. Cochrane and Birkenhead to construct a second and larger boat. The illustrations on the opposite page show this second experimental vessel,[1] and are so complete as to need little additional explanation. Mr. Garrett christened it 'Resurgam.'

In the engraving, A is the cylinder, B condenser, C Root's blower, D air and circulating pumps, E feed pumps, F hot well, G air pipe with automatic valve, H smoke escape valve, I air pipe to blower, J boiler, K safety valve, L blow-off valve, M hand force-pump, N steering wheel, O side rudders, P side rudder adjusting wheel, Q rudder, R manhole, S bull's eye

1 Reproduced by kind permission from the 'Engineer.'



By favour of the 'Engineer

XXXVII.-XLI. REV. GARRETT'S 'RESURGAM'

lights, T steering chains, U air-tight furnace door, and V the air-tight ashpit door.

One of the most noteworthy characters of the boat was the actual means of propulsion under water, which was attained by having a very large steam boiler, which carried a pressure of 150 lbs. per square inch, and had great water capacity, which was utilised after the fire was shut up and combustion stopped. From experiments which were carefully made, there can be no doubt whatsoever that the vessel was capable of being propelled under water a distance of about twelve miles, simply by getting a full head of steam with the aid of the blower before diving below the surface, after which it was necessary to shut up the fire door and chimney, and then go on utilising the latent heat, evaporating the water contained in the boiler precisely on the same principle as that adopted in Lamm's fireless locomotive, until its exhaustion would compel a return to the surface to blow up the fire again and recharge the boiler with water. But the success or it might well be styled triumph which seemed to be so nearly attained was not to be realised, for the untimely loss of the vessel off the Welsh coast prevented the completion of the experiments in keeping up the furnace heat when the boat was submerged.

In turning over the records of this vessel and examining the details in the new light of the twenty years which have elapsed one is struck by one circumstance, namely that in Mr. Garrett's vessel there was no track whatever to trace her through the water when sailing below the surface. The boat was managed, it might be added, by three men, and it was found that if one man in the conning-tower had the secret breathing apparatus in use, the air of the boat was kept in a fit state for the other men to look after the management of the machinery. It will of course be observed the engine was of the return connecting-rod type, and was fitted with a surface condenser. The side-rudders for submerging the vessel were worked from the conning-tower, but their action was not fully experimented upon. The mechanical details of a submarine boat would seem to be capable of a satisfactory solution, but the question of navigating such a vessel is still a matter of grave uncertainty.[1]

[1] The 'Engineer,' January 6th, 1882.

This last vessel of Garrett's had a length of 50 feet and a diameter of 5 feet, though according to F. Forrest her length did not exceed 45 feet.[1]

Mr. Nordenfelt, who later built several submarine vessels himself, took a great interest in the trials of the 'Resurgam,' noting carefully the causes of its failure so that he might remedy them in his own constructions, which he already meditated.

Drzewiecki No. II

On page 77 I mentioned a submarine boat ordered by the Russian Government to the plans of Drzewiecki. The 'Drzewiecki 2' as we will call it, was very much larger than his first boat, which was really little more than a toy. It had a length of 6 metres (19.685 feet) and could accommodate four men sitting back to back, two facing the bows and two the stern; these turned the propellers, of which there were two, one forward and one aft, by means of pedals. These two screws were moveable as in the case of Raeber's boat[3] the forward one in the vertical plan, that in the stern the horizontal plan, so that one served for altering the elevation, whilst the other was used as a vertical rudder. Attached to the propeller shafts were two small pumps, one for air and the other for emptying or filling the water tanks; the air pump was continually forcing the vitiated air over beds of caustic soda, to rid it of the quantities of carbonic acid picked up during respiration. A reservoir of compressed oxygen replaced automatically the loss of this gas occasioned by the breathing of the four men. A circular dome fitted with strong glasses covered their heads. In the forward part of this conning-tower was placed an optical tube furnished with reflecting prisms with a magnifying glass at its inferior or lower extremity by which the steersman could see that which was going on above the surface when they were submerged.[4]

Diving was effected firstly by the introduction of water as ballast into the tanks, thus reducing the flotation, and then by manipulation of the forward propeller. Two torpedoes fixed on the exterior in grooves cut in the hull close to the

1 'Les Bateaux Sous-marins,' F. Forest and H. Noalhat, Paris, 1900.
2 Note from the 'Revue Militaire de l'étranger.'
3 See Part I., pp. 63-65.
4 The optical tube will be described in a later number.

top of the boat, could be released from inside and attached to the keel of a ship by means of two india-rubber cushions, or fenders, placed one on each side of the torpedo.

These cushions were filled with compressed air from inside, and rising one on each side of the vessel attacked, held the torpedo suspended immediately beneath its keel.

The trials of this boat took place on Lake Gatchina during the winter of 1879, and they appeared so conclusive and successful, that the Minister for Coast Defence gave the inventor an order for fifty similar vessels. This class, which will be known as 'Drzewiecki 3,' was built at St. Petersburg in 1881, and will be described later.

Mortensen

In 1879 also, an American engineer from Colorado, by name Mortensen, brought forward designs for a cigar-shaped submarine boat propelled by twin screws. These were worked by a compressed air engine. Immersion was obtained in the usual way, by the introduction of water.

His vessel is worthy of notice in that it was Mortensen who first proposed a torpedo tube in the bows of the vessel. This was an undoubted advance on all other designs in the matter of armament. There is no information obtainable as to the dimensions of this boat.

W. A. Leggo

In 1879 a Mr. Leggo proposed a submarine boat which would move through the water on the principle of the switch-back.[1] Resembling in shape a large aerostat, or flying machine, it would be tilted by means of a moveable weight and slide gracefully down on an inclined curve; when a sufficient depth had been reached, gases produced by heating liquid ammonia by hydrocarbon would be admitted into a large air-tight mattress. The contrivance would at once ascend, and the gas having been expelled a new downward glide would commence. The inventor is generous, and tells us a fishtail or other rudder may be used and also side wheels and screw propellers operated by the gas employed for charging the ascension mattress.

Although submarine navigation lends itself readily enough to a rich variety of forms and fancies it is fortunately not often that one happens upon an idea as weirdly impossible as that described above. It is quite outside the statute of rational limitations, and merely serves to illustrate once again how

1 See Plate illustrating the invention of Boucher, 1885.

inevitable is the intrusion of the unconscious humourist, the incompetent and incomparable would-be inventor, whenever there chances to be a general bid for serious advance in science, or when in times of crisis—as was the case with France when Moltke was hammering at the gates of Paris,—the War Office is temporarily accessible to *soi disant* Archimides.

Designed in the first place as an air ship this submarine was solely an after thought. As Shakespeare says in 'Henry IV.':

> 'It would be argument for a week, laughter for
> a month, and a good jest for ever.'

The only reason that can be assigned for such a fearsome arrangement having been placed in this branch of science is that the inventor imagined that to call an air ship a submarine boat was to make it a submarine boat. Never before nor since the proposal of Mr. Leggo has anyone been so daring as to combine aerial and submarine navigation as one.[1]

H. A. Fleuss

Mr. H. A. Fleuss invented an air purifying apparatus for submarine craft. It was intended originally for divers but is stated to be applicable for submarine boats, the boat taking the place of the dress.

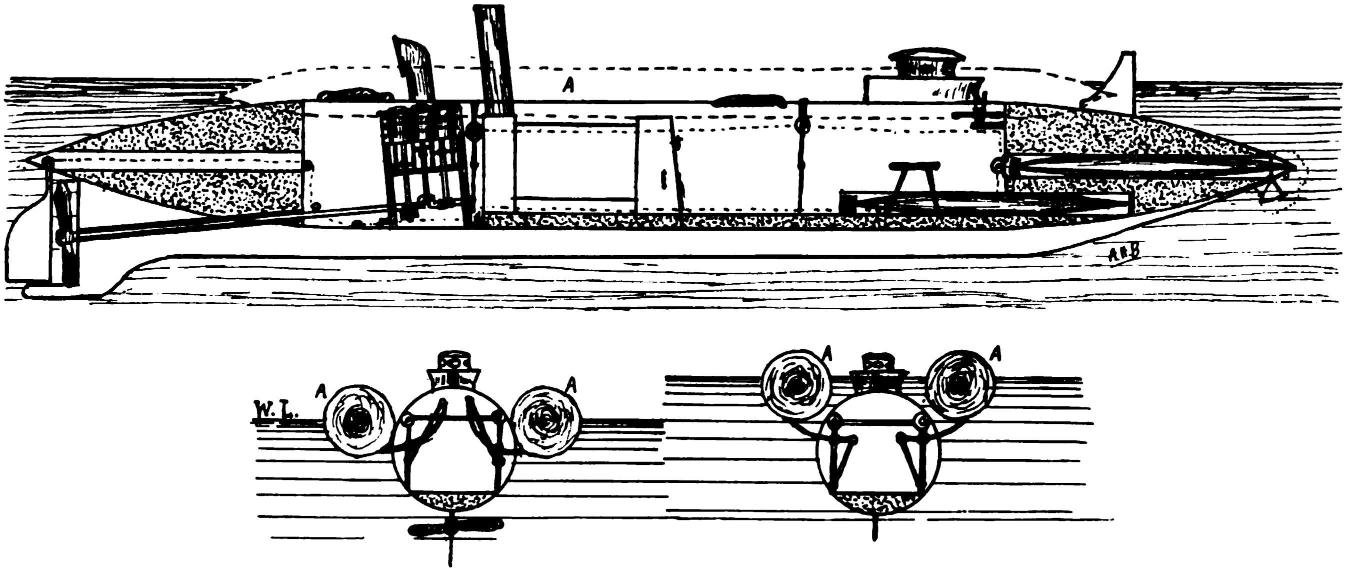
1880 Lambert and Ivernau

Of course the last two decades of the century brought marked improvements. In January, 1880, a submarine boat was proposed by V. P. Lambert and L. E. Ivernau. It consisted of a metal cylinder, terminating in cones and having air chambers and stages or compartments for passengers and merchandise. The vessel could be submerged to any depth by admitting water into a reservoir. It was to be driven by a screw propeller worked by a compressed air engine.

The above description would apply to many of the vessels I have mentioned, and is so vague as to be almost worthless. Form, dimensions and the various purposes to which this craft was to be put are unknown, there being no work, indeed, in which the invention is even so much as mentioned. It could not therefore have been of great importance.

The invention of Mr. Benjamin Berkley and M. Hotchkiss,

1 In a novel 'The Log of the Flying Fish,' by H. Collingwood, the Author takes as his subject a huge cigar shaped vessel, which besides acting as an aerial ship is also utilized for exploring the greatest depths of the ocean.



XLII.-XLIV. . THE SUBMERSIBLE OF BERKLEY AND HOTCHKISS of Paris was not really a submarine boat at all (Figs. XLII.-XLIV.), but rather a submersible, and the distinction is too often overlooked. It was one of the most ingenious and interesting vessels ever designed and that more notice was not taken of it is inexplicable. Berkley and Hotchkiss

On either side of the vessel was placed a long cork float A A (Figs. XLIII.-XLIV.); these two floats were so attached that they alone kept the boat proper, on the surface of the water, and thus if they were raised the vessel between them sank, and on the other hand if they were depressed their buoyancy supported the ship well out of the water, and with a good freeboard.

By the means described above the whole of the hull could be immersed three feet beneath the surface, the top of the funnel, conning-tower and air tubes alone remaining visible. The motive power was steam and the armament consisted of a torpedo-tube fixed in the bows, which ended in a hinged cone. The cork floats were so arranged that whilst they themselves could come to little harm by being hit, they would protect to some degree the vulnerable parts of the boat showing above the surface.

Hotchkiss, it is worth noticing, afterwards invented the famous revolving cannon, called after him.

On February 17th, 1881, Mr. T. Nordenfelt took out a patent for his first submarine.[1] 1881 Nordenfelt and Garrett No. III

It was a spindle-shaped boat having a length of 64 feet and a diameter of 9 feet; the hull was constructed of iron plates with a thickness of 5/8 inch amidships and a 3/8 inch towards the extremities.

The circular frames on to which the plates are rivetted are placed three feet apart, and consist of angles three inches by three inches, with an extreme thickness of 3/8 inch.

The displacement was 60 tons when submerged, and in this position the speed, with 100 I.H.P. was 9 knots. The machinery in the boat was driven by steam and consisted of

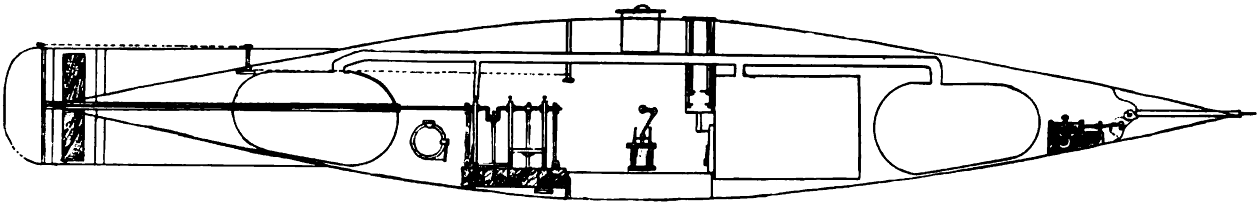
1 The descriptions of the Nordenfelt boats are from the Royal United Service Journal for 1886, the 'Engineer' (by kind permission), and from 'Submarine Boats,' by G. W. Hovgaard, R.D.N., 1887. Considerable information has been extracted besides from contemporary journals and Service publications.

This boat was the outcome of designs by Mr. Garrett.

a compound surface-condensing engine, for driving the propeller in the stern, and two small engines which when submerged drove the two side propellers. On the surface, however, the minor engines were used to drive the blower. The chief feature in the vessel was its continual buoyancy even when submerged, so that in the event of an accident it must necessarily rise to the surface of its own accord. When making submarine trips this reserve of buoyancy was overcome by the action of the two side propellers mentioned above, which, acting vertically, drove the boat beneath the surface. These submersion screws were protected in small sponsons, for, standing out as they did from the side of the ship, they formed prominent projections on the smooth contour of the vessel's lines and were hence very liable to be broken or even carried away by floating debris, or when coming alongside a vessel on the surface or a wharf. By means of these side-propellers the boat could be held submerged at any desired depth.

On the surface steam was generated in an ordinary marine boiler placed in the forward part of the vessel, so as to counterbalance the weight of the engines, which were in position well aft, leaving the centre of the boat free for the crew to move about. When beneath the surface the steam already generated whilst above water is used, the supply of power thus stored up lasting some considerable time. Two large tanks placed fore and aft also held boiling water, which circulated between them and the boiler by a system of return pipes. The supply of water when full up is 8 tons.

The engines are, as mentioned above, 100 I.H.P., and drove a four-bladed propeller of 5 feet diameter. Behind this propeller was placed the rudder for steering in the horizontal sense; the vertical rudders are placed on either bow, being attached to the extreme stem of the boat. The mechanism for working these rudders is extremely simple consisting of a heavy pendulum firmly clapped to the rod connecting the two pins; thus when the boat dipped out of the horizontal its nose pointing downward and stem up, the weight swung forward causing the two rudders to assume an upward slant from the stern forward, with the result that the vessel at once resumed a horizontal position. In theory this method of pre-



XLV. NORDENFELT'S GREEK SUBMARINE

serving an even keel is undoubtedly sound, but in practice it proved to be faulty.

The hull was designed with a view to resisting great pressure and could if necessary navigate at a depth of 100 feet without danger of being crushed; there was never any intention, however, of putting the vessel to so severe a test. Mr. Nordenfelt did not commence his boat without deep and tried knowledge of the subject in which he was engaging, since he had for several years made a study of submarine navigation in all its branches and had followed all and taken part in some of the experiments of recent inventors. The problem to be solved fascinated him. His erudition and his instinctive grasp of what was necessary was manifested in his careful regard for detail. Thus when the boat arrived at a given depth, the vertical propellers stopped automatically, commencing again, however, as soon as the assigned level was passed, either downwards or upwards. This ingenious apparatus works on the principle of the balance engine in the White-head torpedo,[1] and consists of a valve which works the steam supply to the small 6-horse power engine which works the vertical propellers; the piston of the valve is also in direct communication with the sea. When a depth is reached at which the pressure of the sea is greater than the pressure of the weight, the valve closes and the engines stop and the reserve of buoyancy at once raises the boat until the outside pressure diminishes, when the weight again opens the valve. Thus the depth of immersion is regulated.[2]

Besides powerful pumps for ejecting the water ballast, the 8 tons carried in the boiler and tanks can if necessary be ejected. For breathing purposes the air contained in the hull was found to be ample for the requirements of the whole crew during a lengthened period; this vessel is capable of navigating submerged about five hours, during which time it could accomplish about 16 miles.

The armament of the boat consists of two torpedoes, one White-head to be ejected from a tube placed in the bows, and the other a controllable torpedo, designed by Mr. Norden-

1 This will be explained later in the Chapter on the Armaments of Submarines.

2 Hovgaard.

felt.[1] A gun position for a Nordenfelt one-barrel quick-firer was fitted forward of the conning-tower, to be fired from within by the captain of the boat. Enough fuel was carried to take the vessel 150 miles without recoaling.

To proceed with the description we find that when on the surface the top of the boat projects 3 feet above the water, and when about to dive the water in the cistern is brought up to a temperature corresponding to a pressure of 150 lbs. The fire-door and ash-pit are then closed and the funnel which is telescopic, is withdrawn and the opening securely closed. The horizontal propellers are then started, and when the required depth has been attained the propulsive engines begin to work. Even after the full submerged run of 16 miles the pressure in the boiler registers 20 lbs.

The experiments with this boat took place in September, 1885, before a large concourse of scientists and delegates from all the chief Naval Powers. The trials were carried out in the Sound of Landskrona, and the following account by G. W. Hovgaard will be of interest.[2]

The boat was in the course of three hours closed up, and moved about with the cupola above the surface; its speed varying, but in no case did it attain a higher rate than 4 knots. The boat was during this experiment immersed and raised again several times remaining on the same spot. Last time it was down 5 minutes, and touched the bottom. These were the experiments of the first day. The boat could not move along under water as the horizontal rudders had been damaged when being towed out of Landskrona Harbour.

The next day the boat had a run in its light surface condition, working as an ordinary steam vessel. It ran through a distance of 16 miles with a speed which was estimated at about 5 knots. Unfortunately the boiler leaked, so that the full power could not be obtained.

During the last day's experiments the boat moved for 3 minutes under the water at slow speed. It was several times immersed, but only three-quarters of a minute at a time. The whole experiment lasted 25 minutes. Unluckily the

1 A description of this torpedo will be given in a later chapter.

2 'Submarine Boats,' G. W. Hovgaard, R.D.N., pp. 44-45.

stoker had been wounded by some accident. The weather was very unfavourable on the first day's trial, so that, taking every circumstance into due consideration the performance of these experiments is hardly a fair measure of what the boat might be capable of performing.

The employment of steam for under water propulsion was the signal advantage of this boat compared to others, for it may be said without fear of contradiction that, whatever drawbacks are to be found in this system, it has the commanding virtue of simplicity and does not require any expert knowledge beyond what is possessed by every marine engineer. It should be added that the boat has shown itself to be an exceedingly good sea-boat.

[1] 'By using water as the means of storing up energy, I am in possession of a reservoir which can never get out of order, and which can be replaced at any hour in any part of the world, and without any extraneous assistance from shore or other ships.'

As regards blowing out water of the boiler and cistern to produce a sudden force of buoyancy, it ought to be remembered that it would strain them very considerably, and that if the boat should have descended to great depths, the outside pressure may become so great, that only a portion of the water can be expelled, or perhaps the water will even enter the boiler instead of being blown out.

This first submarine boat designed by Mr. Garrett and built by Mr. Nordenfelt was sold to the Greek Government early in 1886, and a very satisfactory trial took place in the Bay of Salamis during the month of April of the same year.

S. Woodhouse

On April 26th, 1881, Mr. S. J. Woodhouse took out a patent for a submarine vessel. This was the second invention of this gentleman, he having already been granted a patent in conjunction with Mr. Watson, for a submarine boat in 1878.

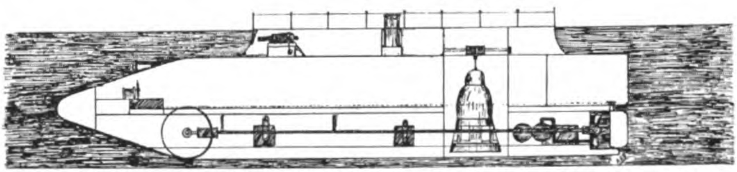
In shape closely resembling a blunt-nosed cigar, cut off sharply at its after end, there ran along the top for two-thirds of its length a raised deck or platform, which would be elevated above the surface when the vessel was in a light condition. The motive power was compressed air which was contained in reservoirs placed round the sides of the vessel. Stability was

1 Extract from description by the inventor.

obtained by the distribution of weight between two water tanks, placed one forward and the other aft. These were connected by pipes and if the bows of the vessel by some means took an upward slant, water would rapidly be pumped from the stern back into that placed in the bows.

By the same means any inclination for ascent or descent could be obtained. There were two modes of propulsion. One by a propeller in the stern, and the other by two paddle wheels fixed in the keel beneath the forward portion of the boat. The engines, of which two were carried, one for the screw and one for the paddle wheels, were driven by compressed air, which after exhaustion from the engines was passed back to the reservoirs through a purifying liquid contained in tanks in the reservoirs.

In a recess in the centre of the boat a diving-bell would be suspended, capable of being lowered through folding doors to the bottom.



XLVI. WOODHOUSE'S PROPOSED VESSEL

The conning-tower besides serving as a look-out station was to be utilized as a lift between the upper and lower decks. Offensive powers were to be provided; a torpedo tube in the bows and a gun just forward of the conning-tower.

This vessel, as the appended plan shows, was novel in several respects.

Firstly the shape is different to any that had been tried up till then, and, given efficient stability, would assuredly be conducive to high speed. The method of obtaining the stability strikes me as being the most feeble point in the whole design. To control the longitudinal stability of a submerged cigar-shaped vessel, by means of regulating water tanks seems well nigh impossible. The diving-bell, paddle-wheels, and conning-tower lift show that the inventor had given some

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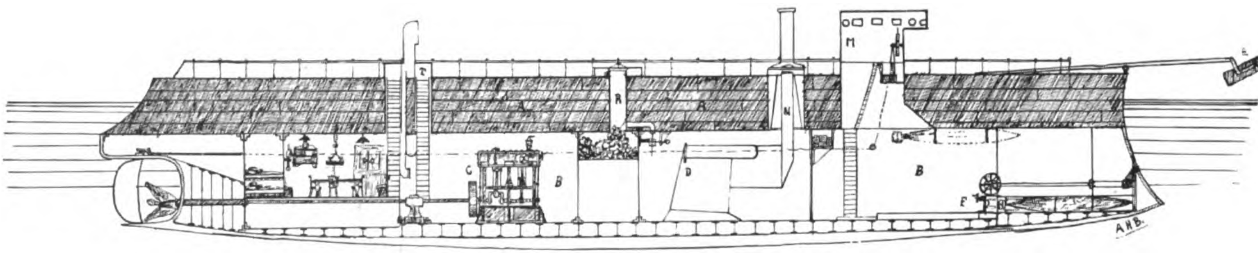


XLVII. LAGANE'S SUBMERSIBLE BOAT

time to the study of the subject, but it does seem to me that here we have another illustration of the old, old story in endeavouring to accomplish too much the inventor has done nothing, and spoilt what might with care have been turned into a practicable plan worthy of a practical test.

On July 28th of this year M. Génoud took out a patent for a submarine boat of his design. Its motive power was a gas engine worked by hydrogen which he obtained by means of iron scraps and sulfuric acid. The speed was to be between 4 and 5 knots per hour when submerged. After a submersion of two hours lack of air would necessitate a return to the surface to replenish the stock. The inventor explained that speed was wholly unnecessary in a submarine boat, and indeed fast vessels submerged anywhere near the shore, would find navigation very dangerous in that either rocks nor other obstructions could be visible owing to the impenetrability of water to the human sight. Génoud

It is a thousand pities that we have been left so much in the dark and that more is not known about the plans of this vessel as 5 knots an hour with a gas engine in 1881 would be a by no means inferior performance. Unfortunately none of the historians do more than accord bare mention to Génoud as having designed a submarine boat, and an invention of undoubted interest and possibly of some importance is therefore lost to us.

M. Lagane, a French engineer, based his invention on that of Berkley and Hotchkiss; yet although the two vessels embodied the same principles, namely, having an invulnerable float holding up the vessel proper, they differed completely in form. Lagane

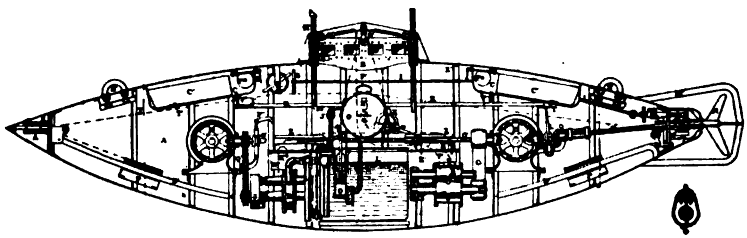
Lagane's vessel (Fig. XLVII.) was to be 28 metres (91.865 feet) long, 3 metres (9.842 feet) broad, and 4 metres (13.124 feet) deep. As will be seen by the plan there were practically two boats one above the other, the upper one A A, being of wood and having a sufficient excess of flotation to support the lower and habitable hull B B. The outside shell was of steel, making the whole a compact mass. Motive power was obtained by the engine C, situated a little aft of the centre, steam being supplied by the boiler D. The wooden float was pierced in four places; the foremost aperture led from the ship to the conning-tower M, in which was situated the wheel and steering gear. The second N, allowed the funnel to pass through and was situated just abaft the conning-tower. The third R, was the engine hatch, and coal shoot, and lastly T was the manhole by which the crew entered.

This last also acted as a ventilator.

The armament consisted of a spar torpedo E, and a torpedo tube for automatic torpedoes at F in the bows. Three of these torpedoes were to be carried, one in the tube, and two in clutches ready for reloading. All vulnerable parts, such as the conning-tower, funnel and the hatchways were to be protected by thin armour plates, capable of resisting the shot of machine guns and rifles.

Drzewiecki No. III

We now return to the Russian inventor. The dimensions of the 'Drzewiecki 3,' were the same as those of 'Drzewiecki 2' (page 84), the chief difference being in the number of pro-



XLVIII. THE 'DRZEWIECKI III'

pellers. These boats had but one screw situated in the stern; this screw, however, was moveable in every direction. Stability and evenness of route were obtained by means of weight so arranged that they could travel from one end of the boat to the other, and thus regulate the centre of gravity, and impart to the vessel the required inclination.

In all other respects these 'Drzewiecki 3' were similar to the preceding type, propulsion being obtained by pedals, worked by the crew, actuating a shaft.

A class was specially formed for the study of these little ships, of which 50 (?) were constructed and for several years they carried out constant evolutions in Cronstadt Harbour. Their weak point, however, was their lack of speed, which seldom exceeded 3 knots under the most favourable circumstances.

A strange vessel was built and launched on the Hudson in 1881 and if her trials did not demonstrate her suitability for warfare, they at least had the merit of showing what things a submarine boat could *not* hope to do. Shortly, these were that steering a direct course under water was impossible, that no particular point in a ship's hull could be made out, and that a ship in motion would be very dangerous to approach when submerged. A certain amount of secrecy enveloped this boat, so that a baffled reporter christened her 'The Fenian Ram,' by which name she has since been referrel to.[1] **Fenian Ram**

This was practically a dead year so far as concerns submarines. We hear of no inventor of submarines but a Roumanian from Arlatz in Moldavia, by name Trojan Todorasco (or Teodoresco) brought forward a novel means of maintaining submarine boats at a constant depth. **1882 T. Todorasco**

The Roumanian's idea was as follows: the vessel would be provided with a reservoir of compressed air and an air chamber which was to be in communication with the reservoir, or with the interior of the vessel, at its upper part, by valves operated by the pressure of the surrounding water. The valve between the air chamber and the compressed air reservoir may be in the form of a plunger working in a cylinder open at one end to the water. The plunger had a passage, which, when the former is pressed inward by the water, coincided with ports in the side of the cylinder, and admits air from the reservoir to the upper part of the air chamber.

The valve between the air chamber and the interior of the vessel is operated by the plunger, and consists of a piston valve mounted on a rod connected to the plunger which is loaded so as to counterbalance the pressure at any given depth. The load upon the plunger may be regulated by allowing mercury to flow into a receptacle on the piston-rod.

If the vessel sinks to a lower level, the increased pressure of the surrounding water forces the plunger inwards until the passage therein coincided with the ports in the cylinder. Air is thus admitted from the reservoir to the air chamber, and displaces a quantity of the water in the lower part of the

1 From an account by Major Field, R.M.L.I.

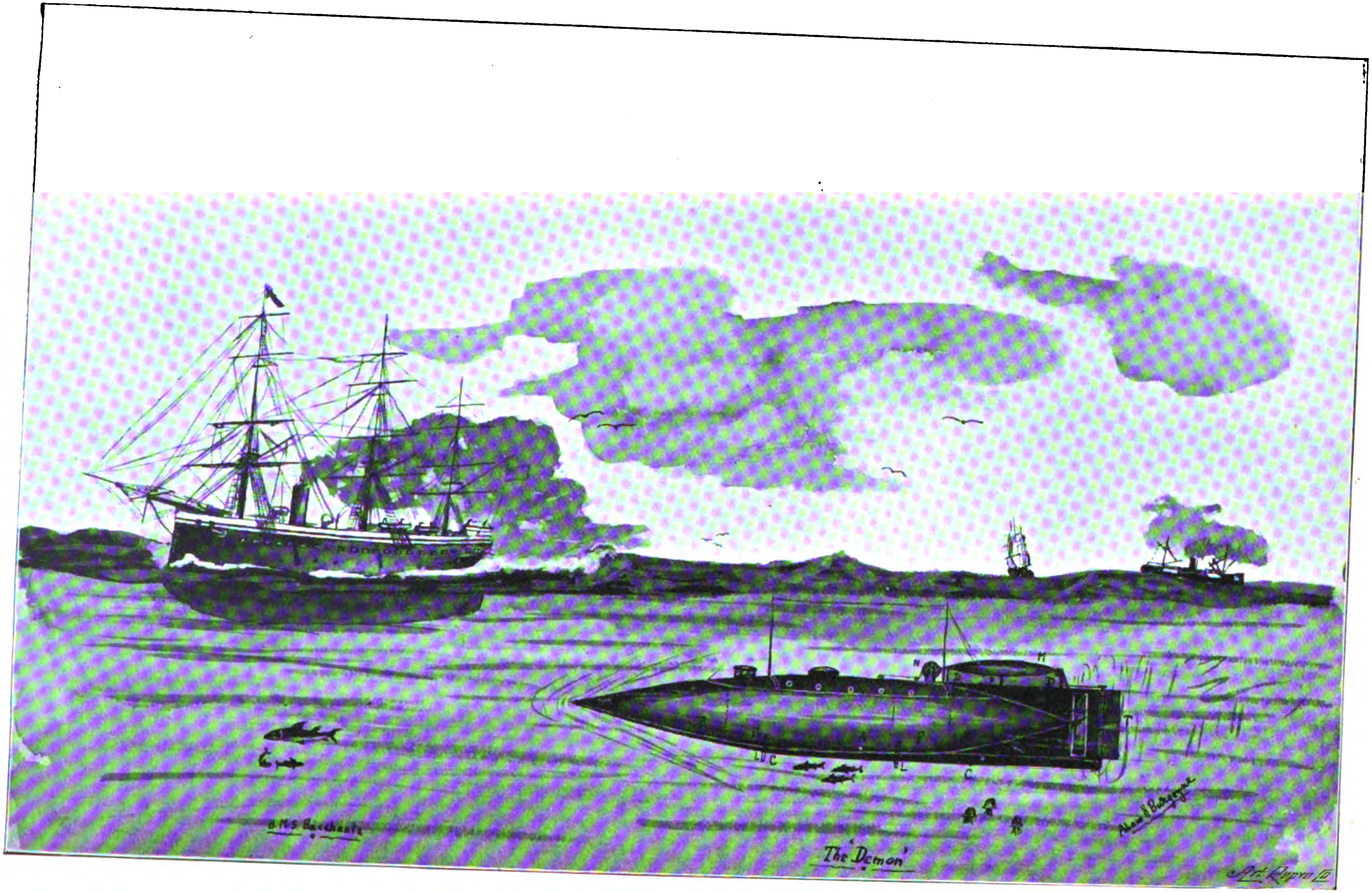
chamber. This increases the buoyancy of the vessel, which returns to the normal depth, the decreasing pressure of the surrounding water allowing the plunger to move outwards, thus cutting off communication between the compressed air reservoir and the air chamber.

To cause the vessel to sink to a greater depth, the load on the plunger is increased by admitting mercury to the vessel on the piston rod, so as to correspond to the pressure of the surrounding water at the depth to which it is desired to cause the vessel to descend. The plunger is then forced outwards drawing down the piston rod, and with it the piston valve, which is thus caused to open the passage between the air chamber and the interior of the vessel. The decrease in the pressure in the air chamber enables the surrounding water to fill the lower part of the air chamber, and thus decrease the buoyancy of the vessel, which sinks to the required depth. To make the vessel remain normally at a low depth, the load upon the plunger is diminished by drawing off a quantity of the mercury. To maintain the vessel in equilibrium and in a horizontal position, four or more apparatus may be used.

Undoubtedly ingenious as is this invention it must be ruled out because of its intricacy—its over elaboration. If only it could be simplified, its utility would be assured. As matters stand the exact fitting plunger would prove an almost insuperable difficulty, and even if made successfully would be liable to be jammed by any slight object floating in the surrounding water. Notwithstanding this evident drawback, however, the machine is interesting and well worthy of notice.

E. Easthope

On August 30th, 1882, Mr. Easthope was granted provisional protection for an invention by which a submerged vessel could be kept continually supplied with oxygen. The gas would be generated in a vessel connected to a deep syphon partly filled with water and having its down leg of small, and its up leg of large, diameter. The syphon connects with the receiver and has a cup and tap on the top for supplying water. A pressure gauge is mounted between the syphon and receiver. When charged the latter is disconnected and the gas allowed to escape into the vitiated air, the whole being driven through a purifier or filter and passed back again by a fan or blower worked either by clockwork or an electro-motor.



XLIX. DAVIES' 'DEMON'

Davies' submarine vessel, which he named the 'Demon' (Fig. XLIX.), had a length of 50 feet and a diameter of 6½ feet. It was made of a cylinder A, terminated at each end by cones B B. The hull was fitted with two keels, one C C underneath, running from stem to stern and destined to preserve the equilibrium of the boat, and the other D D on the top and towards the stern. The latter keel formed a rest for the torpedo M, which was attached to a large reel N, placed a little forward of the torpedo. This reel contained a good length of insulated wire connected in the interior of the boat to a battery. By means of a button the occupant could explode this torpedo at any time he desired. A small wheel in the interior regulated the run of the wire, and could also release the reel altogether and allow the projectile to drift free. The torpedo was held in its place by a screw P, fixed in the hull.

1883 Davies

The hull was divided, as mentioned above, into three compartments, the two fore and aft B B, being used as compressed air reservoirs. The centre one was broken up into two, the smallest F, being the engine room, and G, being the space for the occupant, who managed the vessel while reclining on a couch. Forward of this couch were placed two small air pumps which would be worked with pedals by the steersman. The indicators of the air pressure in the two reservoirs were fixed just above the steersman's head whilst handily placed nozzles permitted him to renew the air in the living chamber. The vitiated atmosphere was expelled by the tubes L L, at the very bottom of the boat.

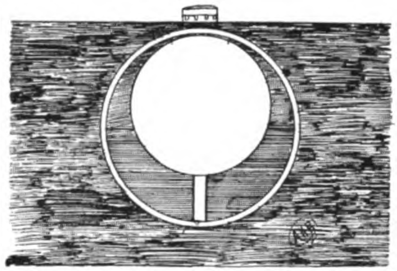
The propeller had four blades and was defended from floating debris by an iron cage; a rudder, T, was fixed forward of the propeller and was worked by a wheel. Whether this vessel proved in any way successful is unknown, and only one authority mentions it at all.

de Telescheff

In 1883 Russia was again to the fore. M. N. de Telescheff patented a design for a hull for submarine boats. Its chief feature was longitudinal channels made in the hull below the water-line whereby 'the *vis viva* of the fluid displaced by the fore part is converted into mechanical action on the after part in the line of motion, thus reducing to a minimum the resistance due to the inertia of the fluid.'[1]

[1] From the Inventor's Specification.

This channel is narrowest amidships and widens out at the ends. The appended sketch gives some slight idea of the theory of its construction.



L. M. DE TELESCHEFF'S IDEA

A. H. Arnold

Mr. Arnold originated a method of supplying air to torpedo boats and submarine vessels. The air is drawn through one side of a telescopic double tube projecting above the surface of the water, into one side of an air reservoir in the boat. This reservoir is divided by an elastic diaphragm which the fresh air presses towards the other side, expelling foul air therefrom through the remaining side of the tube. The sailor breathes through a mouthpiece connected with the reservoir by two separate pipes; or an auxiliary reservoir, with fixed diaphragm and flexible sides, may be worn on the person.

The presence of the elastic diaphragm detracts from the value of this invention, the elastic being very liable to damage from the effects of contact with the salt-laden atmosphere, which in any case would most certainly rot it in a very short space of time.

1884 Blakesley

Nothing is known of the dimensions of Mr. Blakesley's submarine boat, but in designing it the inventor made utility in time of peace the predominating idea. This circumstance undoubtedly disqualified it somewhat for the present purpose, but the idea governing it was clever. The hull was fusiform and constructed of thin metal sheets, capable of withstanding the pressure of water at the depth of over a hundred feet. Both ends were pointed, but the stern fined away more than the forward portion, and presented a thinner cone at its extremity.

The propeller placed in the stern was to be worked by a small engine driven by steam in a fireless boiler. The boiler was placed exactly in the centre of the boat and was to be heated by a chemical composition capable of keeping an even pressure of steam in the boiler as long as any of this chemical remained.

Stability was to be ensured by reservoirs placed fore and aft in which the quantities of water could be regulated according to will. The forward reservoir acted also as a diving chamber, and a door leading from it to the bottom of the sea enabled divers to leave the vessel.

Air for breathing purposes was obtained from compressed oxygen cylinders which supplied the air as it was required on the principle of the Fleuss diving dress. Lighting was supplied by accumulators ; a strong search-light was affixed to the bottom of the hull to enable divers to see their way when on the bottom.

Besides acting as a diving-bell and explorer of the ocean depths, Blakesley's invention could also be used as a submarine torpedo-boat, cable cutter, mine layer, destroyer, and for many other purposes of warfare. Steering was effected by two rudders placed forward of the propeller, one on the top and the other underneath the hull. In the centre a small cylindrical telescopic conning-tower could be raised, for use when on the surface. Blakesley's invention presents no novel points of construction, unless the double purpose to which it was designed can lay claim to novelty. It was to have had the outward form, since used in the French submarine boats, of the 'Morse' type, a form lending itself very readily to submarine navigation although dertimental to longitudinal stability.

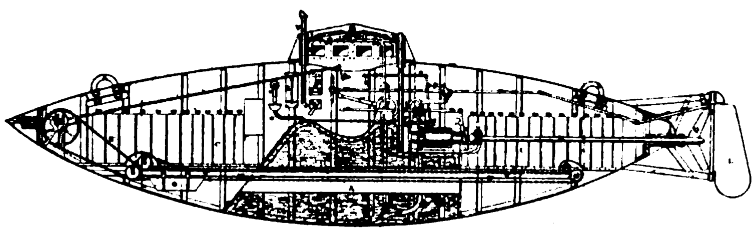
Drzewiecki No. IV

Again we hear of the fertile M. Drzewiecki, this time with a mechanically propelled vessel. The 'Drzewiecki 4' was similar in all respects except propulsion to the 'Drzewiecki 3' class. Instead of pedals for turning the shaft, however, the inventor made use of an electric motor, the current being supplied by accumulators placed fore and aft.

To obtain room and reduce the weight sufficiently to allow of this new installation the crew was diminished by two. The remainder sitting as before, back to back. The propeller was fixed and steering done by rudders.

The speed obtained by this new means of propulsion was 4 knots. In 1886 when the Minister of Coast Defence changed hands and passed from the jurisdiction of the Admiralty to that of the War Department, these little vessels were considered useless and unnecessary, and after a short time experiments with them were completely abandoned.

This decision of the Minister for War was very wise, for although the 'Drzewiecki' submarine boats were very ingenious and indeed fairly successful, their size and lack of speed militated against their efficiency for purposes of war. The appended plan (Fig. LI.) gives a very clear idea of these little boats. It will have been remarked that Drzewiecki was the first inventor to make use of the optical tube. This was by no means the last submarine boat designed by the Russian



LI. THE 'DRZEWIECKI IV.'

engineer, and in 1888 and 1896 he again presented plans of submarines to the Russian and French Governments respectively.

This individual's contributions to the subject were extensive and the next vessel of which we hear is the first of those designed by him. Prof. J. H. L. Tuck, of San Francisco, brought wide knowledge to bear.

Prof. Tuck No. I

This first boat with a length of 30 feet, had a displacement when submerged and fully charged, of 20 tons; it presented several very novel features of which the most important was undeniably the submersion screw placed directly under the centre of the keel. With this to draw the vessel to any desired depth, a large amount of buoyancy could be maintained for safety. This screw was worked by an electric motor; this motor also rotated the propeller in the stern by which forward motion was obtained. The current for running the motor was stored in accumulators.

Situated in the centre of the superior or upper side of the hull was a man-hole in which stood one of the occupants, clad in a diving dress, his body from his waist upwards being in contact with the outer water. This obviated the necessity for a conning-tower and also allowed of work when under water being carried out from the vessel with great ease. Signal levers communicating with those still remaining in the boat were placed in a handy position for the use of the look-out.

The crew consisted of three men, one, as described, half in and half out of the boat acting as pilot, another attending to the engines and elevation rudders, and the third turning the pump for supplying the steersman with air.

The method of getting into the steersman's diving dress was very tedious but could not well be otherwise considering how cramped for room the operator must have been. The member of the crew told off for the purpose would first enter a small water-tight compartment (enclosing the man-hole) and carefully shut the door. He then robed himself in the diving dress, which operation in so confined a space required no little skill. A water-cock was next opened and the compartment filled; removing the trap of the man-hole the occupant then took up his position outside with his hands on the signals. When wishing to return the operations were reversed, the water being expelled from the compartment by compressed air.

The two men left in the boat were supplied with air from cylinders containing large quantities of compressed oxygen. Besides these cylinders were two long india-rubber tubes, fitted with floats through which when sent to the surface, fresh air could be drawn.

Three rudders were fitted, one being vertical and placed behind the propeller, the others horizontal situated on either side of the hull. Submersion reservoirs were also provided in case of need, but for ordinary work the screw at the bottom would be sufficient. The two screws could be rotated by hand if the accumulator ran out or the motor became in any way disabled.

One goes on to learn how the interior was lighted by incandescent lamps and could if it were required, contain as many as five men. The distance of the vessel when submerged from the surface of the sea was ascertained by means of an indicator or pressure gauge.

Defensive powers were supplied by two torpedoes carried one at each end of the boat. These were retained in their place by electro-magnets, and rose by their own buoyancy the moment the current was cut off. When released, cork floats kept them on the surface until their magnets attached them to some steel or iron hull when they could be exploded by electricity from within the boat.

This vessel was tried at New York. During the experiments it was manned by three men, and manœuvred in every direction successfully, a speed of 7 knots being obtained on a straight course. Its trials of gyration were eminently satisfactory and the working of the submersion propeller left nothing to be desired.

K. Degener No. I

Mr. K. Degener took out a patent for his submarine boat on August 13th, 1884. He did not intend his invention to be utilised for war-like purposes, but rather for the exploration of the sea bottom.

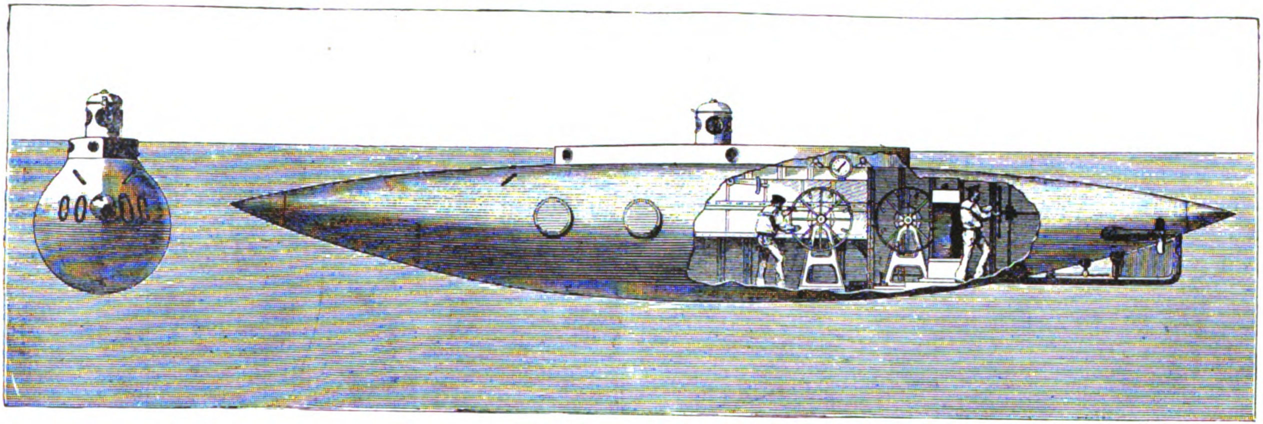
There is a touch of the highly coloured romance of Jules Verne about the particulars of this machine. It was to be mounted on wheels so that it might be available to run on land. Its bows were to be cruciform in shape, and the hull was surrounded by a quadruple air jacket. Propulsion was to be obtained principally by rotating drums within it, and steering was to be effected by projecting magnets. The above vague description gives an idea of novelty in design and one would like to find out more about this vessel. Information regarding it is, however, lacking.

A. Campbell and J. Ash

'Nautilus'

These two inventors designed a submarine boat, which they named the 'Nautilus.'[1] It had a length of 60 feet, and a diameter at its widest of 8 feet. In shape it resembled a cigar and had a superstructure or deck running along the top for 20 feet, in the centre of which was a conning-tower with four lenses of glass. The top of this tower being on hinges,

1 Sir William White, late Chief Constructor to the Navy, made a descent in this vessel.



LII.-LIII. THE 'NAUTILUS'

it formed the mode of exit from and entrance into, the interior.

The 'Nautilus' was constructed by Messrs. E. Wolesley and C. E. Lyon. It had a displacement of 50 tons when fully immersed. The motion in the vertical sense was effected by the reduction or augmentation of the vessel's volume and to this end four cylinders opening out to the sea were fitted on either side. These cylinders were on slides and could be either drawn into the centre of the boat or pushed out to the fullest, by means of a screwed rod connecting those on one side with those on the other, and thus the displacement of the boat could be altered to the extent of one ton.

The value of this boat must be the excuse for lengthy reference. To proceed we find that the hull was built of Siemens-Martin steel, the sheets employed in its structure having a maximum thickness of five-sixteenths of an inch. The frames on to which these sheets were clamped were 3 x 3 x ½ inch and were placed 21 inches apart. The compact build of the hull was calculated to give it sufficient strength to withstand the pressure of the water at 50 feet. Steering in the horizontal sense was effected by a single rudder, and one rudder likewise was thought sufficient to guide the boat vertically.

Propulsion was obtained by means of twin screws driven by two Edison-Hopkinson motors capable of developing 45 I.H.P. Power to drive the motors was stored in 104 accumulators of the Elwell-Parker type divided into two batteries of 52 each. Each battery had a collective power of 108 amperes at a tension of 104 volts. The accumulators were situated in the central part of the vessel and served as ballast. Besides driving the propellers the motors worked a force pump for ejecting water from the ballast chambers, and also the mechanism of the eight cylinders. The accumulators held electricity enough for ten hours at full consumptive power. The speed was estimated to be 8 knots when submerged, and with the motors running at 750 revolutions per minute. At 6 knots the boat was calculated to accomplish 80 miles without recharging.

The crew consisted of six persons who stood in the centre of the boat; the air contained in the hull was sufficient to last them two hours without coming to the surface, but in order to impart a sense of additional security compressed air was carried as well and an emergency thereby guarded against. The inventors had also some brilliant extra features, one being their ingenious apparatus by which the air throughout the boat might be completely renewed as soon as the surface was reached once more. When down to load-line and on the surface, the free board it should be mentioned, was only 10 inches.

The armament consisted of two torpedoes, placed in tubes fixed one on either side of the platform. Fifteen years ago less notice was taken of these matters but experiments were carried out with this vessel in the West India Docks at Tilbury in 1886, and the vessel sank to a depth of 25 feet and remained submerged for some considerable time. These trials were considered, and rightly considered, fairly successful and it is passing strange therefore that nothing should have been heard of the 'Nautilus' since then.

Jacquemin

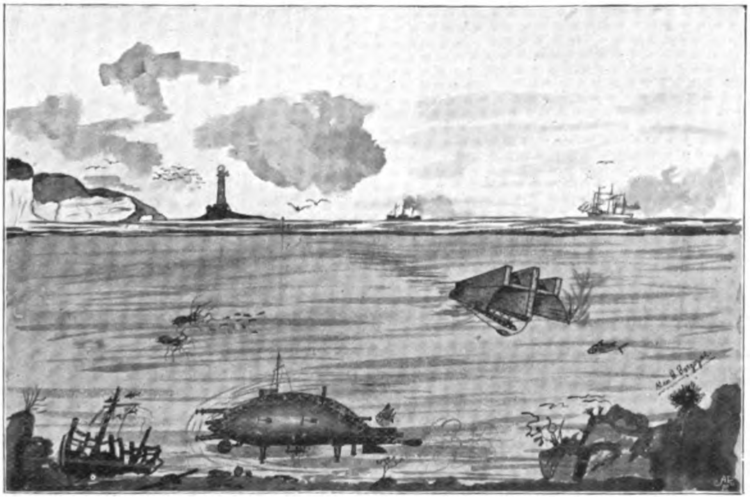
The last important invention we have to chronicle in the year 1884 is that of a workman of the Shipbuilding Yards of la Ciotal, in France. His proposal was for a pencil-shaped vessel supporting a high raking conning-tower, in which would be stationed the look-out. Behind this was a detachable unsinkable boat, evidently a copy of that carried on the 'Plongeur.' There were, amongst other features, several sets of divers' suits fixed in holes in the hull, by means of which, the occupants, by getting into them, might pick up any desired object seen without through the many thick observation lenses provided for the purpose.

1886
Boucher

In this year there came tidings of a most marvellous vessel the idea of which did credit to the wit of man and of the talented French originator. It was the creation of the fertile brain of M. Boucher, a French engineer of some note. The Gallic scientist had been for a long time nursing the notion that it was possible to regenerate air vitiated by aspiration, without it being necessary to mount to the surface. To this end he designed a machine and having the machine, he considered it incumbent on him to design a vessel to contain it. Hence the advent of the wonderful apparatus described below.

M. Boucher's submarine took the form of a gigantic cetacean, and had a length of 15 metres (49.213 feet) and a diameter of 4m. 50 (14 feet 6 inches).

The breathing apparatus was briefly as follows. He extracted the air contained in the water by an energetic pulverisation (if the word may be used of water) of that liquid by passing it under great pressure through perforated metal plates, and drawing off at the same time the air resulting from this use of pressure for the consumption of the vessel's occupants. In fact he attempted to construct a machine which would act in the same manner as the gills of a fish. He signally failed. Even to the French scientist there is the line of the unattainable. It will perhaps be remembered that the principle expounded above is on the lines of that proposed



LIV.-LV. THE PHANTASIES OF BOUCHER AND LEGGO

by Jules Verne in his remarkable and fascinating work 'Twenty thousand leagues under the sea,' where the intractable Captain Nemo travels at will through the remotest ocean depths.

M. Boucher with praiseworthy but misplaced generosity provided no less than three means of propulsion for his vessel, firstly by means of a screw, situated under the keel in the middle of the boat, secondly with the aid of oars fitted on either side of the vessel, and hinged so that the resistance might be all on the backward stroke, and thirdly by a device placed in the stern and destined to work on the principle of a fish's tail by a rotary side to side movement. With such multitudinous persuasions to advance, the speed of this submarine boat ought to have been very satisfactory. These three progressive powers could be worked either all together, when their engines would be connected by a complicated cog mechanism, or else by disconnecting them, either could be set in motion separately.

Boucher's was a safety concern. To avoid collisions the inventor thoughtfully provided four telescopes, one fitted in the bows, one astern, one for looking upwards and the last for examining the bottom of the sea. Should these telescopes fail to act and a collision with some obstacle occur, the boat would still remain intact owing to enormous spring buffers, two of which are in the bows and two beneath the keel so as to make the fall on the bottom devoid of the nerve-shattering shocks which might ensue were the boat unprovided with this protection.

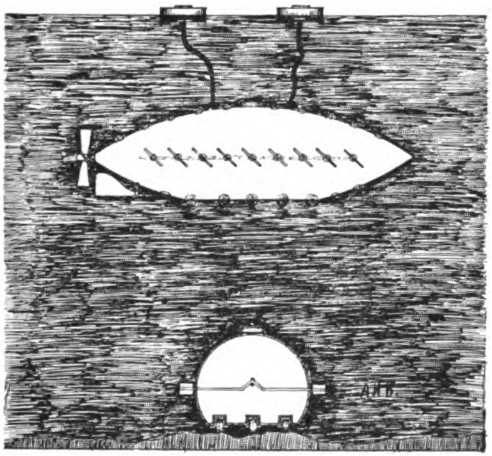
There are further elaborations yet to be chronicled. The vessel was to be two storied, the lower being for the machinery the upper for the crew. The inventor it will have been noticed has forgotten nothing, and he has not been stinting in that which he has supplied; it therefore surprises me that he omitted to include a palatial reception room, fitted with a grand piano and other appurtenances so essential to aristocratic comfort.

But we must give credit to what the inimitable Boucher did do. If he omitted details of comfort, the inventor certainly thought of offensive powers, for above the rudder in the stern was to be placed a large cannon, and if we please (for it is left quite at the discretion of the builder) we may place torpedo tubes in the hull or indeed adopt any form of weapon for defensive or offensive purposes.

Here we find an almost inconceivable fusion of the big and the little. An individual who could plan a vessel so curious as the one above described must either have a ready sense of the humorous or else no knowledge whatever of the absurd, and we can only wonder whether the designer of a craft so fantastic ever really imagined it could prove of the slightest possible utility. The idea of seeing any distance through the water by means of telescopes, of whatsoever make or kind, is absurdly impossible, and that M. Boucher ever in his fairest day-dreams imagined that his buffers would serve him when in contact with so solid an obstacle as a rock, seems incredible. This type of invention, however, has its place and its value; it serves to brighten by its pleasant comic relief the histories of the subject in which dry facts are bound to take precedence of and predominate over the romantic and unreal statements of fiction. As necessary is it as the humorous 'off' scenes of the turgid melodrama.

R. Morhard

An American was the next to devise a submarine boat. Roman Morhard, of New York, did not believe in severing



LVI.-LVII. MORHARD'S SUBMARINE EXPLORER

all connection with the upper world, and so his invention, which took the usual cigar form, except that it was flattened along the bottom, was suspended from two floats by means of flexible tubes. These tubes were utilised for keeping the air in the interior in a fresh condition and could be let out or drawn in according to the depth at which it was required to be submersed.

Mr. Morhard was not a man of war but of peace and his vessel was not intended for any hostile purpose, but rather as an under water salvage boat. To aid it in its researches it was provided with 15 small rollers placed in three parallel lines of five each, along the flat bottom of the boat. By these he could roll along to wherever he desired to go, which method of progression would be faster than that by the propeller in the event of a strong adverse current.

One consideration was given to the old, old question of horizontal stability, which was to be obtained by 18 vertical planes, placed 9 on each side, and capable of being tilted in either direction to almost any extent. A certain amount of light would be obtained through 10 glasses placed on the keel-line along the top of the vessel, five forward and five aft of the entrance hatch which was placed exactly in the centre of the hull. Three similar glasses were also placed in the keel, two in the bows, and one a little forward of the rudder. The propeller was to be four-bladed.

We must spare another word to the invention of Mr. Morhard's. It is characterised it is true by no striking novelty or conception, but he has planned nothing that is incapable of being carried out, and this invention is refreshing, from a scientific point of view, after the freak-like apparatus of M. Boucher. One is a 'sport' the other is business. The floats, which would in war vessels constitute a weakness, can be excused when one considers the purpose for which the vessel was designed, but it seems to me that the inventor added needless complication when he settled on 18 horizontal planes as necessary for stability. Four would, it seems to me, have answered every purpose, especially when the balancing effect of the floats is taken into consideration. Mr. Morhard obtained a patent for this submarine boat on March 21, 1885.

J. G. Lorrain

J. G. Lorrain proposed the application of electric contact-makers acting by variations in the temperature, pressure, density or chemical composition of fluids for controlling various processes and apparatus in connection with heating, cooling and ventilating. The application of this system to the ventilation of submarine boats from a reservoir within the boats is mentioned, the contacts acting to control electric devices for regulating the supply of air. Lorrain also planned a means for increasing the distance through which the moving parts of electro-magnets may be actuated without the employment of intermediate multiplying mechanism.

The inventor with the patronymic which goes half way towards degeneration but who was, as a fact, a source of moving ideas, comes up smiling again with a new invention. It was a submarine boat the year before. This gentleman is a fount of varied and interesting notions, but although this proposal of his may seem ludicrous, it is yet evidently the outcome of much study on the subject of submarine navigation. K. Degener No. II

This time, having already designed a submarine boat, Mr. Degener evolved plans of entering or leaving it whilst submerged. The persons or stores to be introduced into the vessel when below the surface, are encased in india-rubber sacks which are provided with various means for self-propulsion, such as screws driven by treadles, or air jets, or they may be provided with sleeves for the arms by which they can be propelled as in swimming.

They would be directed on their course by a rope and admitted into the vessel by a projecting tube with an inwardly-opening valve at its inner end. Communication may be had with the shore through an india-rubber tube fitted with stiffening rings at intervals to prevent its collapse.

Mr. Welch's boat was of the elastic improvable sort capable of future developments as in the fulness of time further discoveries are made. It could be added to as time goes on according to the wish of the owner. It consists of a string of air-tight cylinders terminating in two cones, strung on a connecting tube. This tube has a propeller fixed at each end, the shaft of which passes through the tube. If necessary twin screws may be carried on divergent shafts. The propellers are moveable about universal joints to obviate the necessity of horizontal and vertical rudders. In the event of war this vessel would be fitted with torpedoes, and had also a special diving rudder, worked by the propeller engines, so that it might dive beneath the protecting nets of any vessel attacked. The details of the above quaint vessel are few, and the description is consequently vague, but from what can be gathered it would have proved useless had it been built. Welch

We are on much firmer ground here. The namesake of the late French Ambassador at the Court of St. James was far from 'being in the clouds.' He designed the 'Porpoise,' which was far ahead of any of the submarine boats that had been Waddington 'Porpoise' designed anterior to it The inventor patented it on October 17th, 1885, and at once had a vessel built to his plans. This vessel was launched in the following year at Seacombe, near Liverpool, and a great number of most valuable experiments were carried out before the progress of modern science rendered it obsolete.

The 'Porpoise' (LVIII.-LIX.) had a length of 37 feet and a diameter of 6 feet 6 inches. It was pisciform in shape and constructed of thin steel sheets laid on a strong skeleton framework of the same material.

There was a sound practical touch all through. Propulsion was obtained by means of an electric motor, the power for which was supplied by forty-five of the Electric Storage Co.'s cells. The electricity thus stored up would take the boat 250 miles at a moderate speed. At full power the speed was 8 knots and at this speed the engines worked for 10 hours. Each accumulator had a capacity of 660 ampère hours,[1] the collective capacity being 29.700 ampère hours. The maximum current taken by the motor was 66 ampères, and, the electric force being 90 volts., a H.P. of 7.96 is obtained, the efficiency of the motor being 8 per cent.

The hull was divided into three compartments, by two bulkheads, the centre one containing the machinery and living space, those fore and aft being used for compressed air. Submersion was obtained by means of water ballast which could be ejected by a pump coupled to the electric motor. In case an unexpected accident affected the operative powers of this electric pump, another worked by hand, was provided.

The point possessing the greatest novelty in this design, is the manner in which the inventor proposed obtaining the horizontal stability of his vessel. A quarter of the length from each extremity of the boat was placed a funnel, right through the boat from top to bottom and open to the water at each end. The appended sketch (Fig. LX.) shows more clearly this ingenious contrivance, and with it before us to assist complete grasp of the plan little explanation is needed.

From the centre was placed a shaft A, to which was attached

1 F. Forest gives the ampère-hours as only 500, and the maximum speed as 6 knots, at which speed 60 miles alone could be accomplished without recharging. These were probably the conditions fulfilled on service.

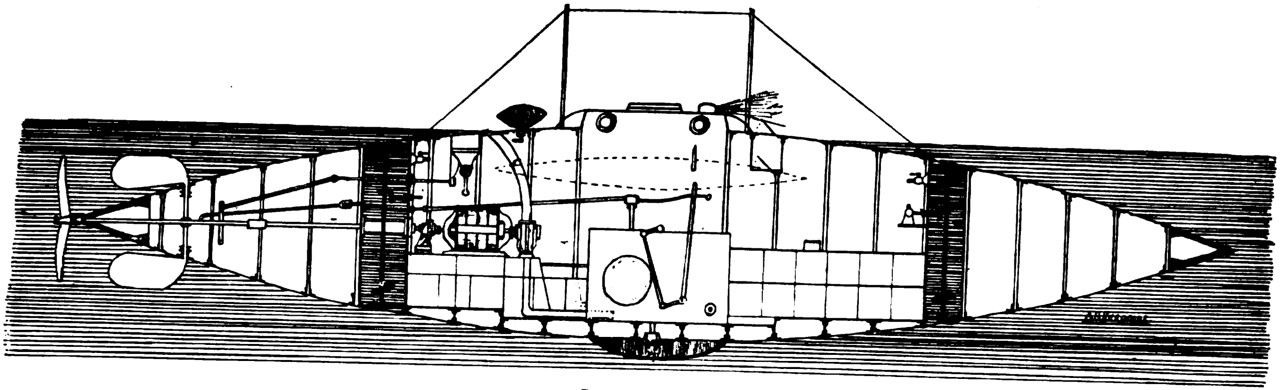


Fig. LVIII. Elevation Plan

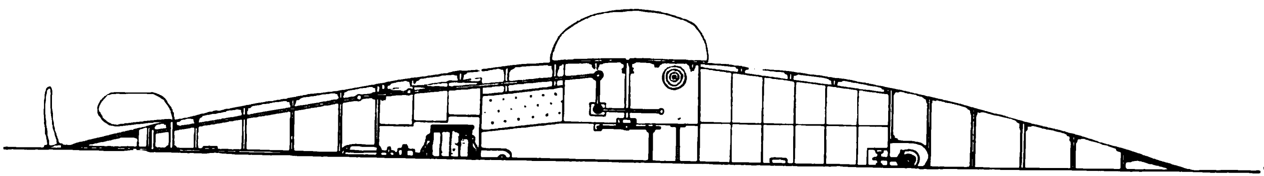
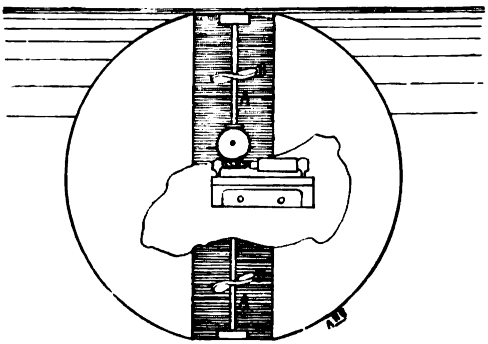


Fig. LIX. Deck Plan.

LVIII.-LIX. THE 'PORPOISE'

two propellers B B. This shaft was coupled to a small electric motor and which revolved the propellers in any desired directions. This motor was attached to a pendulum, which, if the vessel dipped out of the elevation at which it was required to stop, swung either fore or aft according to the direction of the divergence and instantly connected the motor with the current, the result being that the propellers raced round in the required sense until the vessel assumed its proper position. The pendulum then swung straight again, cutting off the current and the propellers instantly stopped revolving. This principle is similar to that of Nordenfelt and is in every way admirable, showing that the inventor possessed a strong appre-



LX. WADDINGTON'S SUBMARINE PROPELLERS

ciation of the value of longitudinal stability and that he had expended a great deal of thought in trying to obtain it.

Waddington was like a strong man armed against the failures of his forerunners. Several of the main difficulties were satisfactorily smoothed away. When it was required to dive two side rudders in the centre of the boat, were used; the power of these whilst inclined would be more than enough to counteract the righting influence of the vertical propellers. These rudders were not used, however, except when it was required to alter the elevation. For rectifying any fault in the trim too great for the vertical screws to counteract, two small fishtail rudders, placed in the stern and worked mechanically, were used.

The two men who composed the crew were supplied with air stored as stated above, in the bows and stern. The pressure in these compartments was indicated by two manometers, and the supply of air was easily regulated by taps, by one of the occupants. If necessary these air reservoirs could be used as water-ballast tanks.

Very accurate and interesting is the account furnished of this vessel. A conning-tower fitted with look-out glasses was placed in the middle of the upper part, and entrance into and exit from the vessel was obtained through a hinged door, fitting tightly over and forming the top to, the conning-tower. Means were provided for holding communication with vessels on the surface; a small box opening to the sea was fitted inside the hull forward of the conning-tower. A properly buoyed message would be placed therein and the door between the box and interior of the vessel, securely shut. The outer door was then opened and the water allowed to enter, when, by its buoyancy the letter would rise to the surface.

And then as to considerations of safety. Security was given firstly by a continual reserve of buoyancy, and secondly by detachable weights clamped to the keel. The interior was lighted by a strong electric globe placed in the conning-tower.

For purposes of offence two automobile torpedoes were carried, one on each side of the conning-tower. These would be set free from the cradles and the same movement that freed them would start their engines. Besides this a mine of high explosives was placed just behind the conning-tower. This could be released beneath a ship and was either allowed to explode on contact or else could be ignited by an electric current when the submarine boat had put some distance between itself and the vessel attacked. A camera-obscura was fitted in the conning-tower for viewing the surface. The steering apparatus, speed and course indicators were also all placed in a handy position, so that the whole of the working could be accomplished by one man. The other man carried was an engineer and had charge of all the machinery and mechanism, and also looked after the submersion tanks, air supply and electric appliances.

The air was purified by passing over some caustic alkali which absorbed all the carbonic acid resulting from breathing.

By this means, and with the air from the two reservoirs, the boat could remain submerged six hours. The 'Porpoise' was intended by the inventor to be carried on board big men-of-war.

Comments on the above vessel cannot be otherwise than favourable. It must always be remembered when remarking on an invention of this type, that it cannot be judged by the exacting standard of the present day. When, therefore, we consider that the design of this vessel is no less than sixteen years old (and sixteen years is a whole epoch in submarines) we cannot do less than pause to offer a tribute of admiration to the man who could devise a machine so vastly superior to anything that had gone before it. Mr. Waddington's learning was unquestioned; he approached the problem in a scientific manner and instead of drawing a rough plan of what he imagined would make a submarine boat (as has probably been the case with many of the inventions already mentioned), he took the difficulties with which every inventor had to contend one by one, and if not conquering all of them, at least made so great an advance on the devices employed to overcome the same perplexities in former craft, as to leave his name for ever prominent on the list of those who have adopted the subject under discussion as their hobby.

It is illustrative of the tremendous leap forward towards the almost perfect craft of to-day that the following year saw the planning of the French vessels 'Goubet' and 'Gymnote,' the latter of which as is well known, is the prototype of the present day fleet of submarines possessed by or building for our neighbours *d'outre-Manche.*

Prof. Tuck No. II

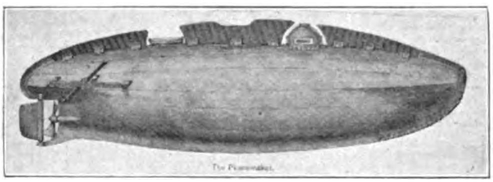
In 1885 Prof. J. H. L. Tuck, of San Francisco, had a second submarine boat constructed by the *Submarine Motor Co.*, of New York. The following description by Lieut. W. S. Hughes, U.S.N., gives all necessary details concerning this craft.[1] He says:

'Peacemaker'

'A submarine torpedo-boat, bearing the suggestive name of 'Peacemaker,' has recently undergone in New York Harbour a series of trials that have excited the curiosity of the public and the interest of naval and military men. This vessel, the invention of Mr. J. H. L. Tuck, is built of iron and

[1] 'Scribner's Magazine,' April, 1887, pp. 435-436.

steel; length 30 feet; width 7 feet 6 inches; depth 6 feet. The crew consists of a pilot and an engineer. The former stands with his head in a little dome projecting a foot above the deck, from which small plate glass windows permit him to see in every direction. Compressed air for breathing is stored in a series of reservoirs within the boat. Not the least notable feature of the 'Peacemaker' is the 'fireless engine,' an invention based on the discovery that a solution of caustic soda can be utilized under certain conditions to produce the heat necessary for generating steam. Side rudders, or deflectors, are placed at the bow and stern, with which, by varying their angle of inclination from a horizontal plane, the vessel is made to dive, or rise to the surface of the water at the will of the pilot. It is designed to approach the enemy's ship under water, and, in passing beneath the latter's keel, to release two tor-



LXI. TUCK'S 'PEACEMAKER'

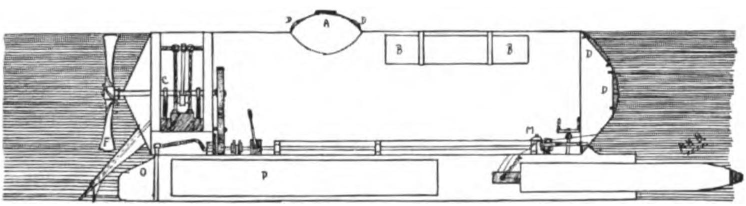
pedoes connected by a short rope. The torpedoes are embedded in cork floats, to which powerful magnets are attached, which cause them to rise as soon as detached from the boat, and adhere to the ship's bottom. Connection is still retained with the torpedoes by electric wires, and after the boat has steamed away to a safe distance, the explosion is caused by an electric fuse. In the recent trials the vessel ran a distance of two and a half miles without coming to the surface, and demonstrated that, although submerged to a depth as great as fifty feet, it was still under perfect control of the pilot. It is proposed by the inventor to make a number of improvements in the vessel prior to the trials soon to take place before a board of army and navy officers at Fortress Monroe.

The trials referred to above did not, however, prove satisfactory, the boat being unable to keep its depth. The speed obtained on the surface was 6 knots and submerged 5 knots. During the experiments the 'Peacemaker' passed beneath the keels of two steamers and approached within 10 feet of a tug without being seen.

Flais

Except the Goubet submarine boats (which will come under the list of modern French vessels which I shall describe by themselves *en bloc*) the invention of Flais is the last one for the year 1885. M. Flais, a French engineer, planned a submarine boat distinctly novel in form. It had a length of 6m. 50 (21 feet circa) and a diameter of 2m. (6.5618 feet).

Submersion was to be obtained by reduction of volume after the principle employed in the 'Nautilus' (Campbell and Ash), and the propeller was worked by a gas engine. The crew would consist of two men. The subjoined plan (Fig. LXII.) from the specification of the inventor will be of service



LXII. FLAIS' PROPOSED SUBMARINE

to show the *raison d'être* of the vessel. It was the inventor's great idea that of all modes of attack, that of the spar torpedo would prove most efficacious, and to this end he fixed a sort of bomb, to be fired by electricity, in the keel, projecting in front of the boat. The contact button for the explosion was at M, within easy reach of the steersman.

The conning-tower was placed at A, the gasometer for gas to work the engine at B B, the engine at C, and look-out glasses at D D. The engines were controlled by a lever N. Air was compressed in the cylinder P, and let into the interior at intervals. A rudder O was placed beneath the propeller F.

Although M. Flais' invention was an engine of some ingenuity and although it was never put to a practical test, it nevertheless was worthy of an experiment. It is to be feared, however, that the explosion of the torpedo would prove as fatal to the attacker as to the attacked; but if the wound caused by the explosion were sufficient to sink the vessel against which it took place, the great difference between the value of the submarine compared to that of the battleship, would make the gain counterbalance the loss, and the victory scored would be worth the sacrifice. But of course the theory is untenable. We hear of the chances of war but here there is only death. Still the extravagance here displayed does not disqualify the submarine. Unfortunately it is this needless exaggeration—for Monsieur Flais could have worked his torpedo without such terrible risk to the operator—which brings forth so much prejudice and opposition to the submarine boat, and is productive in some quarters of a disposition to regard it not as a sound addition to the defence of this England of ours but rather as a means whereby the 'crank' could augment the gaiety of nations, or the French scientist could indulge in wild anticipations of mechanical possibilities which are 'a little bit further on.'

It is interesting to notice how many inventors came running up with new ideas during this year of 1885. No less than eight designs were brought forward either of submarines themselves or their appurtenances, whilst in 1884 six had been the total. These figures illustrate the interest that was now being taken in these sub-aqueous vessels, but what is more striking is a comparison between the vessels designed since 1880, and those designed before that date. '*Plus cela change plus c'est la mêne chose*' does not apply here. We note a jump from absolute failure to partial success. There was only an indefinite something required for men to be able to turn round and exclaim: 'At last the submarine boat has arrived!'

1886 The year 1886 was to witness at any rate a partial triumph for it was then that the 'Gymnote' opened the eyes of sailors as well as scientific men. It is true that whilst submarine navigation had reached the 'definite principle' stage, from which it was impossible to depart and hope for success, yet we find inventors straying away on the by-paths of wild imaginations and getting entangled in the thorny wilderness of the impossible. As late as 1894 we come across such proposals as that of Lacavalerie, which seems to be offered in all good faith, but can only be received with ridicule and as a display of unconscious humour.

R. Watkins

Richard Watkins, an Englishman, proposed a cylindrical submarine boat, with telescopic ends which could be pushed out or withdrawn by screw or hydraulic gear to alter the displacement and thus determine the depth at which it travels. It was to be steered on horizontal and vertical planes by rudders, but could also be manœuvred vertically by operating the ends separately so as to alter the centre of buoyancy.

Propulsion was to be obtained by twin propellers driven by any suitable type of motor, and in the event of steam power being used a sliding funnel would be fitted in the deck. This funnel, as also a glazed conning-tower for the steersman, was to be telescopic. If required for warlike purposes, torpedo tubes could easily be fitted. The bows of the boat terminated in a very pointed cone. No details of interior mechanism are known, but the double sliding hull is of enough interest to make the chronicling of this vessel worth while.

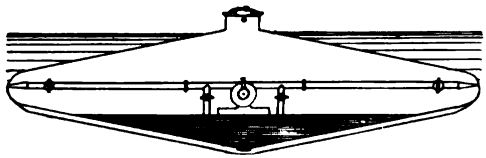
R. Rundle and T. Allen

The invention for which Messrs. R. W. Rundle and T. Allen took out a patent on April 30th of this year (1886) consisted of two air chambers tied one behind the other by a T-iron; and on it a person, attired in a diving dress, would be strapped face downwards. He would then propel it either by using his limbs as in swimming or by rotating a propeller or paddle-wheel. He would be supplied with air when under water from the two sustaining air chambers mentioned above. Steering would be effected either by his legs or a rudder, and by this means he would dive under the hull of a ship and attach a time mine, set to explode after he had made good his escape.

M. Toureau

M. Toureau gave his submarine boat the name of 'Hyponeon,' from the Greek ὑπο = under, and νεων = swimming; it had a length of 7m. 50 (24½ feet circa) and a diameter of 1m. 85 (6 feet circa). The shape, lengthways, was cylindro-conical, and across the centre, cylindrical. The subjoined sketch will give a fairly good idea of the look of this boat.

M. Toureau interests us but he does not convince. Immersion was obtained by letting water into the keel. This water could be ejected if it was desired to rise. An even elevation was obtained by means of a hydrostatic piston, which moved by the pressure of the circumambient water, automatically closed or opened the valve of a receptacle containing liquidfied ammonia gas, which drove the water at once out and thus lightened the vessel, or vice versa. Forward motion was effected by the reaction of water; a tube passed from one end of the vessel to the other and through this water was rapidly driven by a rotary pump, the water being drawn in at one end and forcibly ejected at the other. The boat will then proceed in the opposite direction to the current of water. If it were required to go astern, the pump would be reversed.



LXIII. THE 'HYPONEON' OF TOUREAU

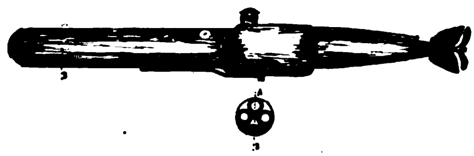
But though this means of progress had the saving grace of novelty it is not one that can be imagined as suitable for submarine craft. It has been tried in surface launches and given a speed of about 7 knots, and therefore 3½ knots is about all that could be expected of the same engines for a submerged vessel having the form of the 'Hyponeon.' M. Toureau's scheme possesses the important quality of originality but whilst being original his invention is rather out-of-date. It would have been a scientific marvel ten years earlier, but it is left too far behind by the inventions of Nordenfelt, Waddington and Goubet to call for serious notice.

A. and L. Brin and L. Chapman

The next submarine boat to claim our attention, was designed by two French engineers, MM. A. and L. Q. Brin, and an Englishman L. Chapman. This vessel (Figs. LXIV.-LXV.) was cylindrical in form up to the engine room and this was elliptical, the stern tapering off from the after-ends of the engine room, to almost a point. The bow was blunt, this form being thought to give less resistance to the water, when in motion.

The rest of the particulars have an interest of their own. The vessel was divided into compartments which were to contain compressed oxygen to effect the combustion of a hydrocarbon either in the cylinders of a vapour engine or in a steam generator. Or the oxygen at a reduced pressure may be supplied to the closed ashpit of an ordinary furnace. The furnace gases could be withdrawn from the smoke-box by a pump which passed them through a pipe outside the skin of the receptacle in which the water vapour is condensed for use as feeder-water, while the remaining gases are ejected into the water outside in such a manner that they are rendered invisible and cannot make known the vessel's approach.

Propulsion was to be obtained by a single three-bladed screw, driven by any suitable engine, whilst the stability *en route* would be regulated by alterations in the water ballast. A sufficient reserve of buoyancy, to make the vessel rise to the surface should an accident occur to the mechanism, was however always present, and the desired depth would be maintained by means of water-jets directed upwards or horizontal rudders controlled automatically by a mercuric pressure gauge.



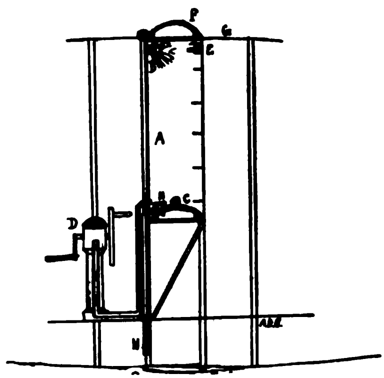
LXIV.-LXV. BRIN AND CHAPMAN'S PROPOSED VESSEL

A telescopic conning-tower would be provided for the steersman and the armament was to consist of three torpedo tubes, placed next to one another around the upper contour surface of the vessel's bows (see sketch). The torpedoes would be fired by compressed oxygen from the engine room; the appended plans will show clearly the form and mechanism of this submarine, and as space is precious it will not be worth my while giving a detailed description of minor attachments.

There are one or two decidedly novel points in connection with the Brin and Chapman submarine boat, and of these the most striking is the form of the vessel. Placing the main engines and all the working parts in a small patch in the middle of the boat is a new departure, and would undoubtedly be conducive to longitudinal stability. The arrangement of the armament too, is out of the common, but it is noticeable that no mention is made of compensator tanks to make up the loss of weight occasioned by the discharge of a torpedo. Nevertheless, this submarine boat is the result of careful study and a thorough knowledge of the required principles, and had these principles been followed more closely in detail we might have heard more of this very interesting vessel.

A. Campbell

In this year also, 1886, Mr. Andrew Campbell produced a design relating to the entrance locks of submarine boats. This was of the ordinary construction but was filled with water from the bilge or ballast tanks and not from outside as is usual, so that the specific gravity of the boat remained unaltered when anyone left the vessel. A longitudinal section of the entrance lock and fittings is appended.



LXVI. CAMPBELL'S WATER LOCK

The chamber A has a door at both top and bottom and means for attaching a diver's signal and air-supply tubes, and is also provided with an electric lamp B, for the purposes of illumination. When a diver is about to leave the vessel he enters the lock through the door C, at the bottom which he closes behind him. He then attaches his air tube and signalling appliances, after which the lock is filled with the water from the interior of the vessel by a pump D, the air escaping by a cock E which the diver opens. When the chamber has been completely filled and air cock E is closed, and the diver then opens the upper door F and steps on to the platform G. On again entering the vessel the upper door is closed and the water allowed to run off through the pipe H into the bilge, the air cock being at the same time opened. This invention, being of but slight importance requires no further comment.

D'Allest

On the other side of the Channel they were never idle. In 1886, M. D'Allest, the famous French engineer, presented his project for a submarine boat. The great feature of his proposed vessel was that it would navigate as well and as fast when submerged as it would on the surface. The subjoined plans (Figs. LXVII.-LXIX.) give one a good idea of this vessel as regards outward form, and for explanation I cannot do better than give an extract from the inventor's specifications.

'Ce bateau, qui affecte la forme d'un cigare de 20 metres de longueur sur 2 de diamètre, est muni à la partie inférieure d'une arête (quoin, keel) creuse formant réservoir étanche (stanch, water-tight) D; la partie cylindro-conique est divisée en trois compartiments par deux cloisons étanches (water-tight compartments) A et B; les deux compartiments avant et arrière sont remplis d'air ou d'oxygène comprimé à haute pression; ils sont reliés entre eux par un tuyau exterieur C; le compartiment central contient l'appariel moteur et le personnel; la partie inférieure D du bateau, qui est, du reste, complètement séparée, contient une caisse à eau douce, une caisse à pétrole, qui est le combustible employé, et enfin offre un volume destiné à être rempli par l'eau nécessaire à l'immersion complête du navire. Le bateau est, en outre, muni de deux gouvernails, l'un vertical, E, qui assure la direction dans le plan horizontal et l'autre horizontal, F, qui assure et règle la profoudeur à laquelle il s'agit de naviguer.

La partie centrale du bateau présente une légère passerelle (foot-bridge) servant de pont, et une coupole, munie de hublots (side lights) et fermée par une porte étanche par où on pénètre dans l'intérieur du navire. Dans la quille (keel) sont placés en guise de lest (ballast), des accumulateurs électriques A, qui sont chargés par une petite dynamo-électrique B, et qui assurent le fonctionnement d'un nombre de lampes à incandesence suffisant l'éclairage.

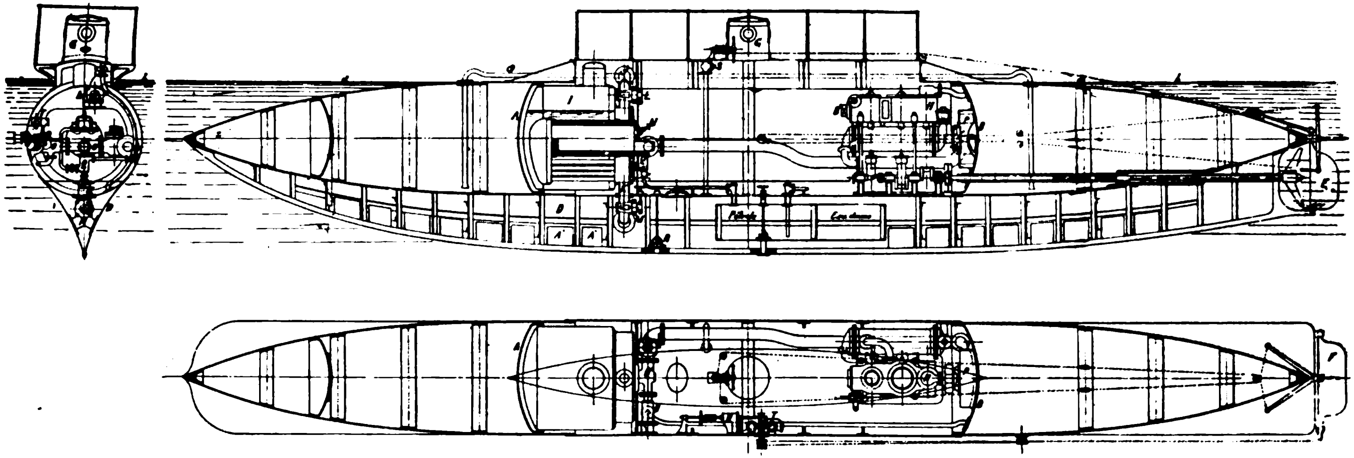
L'appareil moteur est formé par une machine compound à pilon (standard lit: pestle) à condensation par surface, actionnant une hélice et munie de tous les accessoires habituels à ce genre de machine. Cette machine commande également un cylindre compresseur H, qui aspire de l'air à l'exterieur ou de l'oxygène au moyen d'une manche (channel) reliée à une source de ce gaz placée a terre, et le refoule (compresses it) à haute pression dans les deux reservoirs étanches a l'avant et a l'arrière du bateau.

La chaudiere I, est tubulaire et à retour de flammes ; le foyer (furnace) et la boîte à fumée sont complètement fermés et étanches. La boite à fumée et munie de deux cheminées l'une, J, qui aboutit sur le pont du bateau, et l'autre K, qui sort par la partie inférieure ; ces deux cheminées sont fermées par des robinets (plugs) L et M ; sur la devanture (face) du foyer se trouve montés, un brûleur à petrole N, système d'Allest et un tuyau d'arrivée d'air ou d'oxygene venant des réservoirs après avoir traversé un détendeur (detainer, gas check) O, placé dans la chaufferie ; une autre tubulure (tube) O, conduit dans le foyer l'air refoulé par un ventilateur P, le petrole puisé par une pompe dans le caisse d'approvisionnement (reserve tank) et refoule dans un cylindre Q, sous un piston dont la face superieure est en communication avec la mer. Lorsque le bateau navigue à la surface la flottaison se trouve placée suivant la ligne *ab* ; la chaudière fonctionne alors a la façon d'une chandière ordinaire ; le pétrole pénètre dans le foyer avec une pression due à sa hauteur d'écoulement et au poids du piston et de la petite colonne d'eau qui present sur lui l'air soufflé par le ventilateur P, vient brûler ce pétrole, et les produits de la combustion s'échappent par le chenimée J, dont on a ouvert le robinet L.'

The above extract is sufficient to show the principle on which the inventor worked, and his invention was undoubtedly highly ingenious. There are a few more facts with reference to this vessel which are worthy of notice, but as the original description is rather voluminous and this one boat has already occupied considerable space I will continue in English, condensing matters as much as possible.

When the vessel is completely submerged, the pipe L is disconnected and cut off, M being opened instead, this allowing the oxygen necessary for combustion to flow from the reservoirs instead of from the outer air through the ventilator.

When it is required to submerge, the man-hole is clamped down and the cock R is opened ; the compartment D at once



LXVII.-LXIX. THE SUBMARINE OF D'ALLEST

fills with water. The air tap S is then opened and the air escaping from D, allows the vessel to sink gradually. If it is desired to rise again compressed air or the gas formed by combustion expel the water by the tube through which it entered, when the vessel will at once come to the surface. The compartment D can also be emptied by means of a pump worked by the engines, and this failing, a hand pump is available.

The horizontal rudder H for retaining a constant and even equilibrium between waters is worked automatically by a racked bar [1] attached to the hydrostatic valve V.

Air for the crew is supplied in the usual manner from tanks the vitiated air being got rid of by pumps, whilst basins of suitable absorbent matter were disposed about the vessel to rid it of the carbonic acid gas so detrimental to well being.

If it should be so required a coal burning furnace might be fitted in place of that for use with petrol. This vessel we are told, was designed to carry passengers but could if it were desired be easily converted into a war vessel by the addition of torpedo tubes.

Mr. Paul Baron, patented a design of a mixed propulsion engine for submarine boats in which he proposed to employ a gas engine for surface navigation and a motor worked by compressed air when submerged. The surface engine was to acquire its power from calcium carbide in combination with water, an engine known as the hydro-carbure engine. He invented many other things connected with submarine boats, some of which we shall notice later. P. Baron

It is surprising that so little lasting notice relatively speaking (and of course everything is relative) was taken of some of these marvellous inventions. In many cases they had respectful attention, and that was all. The first sensation of novelty had worn away and because an inventor did not at once like our friends in the story books achieve by one miracle complete success and conquer the inner waters the public of the day too often adopted the philosophy of La Fontaine with regard to each new idea.

Quand ou l'ignore ce n'est rien ;
Quand ou le sait c'est peu de chose.

1 'Tige à crémaillère,' Forest and Noalhat.

Lecaudey

Still some amount of interest was excited in the case of M. Lecaudey, a young Frenchman, who designed a boat for life-saving and war-like purposes. It was to be 19 metres (62.337 feet) long, by 5 metres (16.404 feet) in diameter.

The inventor tells us that 'son étambot (stern post) sur lequel sont établis les gouvernails verticaux décrit une pente (slope) de 40 centimètres sur des proportions de 20 mètres de longueur pour permettre d'établir en dedans le drosse (truss) sur la tête du gouvernail sans gêner le fonctionnement de l'arbre du gouvernail horizontal.'

The boat would be immersed by the introduction of water into a reservoir of such dimensions that, when filled, the vessel would be completely submerged.

This could either be ejected with the aid of a force-pump, or else be pumped overboard when the boat had been brought to the surface by means of its horizontal rudders. If the ballast taken in proved too much for the ascensional powers of the rudders, an increase of speed would cause such upward pressure of water on her futtocks [1] as would force her rapidly to the surface. These futtocks should not exceed om. 50, in breadth for a vessel of 20 metres length parting from the bows at zero and ending at zero in the stern. This literal translation from the inventor's specification is a trifle mixed and does not bear in English the same meaning it does in French, but he evidently means that these lee-boards should increase gradually from nothing to 50 centimetres in breadth in the centre of the vessel and again decrease slowly to nothing the other end. These keels would be of the utmost importance for preserving stability the inventor tells us.

The interior of the boat would be made up of:

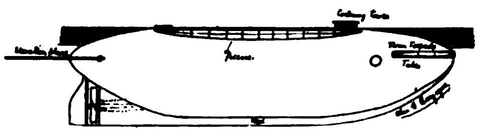
1. The engine room containing an electric motor to work the four-bladed propeller, power being supplied by accumulators.
2. A central passage for communication between the bows and stern parts of the ship.
3. In the bows a torpedo room, a ladder by which the commander might ascend to the conning-tower, at the

1 'Allonges'—futtocks— the middle division of a ship's frame, situated between the keel and the centre line. Here meaning a type of rounded lee-board.

foot of this ladder a pipe by which the ballast water would be ejected.

4. On both port and starboard reservoirs of air would be arranged to renew the atmosphere, and maintain an even pressure in the interior.
5. Two port-holes fitted with strong glass, and large enough to allow of vision over an extended area.

Before turning our backs on Monsieur Lecaudey let it be pointed out that a model of this vessel having a length of 1 metre was tried in the canal at Caen, the experiments giving complete satisfaction to the inventor. [1]



LXX. LECAUDEY'S SUBMARINE BOAT

The next submarine boat we hear of in 1886 comes from Valenza do Minho in Portugal, though the author thereof, M. Cazaux, was a French engineer. His idea was decidedly ingenious although the principle was old. It was founded on the application of changement of volume. The vessel itself had, in outward form, much in common with the 'Goubet II.,' but in the centre of the upper part of the hull projected a globular conning-tower fitted with four lenses or look-out windows. This tower resembled in shape a diver's helmet, and was of a size large enough to admit the head only. Submersion was obtained by the extension or retraction of five oblong reservoirs, like huge dish covers, with their open ends free to the access of the ambient water, at the bottom of the boat. These quaint apparati the inventor called 'ceuillerons.' Besides the five extensible reservoirs, one of which, placed in the centre of the vessel and circular in shape, was for use as a compensating tank, there was a large reservoir destined to contain air at high pressure for the use of the crew. A false keel was fitted for two-thirds of the length, Cazaux

1 The accounts of these trials was published in 'Le Bonhoume Normand,' of November 18th, 1886. This little model was for a long time on view at the house of Mr. Chave, at Paris, where all interested in the subject could go and see it.

beginning a third of the way from the forward end and continuing right up to the stern. Here it formed the support of the horizontal rudder, and in it was cut the screw recess.

This propeller was not, as is the case in the majority of spindle-shaped vessels, placed at the after point of the hull, but rather in the position in which it would appear had M. Cazaux's boat been intended for navigation on the surface. It was actuated by an electric motor, the current being supplied by a number of batteries placed fore and aft in a way to form a staple ballast. Along either side ran a long lateral keel, reaching almost from end to end. The displacement was to be 16 tons. This invention presents several novel features, and of these the most important is the method of submersion. Of all the designs formulated of submarine boats, the means of descent in which were by the reduction or augmentation of volume, this seems the most advanced, though from the plans of the vessel, the amount of space given over to this ingenious device seems exaggerated when compared with the rest of the boat. The lower position of the propeller permits of the engines being placed in a locality more conducive to lateral stability. The design is interesting and not impracticable.

T. Burgal The last design of importance in 1886 was also that of a Frenchman, Thomas Burgal, of Paris. His vessel was to have a displacement of 80 tons, a length of 40 feet, with a diameter of 9 feet 6 inches. He named it the 'Sombreur,' and its most important feature was the torpedo tube in the bows, beneath water, as in the case of the 'Pirabiny' or Ericsson destroyer, now a unit of the Brazilian Navy.

1887 A. Stenhouse and H. Fenoulhet The first invention we will notice during this year, is the propeller guard designed by Messrs. A. Stenhouse and H. Fenoulhet for use with submarine boats. The inventors were granted a patent on January 14th of this year.

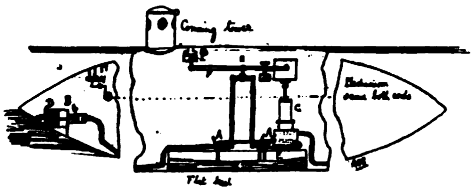
The apparatus consisted solely of bars projecting from the hull and supporting a curved plate which protected the propeller blades from injury through floating wreckage, etc., at sea and from contact with dock walls, etc., in port.

But this invention is trivial and of slight importance and is solely mentioned as being applicable to submarines.

We are of course leaving the 'thin' period of submarine history and getting now in to more crowded streets. The year 1887 was well occupied.

Poore and Storey

These two inventors here named had three main factors in view when designing their vessel. The objects to be obtained were 1st to maintain an even keel, 2nd to rise or fall on an even keel, 3rd to automatically come to the surface should a dangerous depth be attained. A longitudinal section of this vessel (Fig. LXXI.) is shown below. It is maintained on an even keel by ejecting water from a chamber at one end and drawing water into a similar one at the other. Near each end is a small cylinder M which is open to the external water and in which is a piston or diaphragm N. Should the vessel leave the horizontal position the movement of the pistons or diaphragms owing to differences of pressure, through mechanical, electrical, or other means operate a pair of three way cocks, A A, which control the admission and exhaust of water



LXXI. POORE AND STOREY'S PROPOSED VESSEL

under pressure to the cylinders B B. The pistons of these are connected to those of the larger displacement cylinders D D, from one of which water is ejected while it is admitted to the other to bring the vessel back into its original position. The water under pressure is supplied from a pump C, which draws its supply from a tank E into which the exhaust water from the cylinders escapes.

In the above plan pistons are employed in the cylinders M M, which are connected by chains to one arm of a double bell-crank lever H H, the other arms of which are coupled to arms on the three way cocks A A. To raise or lower the vessel water is ejected from or drawn into the displacement cylinders D D, simultaneously. This is effected by a lever F, one end of which is loaded by a spring or weight while the other is coupled to a piston or a diaphragm in the cylinder

P, which is open at one end to the water without. The lever is coupled to a bell-crank lever so that the cocks A A are moved in the same direction; but other means of effecting this may be used. Should the vessel reach a dangerously great depth the movement of a suitably loaded piston opens a cock to eject water from a boiler or other receptacle under pressure to reduce weight so that the vessel immediately rises.

We have reached the end now of how the three great objects were to be obtained, and it only remains to discuss the feasibility of the plans. There is one doubt, however, here—one weak point in the design which cannot be passed over—the pistons or diaphragms. These could never be made sensitive enough to alter the elevation of the vessel instantaneously and the value of the invention can therefore be largely discounted. No means of propulsion is mentioned, nor are we told the way in which the crew were to breathe. These seem important matters and it appears strange that they should have been omitted.

H. Middleton No. I

The invention of Mr. H. Middleton did not lack originality. He proposed no less a thing than flying through the water and the manner in which this seemingly impossible feat was to be accomplished is interesting. Gold, said the great French philosopher is a chimera, and with Mr. H. Middleton's kind permission we must apply the term chimera to some of his fascinating but unconvincing ideas. The vessel was to be either of rectangular or circular horizontal cross-section. The wings by which it was to be propelled were to be so arranged that the direction of their movement could be changed with regard to the centre of the vessel so that they might be employed to propel the vessel either ahead or astern, to steer it, or to raise or depress it. In addition to one or more pairs of these wings screw propellers would assist in propulsion The motive-power engines would be driven by some sort of vapour, which would be evaporated at a very low temperature, even in some cases at the temperature of sea-water. In other cases the necessary heat would be obtained by burning chemicals, which themselves contain all the elements essential to their combustion, or from the exhaust of gun-powder engines which were to be employed to drive the screws to feed the boiler and do other necessary work on board.

Mr. Middleton should make a fortune and name for himself when he brings the details of construction of the gun-powder engines before the yearning eyes of the public. I am sure there are many scientists who would give much to know the manner of their working. I presume the 'other necessary work on board' includes cooking the dinner, scrubbing the decks, etc., etc. The inventor's deductions are so simple, so delightful. To read him seems to be spanning the impossible and makes one feel that a few nocturnal hours of hard thought are alone required to find a means of fluttering up to the further skies.

This invention, or rather shall we say, fantasy, is almost on a par with that of Boucher (1885). We shall yet hear of vessels being softly blown along by liquid air expanded by a compound of cordite and Maximite, with propellers rotated by solar magnetism; the interior would probably be lighted by the collected phosphorescence created by the passage of the hull through the ambient water and the atmosphere freshened by sprays of eau-de-Cologne extracted from the surrounding sea. A circumgyratory periscope, capable of taking in the whole horizon at once, might also be fitted with advantage, while for communication with other boats a system of wireless submarine telephony, effective at any distance, would be found useful.

That such a vessel as the one outlined above has not yet been patented is indeed wonderful. There are inventors knocking about this sad old world who suffer from too much confidence. One wonders if they themselves are convinced of the utility of their marvellous plannings, or is it only paper enthusiasm? We have fallen across designs which if carried into effect would have meant certain death to the operator. Still the amiable and quick witted, if gloriously unpractical theorist, has his niche in the Temple, his place in the social scheme, his right to one blare of the trumpet, for though we are told that 'tout lasse, tout casse, tout passe,' yet it is not so sure at any rate that one wearies of the vagaries of the genial individual who comes breathlessly running up with fancy ideas for regenerating us all.

Some of the inventions are too remarkable for a work-a-day world. If the operators risked their lives in them one questions whether the subsequent proceedings would interest them any more.

We can safely leave them to their dreams while of course remembering that it is often the dreamer, the man of the lone furrow, who is first to find out these things and to make history.

G. Hovgaard

No description of this boat can be better than that of the inventor Lieut. G. W. Hovgaard, of the Royal Danish Navy, fully set out as it is in a booklet published in 1887.[1] He says:

'The essential point of this vessel is that it is able to dive down at any time and continue its course under water for a considerable distance. This is attained by giving the vessel two different modes of propulsion, namely, steam and electricity. The steam power enables it to move along the surface of the water, just as would do most of our modern men-of-war, if we take away their light upper part. When the vessel dives down the electric motors are thrown into gear and thus she may go under the water as long as there is any electricity in her electric storage cells. The cells may be refilled by using the ship's own steam engine as motor, and the electric machines as dynamos.

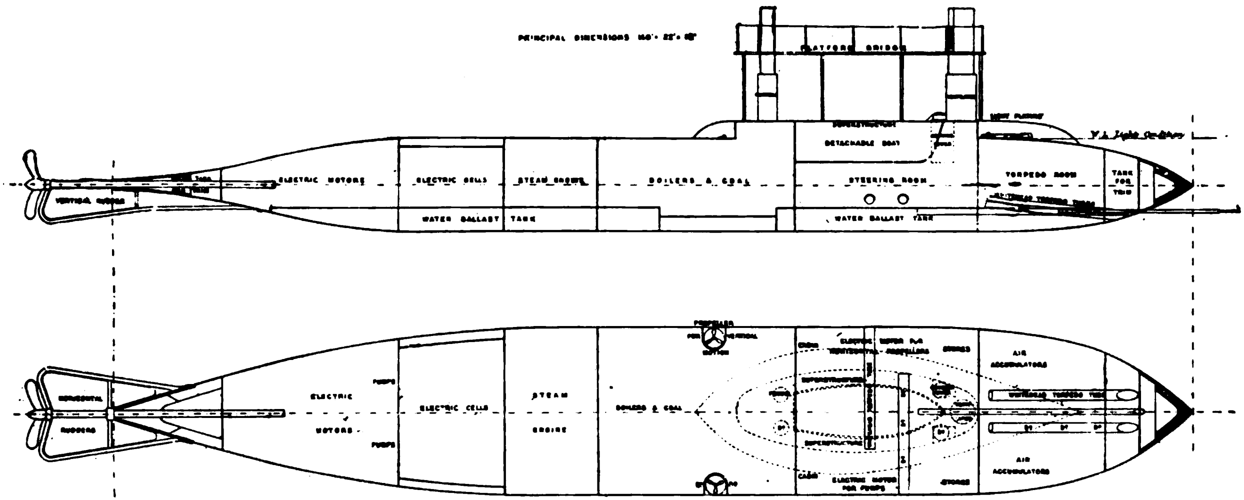
'The transverse section is throughout the vessel an oval with its greatest axis horizontal. This shape has been adopted partly because it is favourable as regards strength, on account of the curved surface, and on account of the small draught of water. The vertical axis has been made just big enough to give the necessary head room, and thus reduce the depth to a minimum; and the breadth is what is required to give the desired displacement and room on the floor for the various fittings. The longitudinal shape is, indeed, very favourable for propulsion, when in the surface condition, which must be regarded as the most important in this respect; but it has to be contended with in view of the other requirements, as explained further on.

'The vertical motion is given by two screws placed amidships of the centre of buoyancy. Horizontal rudders serve to maintain the equilibrium, when at the desired depth.

'The armament consists of two fixed White-head torpedo tubes and one outrigger torpedo all fitted in the stern, and

1 Submarine Boats, G. W. Hovgaard, G. and E. W. Spon, 125, Strand, London, 1887.

SKETCH OF SUBMARINE VESSEL



LXXII.-LXXIII. HOVGAARD'S PROPOSED SUBMARINE

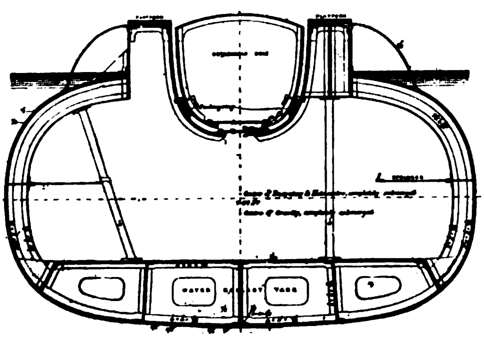
N

two White-head torpedo tubes, one each side in the steering room.

'On the top of the vessel is a superstructure forming part of the hull; it serves to give sufficient depth for the telescopic funnels and the ventilator and for a detachable boat. By this superstructure greater freeboard is also gained when on the surface, corresponding to a given amount of reserve buoyancy.

'In order to facilitate the navigation of the vessel when on the surface, a platform which otherwise rests on the superstructure is raised up well clear of the water.

'In the bottom is a big water ballast tank, and detachable weights are fitted as a sort of bilge-keels, which will also serve to support the vessel when it is resting on the bottom and thus prevent it from heeling.



LXXIV. SECTION OF HOVGAARD'S SUBMARINE

GENERAL STATEMENT OF WEIGHTS.

Hull	410	tons.
Engines, boilers, and spare gear	100	"
Coal	40	"
Electric machinery & accumulators	60	"
Water ballast	60	"
Detachable ballast	20	"
Stores & internal fittings	50	"
Total displacement	740	tons.

'The details of the design may properly be described under the following heads:—

1. The strength and construction, shape and stability.
2. The propulsion and the pumping power.
3. The steering and navigation.
4. The armament.
5. The air-supply and the accommodation of officers and crew.
6. Special fittings.[1]

1.—The Strength and Construction, Shape, and Stability.

Inasmuch as it is impossible to provide sufficient strength to resist the pressure of the water at any depth, there must for every boat be a limiting depth, beyond which she must not go.

'Suppose we want to design a boat for service in the Channel the seaports all round England and in the Baltic, then fifty fathoms would be about all they will encounter in the greater part of those waters.

'Let us then examine what will be the requirements of the structural arrangement in this case. Fifty fathoms—300 feet of water gives a pressure of about 19,200 lbs. per square foot or 8½ tons.

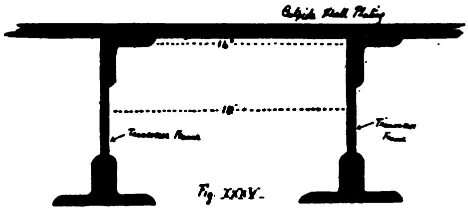
'In order to be on the safe side, the strength of the plating and frames, is everywhere calculated as if they had no curvature.

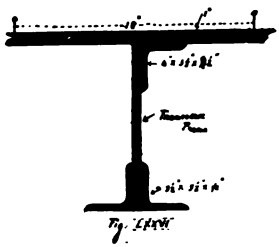
'The frames are put as close together as they can conveniently be worked, say 18 inches, in order to provide not only great local strength but also general stiffness.

'First, as to the plating (see Fig. LXXV.) take a strip one foot wide, and let us assume that no support whatever is given to it by the adjacent material. Let the width of the flange

1 The Lieutenant theorises a great deal in subsequent pages, and although his theories are undoubtedly sound and his methods of working out problems thorough, there is not the space here to quote the whole of his description, much as I should like to have done so. I have, therefore, picked out the essential points and details in construction.

of the outer frame angle be 3 inches, then we have an unsupported strength of the strip 14 inches. Assume the proof stress of the material to be 10 tons per square inch. The load is already given to be 8.5 tons per square foot. Calculating the stress set up by bending this strip, we arrive at a thickness of the plating of about one inch.





PLATING AND FRAME OF HOVGAARD'S SUBMARINE

'Now as to the frames (see Fig. LXXVI.) let us assume a certain frame which can conveniently be worked, say 12 inches deep plate with angles inside and outside of the dimensions shown on sketch; it then remains to find what may be the greatest unsupported length of such a frame, i.e., what must be the spacing of our longitudinals which are to run inside the frames, and distribute the strains from bulkhead to bulkhead and to the system of pillars.

'The frame has all along to carry a strip of plating 16 inches wide, and we assume also here, that there is no support given to this strip by the adjacent frames and strips. Thus the load on the frame will be 1.5 x 8.5 = 12.75 tons per foot run. We assume the frame to be straight and the load to be uniformly distributed. Taking proof stress to be 10 tons, it would be found, that on these assumptions, we may have a length of unsupported frame up to 6½ feet.

'It has already been stated that the shape of the vessel is oval in section; and the reasons for this have been given. This shape is not the best as regards general strength, the cylindrical shape being better in this respect, but, on the other hand, it lends itself readily to pillaring. Suppose we take 8 feet head-room, 3 feet deep-water ballast tank and one foot frame; this will give us a depth of the vessel equal 12 feet, and let the maximum breadth be 22 feet. It will hardly be advisable to make her broader, as we should then get a very flat top and short corners at the bilges.

'The water ballast tank may be built in quite the usual way. Let it be 3 feet deep amidships, transverse frames 3 feet apart, and the longitudinals about 4 feet apart. We cannot very well work the tank closer, but even with this arrangement, it is evident that one-inch plating will be incapable of resisting the assumed maximum pressure. It will be found that only by running extra longitudinal angles and increasing the thickness of the bottom plating to nearly 1½ inches is it possible to resist the maximum pressure. These extra angles may be staple-shaped and worked intercostally from transverse frame to transverse frame.

'As regards the transverse bulkheads, a thickness of ½ inch will be sufficient if properly supported by deep angles. The distribution and number of such bulkheads is seen from the sketch (Figs. LXXII.-LXXIII.).

'No longitudinal bulkhead is introduced except in the boiler room, where it will be desirable to separate the two boilers on account of the forced draught.

'The stem ought to be exceptionally strong, for even if ramming may be regarded as too hazardous for such a vessel, collisions are not unlikely to occur in a boat of this type. The stem should therefore be one big solid steel casting, so as to admit of a most efficient connection to the adjacent plates. These plates ought to be stronger than the ordinary outside plating, say 2-inch.

'The stern will necessarily be a very complicated construction like that of the White-head torpedo. It has to give support for the bearings and pintles of the horizontal and vertical rudders, and at the same time it must protect them. The reasons why it is preferable to place all rudders aft will be discussed further on.

'It has been found through several preliminary designs that if the vessel is to fulfil the above stated conditions as to strength, coal endurance and living space, especially if it is to have both electric and steam power, and a tolerably good speed, it cannot very well be smaller than 7-800 tons, and this gives a length of 140 feet approximately, taking a reasonable block co-efficient.

'As to shape the vessel ought to have fuller lines forward than aft for the following reason:—

'The steering qualities of such a vessel are a most essential matter, for it must be borne in mind that even small variations in the steering in a vertical direction will very soon result in considerable changes of draught, or rather depth of immersion. Contrary to variations in a horizontal sense, to starboard or port, which are as a rule when keeping a course of no consequence if within a few fathoms, a similar variation in a vertical sense, i.e., in draught, may become a very critical matter, as any sailor will admit.

Everything must therefore be done to ensure good steering, by which is meant, not a vessel which will turn round and round willingly as soon as you give her a little helm, without your hardly being able to stop her motion, but a ship which has a tendency to keep the course on which she is at any given instant. The two cases are in a way analogous to stable and unstable equilibrium.

'To obtain such a ship we must do what we do with a rocket, and what nature has done with the birds and fishes—we must give it a heavy fore-body and a long, light and broad after-body and tail. In other words, give her a full entrance, a long fine run, and big horizontal rudders.[1]

'As regards the stability, we must consider this property separately for each of the conditions under which the vessel may have to work. It becomes therefore necessary first to make clear what these conditions are.

'It has been said above that the boat was a 'diving boat,'

[1] It is curious how this form of construction has been followed in the American submarine boats and the French vessels of the 'Narval' type.

which means that under ordinary circumstances she will have a greater or smaller amount of surplus buoyancy, and only when she is going to dive will her displacement and weight be about equal to that of the water displaced when fully immersed. We may therefore speak of a total displacement or immersed condition, and a light displacement and a surface condition. As this design worked out, it was found that the greatest possible variation in displacement was about 80 tons, but of these 20 tons were applied as detachable ballast, and some 20 tons must be carried as ballast in the extreme end tanks, in order to be able to regulate the trim of the vessel when disturbed by consumption of coal or the like.

'Thus, only 40 tons are left. When the first 17 or 20 tons are pumped out, the superstructure will be well above the surface, and a further increase of buoyancy will only very slowly increase the freeboard, although it may increase the stability somewhat.

'It is therefore supposed that the ordinary light condition, that which she would use in time of war, when it is important to be able to dive down quickly, is with about 20 tons of reserve buoyancy, i.e., the superstructure well out of the water. The volume of the superstructure displaces really 17 tons of water.

'In the immersed condition she is absolutely stable all round, and her stability is the same as that of a pendulum 1.07 feet long and of 740 tons weight—1.07 foot is, namely, the distance between her centre of buoyancy, which in a fully submerged body coincides with the metacentre.

'In the surface condition she is absolutely stable all round. The metacentric height is 1.4 foot transversely, and 3 feet longitudinally. If the vessel were made to float with her bottom upwards, she would have a metacentre height of 0.4 foot, but then the centre of gravity will be 0.75 feet above the centre of buoyancy, taking account also of the shift of water-ballast; so that the metacentric height will in this condition be negative, i.e., it is a position of unstable equilibrium.

'These perfect conditions of stability are mainly due to the exceedingly low position of the centre of gravity, which, when fully immersed, lies 0.77 foot below the central axis of the ship, but it is also partly due to the existence of the superstructure.

2.—The Propulsion and the Pumping Power.

'In the present design a combination of steam and electricity is used, namely, steam-power, only in the surface condition and electric-power only in the immersed condition.

'The propulsion on the surface has been considered the most important, and therefore greatest power and weight of machinery has been given to the steam propulsion, and in order to extend the radius of action a considerable amount of coal is carried.

'Thus the steam engine is to indicate 1,400 horse-power in 18 to 19 hours, which would give a distance steamed of about 250 knots, the speed being estimated at between 15 and 16 knots an hour. With reduced speed, say 10 knots, we may expect a distance steamed of about 900 knots.

'The electric motors, on the other hand, will give out 120 horse-power on the shaft for 6 hours, and with a speed of 7 knots we get thus a distance of 42 knots. It must be remembered that 120 horse-power on the shaft will correspond to about 140 indicated horse-power in a steam engine.

'The steam is to be generated in two boilers of the torpedo-boat boiler type, each to develop 700 horse-power.

'The engine is an ordinary compound steam-engine running at 200 revolutions per minute. The screw propeller is placed aft of all the rudders, and is partly protected, as shown in the sketch by the rudder framing.

'Each boiler has a separate funnel and a separate stokehold and fan, so that they are quite independent of each other. The air is drawn from a big ventilator through a passage in the boiler room and then distributed to the two stokeholds. Both the ventilator and funnels are telescopic, and are to be withdrawn before diving; water-tight lids are then placed on top of all the openings. The ventilator serves as the only hatch when the ship is under way. Before diving, the furnaces must also be closed perfectly air-tight, to prevent smoke from entering the stokehold.

'The coal bunkers are to take 40 tons of coal; they are placed in the neighbourhood of centre of gravity of the vessel, so as to cause as little disturbance in the trim as possible.

'The electric power is given off by four motors, of the Rechenzaun type, and as they ought to go with a great number of revolutions for efficiency and room, the motion must be geared down about seven times. The revolutions of the screw at seven knots will be about 90 per minute; and the speed of electric machines should not exceed 650 revolutions per minute on board a ship, in order to avoid excessive vibrations and gyrostatic action.

'The electricity is drawn from a great number of cells, the nature and size of which may be best settled upon by thorough experiments whilst building the ship. When the cells are exhausted, they are filled by means of the ship's own steam-engine, which is made to drive the motors in the reverse direction, as dynamos; the screw propeller is thrown out of gear during this process. That this is possible is one of the great advantages of combining steam and electricity in one vessel. The only condition is that the machines must have a constant magnetic field, in order to charge the accumulators conveniently.

'The cells must be stowed on shelves in such a way that each one of them is easily accessible. The accumulator room must be especially protected against the corrosive effect of the acid which may be splashed about, and particular precautions must be taken to prevent any acid from finding its way into the tank or the bilges.

'The following pumps must be found on board:—As many Downton's or other hand-pumps as can be worked by the hand power available on board; in the present design four.

'At least one powerful independent steam pump and several Friedman's Ejectors.

'The circulating pump must have a separate bilge suction.

But the steam pumps can only be used when on the surface, and it is therefore necessary to fit several other pumps worked by electricity, and, in order to drive them, the available motors may be used.

'The vertical motion (of the vessel when submerging) ought to be produced by means of a force which can not only be destroyed but also reversed almost instantaneously; and not like the forces of buoyancy, require as long time to be destroyed as was required to produce them and again as much time to be reversed.

'This is the reason why propellers are preferable to alterations in displacement. They ought to be placed near the centre of gravity of the ship, so as not to influence the trim, and one on each side; not in sponsons which may easily be knocked off but in cylindrical wells, built in the side of the vessel.

'The two propellers ought to go exactly at the same speed, so as not to produce any heeling, and this may be attained by putting them in mechanical connection with each other.

'In order to be able to produce a sudden and powerful force ot buoyancy in case of emergency, a considerable weight ought to be available as detachable ballast. The ballast ought to be fitted in several pieces, and great care should be taken to make sure that they do not fail when being disconnected.

3.—The Steering and Navigation.

'Now, the suction up and down ought to take place by means of the horizontal propellers only, for reasons already stated above.

It will be a good plan to keep a little reserve of buoyancy when diving, and, like Mr. Nordenfelt, to overcome this by always keeping the horizontal propellers going. This will not only add considerably to the feeling of safety, but will really provide a margin for unforeseen accidents. The desired depth must be kept by the desired action of the rudders and the propellers, the former keep the vessel strictly horizontal, the latter move it up and downwards, according to circumstances, just as in the Nordenfelt boats. Instead of placing the rudders forward as in Mr. Nordenfelt's vessels, it is proposed to place them aft, and to work them indirectly by a pendulum mechanism through an electric motor.

'The horizontal rudders are placed one on each side of the screw shaft, they are turned by the same shaft, and are very large. The centre of gravity of these rudders ought to be brought as far aft as possible, so as to give greater leverage, and to make the steering of the vessel steady. The area of the rudder is in this design 106 square feet; and it has been given the shape of a fish-tail to bring its centre of gravity well aft. By giving the rudder this shape we obtain a good protection of the screw by the framing, which is to surround and protect the rudder.

'A similar principal to that used for the horizontal rudder ought to be applied in connection with the two horizontal screws. Their motion must be regulated by means of a piston, acted upon by a pressure of the water outside, and vibrating about a given position, determined by the load on a lever acting the piston rod. The motion of the piston rod is used to govern the motor, which is here electric, and thus the speed of the horizontal propellers may be increased or diminished, or perhaps they may be stopped, and the motion reversed, according to circumstances.

'As regards the navigation under water, it must be effected mainly by means of the compass, which when properly compensated for the local attractions, will be sufficiently good to keep a certain course, found by observation of at the surface.

'The speed may be indicated by the excellent instrument lately invented by Captain Rung of Copenhagen; it shows the speed at any instant and only necessitates a small tube to be stuck out from the ship's bilge.

'In the top of the superstructure are fitted two conning-towers from which look-out may be kept without exposing any other part of the vessel to the enemy. The steering in horizontal direction is effected by means of an ordinary vertical rudder, placed aft, and well protected by forged iron bars. It is placed underneath the horizontal rudders, so as to be well protected against collisions, etc., and well immersed when the vessel is moving along the surface, and possibly lifting her tail out of the water in pitching. It does not otherwise present any feature of interest. Its area is 38 square feet.

4.—The Armament.

'This vessel is armed with four fixed torpedo tubes, of which two are fitted in the stern to fire right ahead, and two are fitted in the steering room, one on each side to fire athwartships; further, with one outrigger torpedo, which is placed on the end of two telescopic steel tubes, that are to be pushed out for attack by means of compressed air. The outrigger is again withdrawn by means of a chain. A great number of air accumulators are fitted in the torpedo room, from which the compressed air necessary to work the torpedoes is drawn.

5.—The Air Supply and Accommodation of Officers and Crew.

'The air supply is to be stored up in a large number of hollow steel cylinders, of the type now used for the storage of compressed air for filling the White-head torpedoes. Each of these cylinders takes 15 cubic feet of air at 70 atmospheres; they are tested to 150 atmospheres. A total of 36,700 cubic feet at normal atmospheric pressure may be carried in this way. This enormous supply of air is to be used for the torpedoes, and for respiration when submerged.

'By experiments it will be possible to decide whether it is not cheaper and more practical to procure the fresh air by chemical means; at any rate, it appears to be so in theory.

'The total complement of men and officers will be at least twenty. Two officers and two engineers have their cabins in the steering room; the rest of the men must find room for their hammocks in the same compartment, if it is possible, for here the ventilation is best.

'The ventilating shaft is a cylindrical tube, 4 feet in diameter, made of thin plating in two pieces, like the parts of a telescope. It is to be worked up and down either by steel-wire rope pulleys or by some other mechanical method. If otherwise found convenient, the bridge deck may be attached to the lower part of the funnels and ventilators, which then have to move together, but it may be that this will make the closing of the openings more difficult, and it puts a restriction to the height of the bridge deck.

'A separate fan must be fitted to distribute the fresh air to all the various compartments of the ship.

'Electric light ought to be fitted everywhere in the vessel as well as in the detachable boat, which will have its own accumulators for that purpose.

6.—Special Fittings.

'If, in spite of all precautions, the ship should sink to the bottom, without being able to get up again by its own means as might happen by a breakdown of the motors or pumps, or in the case of a great leakage, it must be possible for the crew to escape. This is the reason why a detachable boat ought to be fitted. In the present design it has been placed in the top of the ship, in a hollow built down into the superstructure. The superstructure extends for a length of 32 feet, and has a height above the top of the ship of 2 feet x 3 inches. Thereby we gain head room underneath the boat in the steering room. The detachable boat is designed to stand the same pressures as the vessel itself; it rests on a saddle-shaped packing, against which it is tightly pressed down by means of a number of clips.

'Inside this packing is a circular door in the boat, and a corresponding and smaller one in the ship, arranged in such a way that it is possible to get up into the boat. This done, all the handles on the clips are turned. The water will probably now enter the space inside the packing, and if not, it may be made to do so through a small pipe leading from the outside to this space, and provided with a stopcock. The boat will now have a certain buoyancy, but will hang on in two main clips, placed one at each end of the detachable boat, and in mechanical connection with each other, so that they can only be let go both at the same time, thereby preventing jamming. When these clips are opened, the boat will ascend to the surface. Communication with the vessel, if somebody should be left behind, may be kept up by telephonic connections.

'When the boat comes to the surface, the doors in the upper part are opened. This boat is essentially the same as that in 'Le Plongeur.'[1]

'Two 'conning-towers' or look-out stations are placed in the superstructure forward of the boat, and on the sides of the ventilator. They are water-tight compartments, six feet deep, with small towers projecting beyond the superstructure. The glasses are only three inches high, and consist of segments fitted into a cast-iron frame in such a way that the greater the pressure, the greater the water-tightness will be. The whole tower is surrounded by a thin glass shade, inside which the water may circulate; it serves to prevent churning of the water when the vessel is moving along. Water-tight sliding doors must be fitted in the top of the conning-towers, to be closed in case of accident.

'Glass prisms may be fitted all over the ship, as to admit the daylight everywhere.

'The superstructure is surrounded by light plating, inside which the water may circulate. This is to prevent churning and breaking of the water, and to permit stowing various gear inside, such as anchors, hawsers, davits, collapsing boats, etc.

'The anchors are worked by a steam-winch placed in the steering room; the cables will have to be shackled out when not in use in order to allow the hawse-pipes to be closed water-tight.

'Manometres must be fitted, showing the exact depth of immersion.'

This completes the description of Hovgaard's vessel as given by the inventor, and although only sketched to show the general idea of a submersible boat, this vessel is vastly superior to many that have been designed with practical intent. He is one step nearer to the solution of a great mystery. This plan being more to demonstrate the constituents necessary to make up a submarine vessel, it would be churlish to pick to pieces and endeavour to find fault with it. The Lieutenant has a particularly clear idea of what is required and undoubtedly made a study of the question of submarine navigation in all its branches. One is convinced of his erudition on all details and one can follow his reasoning with admiration.

1 See Bourgeois and Brun. Part I.

Decidedly he is not in that class of theorists who do not hesitate to run counter to scientific facts in order to prove (on paper) that they have found the key of discovery; they only impede the general advance.

The cost of the vessel including the expense of the unavoidable great number of experiments, was to be about £50,000.

One would much have liked to have seen a working model of this submarine constructed, for even if it had been unsuccessful I think there is very little doubt but that experiments therewith would have been of the utmost utility in future researches on the subject.

Nordenfelt and Garrett No. IV

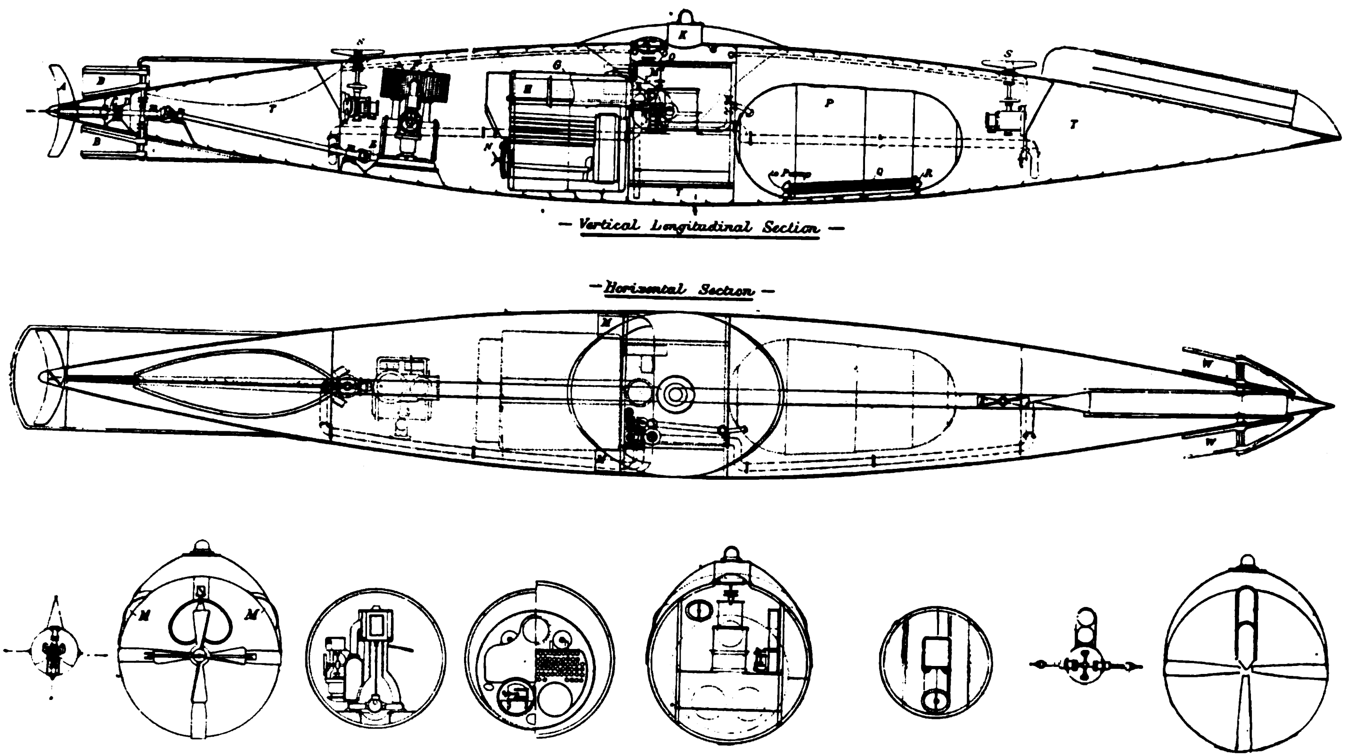
In 1887 the Turkish Government purchased two vessels built at Chertsey to the designs of Messrs. Nordenfelt and Garrett.[1] These vessels,[2] called 'Abdul Hamid' and 'Abdul Medjid,' have the following dimensions:

Length, 100 feet
Beam, 12 feet
Draught, 5.3 feet
Displacement, 160 tons
I.H.P., 250
Speed, 11 knots
Coal, 8 tons—900 knots at a moderate speed
Complement, 24
Torpedo tubes, 1.

The engines are of the ordinary surface condensing compound type, with two cylinders, and are estimated to indicate, at a pressure of 100 lbs. of steam, 250 I.H.P. There is nothing particularly to remark about these engines, except that the circulating and air pumps are worked by a separate cylinder. The main engine is thus left free to work or not, while vacuum is always maintained to assist, the various other engines with which the boat is fitted. It may, however, be noticed that all the engines in the boat are specially designed as regards the valve arrangements, etc., that the utmost use may be made of the vacuum. In respect to this, it may be mentioned that

1 For many of the particulars and illustrations of this and other Nordenfelt boats I am indebted to the Editor of the 'Engineer.'

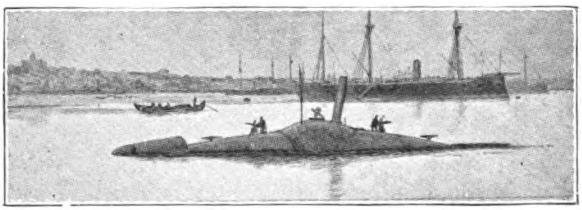
2 There is some doubt as to whether both these vessels were completed.



LXXVII.-LXXXVI. NORDENFELT AND GARRETT'S TURKISH BOATS

By favour of the 'Engineer'

experience has shown that during the submarine operations as much power is developed below the atmospheric line as above it. The boiler marked G in the longitudinal section is of the ordinary marine return-tube type. It has two furnaces, and the heating surface is about 750 square feet. A novel feature about it is, however, that after the products of combustion have passed through the tubes, they again pass through a large pipe marked H in the steam space of the boiler before they reach the funnel. The object of this is threefold: first, the economy of heat and fuel; secondly, to enable the funnel to be as near the centre of the boat as possible; and thirdly, that the inboard portion of the same might be kept the cooler by thus lengthening the passage to it of the heated air. The hot-water cistern is seen at P, and the power to operate all the separate engines during a submarine voyage is the heat

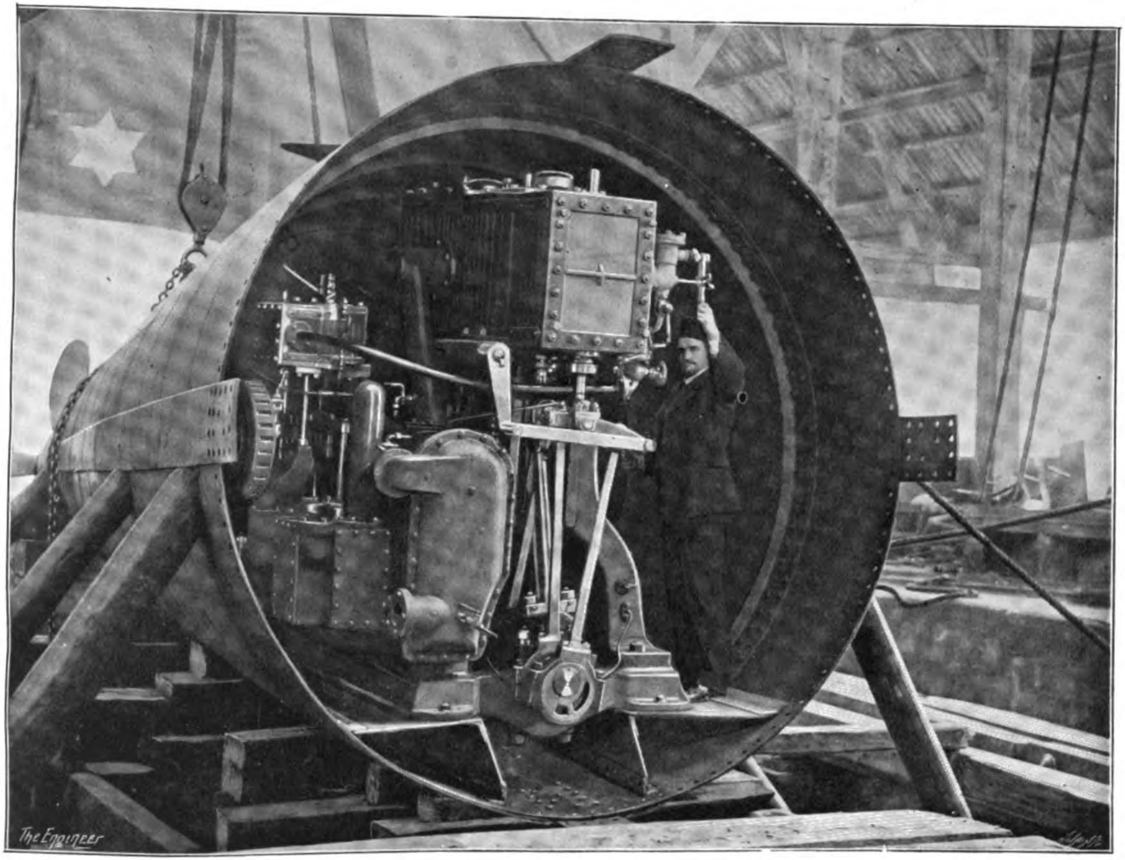


By favour of the "Graphic."

LXXXVIA. PHOTO OF TURKISH SUBMARINE

as previously mentioned, which is stored up in its contents, as also in those of the boiler. In all there are some 30 tons of water, the vapour of which has a maximum tension of 150 lbs. per square inch when the boat is first submerged; and this, with the assistance of the vacuum, is sufficient to drive her from thirty to forty miles without lighting any fire on board or using any air for the generation of heat. The pressure is raised in the hot-water cistern as follows. Live steam from the boiler enters at B a series of tubes which have a superficial area in all of some 500 square feet, and after parting with its latent heat to the contents of the cistern, being then in the aqueous form, is taken off by a small double-acting pump and carried back to the boiler.

The propeller A is placed abaft the rudder B, and it will be noticed that although the shaft is central, working on the thrust block D, the coupling connecting the crank-shaft of the engine E is placed low down in the boat. It is this feature in the arrangement which admits of the use of a marine engine of ordinary type. The engines which operate the vertically-acting screws are of the three-cylinder type. This is in order that there may be no dead centre, as it is highly important that they should start the moment steam is turned on. The steam for these engines passes through a valve of peculiar construction, which is worked by the captain of the boat. By its use he is enabled to vary the speed of the propellers and to stop them, both together or separately, at will, and thus to arrange the depth at which his craft is to operate. As seen in the engraving, the propellers in the Turkish boats are placed in the fore-and-aft line. This is one of Mr. Nordenfelt's recent improvements, these screws in their predecessor having been fitted in side sponsons. In the trials that have so far taken place at Constantinople this alteration has been found to answer very well. Notwithstanding their slight immersion at the commencement of a descent, no jet of water is thrown up as might have been expected, a bubbling at the surface being the only indication that the screws are in motion. It must not be overlooked that this new arrangement materially assists in preserving the horizontal position of the boat, a condition which Mr. Nordenfelt has found, by a long course of experience, to be essentially necessary to the safe manœuvring of any submarine craft. The bow fins W W, upon which the maintenance of the horizontal position also depends, are seen in Fig. LXXVIII. By a very ingenious arrangement of a plump-weight, with other mechanism extending to the conning-tower the action of these fins is rendered both automatic and controllable, and perfect command thus ensured over the movements of the boats, as far as the vertical plane is concerned. To touch now upon the manner in which the Nordenfelt is operated, it should be understood that the boat has two distinct conditions of existence as a torpedo craft—that of a surface boat, and a submarine one. When performing the functions of a surface boat, the air which is sucked into the boat through the conning-tower K, by the fan L, is forced by the said fan into the engine room. From here, having no other outlet,



LXXXVII. THE ENGINES OF THE TURKISH BOAT

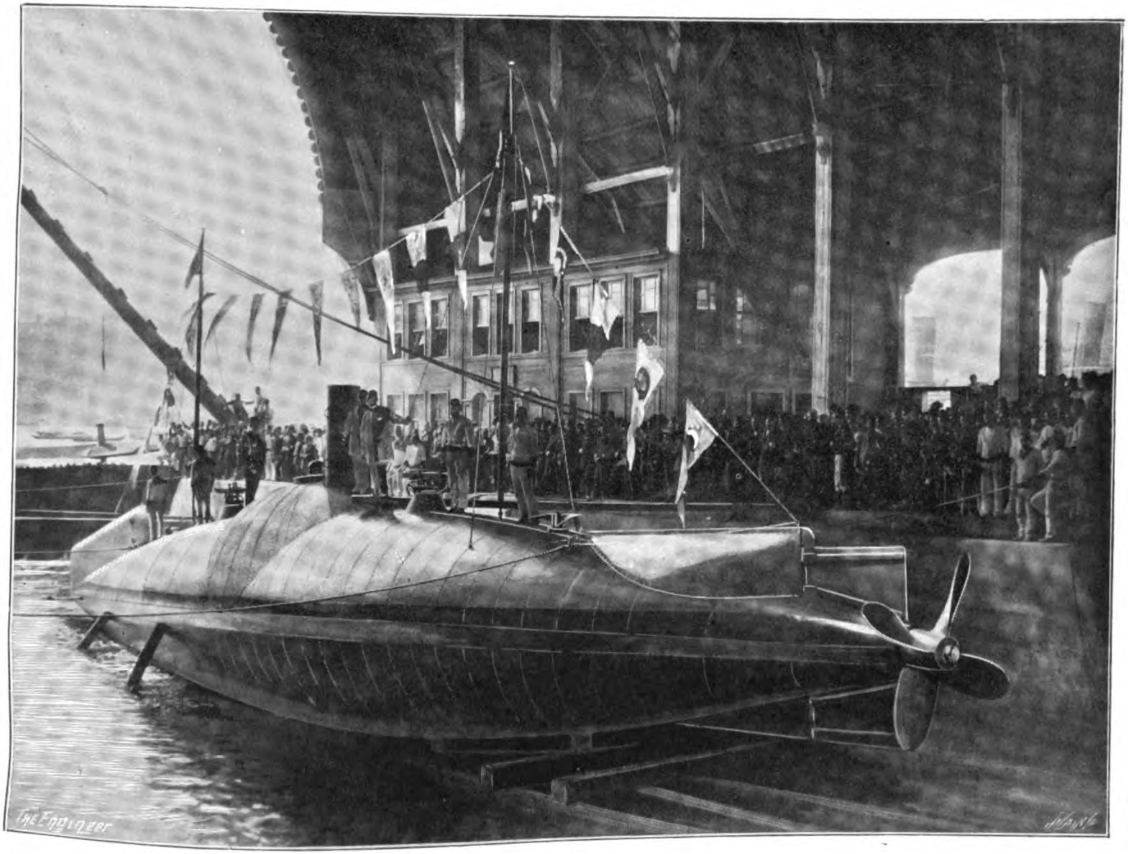
it passes into the furnaces, and after supporting combustion reaches the atmosphere by way of the tube H, as previously described, and the funnel. The connecting link between the inner and outer portions of the funnel M and M 1 is not seen, it should be mentioned in the engraving. In this position with more or less of her bulk immersed, as may be thought necessary, according to the nature of the service upon which she is engaged, the boat can proceed upon voyages only limited in extent by her coal-carrying capacity. This in the Turkish boat is estimated to suffice for the fuel to drive her 900 knots at a moderate speed. The immersion of the boat in her surface condition is regulated by the admission or otherwise of water into the ballast tanks. Of these there are three, one at each end and a third under the centre compartment T T T in the engraving. The two first mentioned contain about fifteen tons of water each, and the central one seven, when the boat is at her proper draught for descending. At this draught there is very little of the craft visible beyond the conning-tower, and knowing even in which direction to look, it is not an easy matter to make her out at any great distance, the eye being unassisted by the ear, on account of the noiselessness of the engines. All those who have witnessed the running of the boat here have been particularly struck with this feature of her performance as also the little disturbance at the surface occasioned by the screw.

Before the boat can assume her condition as a submarine craft, it is necessary to hermetically close the furnaces, which is done by the doors marked N, upon which combustion is soon brought to an end. The piece of funnel connecting the boiler with the outboard portion is then removed, and the doors O and O 1 placed in position, as shown in the engraving. Whilst these changes are being effected, water is allowed to run into the ballast tanks, to reduce the buoyancy to its proper limit, and this arrived at, nothing remains but to close up the conning-tower. The vertically-acting screws may then be set in motion to place the boat quite out of sight, or she may proceed with nothing but the glass cupola of the conning-tower showing above the surface.[1]

The story of this boat is very instructive. Mr. Lawrie, her

1 Extract from 'Engineer,' February 11th, 1887.

engineer, was a man of great coolness and presence of mind; Mr. Garrett, on the contrary, was a somewhat excitable and very enthusiastic inventor—facts which it is well to bear in mind. There were two boats ordered for Turkey; so far as we can gather, only one was completed. We can, therefore, confine our attention wholly to the boat which we have illustrated. Many trials were carried out at the Golden Horn and in the Sea of Marmora. The first attempts to use the boats were failures; nothing could be done with a Turkish crew, and consequently the bulk of the work devolved on Mr. Garrett and Mr. Lawrie, who were aided by a few picked men. It was easily proved that as a boat working near the surface, but not wholly submerged, she was fast, manageable, and a very dangerous foe, because of the difficulty of finding her, and the very small mark which she offered. As a submarine boat she was entirely a failure. She was shaped like a cigar, and had the fault of all submarine boats, viz., a total lack of longitudinal stability. All submarines are practically devoid of weight when under water. The Nordenfelt, for example, weighed by a couple of hundred-weights less than nothing when submerged and had to be kept down by screw propellers provided for the purpose. The Turkish boat was submerged by admitting water to tanks, aided by horizontal propellers, and raised by blowing the ballast out again and reversing the propellers. Nothing could be imagined more unstable than this Turkish boat. The moment she left the horizontal position the water in her boiler and the tanks surged forwards or backwards and increased the angle of inclination. She was perpetually rocking up and down like a scale beam, and no human vigilance could keep her on an even keel for half a minute at a time. Once, and we believe only once, she fired a torpedo, with the result that she as nearly as possible stood up vertically on her tail, and proceeded to plunge to the bottom, stern first. On another occasion all hands were nearly lost. Mr. Garrett was in the little conning-tower. The boat was being slowly submerged—an operation of the utmost delicacy—before a Committee of Ottoman officers, when a boat came alongside without warning. Her wash sent a considerable quantity of water down the conning-tower, the lid of which was not closed, and the submarine boat instantly began to sink like a stone.



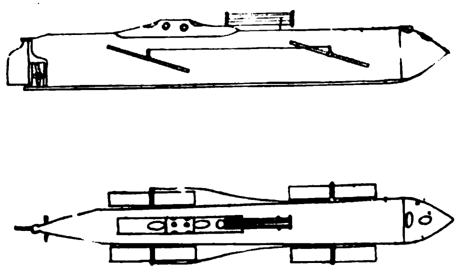
LXXXVIII. THE TURKISH BOAT IN DOCK

Fortunately Mr. Garrett got the lid closed just in time, and Mr. Lawrie without waiting for orders blew some water ballast out. It was an exceeding narrow escape. In spite of these difficulties the Ottoman officers were so impressed that the Turkish Government bought the boat. It goes without saying that it was only with the greatest difficulty the price was extracted from the Sultan's Treasury. But no use whatever has been made of her, and she lies rotting away in Constantinople; unless, indeed, she has found her way piecemeal to the marine store dealers. A paramount difficulty in the way of utilising her was that no engineers could be got to serve in her. If men were appointed they promptly deserted.[1]

The above account is not very encouraging to would-be inventors, but it is perhaps a trifle pessimistic. A feature worthy of notice is the slight disturbance caused by the propellers when in motion.

The design for this submarine resulted from the combined study of Messrs. Noury, father and son, and presents several interesting features. It was to be a steam driven vessel, manned by two persons, and capable of being used either as a torpedo-boat, advance-scout, or submarine explorer. Noury

This vessel was of peculiar form. Its hull was to be cast in whole sections, and was fusiform in shape, long and fine in run, resembling in this the form of the faster species of fish. It had a straight keel and upper surface lines, except towards



LXXXIX.-XC. NOURY'S PROPOSED SUBMARINE BOAT

the bows, which were bent in to a point and resembled the head of the earlier White-head torpedoes. This hull was so weighted that with all its appurtenances, provisions, engines,

1 Extract from 'Engineer,' February 8th, 1901.

personnel, etc., its weight would always be from one-sixtieth to one-eightieth less than the water it displaced when completely submerged.

The two small designs appended show roughly the outward form of this craft.

Horizontal and vertical steering was to be effected by the usual rudders, there being two rudders for movement in the vertical sense placed one on either side of the centre of the vessel, besides the two towards the after extremity.

The vertical rudder was manœuvred by a system which kept the vessel in any direction set by the compass; this system can best be described in the language of the inventor:

'Cette direction est donnée par une boussole (mariner's compass) speciale à alidade (a scale for measuring angles) mobile soigneusement compensée et qui, à chaque écart (digression) accidentel de direction sur le cap choisi, agit par un courant électrique sur la fourche de débrayage d'un appareil à friction, analogue à celui que nous allons décrire pour la régularisation de la profondeur:—

'Cet appareil, veritable gouverneur automatique, est mû par la machine, met la barre a tribord (starboard) ou a babord (port) à chaque embardée (yaw, lurch) avec une extrême sensibilité mieux, que ne pourrait le faire le timonier (helms-man) le plus habile.

'La direction dans le sens vertical, est produite par deux paires de plans directeurs, placés l'un vers l'avant l'autre vers l'arriere.

'Chaque paires de plans directeurs latéraux est montée sur un même axe horizontal passant par le centre de la coque et perpendiculaire a l'axe du bateau. Il est bien entendu que chaque paire de plans est composée d'un plan à tribord et d'un plan à babord.

'En marche ordinaire, l'inclinaison de chaque paire de plans est réglée automatiquement et individuellement par un appareil mécanique et dont l'effet est tel que l'axe de chaque paires de plans est forcé de rester a la profondeur voulue par le capitaine; d'où il résulte une horizontalité constante du bateau dans sa marche. Sans entrez dans des détails par trop longs, disons, que, pour chaque paire de plans, l'inclinaison voulue est obtenue à tout instant par la position d'un piston à ressort (spring-piston) recevant la pression hydrostatique extérieure correspondent sur l'arbre des plans.

'Produisant son action sur une fourche de débrayage qui fait marche dans un sens ou dans un autre l'arbre des plans par le moyen d'un double appareil à friction (cônes femelles marchant en sens inverse l'un de l'autre par le moyen de la machine), il force l'axe de chaque paire de plans à rester à la profondeur choisie par le commandant.

'Il n'y a donc rien de plus facile, pour cet officier, que de maintenir la position horizontale du bateau à tous les mouvements de la submersion.'

Many experiments were carried out with a small model 1.20m. long and 0.20m. wide, whilst in 1882 the appliance was fitted to the steam launch of the Grecian cruiser 'Nauarchos Miaulis,' and during the trials in Phalere harbour proved in every way successful.

The steam for driving the engines was generated in a small tubular boiler, and Mr. Bruant, a lieutenant who took great interest in this invention, considered that at a slow speed this vessel might accomplish 70 kilometres under water.

Air reservoirs would be carried in the bows for the aeration of the interior. They were to be made of soft steel and capable of containing 450 litres at a pressure of 50 atmospheres. This would prove sufficient to supply the men for 2 hours. The pressure of the air was regulated by an aneroid.

The displacement of the boat would be 15.7 tons.

It is curious that in the year when M. Gustave Zédé produced his marvellous creation the 'Gymnote,'[1] there should be so few other inventors come forward. Perhaps it is as well, for it gives to the great genius of M. Zédé a year of improvements.

1888
G. Zédé

Mr. Middleton, the would-be submarine flyer, proposed a means of saving submarine boats should they sink too deep. After a certain depth had been passed, gunpowder was automatically set fire to, the gas thereby generated being used to empty the ballast tanks and bring the vessel to the surface.

Middleton
No. II

The proposed vessel was to have a conning-tower fitted with a camera obscura for observing the surface. Steam, pneumatic, or ordinary guns were to be provided, special propelling-fins

1 The 'Gymncte' will be fully described in Part IV.

employed giving the stability necessary for their use in a submarine vessel.

This vessel would undoubtedly have been a nine-days wonder—certainly curiosity as to it would have died a natural death at the end of the nine days.

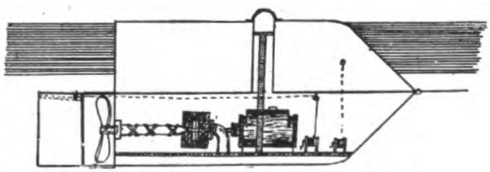
Drzewiecki No. V

In 1888 M. Drzewiecki presented plans of a fifth submarine boat to the Russian Minister for the Navy. This talented engineer recognised that his first vessels had been too small to prove of any great practical utility, and this vessel therefore had a displacement of 150 tons. No particulars are obtainable of this boat.

1889 F. W. Pool

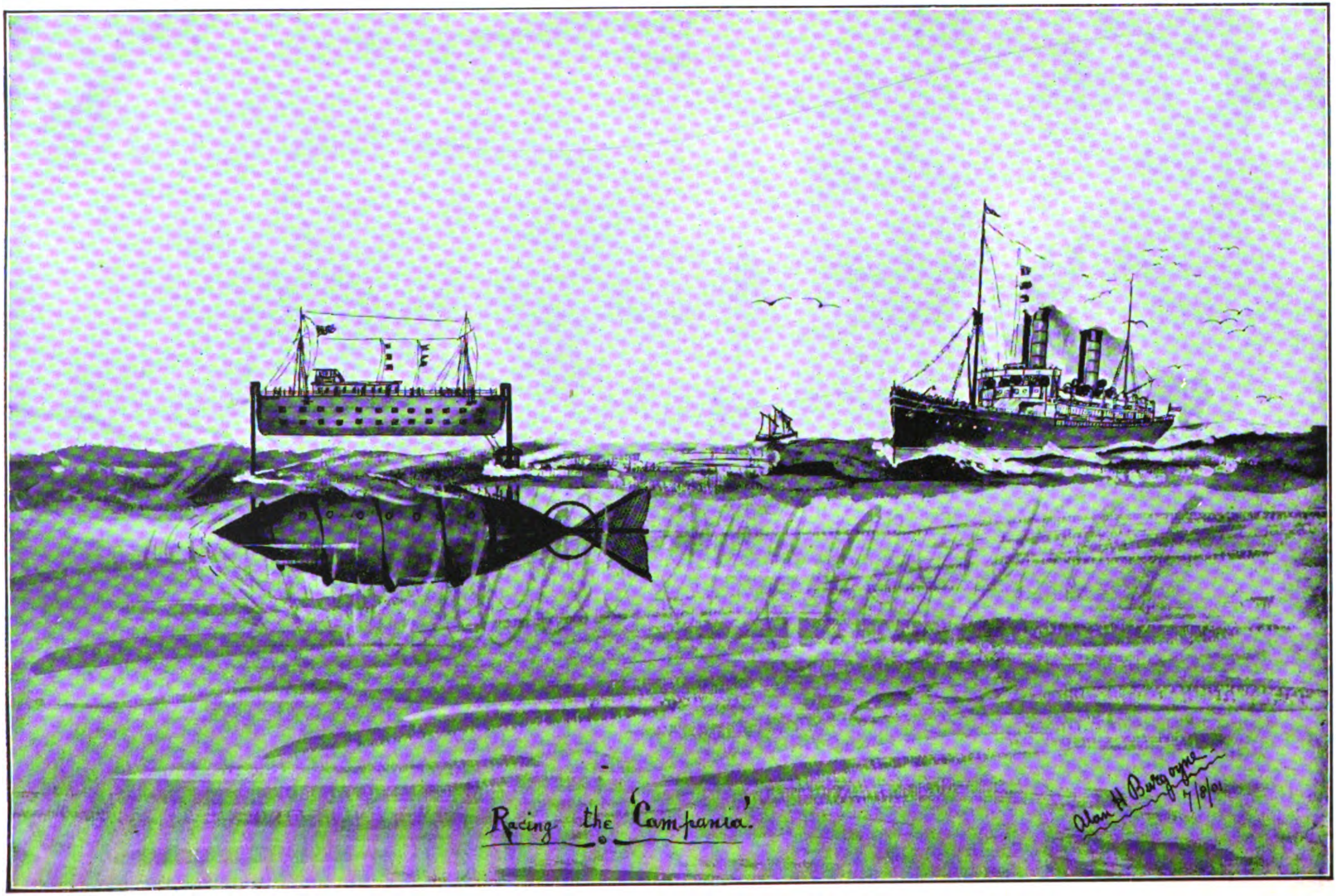
When I described the invention of Mr. Leggo as being the only one designed for both aerial and submarine navigation, the craft for which Mr. F. W. Pool took out a patent on April 25th, 1889, had completely escaped my memory.

As a preface to a short description, I might say that I think the inventor would have done better had he patented his invention 24 days earlier than he did.



XCI. POOL'S AERIAL SUBMARINE BOAT

The hull which was of elliptical section, was to be of steel or any other metal; purely a matter of choice! The bows would be conical and the stern either conical or flat. A horizontal partition would divide the vessel into two equal portions, the upper of which would serve as a buoyancy chamber (or balloon if a flight into the vast unknown were contemplated) while the lower chamber contained the steering and propelling machinery, and was also used as a living room for passengers and crew. A long and thin conning-tower projecting above the upper compartment served as entrance-hatch, coal-shute, baggage-lift and ventilator, and the top of which was covered with a glass dome. The forward motion was obtained by a large propeller placed in the stern; behind this again was an



XCIV. THE APOSTOLOFF SUBMARINE

enormous rudder. An elevation plane of great size was fixed in the bows in much the same way as that of Alstitt.[1]

With so formidable an opponent in the field, a man who seems bent on conquering limitless space 'anyhow,'—Count Zepperlin and M. Santos Dumont will—it is very certain, have to look to their laurels, or they will see Mr. Pool seizing the prize of Mr. Deutsch[2] over their heads in more senses than one. I only have, however, to express one fervent wish, and that is that if ever Mr. Pool soars up into the empyrean I may be spared by a kind fate from being just beneath it when the apparatus alights on Mother Earth once more.

Apostoloff

This inventor considers speed of vital importance in marine transit, and thus designed his vessel to make the trip from Havre to New York in 48 hours, a time of which even the 'Deutschland' with 23.7 knots average all the way might well be envious.

Mr. Apostoloff, a young Russian engineer, took out a patent (through a Mr. Casalonga) for his wonderful vessel in 1889.

His invention, described roughly, is a two-hulled cigar-shaped boat, the outer hull of which being fitted with a gigantic screw-thread revolves rapidly around the inner one, which remains stationary and thus as it were, the vessel screws its way through the water. A stout metal axle runs from end to end and on this is supported the revolving outer shell. From this axle also is swung the inner hull, in which are placed the engines, and which contains the accommodation for the crew.

The idea has claims to attention for it is distinctly novel and indeed it is not altogether impracticable: on June 11th of two years ago (1901) a notice appeared in a certain daily paper (somewhat noted for incredible rumours) stating that 'the Russian submarine boat designed by the engineer, Sakovenko (?), which will be able to cross the Atlantic from England to America in two and a half days, is being built with the utmost secrecy, in a French port. The secret of the extraordinary speed of this boat lies in its peculiarly constructed screw. The boat itself is in the shape of a double pointed cigar.'

It is expected that she will be ready in August next.

1 Page 43.

2 Secured by M. Santos Dumont on October 21st, 1901.

According to this report the Apostoloff, for such it probably is, should be making trial trips about now, and by Christmas time, no doubt, Saturday to Tuesday excursions to the Land of the Stars and Stripes will have been organised. I strongly suspect, however, that the above is but an overflow of wit from an inveterate humorist. It at least makes good reading.

The passengers are to be carried in a glorified boat-shaped railway carriage supported above the surface of the water by two columns. A conning-tower is to be fitted in the stern beyond the revolving part of the hull, which ends about a third from the after end. Two fish-shaped rudders are to be used for steering, one horizontal, the other vertical.

A small model of this invention was constructed and, we are told, proved remarkably successful. At all events experiments with a large vessel of this type are certain to abound in interest. The idea is fascinating but not wildly impossible and is undoubtedly the outcome of much scientific study and forethought.

Cavett

In this year, 1889, Engineer Cavett, of Pittsburg, is credited with having invented the submarine for which R. Watkins took out a patent on January 5th, 1886. According to Mr. Cavett his (?) invention was to have a speed of 20 knots per hour.[1] Such little as is known about it I have given under Mr. Watkins' invention (page 117.)

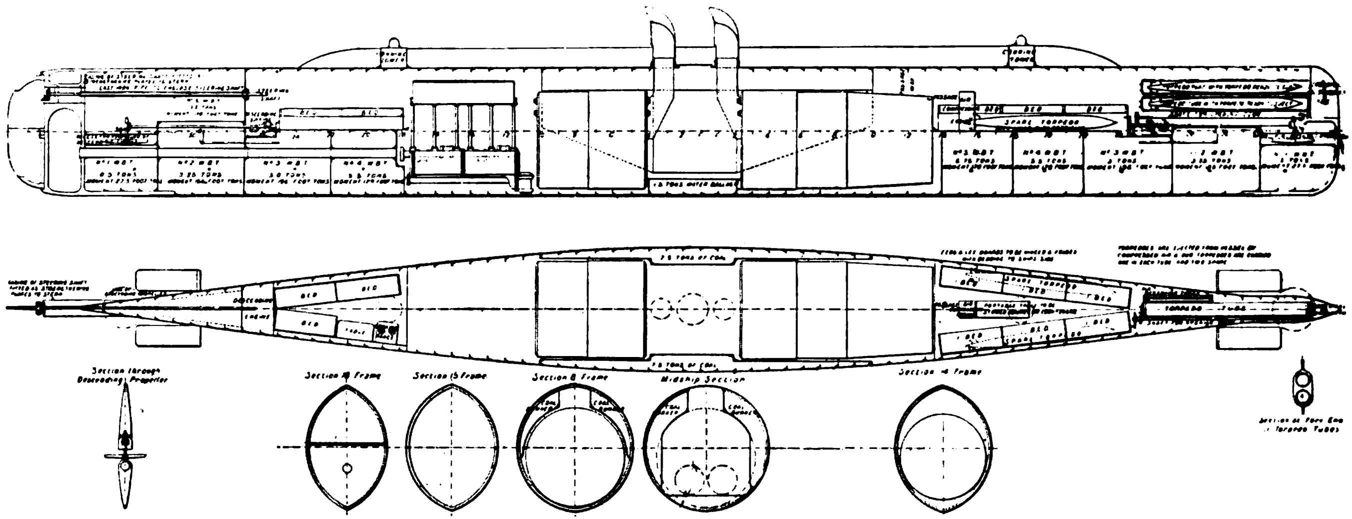
Nordenfelt and Garrett No. V

The last vessel to be described in this second part is Messrs. Nordenfelt and Garrett's most recent and most successful submarine.

Mr. Garrett had four boats built, one for the Greeks, concerning the fate of which we know nothing; two for the Turks, one of which we fancy never was finished, as we have said above; the fourth and by far the most ambitious effort, was the Nordenfelt. The vessel was constructed by the Barrow Shipbuilding Company, and fitted with engines and boilers by Messrs. Plenty and Sons, of Newbury. The Turkish and Greek boats were cigar shaped. This was the worst possible form, as far as regarded stability; the Nordenfelt was 12 feet in diameter, and had each end flattened. The fins attached to the Turkish boat had been found useful, and the flattening of

1 It is quite possible that Mr. Cavett really invented the vessel, and that he got Mr. Watkins to patent it for him, or visa versa.

THE SUBMARINE TORPEDO BOAT NORDENFELDT



By favour of the 'Engineer'

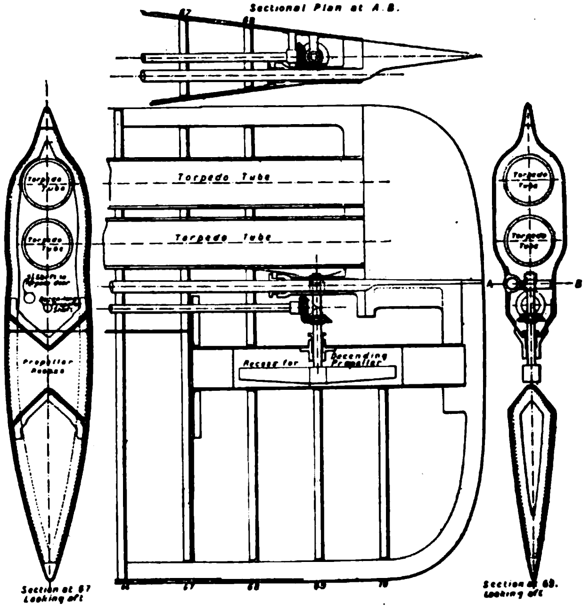
XCIII.-CI. THE RUSSIAN 'NORDENFELT'

the Nordenfelt answered the same purpose; she displaced, when submerged, about 250 tons. The details of her construction will be readily gathered from the longitudinal and cross sections. Horizontal propellers were used to cause her to rise or fall. When she had her water ballast aboard she was usually worked about 200 lbs. light, so that if the machinery stopped she would automatically come to the surface, and bring her conning-towers so far out of the water that her crew could get fresh air. Without any special provision of air she contained enough for a crew of nine men for about six hours. They suffered from nothing but the heat, which rose to as much as 150 degrees The torpedo chamber is seen forward; there were various devices for working fans, discharging torpedoes, etc., but on the whole her mechanism was simple. As a surface boat her engines developed about 1,300 indicated horse-power and she has steamed at 20 knots. When she went below everything was battened down as described for the Turkish boats; and she was then worked by the steam produced from the hot water in the boiler, in a way too well understood to need explanation.

'To all intents and purposes the 'Nordenfelt' was a total failure as a submarine boat. She began badly. As soon as she was launched from the stocks at Barrow it was seen that a mistake had been made in calculating weight, as she was down by the stern, drawing 9 feet aft, and about 4 feet 6 inches forward.[1] This would have been partially rectified by her torpedoes, but she never had one on board. Extra ballast had to be put in forward, and it was always held, rightly or wrongly, that this made it all the more difficult to keep her on an even keel when submerged. The extra weight carried militated greatly against her speed as a surface boat. Another mistake was that the water ballast tanks were too large, or perhaps it would be more correct to say that they were not sufficiently subdivided. When she was in just the proper condition to be manœuvred by her horizontal propellers the ballast tanks were only about three-quarters full, and the water being left free, surged backwards and forwards in them. It must

1 This accident at the launch so affected her designer, Mr. Garrett, that the poor gentleman was laid up for six months with brain-fever.

not be forgotten, however, that ample tank capacity was necessary because the quantity of ballast needed depended on the number of tons of coal and stores on board. Subdivision would, however, have prevented the surging of the ballast water. If, for example, the boat was moving forward on an even keel at say, two knots, if a greaser walked forward a couple of feet in his engine room, her head would go down a little. Then the water surged forward in the tanks, and she would proceed to plunge unless checked, and in shallow water would touch bottom, as she did on the Mother Bank in



END COMPARTMENTS OF THE SUBMARINE BOAT 'NORDENFELT'

the Solent; or, if in deep water, she would run down until the pressure of the water collapsed her hull. No one who has not been down in a submarine can realise their extraordinary crankness. The 'Nordenfelt' was always rising or falling, and required the greatest care in handling.

'It may be said, of course, that the defects of the 'Nordenfelt' might easily be avoided in another boat. Perhaps so; but none the less the fact remains that this rendered the construction of other boats, by the English Government, unnecessary. With the information which she supplied available we can quietly watch the progress of events in France and the United States, the Governments of which countries are now going over ground which we have already traversed.

'It may also be said that the 'Nordenfelt' was a failure because of her construction, but this is not the whole truth. A difficulty remains to be discussed about which we have said little or nothing as yet. In dock the 'Nordenfelt' could be submerged quite easily and safely. On calm days when the water was smooth she was easily enough submerged in the Solent, but it was found impossible to sink her in the Channel without risking the life of all on board.'[1]

With the above description and the appended plans and photographs of the 'Nordenfelt,' I need hardly go into details of construction. She was a brilliant attempt to solve the problem and well worthy of the great genius of Mr. Garrett. As recent events have proved, however, the 'Nordenfelt' was scarcely the last word of the submarines.[2]

It may not be generally known that although Mr. Nordenfelt as a rule receives all the praise for the invention and construction of these four boats, it was in reality Mr. Garrett, the designer of the 'Resurgam,' who proposed and planned them. Mr. Nordenfelt, however, supplied the funds, and with the aid of Captain D'Alton[3] built the vessels. The 'Nordenfelt' attained a speed of 19 knots on the surface and what was most satisfactory presented a surface one-thirteenth that of a torpedo boat of equal length. From this the size of target she made can be gauged, and Captain D'Alton, though disbelieving in submarine boats, considers that submersible vessels or ships level with the water and possessed of an adequate speed have an undoubted future.[4]

Whether this view of the question is correct, time has yet to show. The next few years have many secrets in their keeping, but as matters stand, much information can be obtained from the trials conducted with present vessels.

1 From the 'Engineer,' February 8th, 1901.

2 This last Submarine boat, designed by Mr. Garrett, was intended for the Russian Navy.

3 Captain P. W. D'Alton, Mem. Inst. C.E., superintended the trials of the 'Nordenfelt.'

4 The 'Nordenfelt' was wrecked on the Horne Reef off the Coast of Jutland, on September 18th, 1888, whilst on her way to Russia.

PART III

THE following description of the strange contrivance of Messrs. Barton and Higgins is extracted from the inventor's specification. They patented their design on March 11th, 1890. The vessel contains a stationary charge and is self-destroying but carries a crew for whom means are provided for escaping before the explosion takes place. The vessel is provided with a pointed bow or ram in which the charge is lodged, and the forward part is armoured with a vaulting deflecting-roof in which are a series of look-out holes for the use of the pilot. For the escape of the crew, a steam-launch, tender or life-boat is swung on davits mounted on the after deck, in such a way as to be afloat when the vessel is partially submerged and ready for action.

1890 Barton and Higgins

The submersion is effected by admitting water to a tank. The hull is mostly filled with the boilers and engines for driving the twin propellers which propel the vessel. The charge is fired by a percussion cap or clockwork operated by an electro magnet. The latter is in the circuit of a battery, which is closed by a button or other means located in the pilot house, which also contains the mechanism for starting, stopping and reversing the engines, together with means for lashing the steering wheel. The crew would consist of from eight to ten men.[1]

The above idea is ingenious, but it seems to me that in the event of the launch, by which the escape is to be effected, being pierced by a few projectiles, the chances of the crew seem very limited, whilst the premature explosion of the charge carried in the bows, through the concussion of a shell or the

1 In the specification is described the conduct of an attack and the method of effecting the escape of the crew.

completing of the electric-circuit by accident, would send the occupants of the vessel soaring swiftly to another and perhaps less dangerous world, where battleships are phantasies and Maxim guns unknown.

McDougall Mr. McDougall was granted a patent on March 5th, 1890, for a design of a submersible cargo or passenger steamer.

This vessel is very similar in type to the American whale-back steamers differing from them, however, in principle, by having water tanks by which the submersion can be regulated. It is not intended that this vessel should completely submerge or make submarine trips; it could only sink to the level of the upper decks, and thus escape the heavy wave motion.

The deck is ellipsoidal in form, the bow being spoon-shaped; the rest of the hull is of the ordinary design. This form of hull, we are told, enables the plates to be arranged in straight lines, and to be practically rectangular and of the same dimensions. The plates are riveted to continuous frames with longitudinal braces, the lower part of the hull being strengthened by auxiliary ribs. On these is secured a floor extending from bulkhead to bulkhead, and beneath which are the tanks for regulating the submersion.

Access is obtained to the interior by two turrets placed one at either end of the vessel, and surmounted with decks for the use of the crew. These decks have as an additional support, a number of pipes which are used for ventilating the interior. Beneath the forward turret is placed a boiler which supplies steam to a pump for ejecting the water ballast, while under the after turret is a steam winch, the pipes for which run along directly beneath the deck so that in the event of being frozen in the ice, the heat would be communicated to the exterior and thus free the vessel. A lift or sliding hatch is used for communicating with the various lower decks and the hold.

This vessel does not in reality belong to the subject under treatment, i.e., submarine navigation, but it is interesting as an endeavour to avoid the action and motion of the waves so detrimental to the structure of a ship, and so unpleasant to those forming the passengers and crew.

Mr. McDougall patented a second design on June 12th, 1890.

F. Forest The inventions of M. F. Forest, a celebrated French engineer

(Laureat du Ministre de la Marine et Ingenieur-Constructeur), call for special notice. M. Forest designed several submarine boats and in 1896-97, placed three models differing only in their methods and means of propulsion before the Minister of the Marine, and for them received a prize of 3,000 francs, whilst the Constructional Department kept one of his 'heavy-petrol' motors for trial on a torpedo boat. There is a very excellent description (from which the appended plans have been reproduced) of two of M. Forest's boats in a work devoted to submarine navigation recently published by himself in conjunction with M. Noalhat, a civil engineer.[1]

The first of these proposed vessels (Figs. CVI.-CVIII.) has a length of 30 metres (98.427 feet). The shape transversally is elliptical,[2] longitudinally the form is symmetrical, the two ends being parabolic.

'L'hélice est actionée par trois moteurs montés sur le même arbre et accouplés par des embrayages progressifs et élastiques à friction système Forest, qui permettent d'actionner l'hélice par un moteur, par deux, ou par trois, d'embrayer en pleine marche un ou deux moteurs, ou de les retirer du circuit. Un appareil spécial sert à faire marche avant, marche arrière et à stopper.'

The second design described is of circular form; it has a length of 33 metres (108.27 feet) and a greatest diameter of 2m. 80 (9.1,865 feet); displacement 135 tons.

Immersion is obtained by the introduction of water, and diving is effected by means of a special rudder.[3]

Water is allowed to fill the tanks placed right at the bottom in the centre of the boat; then four horizontal rudders, placed two forward and two aft, are by one movement inclined from the stern forward, and the vessel plunges to the desired depth, by the effect of her forward motion, whilst preserving the while absolute horizontality of axis. The four rudders or planes are fixed two and two on the same bar, movement being transmitted to them through the winch O, in such a way that the angles of incline presented by all four are equal.

1 'Les Bateaux Sous-Marins,' par. MM. F. Forest and H. Noalhat 2 vols. Paris, 1900.

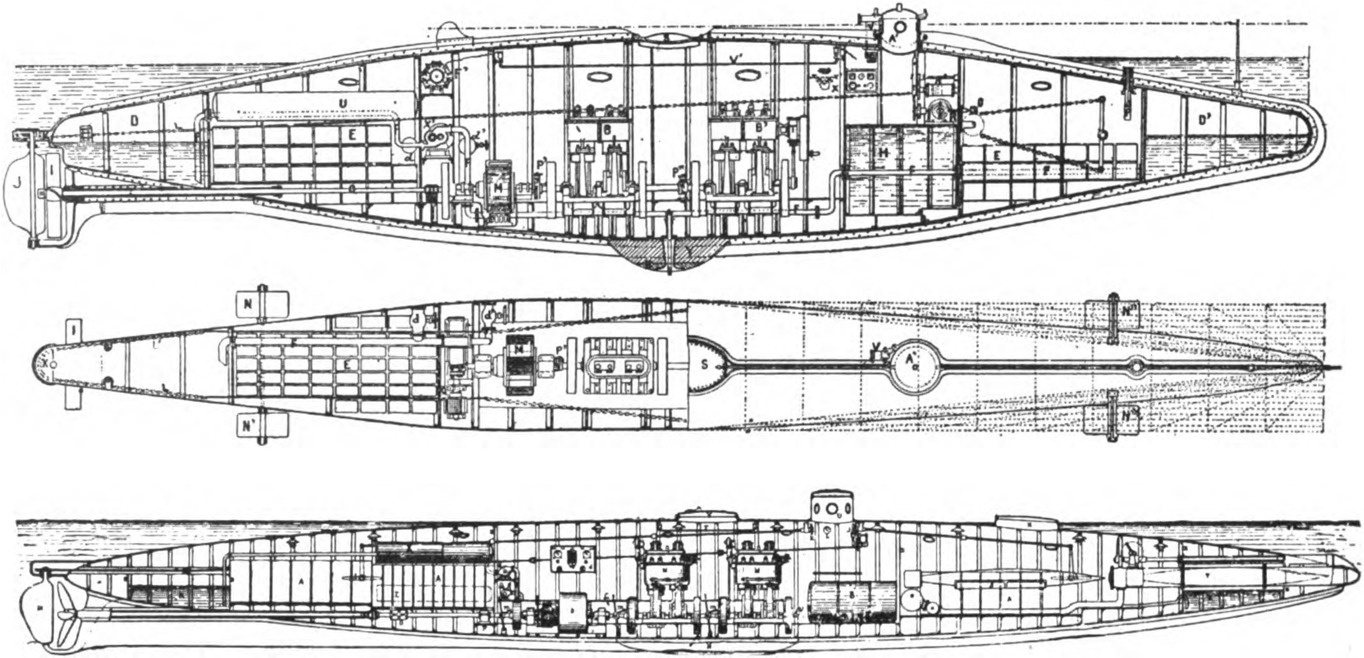
2 This elliptical shape was afterwards adopted in the 'Baker' submarine boats.

3 The following description applies to both types of vessels.

The depth of immersion is shown by a manometer divided up from one to three atmospheres so that the needle may have an ample swing. This manometer is in connection with the circumambient sea, which presses on the diaphragm and this in turn affects the needle showing exactly the depth which the vessel has reached. This needle, when set to a certain depth, completes an electric circuit connected with the submersion tanks which fill or empty automatically should the assigned depth be exceeded. In shallow waters and when the vessel is motionless, vertical stability is maintained by detaching from the hull a heavy weight, which is allowed to rest on the bottom. Horizontal stability when immersed is maintained by changing the amount of water contained in two tanks, one placed in the bows the other in the stern; this is effected by a Greindt rotary pump working the current of water along a pipe connecting the two tanks. This pump is worked by an electric motor. The slightest deviation of the longitudinal axis effects a mercury bath and causes the liquid metal to form a connection, setting the rotary pump in action in the desired direction until the deviation has been counteracted; the mercury then flows back into its bath, cutting off the current, the pump stopping instantaneously.

Vision, when on the surface, is obtained through the conning-tower A, fitted with four small glasses, protected by metal cases. This tower is closed by a moveable cap which furnishes access to and exit from the interior for the crew. The commander steers the boat by a wheel which is placed under the tower. A greater range of vision may be obtained by making use of an optical tube, having prismatic lenses and reflecting discs at the lower end. This tube may be made to project several yards above the surface by means of a telescopic screw tube, working in a stuffing box. When submerged a straight course is kept by means of a Foucault gyroscope, seen at R. The action of the gyroscope tends to keep all moving objects to which it is attached on one set course. A fuller explanation of this apparatus will be given later. A search-light P is also provided for night work.

The air necessary for respiration is compressed in reservoirs U. These reservoirs are made of steel sheet and can bear an interior pressure of between 50 and 60 atmospheres; they are



CVI.-CVIII. FOREST'S PROPOSED SUBMARINE BOATS calculated to last for a submerged run of twenty hours, and also to establish an air pressure in the hull equal to the pressure of the surrounding water at any depth up to 25 metres (82 feet circa), a pressure which could be borne by the crew for a short moment. By this opposing interior pressure, the ambient sea could be prevented from entering the hull should it by some accident become damaged, this forming an efficient safeguard in unlooked for events, such as collisions with submerged wrecks, etc.

As with all serious submarines, a large detachable ballast weight is clamped to the keel; this would be dropped if necessity arose. A manometre for registering the equalization of the interior pressure of air with that of the water without, is also fitted.

The following extract re motive power is interesting:—

'La force motrice nécessaire à la propulsion est donnée par trois moteurs indépendants pouvant être réunis à volonté à l'aide l'embrayages.

1. 'Deux moteurs à hydrocarbures (essense de petrole) B B, système F. Forest et Gallice, dont la force maxima est de 30 chevaux chacun. Les moteurs sont indépendants l'un de l'autre et peuvent être réunis ensemble à l'aide de l'embrayage P, de façon que leur force totale puisse être utilisée à la propulsion ou bien encore l'un d'eux, B par example, étant inactif soit employé à faire fonctionner le compresseur d'air T.

2. 'Une dynamo M de la force de 30 chevaux environ. Cette dynamo à une double fonction; *1st*, celle de recharger les accumulateurs, E E; dans ce cas, elle est disposé pour être génératrice, et la force motrice lui est fournis par un des deux moteurs B, ou par les deux ensemble au moyen de l'embrayages P; *2nd*: d'être une dynamo productive de force pour actionner l'hélice; dans ce cas, elle devient dynamo recéptrice par inversion de courant, les deux moteurs étant débrayés, et la dynamo est réunie à l'arbre de l'hélice au moyen de l'embrayage P.'

'Cette disposition permet, si l'on veut obtenir une maximum de vitesse, d'additionner toutes les forces produites par les deux moteurs B B, plus cella de la dynamo.

'La provision d'essense de pétrole est emmagasinée dans un réservoir.

'Ce réservoir est devisé en un certain nombre de compartiments qu'on laisse se remplir d'eau de mer au fur et à mesure que l'un des compartiments est vidé de petrole, de façon de conserver le tonnage total du chargement.

'Par l'emploi des moteurs à hydrocarbures, on obtient les avantages suivants:

'(1) Mise en marche instantanée, sans perte de temps pour la mise en pression;

'(2) Absense complète de fumée qui décèle au loin la marche d'une embarcation à vapeur;

'(3) Absense de dégagement de chaleur, qui rendrait le sousmarin inhabitable;

'(4) Renouvellement forcé de l'air dans la coque, lorsque le sous-marin en flottaison est actionné par ses moteurs à hydrocarbures, ou par l'un d'eux;

'(5) Emploi d'un combustible riche en carbone, le quel est complètement utilisé, sans résidu. Combustible facile à arrimer sans perte de place.'

'L'emploi de la dynamo comme moteur offre les avantages suivants:

'(1) Elle assure une marche absolument invisible, lorsque le sous-marin est en immersion;

'(2) Elle ne vicie pas l'air renfermé dans la coque, et elle ne le raréfie pas comme le ferait une moteur quelconque, ce qui permet de réduir considérablement le volume d'air comprimé dans les réservoirs et de limiter ce volume aux besoins de l'equipage et de certaines manœuvres;

'(3) Elle n'exige pas de conserver une communication avec l'air exterior, lorsque le sous-marin est en immersion.'

The combined I.H.P. of M. Forest's boat is therefore 90; 4,200 kilos of oil would be carried at a density of 700 kilos to the cubic metre. Each motor of 30 I.H.P. requires 15 kilos of petrol per hour, the two would therefore consume 30 kilos, which would give almost a week at full speed, or about eleven days at half speed, plus ten hours at 30 I.H.P. with the electric motor coupled up.

The inventions of M. Forest are in many respects deeply interesting but his chief claim to notice lies in his theory of propulsion. His hydrocarbure engines have an undoubted value, a value fully recognised by the French Government, who desired that they might be thoroughly tested. The only point to which any weakness can be ascribed is the employment of tanks for regulating longitudinal stability in preference to side rudders, or rather in making water ballast the main factor in preserving an even keel. For the rest M. Forest's boats are what one would expect from so gifted an engineer.

In 1891 we again hear of Mr. H. Middleton[1] who is persistent if not convincing; the third invention for which he takes out a patent is a submarine boat, and it is distinguished from his former invention by being practicable. 1891 Middleton No. III

The vessel, of which no dimensions or form are given, is to be driven by electricity when submerged, and by steam or vapour engines on the surface. Its great feature is the detachable centre compartment which is to contain the crew. This compartment always retains a reserve of buoyancy and can be released from the main hull in the event of serious accident to the latter. It is fixed on a piston which would be pressed out by the ignition of some high explosive, sending the detachable part swiftly to the surface.

This idea is ingenious and practicable, and it is a pity the inventor did not stop here. He goes on with impartial liberality to provide his vessel with vibrating fins with or without auxiliary screws, and tells us that ordinance may be fitted in the vessel with water-tight shields and tompions automatically operated by the recoil.

It was intended that the vessel should be manned by two persons sitting back to back as in the 'Goubet' boats, with their heads in a small conning-tower projecting from the hull.

On September 9th this fertile inventor patented a vessel which would be connected with the shore by a cable and thus require no crew. The current for driving the propellers was to be obtained from batteries on board, the manœuvring only being accomplished by a current from the shore. This boat might carry guns or discharge torpedoes.

The vessel designed by Mr. T. H. Thomas and patented by O. Imray on July 21st, 1891, was not meant to carry passengers, but to work automatically. The subjoined plan gives a good idea of the form of this invention. T. H. Thomas

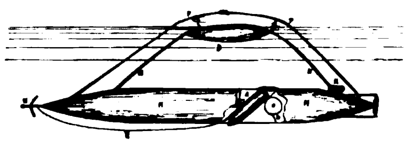
It was designed for carrying and automatically discharging

1 See page 151.

a torpedo, which may be seen at A. The apparatus consists of a boat M M, containing batteries and the electric motor, besides the torpedo mentioned above; this boat is suspended from a float B fixed beneath an arched metal frame N N, joined to the main hull fore and aft. It is controlled from an operating station on shore or ship as the case may be.

The frame N N is protected by two bifurcated arms P P, which are so arranged that should any object be encountered, they close in on the inner frame N N and force the boat beneath the obstruction.

In the stern is fixed a rudder K, which has its spindle connected to a solenöid forming the core of two electro-magnets, by charging either of which the solenöid is moved and the rudder operated.



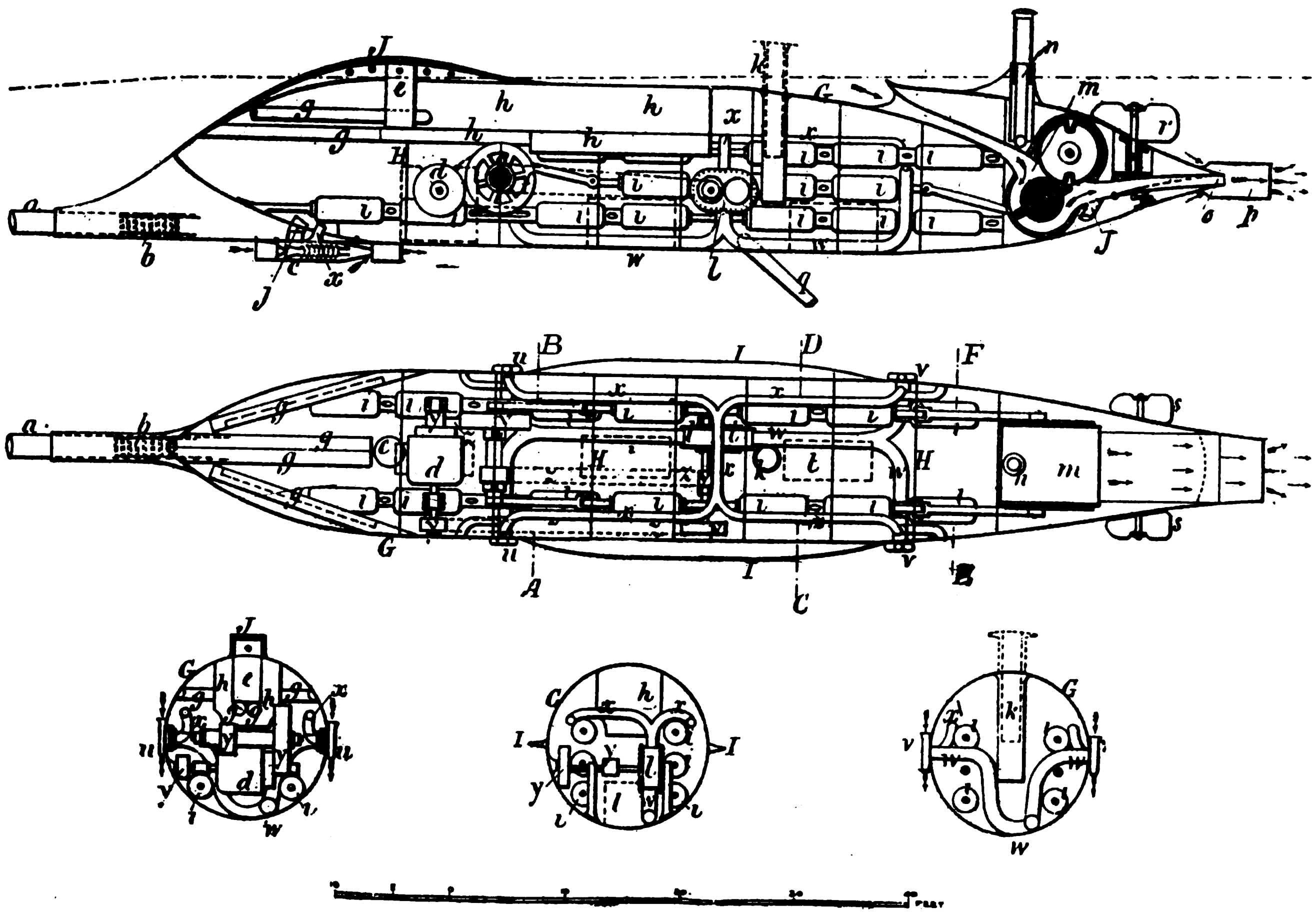
CIX. T. H. THOMAS' INVENTION

The torpedo A is held in its channel by catches connected to a rod. This rod is pushed back by a piston when the boat strikes such an obstacle as a ship and the torpedo is then ejected by a spring plunger, the explosion of powder or any other suitable method. The torpedo then passes down under the torpedo net and the hull of the ship, but is impeded from overshooting the mark by the cord R, so as to explode just beneath the hull. The piston which detaches the torpedo is fixed in the bows at H, and this when striking violently not only discharges the torpedo but also reverses the engines. Signal lamps are fitted on the upper frame P P for directing the course of the vessel at night.

B. de Souza

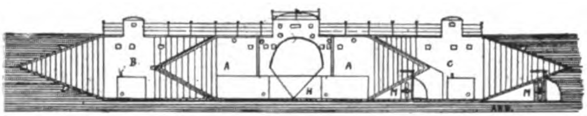
Novelty is a striking feature in the proposed submarine boat of M. Virissimo Barboza de Souza, of Pernambuco.

His vessel, as can be seen by the sketch, was to be made in three portions in such a manner that the ends of the central section A A fitted into the conically recessed ends of the outer sections B C. The attachment of the three hulls was so arranged that in the event of either of the outer sections becom-



CXI.-CXV. SIR G. STRICKLAND'S SUBMARINE. DESIGN I.

ing damaged, the damaged portion could be released without seriously effecting the stability and seaworthiness of the remaining and intact parts or part. Thus the two forward portions B A, or the stern portions A C, or even the centre portion A alone, form complete navigable vessels. The stern and centre sections are each provided with a screw propeller M, whilst each section has a separate conning-tower. The propellers were to be driven by independent engines actuated either by gas, compressed air, liquid ammonia or electric motors, and secondary batteries may also be carried. Submersion was to be obtained by filling tanks fitted at the bottom of each section; the quantity of water in these ballast reservoirs would be regulated by pumps by which means also the horizontal stability would be controlled. A tank H is filled



CX. B. DE SOUZA'S PROPOSED VESSEL

with compressed air to aid the pumps in emptying the ballast tanks and to provide air for respiration. Light is obtained through a large number of square windows fitted in all three hulls, and exit from and entrance to the interior is made through the swing conning-tower of the central section.

The idea of M. de Souza is distinctly ingenious if a little unpractical, and one can imagine the wounded submarine dropping a portion of its hull like a frightened snake throwing off its tail. For taking originality this method of casting away a useless member, would be hard to beat, and as the subject of a thrilling adventure story M. de Souza's boat would gain some notoriety as an idea emanating from a fertile imagination.

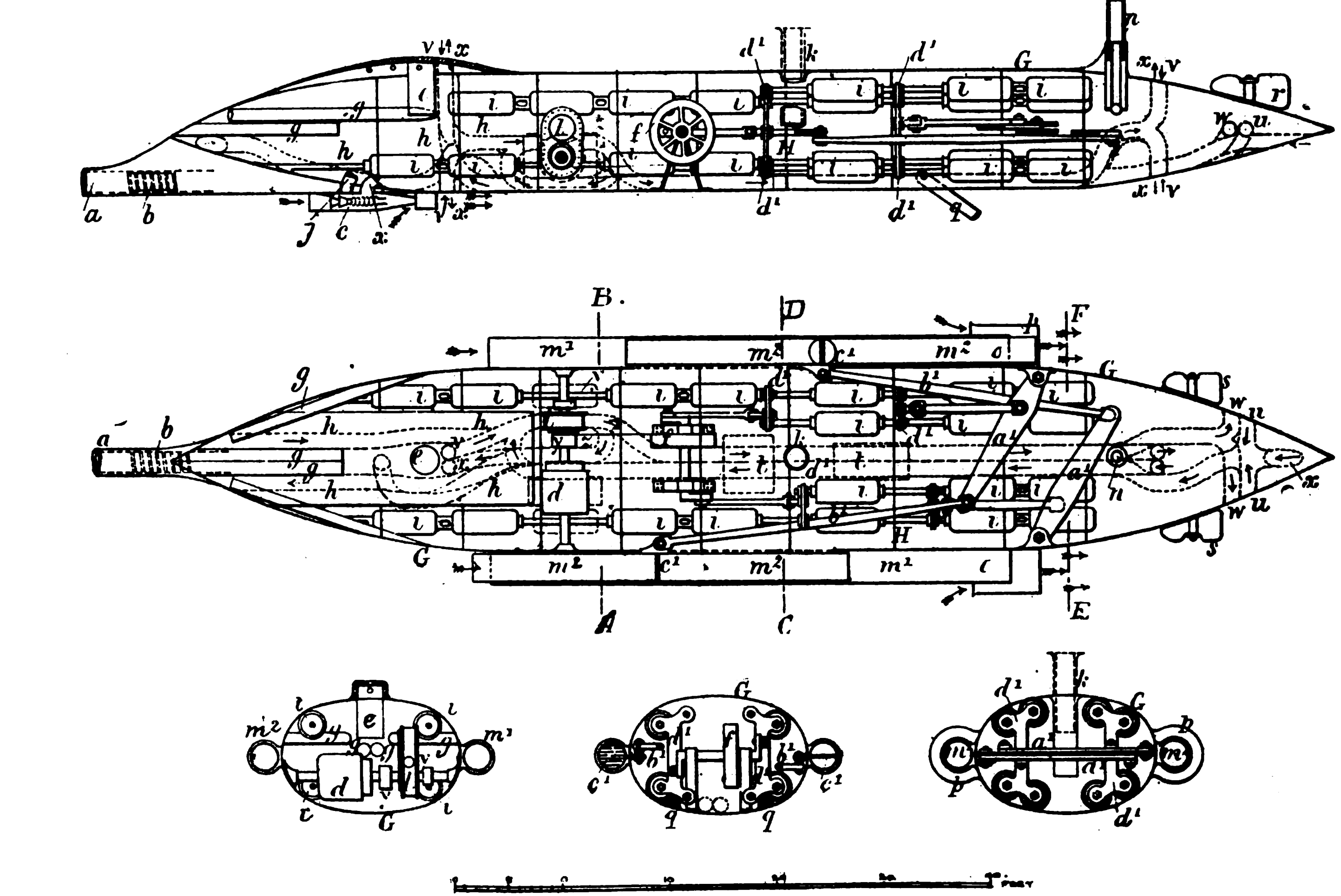
1892 Sir G. Strickland

The first submarine of 1892 which we come across is one invented by Sir Gerald Strickland (Count della Catena, of Malta) a resident of Kendal. The description is extracted from the inventor's specification, from which also the plans have been reproduced.

In a fore and aft line are arranged two or more parallel rows of cylinders, constituting two sets of oil motor engines, the valves for which are arranged so that the several cylinders of each set operate in such different phases as to equalise as much as possible the power developed in each stroke. These rows of cylinders with their connections, constitute as it were, the backbone of the vessel which is virtually a shell or casing of suitable form enclosing them, and the mechanism worked by them. While the oil motor engines are operating, part of this power is applied to work a rotary pump, which may be of any known kind, and of which there may be several so as to effect hydro-propulsion of the vessel. A large portion of the engine power is, however, applied to work a dynamo electric machine for charging secondary or storage batteries. When the vessel is submerged so that there is no supply of air for the oil motors, they are entirely stopped and the dynamo machine is supplied from the batteries to operate inversely as an electro-motor, driving the propelling apparatus. The oil tanks for supplying the engines and the storage batteries are arranged along the lower part of the hull, where they serve as ballast.

Besides the main nozzle or nozzles for hydro-propulsion ahead or astern, other nozzles are arranged which by directing currents of water laterally may affect or aid in steering, or by directing currents upwards or downwards may produce more or less submergence of the vessel. The propelling nozzles are preferably arranged with two or more parallel channels to operate with injector action, so that a current at considerable velocity may produce a current of greater volume and less velocity. The hot products of combustion from the engines are directed through or along tubes or other extended surfaces to generate steam, which is applied to operate as an injector creating a current of water for aiding in propelling or steering laterally or vertically. The exhaust products may, however, be discharged through numerous small holes in the lower part of the hull, so as to produce a jacket of gaseous fluid, keeping off the water and so reducing the resistance due to skin friction. The vessel may have several rods jointed to it with springs, and projecting downwards and forwards from it so as to operate as feelers or buffers, to give notice of their contact with the bottom, or with rock or other obstructions and to deaden the shock.

Sir G. Strickland designed two submarines on slightly differ-



CXVI.-CXX. SIR G. STRICKLAND'S SUBMARINE. DESIGN II.

ent lines, and a detailed explanation of one will serve for both, for although they differ in form of hull, the interior fittings and principles of construction are identical. Figures CXI.-CXV. represent the first type. This has a length of 106 feet (not including the buffer) and a diameter of 15 feet; *i i* are the internal combustion oil motor engines, the cylinders of which are preferably constructed of solid drawn steel and arranged so as to constitute the backbone of the vessel, the shell *g* being suspended around this skeleton by water-tight bulkheads H. The hydraulic jets for propelling the vessel are seen at *p*, these being worked by a suitable pump *m*, which forces a comparatively small current of water at high speed through the nozzle *o* into the nozzle *p*, which is open at the rear end so as to induce a large current at a slower speed through this. The exhaust from the motor cylinders may be discharged through the same ejectors, or may be led forward through pipes *j* provided with non-return valves to an ejector *c* under the bottom of the vessel. The hot air and oil vapour rising from the ejector to the surface along the outer surface of the vessel, are adapted to lubricate the vessel's skin, by forming an envelope of non-adhering bubbles thereon. The oil engines *i i* are coupled tandem-wise in parallel rows, and are designed to develop from 3,000 to 4,000 H.P., the whole of which, however, would only be available when navigating on the surface, when air could be drawn through the trapped air-inlet *n*, fitted with spray-screens and syphon traps. Lateral fins I I and rudders *r s* are provided for adjusting the inclination of the vessel at varying speed, and also to assist in steering for effecting change of direction in cases of emergency. The speed under water will be 5 knots or less; torpedoes are to be discharged from the four fixed tubes *g g*, two right ahead and one sternward each side of the bow. A portion of the crew, when the boat is in action as a torpedo boat, would be provided with a form of diving dress carrying a small supply of compressed oxygen to enable them to leave the vessel on the unexpected introduction of water after sinking at not more than 200 feet, this being the greatest depth at which the vessel can bear the pressure without undue strain. In warfare the vessel would endeavour to enter a harbour or approach a hostile fleet unobserved, by working under water; when as near as prudence permits it would rise to the surface and discharge its torpedoes and would rely on its speed to get out of danger before again submerging. The vessel is conned from a heavily armed turtle backed projection J forward beneath which is a conning platform *e*.

The following reference for the designs of No. I. will be found useful: a—Spring buffer: b—Buffer spring: c—Exhaust ejector: d—Dynamo and motor: e—Conning position: f—Flywheel and pulley: g—Torpedo tubes: h—Crew space: i—Prime motor cylinders: j—Connection of prime motor exhaust with ejectors fitted with non-return valves: k—Exit with telescopic platform to be raised when in harbour: l—Pump for auxiliary propulsion under water and for raising, lowering and steering arrangements: m—Main motor pump: n—Air inlet for supplying engines: o—Main high pressure water outlet: p—Ejector transforming smaller current at high pressure to larger current at lower velocity: q—Sledge runner attachment: r—Perpendicular rudder: s—Horizontal rudders: t—Spaces for electric accumulators: u and v—Auxiliary jets for raising, depressing, propelling and guiding: w—Suction pipes for above: x—Delivery pipes for above: y—Pulleys provided with friction clutches: z—Belts or pitch chain webs.

The following are additional references for the designs of No. II.

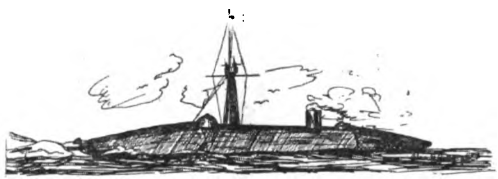
u—Suction inlets for steering: v—Suction inlets for raising, lowering and trimming: w—Discharge outlets for steering: x—Discharge outlets for raising, lowering and trimming: y—Pulleys or friction clutches: a1—Main motor levers actuating reciprocating pump: b1—Rods connecting above with centres of hollow plungers: c1—Throttle valves in hollow plungers opened and shut automatically on change of direction of plunger stroke: d1—Main cross head connecting piston rods of series of motor cylinders m1, m2—Pumps.

Design II. shows a vessel ovoid in its cross section, Design I. being circular; the length is 118 feet, the beam without the suction pipes and pumps m1, m2—17 feet 6 inches, and the height in the centre 11 feet.

There is something very fascinating about this weird invention. Picture for instance its sudden advent some morning crawling up the foreshore of a fashionable watering-place, green with the weeds of the ocean and reeking of the inevitable ozone. What a profound sensation it would create, if not a general panic amongst the residents and visitors, whilst any owner of a facile pen should be able to furnish a fetchingly written little resumé of the inexplicable apparition and supply good matter for an exciting article in the various publications of the following day.

Mr. McDougall, who it is interesting to note, has taken out some dozen patents, chiefly concerned with whaleback steamers, patented on August 19 a design for converting ships of this type into war vessels. McDougall

The decks and cabins are all removed leaving nothing but the hull and the interior fittings. The bow and stern are then heavily armoured with plates and conning-towers also well protected, placed fore and aft.



CXXI. MCDOUGALL'S ARMOURED WHALEBACK

In the centre a strong armoured mast is erected carrying a top mounting small quick-fire guns. The bow and stern are then fitted as gun ports with armoured lids. When going into action the water-tanks would be filled until only the rounded armoured deck, conning-towers and guns projected above the surface, when the vessel would be ready for the combat.

The above vessel belongs to that type of 'submersible' which includes the 'Katahdin' and 'Polyphemus,' [1] but

1 A description of the 'Katahdin' will be found under the year 1893-94. The 'Polyphemus,' a torpedo-ram was launched at Chatham on June 15th, 1881, having been laid down nearly four years previously. She is a low freeboard ship, built of steel, with one funnel and one signal mast. Her dimensions are as follows:—Length, 240 feet; beam, 40 feet; mean draught, 20 feet; displacement, 2,640 tons. Her designed I.H.P. was 3,000 = 16 knots natural draught, and 5,500 = 17.8 knots (trial speed) forced draught. Coal cap. 200-300 tons = 2,600-3,400 miles at economical speed. She has a 2/3-in. steel deck, which protects the engines; these are by Humphreys and Tennant and are supplied with steam by 8 boilers. Armament 6-6 pdr. Q.F. and 2 machine guns; five submerged torpedo tubes. Torpedoes 18. Complement 142.

whereas these were built for the purpose of war and have had very mediocre success although costing large sums of money, Mr. McDougall's war-ships could be constructed in a few weeks time and during peace would be fulfilling their original *raison d'être* of passenger and cargo-ships to the financial satisfaction of their owners. Although 'whalebacks' have long been plying between the various commercial townships of the Great Lakes, it is only recently that they have been proposed for Transatlantic service and from the experiments that have so far been carried out, this type of vessel seems likely to come very much to the fore on account of its great carrying capacity, on a comparatively small displacement. Should the 'whale-back' become general there is no reason why, in the event of war—in which case much of the traffic must necessarily be suspended—these ships should not be converted in the manner proposed, when they would from their invisibility and practical invulnerability (owing to the obliqueness of hits on the rounded armour) be of much service for coast defence.

D. Abbati

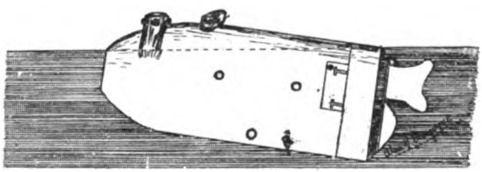
Degli Abbati, an Italian engineer, had no warlike ends in view when he designed the submarine boat 'Audace.' It was rightly named and the Italian inventor had evidently laid to heart the Frenchman's advice 'De l'Audace encore de l'Audace, toujours de l'Audace.' The boat was to make the sea give up its riches, natural products such as pearls, corals, or sponges, or the wealth contained in the various shipwrecked and foundered vessels. It was a grand proposal. With this project before him, the inventor produced a vessel absolutely original and yet perfectly practicable (Fig. CXXII.).

To carry out researches in great depths it was necessary to have a hull well able to bear enormous pressure. After much hard work he produced a vessel 32 metres (104.99 feet) long, fulfilling all the necessary conditions. Unfortunately lack of means prevented him from building a vessel of this size, so a reduced model was designed and constructed. The compromise obtained a measure of success. He named it as already stated the 'Audace' and gave it the following dimensions:—Length 8m. 70 (28.543 feet), beam 2m. 16 (7.0867 feet), height 3m. 50 (11.4831 feet).

Its shape, which was not unlike that of a fish, had been much studied in order to obtain a vessel little given to rolling

The main hull was of steel, and surrounding it was a second hull of the same metal having a thickness of 12 to 23 millimetres. It was so supported and ribbed that an outward pressure of 10 atmospheres could be supported without causing appreciable deformation; thus the 'Audace' could theoretically descend to a depth of 100 metres (330 feet circa). On the forward part of the upper side is a small conning-tower fitted with look-out lenses, and here the commander would stand for steering the vessel. The entrance hatch is a little forward of the centre. On the port side near the stern was a little door by which divers might leave the vessel when submerged. On each side too were placed three glass ports which magnified rays of electric light projected through them and thus aided the diver in his researches.

The 'Audace' is propelled by a small screw and steered by two rudders, one of the ordinary kind and one shaped like a fish-tail.



CXXII. 'THE AUDACE'

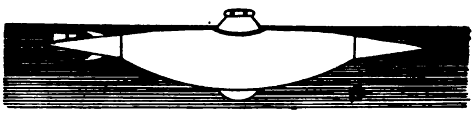
An apparatus for preserving the freshness of the atmosphere is fitted, and also pumps for regulating the depth of submersion. The whole of the work is accomplished by electricity, the lighting included.

The inventor carried out multitudinous experiments with this small boat during the year 1892 in the Bay of Civita-Vecchia, but never descended to a greater depth than 16 metres (53 feet circa). The air supplying mechanism worked splendidly, and at a speed of one yard a second the vessel, we are told, moved without rolling or shaking, as smoothly as a balloon in air (?). During one of these experiments a son of the inventor received a serious injury and the vessel was brought quickly to the surface but not before the perfect working of the vessel had been demonstrated.

This little vessel stands almost by itself and there is none similar in the history of submarine boats to which it can be compared. It shows originality in design, but final judgment as to its utility or otherwise is impossible with the few facts obtainable concerning the fitting of the interior, the means of submersion, the method of obtaining stability, etc. From what can be gathered, however, Signor Abbati spent much time and money on and gave considerable thought to his invention, and although nothing is known of the fate of this vessel, yet it deserves a place amongst the serious and praiseworthy attempts to solve the interesting problem.

J. Auer

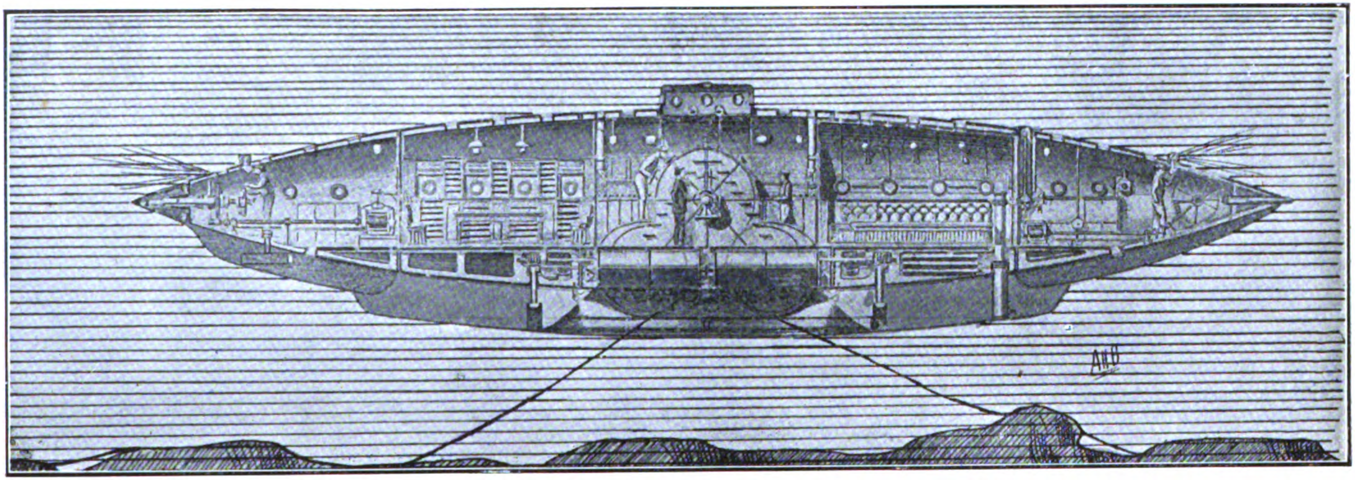
John Auer's proposed submarine boat (Fig. CXXIII) was cylindro-conical in shape, and was driven by electricity. The hull was in three parts, the ones fore and aft forming air reservoirs, that in the middle, twice as long as either of the others, formed the living space and containing all the machinery accumulators and the mechanisms necessary for working the boat. The deck stretched from the bottom of the fore compartments to the bottom of that in the stern and beneath this



CXXIII. J. AUER'S PROPOSED SUBMARINE

was situated the submersion tanks. These tanks were divided into four compartments connected to one another by pipes. They were connected with the ambient sea by swing shutters which from the force of the water without, kept shut. When, however, compressed air was forced into either of the compartments, the shutters opened and the water immediately flowed out, forced away by the superior air pressure within.

When the tanks had been filled, the floatability was reduced to practically nil, and it only required the forward motion of the boat to make the horizontal rudder, placed beneath the propeller cause the vessel to dive. The propeller was rotated by a motor, the power for which was contained in accumulators placed all round the deck in the centre compartment. Safety was assured even if the water could not be forced out of the tanks; a heavy detachable weight was clamped to the bottom and this being released, the vessel would rise quickly to the



CXXV. GOUBET'S PROPOSED 'TOUEUR'

surface. Habitability was obtained by the employment of an air purifier, which besides keeping in check the dangerous gases produced by breathing, was used as a pump for forcing pure air when on the surface, into reservoirs, for use when submerged. A conning-tower fitted with four look-out glasses, and all the necessary air and water gauges was placed in the centre of the boat, and through the moveable top of this the crew or passengers gained entrance into or exit from the interior. A rudder for steering in the horizontal sense was also provided.

Mr. Auer's vessel presents no very novel feature and is only a unit among those numerous inventions which help to make up that long line of submarine boats leading from the earliest time of their conception to the potent weapon of naval warfare of to-day. This boat, however, deserves its position in the history of our subject, and if its structure and purpose of design were to be carefully diagnosed we should no doubt find that it had done its share in the evolution of the modern craft. It is too much to expect every invention to present points of novelty and when one thinks of the variety of ideas that have been considered up till now, one is only too pleased to find the practicable and possible without searching for the novel, which when found, so often turns out to be the impossible.

Goubet

M. Goubet, the inventor of the well-known 'Goubet' boats (see the French submarines) designed a novel cross-channel submarine vessel, which was to commence its Dover to Calais trips on the opening of the Paris Exhibition 1900. The project was not carried out, however. The following paragraphs are by the inventor M. Goubet and explain the method of traction proposed.

'C'est sur des bases, désormais indiscutables qu'ont été établies les études complètes, plans, détails et devis de la transformation du sous-marin le 'Goubet' en toueur sous-marin (submarine ferry boat) se tractionnant sur un câble on sur une chaîne sans que l'équipage ait à s'occuper de la direction pour aller sûrement et sans aléas [1] (risk, hazard), d'un point à un autre, quelle que soit la profondeur à laquelle le sous-marin doive naviguer et la distance qu'il doive parcourir dans ces conditions.

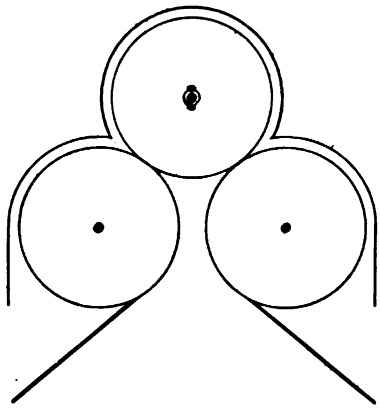
1 An almost obsolete word.

'Les dispositions adoptées pour la construction de sa coque et du mécanisme complet, jusque dans ses moindres détails, reposent sur de multiples observations et des essais nombreux.

'Les raisons peuvent être démontrées très rapidement, après une court aperçu concernant la stabilité du sous-marin.

'Afin de mieux assurer la stabilité, les principaux organes du mécanisme: dynamos ou autres moteurs quelconques, batteries électriques, cylindres—réservoirs d'eau, poulies (pulleys), pompes à air et à eau, etc., sont installés dans le compartiment central.

Les plupart de ces organes les plus lourds reposent au fond du sous-marin; aucun ne dépasse le métacentre.



CXXIV. MECHANISM OF GOUBET 'TOUEUR'

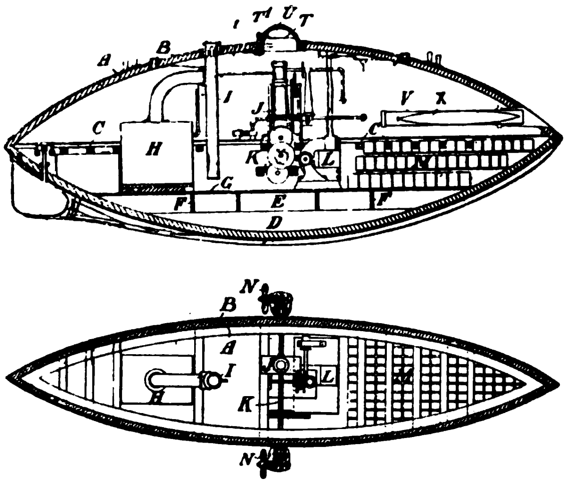
'Le câble vient s'appliquer directement sur les 3/5 de la circonférence de la poulie centrale de commande actionnée par le moteur aux vitesses voulues; l'axe de cette poulie est situé au point d'intersection du grand axe longitudinal et de l'axe transversal au maître-ban. Cette disposition à pour but d'éviter les inclinaisons longitudinales que pourrait subir le sous-marin, si le câble, avant d'arriver sur la poulie centrale, passait préablement sur des poulies fixées à son avant et à son arrière.

'En effet, le câble étant immergé, ainsi qu'un câble télégraphique, sur les fonds inégaux de la mer, présenterait, étant soulevé jusqu'à la ligne suivie par le sous-marin, et ce à chaque instant, des différences de poids soit sur l'avant, soit sur l'arrière proportionnellement aux profondeurs et aux hauts-fonds sur lesquels il repose.'

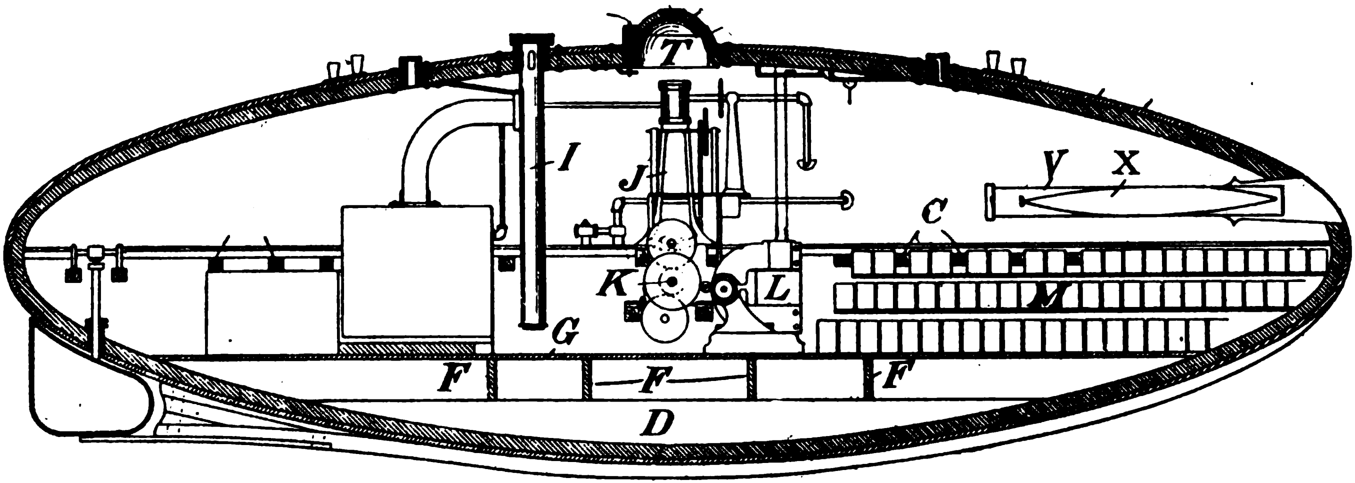
The sketch shows better than can an explanation, the method of propulsion and elucidates the rather hazy description of the inventor. The illustration on the opposite page gives a good idea of the shape of this proposed vessel. In the centre is a conning-tower, but this is only for use on the surface when entering the home-ports, steering when submerged being unnecessary owing to the guiding influence of the cable. Men are placed in bow and stern, however, to look out, by means of a camera-obscura, for any obstructions ahead or any danger astern. A steadying ledge or lee-board runs along each side of the vessel. In the event of the cable breaking an auxiliary propeller would be utilized, the pulley motors being connected to its shaft; a special motor would also be provided. The blades of this propeller were folded into recesses in the stern when not in use and so left a clean run of the hull. A most important feature was the main optical tube (minor ones being provided for the look-outs fore and aft), which was telescopic to such a degree that even when submerged 6 metres or about 20 feet, the top could be projected some distance above the surface of the sea, and revolved so that the whole horizon could be scrutinized, the image received being reflected on to a mirror at the lower end of the tube. Automatically working horizontal rudders were to be provided, the mechanism working them being a special invention of M. Goubet. There was also a vertical rudder although this was unnecessary as the propeller was fixed on a universal joint, giving it greater power than the ordinary rudder, in that force could be exerted in a direction directly at right angles to that in which the vessel happened to be moving. On arriving at either Dover or Calais the 'Goubet Cross-Channel Boat' would move gently on to a truck bearing stocks which just fitted the form of the hull. This truck was to be on rails laid down an inclined way into the sea, and was so arranged that when the submarine had settled firmly thereon, and the motors turning the pulleys been restarted, the truck with its burden would run smoothly out of the sea into the station and stop beside the train, into which passengers could get and mails and baggage be placed without an intermediate change. If the motors were not found to possess sufficient power to haul the truck with the submarine up the inclined plane by means of the cable, a chain might be attached to the forward end of the carriage and a donkey-engine used to pull the vessel into the station. There is something very attractive in the proposal of M. Goubet—perhaps it is the novelty which comes near to romance, perhaps again the neatness and good order of the arrangements, or may be it is the immunity from mal de mer, that spoiler of pleasures so feared by nearly all the fair half of creation and by many of the sterner sex as well. It is to be feared, however, that the cable would be in a constant state of breaking; the drag of the vessel to and fro combined with the *va et vient* of the current must indubitably fray in a very short space of time even the strongest cable in existence, for no texture however durable unless indeed it were of such a size as would overcome the buoyancy of the vessel could long stand the constant rubbing on the ragged inequalities ever present at the bottom of the sea.

G. C. Baker

Mr. G. C. Baker, of Chicago, County Cook, Illinois, U.S.A., was one of the competitors in the competition opened by the American Government for the best design for a submarine



CXXVII.-CXXVIII. THE 'BAKER' BOAT. DESIGN II.

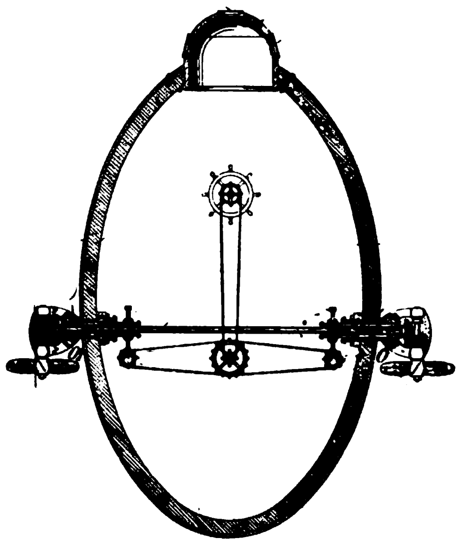


CXXVI. THE 'BAKER' DESIGN I.

boat. He presented two (of which I am able to reproduce the original plans), differing only in outward form of hull. Mr. Baker says:

'In carrying out my invention, I construct the boat upon uniform lines, the general shape or outline of the boat being converged so as to render it pointed or wedge shaped. By the term 'uniform lines' I mean that the portions of the boat above and below a plane passing through its longitudinal centre are in outline substantially duplicates of each other, and the same is true of the portions of the boat on each side of a vertical plane passing transversely through its middle. The vertical diameter of the body of the boat is preferably greater than the transverse diameter, and the proportions which I recommend are that the length of the boat shall be to its greatest vertical diameter as—say—four to one, and its vertical diameter is to its transverse diameter as—say—two to one. The shell or body of the boat may be constructed of wood or metal or a combination of the two. As shown in the drawings, A is intended to represent a wooden shell with a metal sheathing B, but steel ribs may be substituted for the wooden shell and the sheathing may be of boiler or other suitable plate. The interior framework of the boat may be of a simple character as its general form makes it self-bracing. In the drawings I have shown a line of transverse beams C, which suitably brace the sides of the boat and also serve to divide it centrally and longitudinally into upper and lower decks. D, represents a fixed or solid ballast, and E, water compartments with suitable bulkheads F, which furnish the division walls for the compartments and sustain a lower deck G upon which a part of the machinery may be mounted. The permanent ballast is designed to maintain the boat upon an even keel while the liquid ballast is used to assist in the total submersion of the vessel, and suitable provision will be made for withdrawing the liquid ballast when running on the surface.

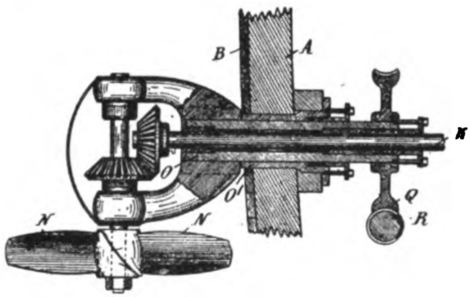
Upon the deck G is placed the boiler H, the smoke-pipe from the furnace of which delivers into the vertically adjustable smoke-stack I. The ends of this stack are closed and its side wall is perforated near its bottom to register with the opening in the smoke-stack from the furnace when the stack is elevated, while a perforation in the upper end of this smoke-stack permits the discharge of the smoke into the atmosphere. The under side of the closed top is flanged and adapted to seat upon the flange of the opening in the top of the boat in which the stack slides. When the smoke-stack is lowered its imperforate portions seal the end of the smoke-pipe from the furnace thus preventing the escape of smoke into the boat through the opening in its shell. The steam from the boiler is supplied to a suitable engine J, which is adapted to drive the main shaft K carrying the propellers. This engine is also so geared with the dynamo L that the latter may be driven thereby to charge the storage batteries which are arranged within the interior of the boat. The dynamo also has driving connection with the main shaft so that when it is not practicable to run the engine for the driving of the boat the dynamo may be converted into a motor which is supplied with current from



CXXIX. PROPELLING MECHANISM

the storage battery and driven by this electrical means. The propelling apparatus is shown particularly in Figs. CXXIX.-CXXX. and consists of the propellers N, which are mounted upon short shafts carried in sleeved bearings O, which sleeve encircles and is rotatable upon the main driving shaft.

Bevel gears mounted upon the respective ends of the main shaft and enmeshed with similar gear wheels on the propeller shafts furnish means whereby rotary motion may be imparted to the propellers. The inner ends of the sleeves are provided with worm gears Q which are turned by the worms R, the latter being arranged to be manipulated preferably from the conning-tower. Obviously propellers thus omni-jointed can drive the vessel either forward, astern, up or down or any possible angle. The particular location of the propellers, says the inventor, is of the utmost importance in the operation of a submarine boat. If this propelling apparatus were placed nearer to one end of the boat than to the other the tendency to dive or rise out of the water, depending on the location, would be irresistible, but by arranging the propellers at or about the middle of the sides of the boat, the equilibrium is undisturbed by the action of the propellers.



CXXX.

The following additional explicatory notes will be useful: T is a conning-tower with swinging top T 1 opened by a rod *t*; U are openings fitted with glass for the admission of light; V is a torpedo tube and X the torpedo.

A boat constructed as described above can be used for a variety of purposes, i.e., the examination of wrecks, inspection of the character of the beds of lakes and other bodies of water, locating submarine structures, for laying and inspecting telegraphic and other cables and like work, but the chief object of the invention is to provide a boat well adapted as a war-vessel and capable of discharging torpedoes.

Mr. Baker built his boat in 1892; it has a length of 46 feet; a beam of 9 feet and a depth of 13 feet. Its displacement when submerged is 20 tons. The steam power is obtained from a boiler by C. P. Willard and Co., of Chicago, the I.H.P. developed being 60. The dynamo works at a tension of 220 volts. with a power of 50 H.P., the current being supplied by 232 Woodward accumulators.

The first trial of this boat took place on April 29th, 1892, when the inventor accompanied by his foreman, Mr. Goddard, remained submerged for one hour and fifty minutes, during which time the perfection of stability was ascertained.

Shortly after on May 20th a second trial was made in the river close to Detroit, the inventor having as companion, besides his foreman, the editor of the *Western Electrician*. The following is said to have been the experience of this daring journalist:—

'Having closed the conning-tower, Mr. Goddard examined all the machinery with great care. A few moments after the inventor said briefly:

''Let in some water, Goddard,—there, now she begins—wait a minute and we shall sink,' all of which orders were accompanied by rapid clangs on a bell, and the flapping of the waves on the outside; all these things made one forget the personal danger. . . !'

The reporter (so he himself tells us) was plunged in reflection at the wonders around him and the novelty of his experience when Mr. Baker touched him on his shoulder. He, Mr. Baker, had augmented the weight of the vessel until she slowly began to sink little by little. At this moment the surface of the water came level with the centre of the look-out glass, and by placing one's head and shoulders in the conning-tower, a last glimpse of the outside world could be obtained.

'A little more water ballast, Goddard.'

'This was the final order and the propellers being started the vessel commenced her voyage beneath the waves at full speed.' Mr. Baker's invention can be put under the heading 'successful,' in this much that a boat was built to his design and successfully navigated for a long time. Some little difficulty was found in depth-keeping, however, and this was perhaps the chief fault of the boat. The twin propellers with their every-way gearing, are distinctly novel and the 'Baker' is on the whole a great credit to her inventor.

In 1892 a submarine vessel was built to the plans of Herr Van Witten, a Dutch ship-owner resident in Newfoundland. In form it was cigar-shaped, the extreme length being 68m. (223.10 feet). It was propelled by two screws and was furnished with two rudders, and the inventor is said to have navigated at speeds over 10 miles an hour at a great depth. 1892 Van Witten

Fourteen men were required for the management of this gigantic vessel and Herr Witten proposed to cross the Atlantic to Bordeaux after carrying out exhaustive trials in Newfoundland. Information concerning this vessel is very scarce.

This year also, Engineer Sims, of Willet Point, New Jersey, inventor of the 'Sims Torpedo,' produced an electric submersible torpedo boat. It was connected with the shore by a cable and drawing its current from accumulators ashore it accomplished 4,000 yards in 6 minutes, which is almost 24 miles an hour. Considering the power was obtained from the shore this is not wonderful, and if this shore connection is a necessity, then the 'Brennan' torpedo would be every bit as useful as Engineer Sims' invention. Sims

The submarine vessel proposed by Mr. Schwann was to be indeed a startling revolution in naval warfare. The surface speed was to be 32 knots, whilst at a depth of 150 feet a rate of 15 knots could be maintained. The motive power is a vapour-petrol motor which sucks and rejects water violently in the same way as the invention of Count della Catena. Schwann

The hull of this submarine is double and is constructed of mild steel. The dimensions are as follows:—

Length - - - - - -	10m. 50
Beam - - - - - -	2m. 40
Depth - - - - - -	2m. 70
Displacement - - -	65 tons.

The bottom was fitted with two keels or lee-boards 0m. 30 square. Along their surface are the openings for drawing in the water and rejecting it, by which means motion is to be obtained. Submersion is regulated by augmenting or decreasing the quantity of water in the ballast tanks, and this ballast water which is continually circulating around the boat's hull, serves for propulsion and aeration. The air carried and forced into the boat by the circulation of water above described, is sufficient for the combustion of the motor and the respiration of the crew.

The miraculous speed of this vessel and the means of providing air remind one forcibly of Jules Verne's marvellous creation, the 'Nautilus,' of which the author says:

'Ce bateau ne comporte pas de reservoirs d'air et est éclairé à la lumière électrique.'

This invention is another of those illustrating how an imagination can run riot. I would be the last in the world to deny the possibility of submarines eventually attaining 32 knots, in fact if the threatened antidotes to these vessels do not curtail their existence and advancement, there is every reason to believe they will have speeds of 32 knots and more, but with the powers to-day available any surface speed between 15 and 20 knots may be considered the present maximum for a submarine.

1893 J. R. Haydon

The inventor of this boat, James Ryan Haydon, hails from Cleveland, Ohio, U.S.A. The boat is cylindrical with pointed conical ends. Near the stern is a conning-tower fitted with look-out glasses and carrying a small signal mast. Just forward of this is a small dome supporting a tube through which air may be drawn from the surface of the water; a wire in electrical communication with the vessel on the surface also enters this dome. In the stern is a propeller driven by an electric motor supplied either by accumulators or with power from a ship on the surface, by means of a cable. Beneath the screw again is a balance rudder for steering in the vertical sense, while on either side is placed a horizontal plane for preserving a level course when navigating submerged. A clutch for throwing the motor out of gear is connected to the propeller shaft. Port lights for illuminating the interior are fitted at various intervals around the hull.

The most important feature of this boat, however, is the method employed for submerging it; this is accomplished by means of an interior cylinder [1] placed near the bottom of the

1 In their history of Submarine Boats, M. Forest and Noalhat give an illustration of this cylinder, but it must be more misguiding than useful to those not cognisant with the subject, as the drawing has been reproduced ***up-side-down!***

boat and connected to the exterior cylinder by rings. The weight is so disposed as to prevent rolling and increase stability. This cylinder contains two pistons closing on one another by means of a long bar fitted with right and left hand screw-threads; these are worked by gearing wheels, pushing the pistons in or out according to the direction in which the wheels are turned. Beneath the space between the two cylinders is a small opening free to the outer sea and this intermediate space is thus always full of water and serves as a ballast tank. The purpose of the sliding pistons can now be clearly understood, for by drawing them in or sliding them out the amount of ballast can be nicely regulated, and thus compressed air or other expellants are avoided. This vessel is not intended for martial deeds but was designed in the interests of peace; the exploration of the ocean bed is the purpose of this inventor and in the bows is an air-lock with air and water-tight doors for the use of divers who may wish to descend and make a more minute study of the bottom than can be carried out through glass windows. There is wide scope here for speculation as to hitherto undreamt-of possibilities of adding to scientific knowledge, but such speculation is necessarily outside the sphere of this work.

Admiral Daniel Ammen, U.S.N., was a great believer in the ram as a weapon of offence and desirous of having his opinions proved to be right or otherwise, agitated for the construction of a vessel to his designs. D. Ammen

On March 2nd, 1890, Congress passed the plans submitted for consideration and called for tenders; that of the Bath Iron Works Co., Maine, was eventually accepted on January 2nd, 1891. The vessel was given the name of 'Katahdin' and according to contract was to have a speed of 17 knots, be completed in 18 months and to cost only £186,000. 'Katahdin'

She was laid down in July, 1891, and was launched on February 4th, 1893, or in under 19 months,—a record I should think in shipbuilding to a Government contract. And this was accomplished in spite of the brilliant endeavours of the Navy Department to retard its construction, by altering the design on March 27th, 1892, and ordering the length to be increased by some 4½ feet, so that a light armament might be carried. This addition of a few guns to the ram for offensive purposes is probably the cause of her failure—for the 'Katahdin' proved a failure in every way, so much so in fact that she was not manned during the Hispano-American War. Her final dimensions are:—[1]

Length over all	251 ft.[2]
Length on W.L.	250 ft. 5 in.
Extreme Beam	43 ft. 5 in.
Beam at W.L.	41 ft. 10 in.
Extreme Depth	21 ft.
Draught	15 ft.
Displacement	2185 tons [3]
I.H.P. 4800	17 knots (designed).

For protection the 'Katahdin' has a complete curved deck reaching down below the water-line, and having a thickness on the top of 2½ inches increasing gradually to 6 inches on the sides. The funnel and ventilators are protected by 6-in. glacis, and the conning-tower is made of 18-in. plates. At a speed of 17 knots it was calculated that her weight on impact would equal 400,000 foot tons, a force capable of sending any ship afloat to the bottom.[4] She has very few vulnerable points, the only objects capable of damage being a small signal mast, the funnel and two ventilator shafts. She is driven by twin screws rotated by two sets of horizontal triple expansion engines, steam being supplied by 2—2 ended 6 furnace and 1—1 ended 3 furnace boilers. The designed horse-power was 4,800 tons but this was much exceeded although the designed speed was never attained. The armament consists of 4—6 pr. Q.F., and her complement numbers 100.[5] Four boats are carried, two on each beam also one or two collapsible boats of the Berthon type. The interior receives a meagre ventilation through the two shafts already mentioned and four small air funnels placed two before and two aft of the funnel. In the bows is a crane for lifting in

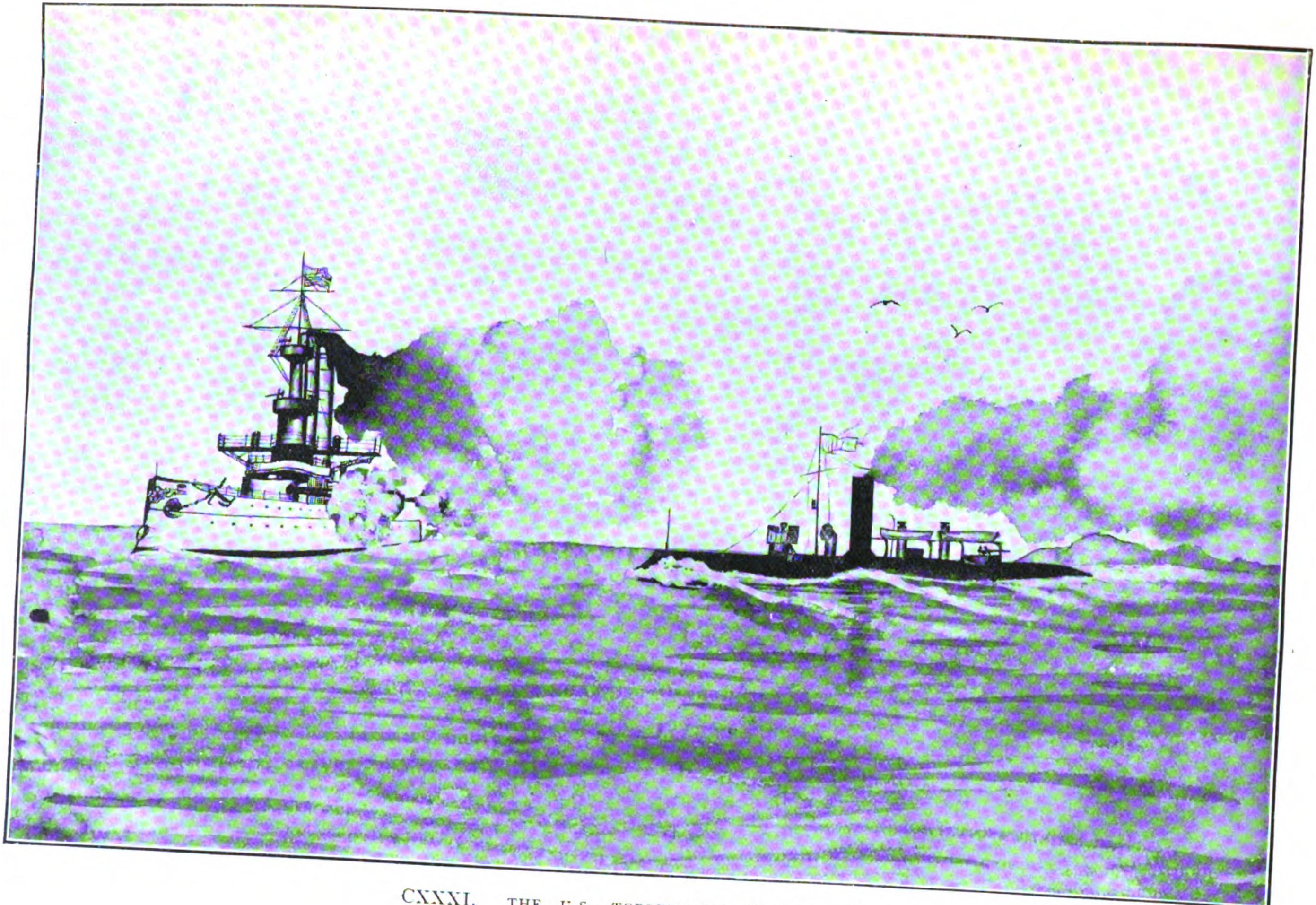
1 American Authorities.

2 Laird-Clowes in the Naval Pocket Book, 1901, gives the length as 250 feet 9 inches.

3 H. W. Wilson gives displacement as 2,183 tons (Downfall of Spain, p. 47); Laird-Clowes says 2,155 tons.

4 'Engineer,' April 6th, 1894.

5 F. T. Jane.



CXXXI. THE U.S. TORPEDO-RAM 'KATAHDIN'

and out the anchors. The guns are mounted on little turrets placed fore and aft.

The normal coal capacity is 175 tons, the maximum 192, with which amount the 'Katahdin' can steam 1,000 knots at 10 knots an hour. The following resumé of her trials is not without interest:

A preliminary trial was run on December 10th, 1894; with a very foul bottom a speed of 14.4 knots was logged with an I.H.P. of only 2,440. From observations made during this trial the contractors decided that a change of propellers would be beneficial and while this operation was being effected the opportunity was taken for scraping the hull which was then repainted with a special non-fouling composition. These repairs and refittings took the best part of three months and the second trial trip was run in March, 1895, four years after the keel-plate was laid down, when with 4,124 I.H.P. a speed of 15.71 knots was obtained. This unsatisfactory result was bettered shortly after by the 'Katahdin' making a speed of 16.06 knots with 5,750 I.H.P. Here there was a disappointment for the builders for although the original horse-power had been exceeded by 950, the speed was almost a knot less than that contracted for. They were not in any way discouraged, however, by these failures, but after a consultation with the Government Naval Constructors decided that the fault was to be found in the propellers, and therefore had new ones cast at once. A slight gain resulted the speed made being 16.07 knots with 4,900 I.H.P. Disheartened at the continued unsuccess, and after having spent over £8,000 on experiments the Bath Iron Works handed the 'Katahdin' over to the Government who, during a stay of the vessel in a dock decided that a fourth change of propellers was necessary, the last having been somewhat damaged by coming in contact with the hull of the ship. The official trials then took place on October 31st, 1895, in dirty weather; with 5,300 H.P., the 'Katahdin' made 16.11 knots and at a later trial accomplished 16.13 knots. However much a failure the 'Katahdin' is at high speeds she is still a very good and steady steamer at all speeds up to 14 knots. The trials proved that her peculiarly shaped bow raised a wave so impeding to speed after 15 knots had been attained that even with double the engine power it is doubtful whether she would have added to her record of 16.13 more than a few decimals of a knot.

But though this vessel could never be assigned a prominent place in the list she might be found useful in the second phase of a war, when, the first-class battle-ships having been maimed or sunk, the second line with its 12 to 14 knot units would come to the fore. The 'Katahdin' can submerge herself many inches and in this condition would be practically invulnerable except to torpedoes. Her powers of gyration are remarkable,[1] this being due to the two balance rudders placed one behind the other on the keel line. The 'Katahdin' has been aptly described as a cruiser with everything above her armoured deck removed. On the water she presents a not ungainly appearance and gives one the idea of power especially when seen steaming fast (for her) and raising a good solid wave in front. Although she never fulfilled the sanguine expectations of her designer and constructors the 'Katahdin' will always be a curiosity of naval architecture, and has certainly proved, with the exception of the 'Polyphemus,' the most successful of the 'submersible' monitors.[2]

Middleton No. IV — This inventor patented another incomprehensible apparatus on June 29th. Explanation of details is difficult, but after much time spent in study over the explanations it appears to be a modification of the machine invented in 1891 and patented on September 9th.

1894 C. A. Story — On January 20th Mr. C. A. G. Story patented (through O. Imray) a novel propeller, adaptable to submarine boats. Straight or curved blades are fixed on a cylindrical boss to form a long screw-propeller, the whole being partly enclosed in a metal casing so that the outer skin of the vessel is tangential to the boss. These screws can be arranged either singly or in pairs with their axis horizontal, inclined or vertical, and may be placed in the front, centre or stern of the ship.

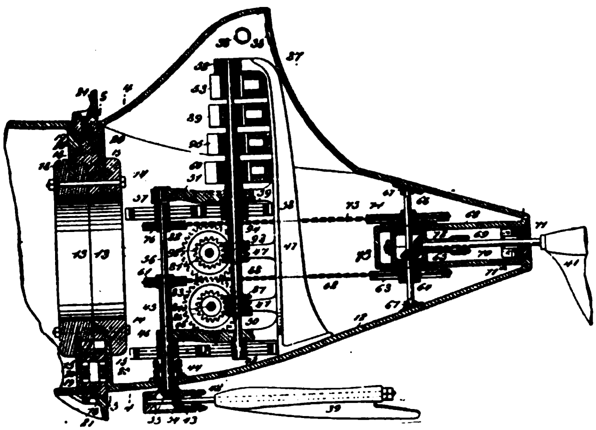
S. Lacavalerie — The most remarkable inventions of the year 1894 are the two vessels designed by Dr. Sebastien Lacavalerie, a dentist of Caraças, Venezuela, South America. In principle they resemble the 'Apostoloff' boat,[3] but in design they are very

1 This is denied by some authorities.
2 See illustration.
3 See page 153.

different. Below is a side-view of the first of this inventor's vessels.

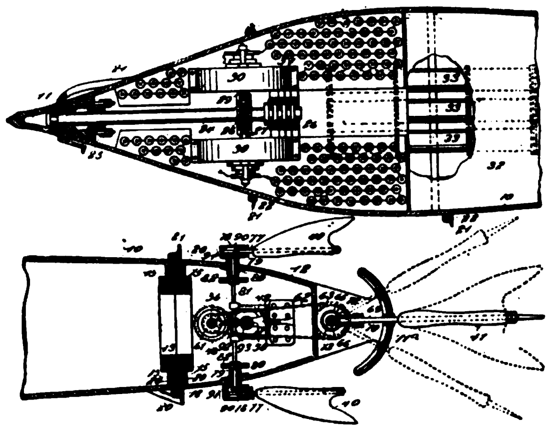
CXXXII. LACAVALERIE'S FIRST SUBMARINE

As can be seen, it consists of a cylindrical screwed body supported on a keel by two terminating uprights. This body is made to revolve rapidly and cut its way through the water. It is suspended on a longitudinal axle and swings freely thereon; inside it there is another hull, as in the case of the 'Apostoloff,' and this contains the machinery which is electric, and the current for which is stored in accumulators placed in the bow section. The vessel is provided with a keel for steadying it and stern and bow sections. The bow section contains the accumulators as stated above, and all the stores; the stern section is for the crew and contains the conning-tower and the mechanism connected with the working of the vessel.



CXXXV. STERN SECTION

A rudder for steering a straight course is provided, but nothing is said about horizontal rudders for keeping an equal depth when submerged. The second vessel (Figs. CXXXIII.-CXXXIV.) can be so well understood by a study of the appended plans that a very brief explanation is all that is called for. The following will elucidate a few of the figures on the plans.

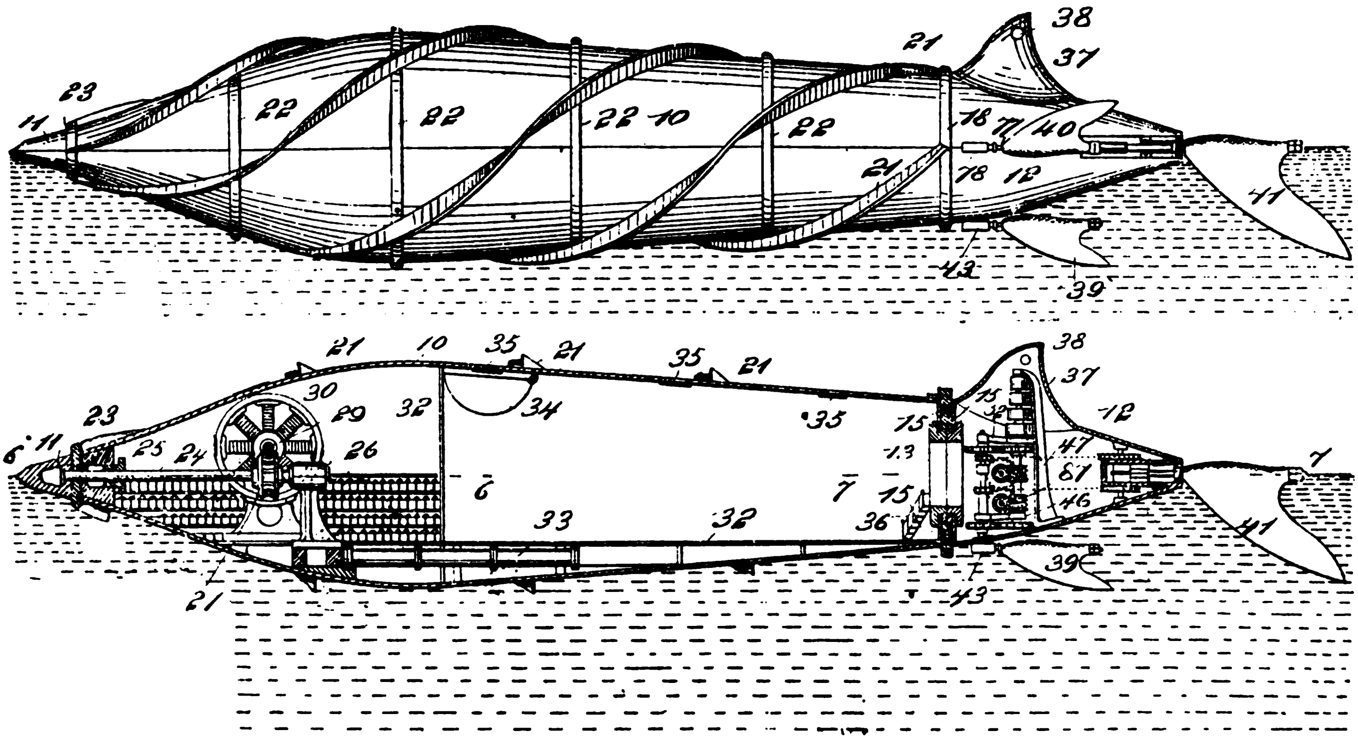


CXXXVI.-CXXXVII. PROPELLING AND STEERING MECHANISM

10—the main hull; 11—the bow cone; 12—the stern compartment (also conical); 13—coupling rings connecting the stern cone with the hull; 24—the driving shaft; 30—electric-motors; 31—storage batteries; 32—bow compartment; 33—air-tanks; 34—hatchway; 35—windows; 37—conning-tower; 38—look-outs; 39-41—steering rudders, shaped like fish-tails.

The object of this invention, Señor Lacavalerie tells us, is to provide a vessel which may be easily and rapidly propelled either on or beneath the surface of the water, and to provide a means of propulsion for the vessel which is not likely to get out of order, and a means of steering by a series of rudders, which by a special mechanism may be either oscillated or revolved and thus give any desired up, down or laternal motion and impart to the vessel a helical movement through the water similar to the movements of a fish.

There is one fatal objection to all vessels of this type, the excessive friction which must obviously be present, however finely balanced the revolving hull may be. It would be

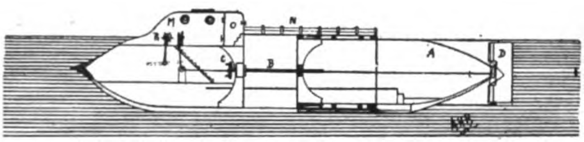


CXXXIII.-CXXXIV. LACAVALERIE'S SECOND SUBMARINE

extremely awkward if, during a submarine trip, the gearing of the connecting shaft were to stick, for the whole body of the vessel, passengers, crew, accumulators and all, would at once go whizzing round, to the detriment of the said passengers and crew. I would like such a vessel to have a year's trial before myself risking a voyage therein.

The next submarine which comes under notice is the invention of Messrs. Silias and George Rogers, of Brighton. The novel feature of this vessel, which was to have a length of 55 feet and a diameter of 9 feet 6 inches is the sliding stern (see Fig. CXXXVIII.) S. and G. Rogers

The hull is cylindrical with a conning-tower M at its forward end, a deck N running along the first portion of the hull. The stern end A is of smaller diameter than the forward portion, and fits inside it, the space between the two being made water-tight by means of circular packing rings.



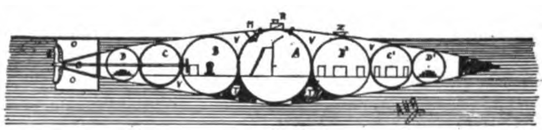
CXXXVIII. S. AND G. ROGERS' SUBMARINE BOAT

This cylinder A slides in and out on a rotating screw B worked by the wheel C. The door for egress and ingress is at O, this being kept water-tight when submerged by being pressed against packing by means of iron bars engaged with hooked projections on the bulkheads. A rudder D is provided for steering and two planes worked by the wheel R are used for regulating the submersion. The difference in displacement of the vessel with the stern section right in, and when extended to the fullest is 4 tons. No details relating to the mode of propulsion are mentioned and the information obtainable does not offer enough basis upon which to give an opinion. The sliding cylinder is a new application of the reduction of volume means of submersion, but it seems to me that this invention would suffer from friction the same as the inventions of Lacavalerie, and it would be quite as dangerous for the screw to jam in Messrs. Rogers' vessel as for the gear wheels to refuse to work in the boat of the Venezuelan gentleman.

Inventors have not yet fully grasped the maxim that simplicity is the necessity of scientific advance; one invariably finds that the finished article is much less complicated than the various endeavours that have led up to it.

P. del Pozzo No. I

Count E. Piatti del Pozzo (the inventor of the submarine worker 'La France'), designed in 1894 a submarine boat having a length of 22m. 50 (73.82 feet) and a diameter at its greatest point of 3m. 50 (11.4831 feet). This boat, as may be seen by Fig. CXXXIX., is to be constructed on uniform lines, i.e., if a straight line were to be drawn through the centre from point to screw the hull curves on each side of such a line will be equal. The hull is divided inside into seven compartments, these being made up of three pairs of spheres B B, C C, D D, arranged symmetrically on either side of a main sphere A which forms the living space of the crew, and which is entered by the hatch M. The engines, the type of which is not defined, are contained in the compartment B, the batteries or accumulators for working them being placed in B and C. Small auxiliary engines or pumps are placed in the



CXXXIX. PIATTI DEL POZZO'S INVENTION

two end compartments D D. The vessel is driven by a screw N, and steered by four rudders O O O O, two for horizontal and two for vertical steering.

The most important feature of this boat is that, in case of collision or any damage to the hull taking place, the sphere A can be detached from the rest of the boat, when by its buoyancy it will rise at once to the surface.

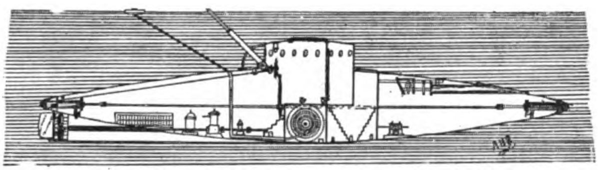
The conning-tower is placed at R over the centre compartment and under it a platform from which the vessel is conned. The vessel is ballasted in the spaces T T between the three middle spheres, whilst the remaining spaces V V are fitted with absorbant leak preventing matter. Communication is obtained between the various compartments by means of water-tight doors.

Count Pozzo adopted the strange method of construction above described that his vessel might the better withstand the excessive pressures of great depths. Although he did not intend his vessel primarily for warlike purposes, he provided a torpedo Z which could be attached to the bottoms of ships.

Freeze and Gawn

These two engineers, hailing from North Amhurst, Ohio, U.S.A., prepared a design for a mixed propulsion vessel which embodied many novel features. Of these the most important is undoubtedly the employment of two pistons (Fig. CXL.) for regulating the longitudinal balance when submerged.

As may be seen by the plan, this vessel is fusiform with sphero-conical extremities, the upper half of the vessel having a greater curve than the keel line. Midway is a large conning-tower from which all the machinery is operated. This consists of a steam-engine for surface propulsion and an electric-motor



CXL. THE PROPOSAL OF MESSRS. FREEZE AND GAWN

for use when submerged. The motor is supplied by accumulators which also provide power necessary to drive all the auxiliary engines, pumps, etc. The depth at which the vessel is navigating is indicated by a manometer made up of a cylinder containing a hydrostatic piston, which, by the alteration of the external pressure causes a needle to mark, on a graduated rule, the distance from the surface. Submersion is obtained by the introduction of ballast water, and when the buoyancy has been reduced almost to nil the vessel is forced beneath the sea by planes. The longitudinal stability is obtained, as above mentioned, by the manipulation of two cylinders. These cylinders are placed one at each end of the vessel, the outward end of each being open to the ambient water; each is fitted with a piston, and the two pistons are joined by a bar passing right through the vessel and made moveable by a jointed connection to a lever placed close to the steersman. It will thus be seen that if the latter moves this lever either fore or aft the pistons will slide correspondingly and while one pushes water out one end, the other draws it in at the other. In this way the balance of the boat can be fairly nicely regulated. This means of obtaining stability seems to me to be the simplest that has as yet been propounded, for the motion of the lever is bound to keep the weight evenly distributed.

Behind the conning-tower is placed a diving chamber by which it will be possible to leave the vessel when submerged. Air for respiration is not to be carried compressed as in the majority of submarines, but will be obtained by the simple means proposed many centuries ago. A float attached to a long tube conveyed the air to the interior. This tube is rolled on a drum and according to the depth of submersion so is the tube run out. A long telescopic optical tube is used for seeing when making submarine trips and its superior reflector can be rotated in all directions thus giving a good circular view. The vessel is fitted with a single propeller the shaft of which is geared to both motor and steam engine; steering is effected by means of an ordinary rudder.

This invention, like Mr. Haydon's, is not intended for any warlike purpose and has therefore no offensive appurtenances attached. It shows some novelty of design and the piston movement for retaining stability is excellent in theory although in practice it might not work as satisfactorily as should be expected from the design. The method of obtaining air is rather dangerous in that smooth water cannot always be depended upon, and in rough weather a certain quantity of it is almost certain to find its way down the tube. On the whole, however, the invention of Messrs. Freeze and Gawn is a model of much ingenuity and is moreover distinctly practicable.

S. Allen

In October, 1894, Mr. Seymour Allen,[1] of Sydney, Australia, produced a submarine torpedo boat, or rather a working model of one, which showed great promise. The inventor claimed for his boat that it could travel as quickly below water as on the surface. This if true is remarkable as in every other boat the speed when submerged has invariably fallen tremendously.

The model was tried in the presence of Lord Hopetoun, the Governor of Victoria, and Admiral Bowden Smith, Naval

1 Allen or Allan; which, is uncertain.

Commander-in-Chief in Australia at that time.[1] The experiments took place in the public baths of Sydney and the model's powers of running, diving and turning were so remarkable that the Admiral is reported to have declared that if the vessel would do what the model performed, naval warfare would be revolutionised.

The British Admiralty, however, are not given to encouraging experiments of such a novel and risky nature and up to the present Mr. Allen's invention has not received that attention from the authorities which its model's performances would appear to have called for; or perhaps the vessel herself, was not so satisfactory as her designer had hoped she would be.[2] The 'Allen' is propelled by electricity, and can fire torpedoes either ahead or astern. Stability is obtained by lead ballast and the action of rudders keeps the vessel level when submerged. Submersion is obtained, as is usual, by introduction of water into ballast tanks. Suitable conning-towers are provided for the use of the steersman. In shape this Australian submarine boat resembles a finely pointed lemon; at the after extremity is the propeller by which the vessel is moved, and along the top are the torpedo tubes.

1895

This year is the only barren year of the nineties, not one inventor of submarine boats coming forward in the course of the twelve months. Mr. J. P. Holland, it is true, applied for a patent on April 9th, but the invention which he wished to cover by this application is only an addition to the patent he was granted on May 21st, 1892. It relates to a compensator for loss of weight sustained on the firing of a torpedo, and will be fully described in the description of the 'Plunger' further on.

1896
Drzewiecki
No. VI

In 1896 we hear of the last but one of the Russian engineer's inventions, his very latest plans being even now (1901) in the hands of the Minister for the Navy.

This vessel was one of those designed for the competition opened by the French Naval Minister in 1896. It differs from his earlier designs, being a 'submersible' rather than a 'submarine'; it was to have a displacement of 190 tons and could steam 15 knots on the surface and 12 knots submerged. Steam

1 Major Field in the 'Wide, Wide World,' April, 1901.

2 Lieutenant Armstrong, in 'Torpedoes and Torpedo Vessels,' 1st edition.

would be the motive power for above water navigation and an electric motor for use when below the surface but this was only to be utilized in case of great danger, most of the work being accomplished by the vessel when just level with the surface. To this end the accumulators did not contain power for more than three hours at full speed. This vessel would be armed with torpedoes launched from a special launching-cradle, the invention of M. Drzewiecki himself, and was moreover provided with all the necessary appliances for maintaining stability, constant submersion, etc.

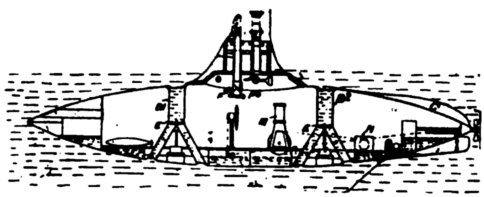
This design was placed in the second class, and the inventor received a prize of 5,000 frs. (£200); besides this, however, his launching-cradle was retained and has been adopted in the French Navy for all their vessels of the submersible type, to which it is especially applicable.

J. Huber

This gentleman applied for a patent on February 1st of this year for designs relating to the construction of the hulls and frames of submarine vessels. His vessel was to be oval in cross section and strengthened by channel-iron ribs. Little is known of this invention, however, and we will leave it for something of greater interest.

M. R. Rutley

In 1896 M. R. Rutley patented a submarine boat which in principle resembled that of Waddington, its chief feature being two submersion screws fitted in wells. The design of Mr. Rutley differed from that of Mr. Waddington, however, in



CXLI. RUTLEY'S IDEA

having the propeller wells of peculiar shape. The channels were three in number, two of which started from the bottom the third descending from above to meet them. At the apex of the cone thus formed by the two lower channels was placed the screw worked by a motor contained in the cone.

In the centre of the vessel is a raised portion to accommodate a conning-tower, air-shaft, and glass-ports. The motive power is supplied by an oil engine driving a dynamo, and suitable storage batteries are also provided. For steering when submerged an optical tube is carried and this can be raised or lowered in its sleeve and is supplied with suitable lenses and reflecting mirrors while the air-shaft is also adjustable and provided with a valve worked by a float to close the air-pipe should the shaft become flooded. The boat is constructed with tanks provided with sea-cocks for water ballast and for storing oil, whilst torpedo tubes, are also fitted; the fins at the stern are intended to prevent rolling. After the discharge of a torpedo the loss of weight occasioned is compensated for by the automatic introduction of water. No information is given us as to the power or type of his engines. Mr. Rutley's boat, though ingenious, calls for no special notice and we will therefore proceed to the next invention without further comment.

This year a Mr. L. Gathmann, of U.S.A., patented an ingenious conning-tower for submarines, provided with an upper compartment forming a support for and partially protecting a series of tubes which pass down into the lower part. The ventilating tubes and funnel also pass through this compartment. At the top of these tubes the compass and reflecters are fitted and at the bottom telescopes are placed by which the compass is read and external object examined. I hope to give a more detailed account of this invention later on. I.. Gathmann

The submarine of M. Vassel is composed of a cigar-shaped hull, pointed at its two extremities; it is made up of three sections jointed closely together by clamps fitted on the interior. The hull is of bronze and possesses a small conning-tower in which the steersman places his head and from which all the various mechanisms are controlled. At the bottom is a heavy safety weight and round the hull run two lee-boards which besides steadying the vessel considerably, serve as supports for two torpedoes, which by means of an intricate interior mechanism may be started at any desired moment. Submersion is obtained in the usual way by the introduction of water into ballast-reservoirs, the supply of which can be augmented or reduced at will. Manometers are provided for indicating the depth of submersion and telescopic optical tube is used Vassel for steering when navigating submerged. Propulsion is obtained by an oil-motor working a screw placed in the stern of the boat and capable of being turned in such a manner as to render horizontal or vertical rudders unnecessary. The resemblance of this little vessel to the 'Goubet' is very striking and the only real point on which they show a radical difference is in the type of motor, for whereas M. Goubet employs electric power in all his vessels, M. Vassel has chosen an oil-engine as a means of propulsion.

A. Templo

Mr. Alvary Templo, a resident of Brooklyn, New York, invented a striking novelty in his 'Aquapede.'

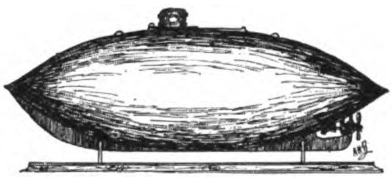
This curious vessel is cigar-shaped and made of aluminium; its length is 16 feet and diameter 2 feet 3 inches. It is divided into three compartments; the two end ones are used as air reservoirs. The centre one, however, contains a diver's suit, which projects above and below the vessel. Into this the diver gets and his pipes being connected with the two air reservoirs at either end he is ready for the trip.

The propeller, fixed in the stern, is geared to a sprocket wheel to which bicycle cranks are fitted and the diver, having filled little water tanks until the requisite amount of submersion has been obtained, pedals his way along under the water. To the outside of the hull are fixed all the necessary implements for repairing, cutting, etc.; under-water, and to each flank is affixed a long spar torpedo which an enemy's ships could be attacked. In the bows is a strong electric light and in the stern suitable rudders which the steersman works by bicycle handles fixed in a convenient position. Mr. Templo has made many voyages in his invention and during one of his trips remained submerged six hours.

This is something quite new—one might say refreshingly new,—in the history of submarine navigation. Although the 'Aquapede' can never have any real military value it is a highly ingenious and well-planned invention, and it cannot be denied that the inventor has discovered an exceptionally novel,—and on hot days, deliciously cool—way of spending an afternoon. I do not think, however, that submarine pleasure boats are likely to become general, the average human being considering a voyage on the surface sufficiently exciting without seeking the mysterious delights of the regions below.

M. H. Philippeau, a French enthusiast, presented a model for a mixed propulsion submarine boat to the French Government in the Concourse opened in 1896. His designs although not accepted secured for him the third place amongst the civil inventors whose plans were considered worthy of notice. H. Philippeau

His proposed vessel had a length of 16 metres and a diameter of 5 metres. In shape it was cylindro-conical,[1] and circular in its cross section. On the surface it was driven by a petroleum-engine but submerged two electric-motors were used. The hull was double and the interior of the inner skin was squared into a compartment 8 metres long by 3m. 20 square. This compartment contained all the machinery and the living space, whilst the two ends were devoted to air-reservoirs and tanks. A conning-tower for use when on the surface projected from the upper surface of the hull and was fitted with thick glass lenses and a swing top so that by it ingress to and egress from the interior might be effected.



CXLII. PHILIPPEAU'S SUBMARINE VESSEL

The appended sketch (Fig. CXLII.) although not showing the internal mechanism, displays very clearly the outward form of the vessel. It will be seen that the propeller, which is omni-jointed, thus obviating the use of rudders, is situated in a position very different to that of most submarines. Stability of route is maintained by means of four horizontal rudders placed in pairs at either end, one on each side of the hull. These are worked electrically from the interior by small worm-screws and cranks. The accumulators are carried all round the inner square and beneath them are the ballast tanks. The offensive powers lie in the presence of two tubes pointing upwards from the keel. In these tubes are placed two tor-

1 It resembled as much as anything an alligator's egg with pointed ends, being very broad for its length.

pedoes joined at their bases by a short cord. When the submarine passed under the keel of a hostile vessel, the torpedoes are detached and being buoyant ascend at once, one on each side of the keel of the ship attacked. Having accomplished this the officer in command steers his vessel out of harm's way, the while unrolling a wire; when he has arrived beyond the dangerous zone, the current is connected and a spark produced, the torpedoes both exploding at the same time,—the result, of course, being the absolute annihilation of the ship. This method of attacking a ship from below and of exploding a charge on opposite sides simultaneously would tend (so the inventor tells us) to break any vessel in half, and would also do away with all risk of the charge exploding against an armour belt, and thus loosing the major part of its effect.

The oil-motor, which was of peculiar type, has an I.H.P. of 400 and enough oil is stored to allow of its working for 100 hours at the maximum power. The electric-motors will vary in power between 200 and 400 H.P. according to the storage capacity of the accumulators carried. It will thus be seen that in case of necessity a combined force of 800 H.P. can be made use of, but this could of course only be on the surface. No mention is made of the speed expected of this submarine.

Fresh air is supplied and the vitiated air expelled by the action of centrifugal pumps connected either to the main motors or worked by an auxiliary dynamo. The interior is lighted, when submerged, by incandescent lamps and a strong searchlight is also placed at each end of the hull for lighting up the surroundings. Lastly, an obtical tube is provided, which would be of great use in steering when not too deeply submerged. Although this vessel is not very novel in general design, it has several points of particular interest, and is assuredly no ill conceived idea.

1897
P. del Pozzo
No. II

Count E. Piatti del Pozzo invented a submarine worker and patented it on February 18th, 1897. It scarcely enters into the category of submarines, however, bearing to them the same relation that a buoy does to a steam launch, and I will therefore do no more than notice its appearance. One of these workers was built and under the name of 'La France' has been rendering yeoman service at the port of Cherbourg.

This gentleman patented a design for a vessel which although not a true submarine, had so much to do beneath the waves as to merit an inclusion in the list. H. Shaw

It is a cigar-shaped vessel with an outer rotating shell (much on the same principle as the inventions of Lacavalerie and Apostoloff). This outer shell is supported on friction rollers and is also guided by external rollers which are supported in the framing of the keel and upper decks. The inner shell is rigidly connected to the keel and is provided with the usual saloons, berths, etc., connected by staircases. There are spiral staircases also at bow and stern to afford access to the bridge which connects the two supporting uprights and stretches in circular form over the revolving hull. This bridge has extensions serving as promenade decks, with deck-houses, ventilators and air-funnels, the purpose of which is to expel the foul and carry the fresh air into the saloons, etc., in the inner hull. An outlet is also provided for the escape of hot gases from the furnaces. A pivoted landing-gangway is hinged to the stern-support, which rises high above the decks and bridges in the form of a look-out tower. The vessel is propelled by spiral blades fixed on the outer casing which is supported on trunnion bearings and rotated by spar gearing from separate engine shafts. The spiral blades are divided so as not to interfere with the supporting rollers of the revolving shell.

I am afraid that however cunningly this vessel were designed it would always be found that owing to the friction the principle of construction is impracticable.

The invention of Mr. R. Hinsdale resembles that of Mr. Simon Lake so very closely that it is unnecessary to give a detailed description in view of the amount of space given to the 'Argonaut.' R. Hinsdale

The two inventions differed in this way, that, whereas the vessel of Mr. Lake is its own car, that of Mr. Hinsdale is supported from the runner by cables, much in the same way as the marvellous idea propounded by Dr. Lacomme. The car was a short heavy platform supported on eight small wheels and having two strong sustaining hooks fixed on its upper side. From these hooks (which are imbedded in baulks of wood) is suspended the submarine boat, or rather explorer.

The chief features of this boat are a flexible aeration tube leading to the surface through which a plenteous supply of air may be drawn, a circular conning-tower and entrance hatch in the centre of the boat, and another steering dome in the bows for looking on whilst submarine work was in progress, two motors, electric and oil, for propulsion and all other necessary work. If required, we are told, this vessel can be provided with torpedo tubes and torpedoes and thus turned into a serviceable war-ship.

The submarine worker of Hinsdale would not go off on its submarine explorations by itself, but it would take with it a large metal cylinder in which to bring back any spoil, and also an hydraulic crane worked by pipes from the submarine. This crane would lift any object required and deposit it in the metal cylinder until a sufficient load had been obtained. The cylinder would then be hermetically closed and the water in it expelled by a power transmitted from the submarine. This latter and the cylinder would then at once rise to the surface and the explorer would tow the recovered treasure into harbour. In the event of rough weather, however, this towing could take place on the bed of the ocean. The submarine explorer has an undoubted future, but I am inclined to favour the type designed by Mr. Simon Lake.

G. P. Thomas

Colonel Gideon P. Thomas is no ordinary inventor; nor indeed would one call him a one subject inventor, for he invented the world-famous thinking machine (vide interview with inventor in well known halfpenny paper), which when attached to the head removes the necessity for expressing your thoughts, these being transmitted in writing to a paper ribbon as quickly as they are formulated. In fact, as the gallant Colonel said, 'you think, I do the rest.' This is a digression, but it will be pardoned, as being necessary to show the power with which we are dealing.

Colonel Gideon's submarine boat was driven by electricity and he claimed for it that it could go under the ice in the frozen Alaskan seas and make the trip to Klondyke a pleasure even in the depth of the severest winter. The boat was to have a speed of 10 knots an hour and to carry a six days' supply of air. This could be replenished by means of tubes which would be projected through holes bored in the ice to the surface. Strange as it may seem and to the utter astonishment of the inventor, the Washington authorities put no faith in this idea. The inventor said that the boat would go down, a fact which was not disputed; the rest of the business was rather uncertain.

I only hope that, should these lines come before the notice of Colonel Gideon Thomas, that he will not endeavour to invent an infernal machine for use against sarcastic scriveners. The Colonel is a native of Tomkinsville, Colorado.

The competition opened by the French Government proved a boon to inventors and of course many new designs were forthcoming.

Romazzotti and Maugas

Messrs. Romazzotti and Maugas each presented plans based on the knowledge they had gained in directing the construction of the earlier French submarines. Their vessels were to be solely electrically driven and would have speed of 13 to 14 knots. The radius of action, however, was insufficient, and they would be continually returning to the Arsenal to have their accumulators recharged.

Drzewiecki

The plans sent in by the Russian engineer, have already been described under the year 1896.

Seuchet

Commandant Seuchet proposed to enlarge torpedo boats and make them invulnerable by thickly armouring all exposed parts. Tanks for partial submersion would be provided and on going into action the visible portions of the vessel would be so small as to present an almost impossible target to the defending marksman.

Darriens

This officer had gained so much knowledge from having been captain of the 'Gustave Zédé' that he considered himself competent to design a modification of the existing submarines, and received a gold medal as a result. M. Lockrey said of him, 'le Gustave Zédé, dont le succès sera dû tout entier à M. Darriens,'—and no higher praise could very well be bestowed. It is enthusiasts of this order who aid the advancement of scientific knowledge and do honour to the service to which they belong.

Chéron

M. Chéron was likewise one of the first French Naval officers to show a real enthusiasm in the matter of submarine boats. His knowledge on the subject is very deep and his experience as commander of the 'Gymnote' has proved of immense value.

For his design, which was only an improvement on the 'Gustave Zédé,' M. Chéron also received a gold medal.

1898 C. Möller

Herr C. Möller patented in February, 1898, the designs of a submarine vessel of which the chief feature was a telescopic conning-tower, which enables one of the crew of a submarine to release or discharge torpedoes which are carried in recesses, and fired upwards as in the invention of M. Philippeau.

The recesses are arranged in a circle round an opening in the upper side of the boat which has a water-tight door. This opening is surrounded by a cylindrical casing in which moves a guide-ring. To this ring is secured a flexible water-tight covering provided with a glazed observation light.

When the boat is directly beneath the object of attack the operator stands on a platform with his head and shoulders inside the covering mentioned above which resembles the upper portion of a diving suit. A cock is opened to admit water to the casing, the water-tight door is lifted and the platform raised by a jack or rack rod until the upper half of the operator projects beyond the outer hull of the submarine. He then discharges one or more torpedoes which may be of the suction or any approved type, and which rise and attach themselves to the vessel. This accomplished he returns into the interior of the submarine by reversing the process described above.

This idea is not of any great utility despite its practicability and it is not one which we will expect to see applied to any modern submarine, for it will be a long time before the torpedoes as proposed above will be considered an efficient substitute for the automobile White-head and others of similar type.

A. MacLaine

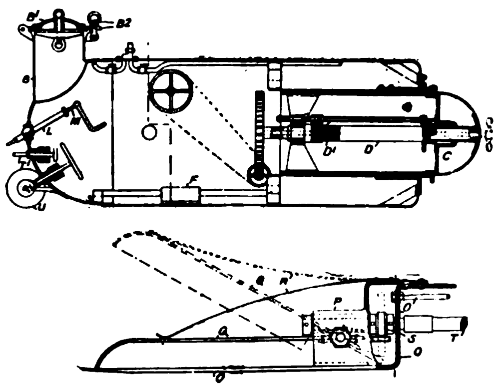
A Mr. A. MacLaine proposed a submersible battle-ship, 400 feet long and 70 feet beam, to have an armoured citadel mounting 16—12-in. guns, 8 to fire forward and 8 aft. Smaller weapons might be provided for broadside fire, but it was in the large calibre guns that the power of this vessel lay. Mr. MacLaine should present his plans to those many whose constant—and in many cases just—plaint is that our ships are under-gunned. The most pessimistic of these would be content with a main armament of 16—12-in. wire wound B.L. But is it practicable?

Another novelty! Mr. A. A. Good proposes that ferry-boats and other vessels should consist of a superstructure carried out of reach of heavy seas on a submerged torpedo boat or other hull. The propelling machinery is carried in the submerged portion, the columns supporting the platform serving for ventilation and as funnels. There is an analogy between the inventions of Mr. Good and Donati Tommasi, both being impracticable and both being little more than the result of wild unchecked flights of the imagination into the unlimited regions of the impossible. However this type of invention bears to the serious history of submarine navigation the same relation that the genial madman does to the heartsick hero of a modern drama—they are both essential to sweeten the insipidity of the serious.

A. A. Good

Mr. C. Paul's submarine boat bears a great resemblance to an ordinary locomotive boiler, being a cylinder with slightly

C. Paul



CXLIII.-CXLIV. C. PAUL'S INVENTION

spherical ends. The subjoined plans show more clearly than could explanations the details of this invention.

In the forward part is a dome B through which access to the interior is obtained. This is covered by a cap B^1 resting on and secured to a hinged ring B^2, which is fastened by an ingenious catch thus making the whole water-tight, and allowing the crew to remove the lid from either the inside or the outside. Submersion is obtained by reduction of volume, a domed cylinder C being thrust out or drawn in by a screw D^1

working through a tubular ram D. This screw is rotated by a series of cogs and is made tubular to allow of the passage of the propeller shaft. This method of submersion bears a striking resemblance to that proposed by Messrs. Rogers four years previously and can not be considered an advance on their design. Longitudinal stability is maintained and regulated by a sliding weight F moved either by manual or mechanical means. Air is supplied by a system of pipes which are provided with ball valves which automatically close should water force its way in. The vessel can be warped by means of two windlasses rotated by hand-wheels within the vessel. These windlasses are placed in the bows at U. Various minor fittings are also supplied for convenience in working when beneath the surface. Of these the most important is a pair of large nippers. These pass through the tube L mounted in a ball and socket joint and are worked by the shaft M which extends and closes up the tongs when gripping any object. In Fig. CXLIV. the working of these nippers is clearly demonstrated. The lower jaw O is secured by a spring catch to the tongs and has attached to it a box P to which is pivoted an upper jaw Q pressed downwards by a spring. The jaws are separated by rotating a cam S by means of a flexible shaft T coupled to a shaft T^1 passing into the vessel.

It seems to me that in perfecting his system of tongs the inventor gave but little thought to the submarine boat itself. One cannot imagine a vessel of the shape propounded by Mr. Paul ever proving a good sea-boat and it could never be much more stable than a barrel propelled beneath the surface. The form is impossible for speed and no method of propulsion is mentioned by the inventor. However, his invention is not absurdly impracticable and that is something to be thankful for.

H. L. Turc

Mr. H. L. J. C. Turc, a French lieutenant, thinks that all warships and passenger vessels would be much improved if the main portion of the vessels were spindle-shaped. This cylindrical hull would contain all the machinery, steering gear and other mechanisms, as well as stores, sleeping accommodation, etc. On it would be carried one or more superstructures rising above the water-level and through which would pass the funnels, ventilating shafts, ammunition-hoists, hatchways, etc., and on them would be carried the guns in the case of a warship. These superstructions would be thickly armoured to the necessary depth below the water-line and contain woodite (?) or analogous material. The funnels, air-ways, etc. are also to be provided with gratings to prevent the descent of splinters into the submerged hull. The hull may be weighted by a keel or lead ballast and may have towards the stern, large horizontal plates to prevent pitching. In openings in these plates are placed horizontal rudders. The superstructures are preferably surrounded by a shell perforated to allow the sea free ingress and egress to ensure constant submersion. When there are two superstructures, one fore and one aft, they may be connected by a vertical plate and strengthened by horizontal ribs or flanges. In the case of a passenger vessel, the cabins are carried on the superstructure out of the way of heavy seas.

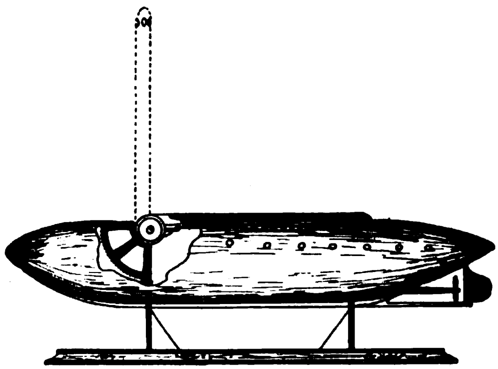
There seems no end to quaint ideas in naval construction. The possibility of the Channel Squadron carrying out submerged manœuvres in the Solent or of a Transatlantic submersible 'Krönprinz Wilhelm' accomplishing a record passage do not appeal to one as the inventor of the above vessel would no doubt wish. Half measures such as he proposes are apt to be thought dangerous, and yet for my part I would infinitely rather take a trip in a true submarine boat than be aboard one of these non-submersible semi-submarines during submerging practice.

Urzua-Cruzat

The year 1898 has a good crop of strange inventions. That of D. Urzua-Cruzat, although in principle resembling the 'Hyponeon' of Toureau, possesses some very novel features. It was to be propelled and steered in the horizontal or vertical plane, by means of water-jets. The hull could be of the cigar or other suitable and approved shape and was submerged by the reduction or augmentation of the quantity of liquid contained in the ballast tanks. This water ballast chamber communicates with the suction and delivery pipes of the propelling pump, and contains a collapsible bag in communication with an air reservoir provided with a pressure gauge from which the depth can be determined. The bag can be distended or reduced at will, thus regulating the amount of water in the chamber. The ballast tank is filled to the required extent by manipulating a stop-cock and its contents may be regulated by a piston in place of the bag if it should be so desired. Senor Cruzat does not, I presume, claim novelty for his design, in that the collapsible bag was a feature of the submarine boats of three hundred years ago.

C. H. Homan

The most important feature of the submarine boat (Fig. CXLV.), designed in 1898 by Mr. C. H. Homan, is a hollow mast A pivoted to the hull by a rack and pinion and capable of being raised from its recess in the deck to a vertical position. This mast has windows to admit light and a passage fitted with steps, large enough to permit a man to ascend and make observations. A camera and lenses may be fitted to allow of these observations being taken without a man ascending to



CXLV. MODEL OF HOMAN'S SUBMARINE

the top. The vessel, of which very few details are known, is propelled by a single propeller and is steered by an ordinary boat rudder. No informative as to the means employed for rotating the screw, the method of submersion or aeration, is obtainable.

Goubet

The following is a description of one of the two 'Goubet' boats built for the Brazilian Navy.[1]

'The newer 'Goubet' is much smaller [2] (?) than her prototype, being 26 feet in length, 5 feet 6 inches in diameter in the middle, and with a displacement of 10 tons. She is

1 'Torpedoes and Torpedo Vessels,' 2nd edition, Lieutenant Armstrong, late R.N., pp. 267-269.

2 This is evidently a slip, as the Lieutenant undoubtedly means *larger*.

spindle-shaped, and cast in three sections bolted together, the material of her hull being gun-metal. A little manhole-dome surmounts the middle section, and projects about a foot above the top. On each side of her is a lateral horizontal keel as a guide to stability, and each keel carries a White-head torpedo. The boat is propelled by an electric motor, the electricity for which is derived, not from accumulators, as in the case of other submarine boats, but from Schanschieff batteries capable of developing one-and-a-half horse-power in the motor. This is sufficient for pumping purposes as well. The screw is mounted in such a way that it can be turned about like a rudder, and therefore dispenses with the necessity for the latter;[1] and so effective is it in its action that the vessel can turn almost in her own length. In addition to her electrical engines, the 'Goubet' has a 'stand by' in the shape of a pair of oar-like fins which can be manned by hand, and which propel her at about two knots. These 'oars' would be used when the boat has approached close to the object aimed at. The engines would then be stopped, the 'oars' manned, and the boat placed in such a position that her torpedo would point direct for the enemy before being fired.

The air is kept at a normal condition and pressure by steel tubes containing oxygen and ozone, whilst the vitiated gases are expelled by a special form of pump. On ordinary occasions enough air could be carried to last about fifteen hours.

On board the 'Goubet,' as also in every other submarine vessel, the surface can be scanned by the use of an optical tube called a 'périscope,' which by means of a pneumatic telescopic apparatus, can be protruded above the surface and pulled down in a moment. This telescope has a system of prisms and lenses which causes the image of the sea surface to be deflected down to the eye of the observer below, the object-glass above being no bigger than a crown piece. With this simple apparatus the surface can be scanned in fine weather, and then only with the greatest difficulty. It may, indeed, be affirmed that up to the present no satisfactory mode of vision beneath the surface has been discovered.'

It will be seen by the above description that the Brazilian

1 Nevertheless these vessels are I think fitted with rudders.

vessels differ very little from their confrères of France, the chief difference being in size. They are also more perfect vessels, having the advantage of three or four years additional experience. No detailed information re the trials of the boats on their arrival at their destination is obtainable, all we know being that they were very successful. A new vessel of Brazilian design is at present under construction, but reference to this boat will be found under the year 1901.

1899 W. Atkinson

In 1899 there was tested in the public swimming baths at Buckingham Palace Road, a model of a submarine boat designed by William Atkinson, a retired Naval engineer. Some account of the marvellous performances of this vessel was published in a well-known evening paper, one of the staff of which, had by request, been present at the experiments.

The little boat showed wonderful diving and turning powers and left the 'Goubet' vessels far behind (?) in the matter of stability. In honour of the well-known and popular admiral, the inventor named it the 'Charles Beresford'; it was fitted with perpendicular tubes so arranged that torpedoes would be fired upwards as the sumbarine boat passed under the keel of a hostile warship. Owing to lack of funds the inventor was forced to give up the idea of building a larger model, for which he had already drafted the plans.

A. J. Body

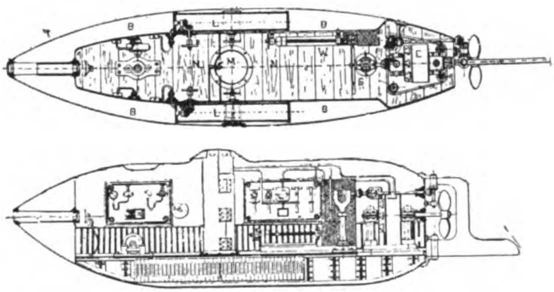
On June 14th of this year, H. Lake took out a patent for Mr. A. J. B. Body, for a submarine boat. His invention is of a vessel which can be employed either on the surface or submerged, and is intended to be carried on mail-boats, merchantmen, or men-of-war. It is a small vessel and could easily be transported from port to port by rail and be thus used for harbour defence.

In shape it is cylindro-conical, flattened at the bottom and with the forward point lopped off to the diameter of a torpedo tube. It is made in ten sections,—a large centre one for the crew, containing the motive power and other mechanism, and nine small ones, five forward and four aft. The foremost is merely the stem. The 4th, 5th, and 7th are compartments for the storage of compressed air, the remainder serving as water-ballast tanks, the filling of which is regulated by compressed air. A long torpedo tube pierces the forward five sections, and in this tube several torpedoes of a special kind, are placed one behind the other. Spare torpedoes are stowed in the lower half of the 4th section. The torpedoes, which run on a small race or rail, are fired by compressed air, the tompion closing directly after the first has been ejected so as to leave the tube ready for the next. The four-bladed propeller is driven by an electric motor.

Anon English

This vessel is the design of an Englishman. The hull, as may be seen by the plan, is double, the interior portion being devoted to the crew.

The following points of interest may be noticed: L L in the exterior compartment, are reservoirs of compressed air, the electric motor E by which the propeller is rotated, is supplied by electricity stored in accumulators in the keel (see Figs. CXLVI.-CXLVII.), the even flow of the current is controlled by a rheostat;[1] the depth at which the vessel is



CXLVI.-CXLVII. ANONYMOUS BRITISH SUBMARINE

submerged is registered by manometers; submersion is obtained by filling the spaces B B of the outer compartment with water.

All the gear for a diver is also carried so that, one of the crew could leave the vessel and remove obstacles, cut mine-connections or cables, fix torpedoes or lay mines as the case may be. The interior is lighted by electricity and a strong search-light is also fitted in the bows. The illustrations are reproduced from a foreign scientific paper.

In June, 1900, reports were circulated that a new submarine boat, invented by M. Hoffman, an officer in the Austrian Navy,

1 A Rheostat is an instrument for regulating electric currents in the same way as a governor regulates the speed of a steam-engine.

1900 Hoffmann

was being constructed for the French Government; this vessel is expected to completely revolutionize (?) submarine navigation.

J.R.

In the 'Armée et Marine' for June 3rd, 1900, appeared an article signed J.R. headed 'Torpilleurs Aquablindés.' This article accompanied by two plans gave a description of a new armoured submersible. The dimensions given are as follows:

Length	46 m 80
Beam	5 m 60
Light draught	3 m 40
Submerged draught	5 m 38
Displacement, light	309 tons
I.H.P.	4,500 = 25 knots light
	= 21 knots submerged
Coal capacity	30 tons
Radius of action	300 miles at full speed
	2,500 miles at 10 knots

In shape this vessel in every way resembles the ordinary surface torpedo boat, having ram-bows, a signal mast, two funnels fore and aft and two towers, one at each end, serving as conning-towers and having small quick-firers mounted. Submersion is obtained by admitting 25 tons of water into 2 large tanks placed fore and aft and this leaves only a few inches of the boat visible. The vessel is divided into 2 parts by an armoured deck, and this armoured deck is, when ready for action, protected by a bed of water. The author of the designs thinks that submersion could easily be carried out in two minutes at a moderate speed. The engines are on the Parsons' turbine system and are supplied with steam from 2 boilers. In conclusion the journal says—'L'idée ingénieuse qui a présidé à la conception de ce type de bâtiment aurait été accuellie avec chances de succès, dans notre marine, il y a quelques anneés. A l'heure actuelle, l'aquablindé ne constituerait qu'un compromis entre le torpilleur et le sous-marin.'

Hudson Maxim

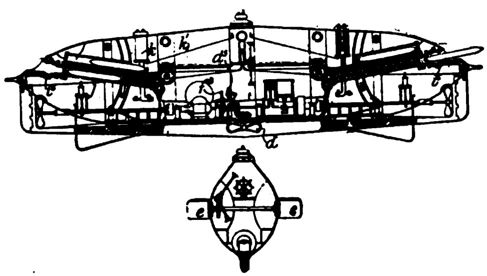
In the 'Home Magazine' (U.S.A.) for April, 1900, Mr. Hudson Maxim, published an article entitled 'The War of the Future.' He described here a type of submersible boat fitted with tubes for firing his aerial torpedoes. In principle this vessel very much resembled the French one described, it being fitted with two sets of turbines. These were to be driven by sticks of 'Motorite' and a power of 30,000 I.H.P. could thus be developed. The dimensions of Mr. Maxim's proposed boat are:—

Length	275 feet.
Beam	33 feet.
Depth	30 feet.

Unfortunately 'motorite is very costly and an hour's steaming at 30,000 I.H.P. would cost no less than £12,000. This seems to preclude its use in modern war-vessels, unless some 'great combine' manages to manufacture this potent motive power very much cheaper.

Besides the aerial torpedo cannons, two submerged torpedo tubes are fitted and these have each ten torpedoes which by an ingenious automatic device of the inventor, can be discharged like Maxim bullets one after the other. The torpedo tubes are 50 feet long. The aerial torpedoes would carry 1,000 lbs. of a very high explosive,—probably Maximite.

The next inventor in 1900 hails from Australia. Mr. A. H. Argles resides in Bendigo Street, Neutral Bay, North Sydney. New South Wales, Australia, and his design is somewhat out of the common. A. H. Argles



CXLVIII.-CXLIX. A. H. ARGLES' PROPOSED SUBMARINE

As will be seen by the plan below, it is cigar-shaped, or rather egg-shaped, oval in cross-section and very pointed at the ends I cannot do better than take an extract from the inventor's description, which is very lucid.

The skin on the upper side is preferably double so as to form a protection against projectiles. Submersion is obtained by the screw *d*, and the boat is manœuvred in the vertical plane by means of side fins *e*, connected in pairs and controlled from the conning-tower. A heavy keel is fitted to aid in keeping the boat stable. It can be propelled in either direction by screws driven by an oil-engine while on the surface and by an electric motor when submerged. These motors run continuously in one direction and are geared to one or other of the screws by clutches controlled by a lever. The screw *d* is driven from the main shaft by a bevel gear, which can be disconnected by the movement of a suitably placed lever.

Two rudders are fitted, one at each end, both being connected to a wheel in the conning-tower, by which they are operated. Either rudder can be locked by a spring bolt which is disengaged by a line. Cutting blades are fitted at each end of the vessel to clear away weeds, etc., whilst hinged blades *o* fitted on the bottom, ring electric alarms when the vessel touches ground. Compressed air is carried in side compartments but when the vessel is near the surface a supply of air is obtained through telescopic tubes *k*, provided with valves to exclude water. These tubes may be pushed outwards by springs or screws, and are withdrawn by cords. Air may be drawn in by a pump or by an ejector nozzle.

The armament consists of torpedoes, which are carried in cylinders so situated that they can be brought one at a time in line with ejector cylinder *j*. This contains a piston pushed outwards by a powerful spring which is compressed and the piston withdrawn by a line wound upon a barrel rotated by a small oil or electric-motor. This discharging cylinder is connected to the ship by a ball and socket joint, and is elevated and depressed by rack and pinion gear. After a torpedo has been discharged the cylinder is closed by a shutter to exclude the water when the piston is withdrawn.

Drzewiecki No. VII

This is the last invention of the Russian engineer that I have to chronicle. Although very few details have been published concerning this boat, we know that, unlike his first designs, it is a 'submersible,' and that only to a certain extent, as the inventor now believes that no vessel will ever have cause to submerge completely, the invisibility of torpedo craft when in the 'awash' condition being ample protection. M. Drzewiecki's designs are at the present moment receiving the careful attention of the French Naval Department and there is more than one chance of a favourable opinion being expressed on them. Should this be so we shall no doubt hear more of this latest invention of the talented Russian. Perhaps no man deserves success more than M. Drzewiecki for he has studied the question seriously and thoroughly ever since his embryo submarine of 1877. May he have the best of luck.

In 1900 a Mr. E. Howard, of Hobart, Tasmania, produced a successful model of a submarine. The presence of this vessel was much noised about by a well-known paper and weird rumours of Government orders were current for some months. The following cutting is a good specimen.[1]

E. Howard

'Stores are being drawn from Woolwich and other stations in connection with the trial by the Naval Authorities of a newly-designed submarine boat. So far as the experiments have proceeded the trial has been satisfactory. The boat submerges and travels well, and is so constructed as to admit of its passing under an enemy's heaviest warship. In this way a submarine mine, charged with 500 lbs. of guncotton, equivalent to 2,000 lbs. of gunpowder, can be attached to the warship, and allow time for the submarine boat to get out of danger before the exploder acts. The boat is fitted with two tubes for discharging torpedoes both above and below water, and is armed with quick-firing and machine guns. The vessel thus equipped will, when finally approved by the Admiralty, be a formidable engine of war. Should the exigencies of naval warfare necessitate the use of this terrible little craft, it is believed it will be able to successfully encounter the largest battle-ship afloat.'

The following cutting is of later date:—

'Mr. James Ellis Howard, an old Tasmanian, who claims to have successfully solved the problem of submarine navigation, has returned to Hobart for a few days after visiting England. He had great trouble in inducing the Admiralty authorities to notice his invention. They have now, however, gone so far as to say that they think his design will be adopted, but they desire first practical demonstration with a fully-equipped boat.'[2]

1 'Naval and Military Record,' August 30th, 1900.
2 'The British Australasian,' September 3rd, 1901.

This may be an explanation of the rumour that a tenth submarine boat is under course of construction for the British Navy.

1901
J. Gomez

The first years of the new century have been up till now wonderfully fruitful in the matter of submarine boats. The first to come under our notice is the invention of one, L. Jacintho Gomez. Details concerning this boat are unobtainable, but its trials have up to the present been remarkably successful. Señor Gomez is a mechanician of the Argentine Navy.

Recaldoni

Simultaneously with the report of the invention of Señor Gomez, we hear of a second submarine vessel built for the South American Republic. This second one is a submersible torpedo boat and the working model, which has been tested at Buenos Ayres, is highly approved of by naval experts. Señor Recaldoni the inventor is a civil engineer and had already acquired some fame locally as a man of great ability and striking ingenuity.

Mello
Marques

Not to be behind in the matter of submarine navigation Brazil has considerably encouraged inventors during the last few years, and in September, 1901, a model was tried in the Aquarium at Rio de Janeiro in the presence of the leading officers of the Brazilian Navy.[1]

These trials proved an unqualified success and a larger vessel is to be built from the same plans as the model, which has been named after the inventor Señor Mello Marques, a naval engineer. At the beginning of October, 1901, the 'Mello Marques' was again tried before the President of the Republic, Minister of the Navy, Members of Parliament and Civil and Military Officials with splendid results.[2]

When the 'Mello Marques II.' is completed the Brazilian Government will be in possession of three valuable submarine boats, the two 'Goubets' built in 1898 being much superior to those tested recently in France.

Vernon

In January, 1901, experiments were carried out with the model of a submarine boat in the dock basin at Marseilles in the presence of Admiral Besson and other Naval authorities.

1 From despatch in the 'New York World.'

2 Cablegram to Brazilian Chargé d'Affaires in London, October 4th, 1901.

The vessel with which these trials were executed was constructed by a coppersmith named Vernon, employed in the workshops of the Transatlantic Company. The model is in the shape of a cigar and measures two metres in length and fifty centimetres in diameter. It is provided with fin-like blades on both sides and its motion resembles the movements of a fish.

Graydon

Lieutenant Graydon, an American inventor, claims to have improved the turbine type of engine to such an extent, that a submerged speed of 50 knots will be the rule rather than the exception, if only his plans are followed. One can lend a sympathetic ear to Lieutenant Graydon (whilst receiving all information re his inventions with respectful reserve) since it was he who patented the design for the Great Wheel, at Earl's Court Exhibition, and he again, founded the 'Gigantic Wheel and Recreation Towers Company, Limited,' in 1895.[1]

T. H. Williamson

More inventions have seen light in the columns of the 'Daily Express' than in any other periodical, and the following description and plan of an invention by Mr. T. H. Williamson, have been extracted from that paper.[2]

'For months Mr. Thomas H. Williamson has been attempting to bring before the Admiralty the details of a new submarine, a craft containing elements of startling novelty, which has cost the inventor nearly £5,000 and four years' hard work.

'All communications addressed to the Admiralty and to Mr. Arnold-Forster have been acknowledged with the usual printed form, stating that the matter would be 'laid before the Board.'

'Though the inventor is a London man, and his workshop is open to Government inspection, no submarine expert has been sent to spend an hour with him and discover whether there is anything in the patented features of the Williamson boat.

'Mr. Williamson has so far passed the theoretical and experimental stage that he has constructed one large and expensive model, operating it with great success a year ago, and is now

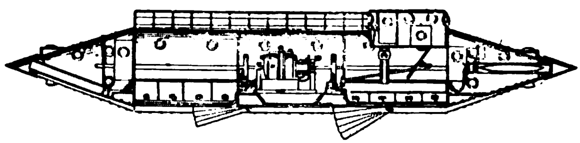
1 'Discoveries and Inventions of the Nineteenth Century,' Robert Routledge, B.Sc., F.C.S.
2 August 26th, 1901.

engaged upon an improved edition. The boat is certainly ready for serious consideration.

'Mr. Williamson has planned his full-sized boat to a length of 100 feet, and a diameter of 12 feet. Its ends are sharply conical, and carry two propellers each, set at an angle to the centre line of the craft.

'Looking at the model, the features which demand immediate attention are the fins issuing from the tube. There are six of these; two set perpendicularly on the sides to aid in steering the boat; two placed horizontally, like inclined planes, to assist the tube in diving and rising, and two emerging fan-like from the heavy keel to act as slip keels or centre-boards, giving an additional draught of 4 feet.

'Examining the ends more closely, an ingenious device is disclosed, whereby each will split open, allowing torpedoes to issue.



CL. THE WILLIAMSON SUBMARINE BOAT

'In the development of his idea for firing a torpedo from either end Mr. Williamson has worked in a ball-head, by which the torpedo tube can be deflected through a considerable radius. By this means the submarine need not itself be pointed upwards to the vessel it wishes to strike, and the torpedo can be sent on its deadly errand with a more certain aim. A water-tight head also follows the torpedo as it leaves the tube, and effectually prevents the water from entering the conical end of the submarine.

'Four compressed air compartments and two air compressors supply the motive power to eject the torpedoes, and another apparatus oxygenates and purifies the air breathed by the crew, enabling the boat to travel many hours entirely submerged.

'When travelling half immersed the deck of the submarine is 36 feet by 3 feet wide, with a conning-tower 3 feet high and a collapsible railing.

''I claim for my submarine,' said Mr. Williamson to an

'Express' representative, 'novelty in shape, construction, armament, air supply, and motive power. The last-named is produced by an electrical motor of my own invention, which is wonderfully economical of power. My 10-ft. model developes easily two-and-a-half horse-power. I estimate a speed of twenty miles an hour under water. The forward propellers materially assist the boat by reducing the resistance of the water, and the novel angle at which they are placed enables me to use them with great effect in turning so that the boat will turn in twice her own length. My model, operated by means of an electric switch-board from a dinghy, exhibited great powers of turning, rising, and diving, thanks to the control I had over the six fins.'

'Mr. Williamson's first request for a Government inspection of his craft and plans were made on April 2nd.'

'If the hopes of its inventor are realised a new submarine torpedo-boat superior to any yet in existence will shortly be added to one of the world's Navies. The inventor is Mr. W. Polson, a bootmaker in Shadwell, who, after seven years' study, has completed a working model of a boat which he is confident will have an important share in the revolution of naval warfare. Mr. Polson claims that his boat could be submerged with great rapidity, could carry twice as much compressed air as any submarine so far invented, and that its crew of seven men could live under water for forty-eight hours. **W. Polson**

'My boat is to be built of steel and propelled by a single screw, driven by a powerful electric motor,' he said yesterday; 'the length, including a sharp-nosed ram, will be 58 feet, the beam 12 feet, and the depth of the boat, without the detachable iron keel, 10 feet. The detachable keel will add eight inches to the boat's draught. By detaching this keel the boat would be able to rise very rapidly to the surface. The lower four feet of the body of the boat is taken up by the water compartments. The remaining six feet of its ten feet of depth is in one large compartment, with the exception of a small water-tight companion-way, by means of which the men may leave and enter the large compartment at will, thus being able, with the aid of diving suits, to get out of the boat and cut away cables.'[1]

1 'Glasgow Record,' October 1st, 1901.

F. J. Sweeting

Mr. F. J. Sweeting patented a submarine boat last year, but details concerning it are unknown.

Anon English

This time it is an Englishman who brings forward a submarine boat; the inventor, whose name cannot for certain reasons be divulged, is a marine engineer, resident in Newcastle.

The model, which has been strangely successful, as indeed most models are, is we are told, buoyancy perfected, and the rapidity of propulsion claimed is abnormal. It has very fine lines, speed being the main factor in view. Submersion and emersion are not obtained by the usual method of augmentation and reduction of water, but by the power of machinery which forces the vessel beneath the surface. The motive power is electricity for both surface and submerged navigation, whilst the ram is also worked by electricity.

It is in this ram that the novelty lies; no automobile torpedoes or kindred means of offence are carried, but the ram works out of the vessel piston-like, delivering a powerful stroke. Then to the weakened spot a time-mine is attached and the destruction of the vessel attacked follows in due course. The inventor also claims to have attained great results in overcoming sighting difficulties under water.

The vessel would be of steel, 40 feet long, 8 feet deep, and 7 feet beam, and one of them would cost the small sum of £5,000.

A. Kampfe

One can never tell to what heights ambition may not soar, but surely M. Anschütz-Kampfe, of Monaco, must be very near the summit; he proposes to follow the teaching of Jules Verne and essay a trip to the North Pole by submarine boat.[1] He has proved to his entire satisfaction that the greatest depth of ice in the Polar Seas does not exceed 30 metres (?) and to allow a good margin for icebergs having the audacity to float deeper than his calculated limit, he proposes to navigate with his vessel at a depth of 50 metres.[2]

He provides enough air for the crew for 15 hours and considers it a certainty that during this time he will be able to find a 'blow-hole' to come up and have a breather. And, if in spite

1 'Le Journal des Débats,' October 6th, 1901.

2 According to the 'Moniteur de la Flotte' this vessel is now under construction at Wilhelmshaven.

of his earnest endeavours, the ice-flow still insists on barring his road to Heaven, he will break it, trusting to a manometer to show him the weakest places. It will be perceived that every eventuality has been amply provided for. One wonders if, following the example of André, de la Vaulx and others who used pigeons for keeping their friends at home cognisant with their whereabouts, whether M. Anschütz-Kampfe will utilize fish for the same purpose; who knows?

M. Kampfe, with great courage, placed his project before the Geographical Society of Vienna; the result is unknown.

If this audacious explorer cares to make a short experimental trip beneath the waters of the Baltic in the middle of the ice-bound season, I fancy his praiseworthy enthusiasm would receive a rude and chilling rebuff. Here he would find miles and miles of ice-flow twenty feet thick, and only an occasional crevass, too small to allow of even a fair-sized sturgeon coming to the surface.

The following is an extract from the 'Pall Mall Gazette,' October 19th, 1901: Bow Koru

'A patent has just been applied for in Tunis for a new kind of industrial submarine—the Bow Koru, and for a dredging or grappling mechanism with which it is fitted. This mechanism is designed to catch and retain interesting objects on the sea bottom, to a depth of 100 metres. It is expected that the invention will prove extremely useful in exploring lakes and gulfs.

Messrs. Graydon, Apostoloff and Lacavalerie are not the only inventors of recent years who have claimed high speed for their vessels. Mr. Zacovenko, a Russian, possessed of much scientific knowledge we are told, has designed a submarine boat from which he expects the enormous speed of 60 knots per hour. He is indeed a daring man to prophesy to such an extent! True he does not go as far as Apostoloff, whose boat was to have been meteoric in its progress: Havre to New York in 28 hours, or an hourly speed of 111 knots!! Zacovenko

A Frenchman is this inventor, as have the majority been. M. Ponthus has already received awards for his designs, at Liverpool in 1886 and at Toulon in 1889, both for plans executed as far back at 1882. This present idea, however, far transcends all his former efforts, and deserves a notice, 1902 Ponthus taking into consideration the extraordinary perseverance of the inventor.

It is in the form of a spindle, similar to the Goubet II., but somewhat more elongated. At each end is a propeller incased in a peculiarly shaped guard, resembling in form the Japanese religious emblem known as a 'tokko.'

A large flat-topped circular conning-tower occupies the central portion of the top of the vessel, and this also serves as the means of exit and entrance. Forward of this is a search-light and abaft a horizontal fin or keel, a similar one being placed in a corresponding position beneath the hull.

On either side, at the same distance from the stern as the horizontal rudders, are two vertical planes or fins, and beneath them are detachable ballast weights.

The propellers are three in number, one at each end, as mentioned above, and a third in a recess in the keel. The motive power is to be an oil-engine, whilst an auxiliary air-engine will be carried with the ingenious idea of obviating the excessive cavitation inevitably resultant upon the rapid revolution of propellers, by blowing water, the medium of power, into the cavities so formed. The inventor hopes that his vessel will have a speed of over forty knots an hour, and is very sanguine that this result will be easily obtained.

T. J. Moriarty

This small vessel is the invention of Mr. Thomas J. Moriarty, for many years the mechanical expert in the employ of the United States Government at the torpedo station of the United States Navy, located at Newport, Rhode Island. The Moriarty boat is a one-man boat, and this has set many people against it, although there are those who believe that if two men formed the crew, it might be a useful craft in time of war. It has not yet been constructed, but the following is a description of it as it will be.

It is a cigar-shaped boat, about 10 feet long, 3 feet deep, and having a 5 feet beam. Beneath the boat is suspended the Whitehead torpedo in a frame, and within easy command of the man in the boat is a wheel, to which is attached a rod for releasing the torpedo from its carrying frame. As the torpedo is released, the starting lever of the torpedo is automatically moved, which in turn admits air under high pressure to the propelling engine. The instant the torpedo is released from the boat the man changes the angle of the blades of the propeller, and thus is able to back the boat. The inventor claims that the man in the boat can without injury to himself discharge the torpedo 100 feet or thereabouts from the object of attack. The motive power on the surface is a gasoline engine, and when awash, or submerged, the boat is propelled by a bicycle mechanism worked by the hands and feet of the man. Provision has been made whereby the man is seated in a cradle, whose construction is of such a character as to enable him to brace himself to work most effectively. There are hand and foot levers, and the propeller is similar to that used in the Howell torpedo.

If higher speed when running submerged is required the torpedo, whilst still attached to the boat, can be put in motion, and thus increase very materially the speed of the boat. The Moriarty boat is submerged by the admission of water into tanks, and on each bow and each quarter there is a hydroplane, or horizontal rudder, by means of which the boat is made to descend or ascend as desired. The depth of submersion is regulated in practically the same manner as the submersion of a Whitehead torpedo is regulated, i.e., by the amount of tension on the spring of a hydrostatic piston.

The inventor claims that the boat will travel about four miles an hour under bicycle power, and that the man could remain in the boat at least six hours, during four of which he could keep up the bicycle propulsion. As the boat is very small, it is impossible for the man to stand up, and he is forced to occupy an almost horizontal position. Mr. Moriarty claims that he can shift his position, so that he can sit 'with some comfort.' He said, 'You will find that there is sufficient room for him to do considerable shifting around.' In reply to a question as to how long a man can stay under water, Mr. Moriarty said, 'Two hours without any artificial aid. You must remember, however, that the boat can partly rise to an extent that will permit the top of the ventilator to be above water. This will permit the automatic stop valve to the ventilator to be opened, and considerable fresh air can be introduced. I may say that we are experimenting with substances that will take up the carbon dioxide. Considerable success has been experienced with the French boats in admitting substances that will absorb these noxious or dangerous gases that are exhaled by the men sealed up in the boat.'

The inventor estimates the cost of his first boat at 15,000 dollars, but the next dozen should be made for 7,500 dollars each. These are intended to be carried on surface vessels and are capable of being transported by rail or wagon.[1]

C. L. Burger

'Last scene of all that ends this strange eventful history': An American engineer, Mr. Clarence L. Burger, is the inventor of the final invention I have to chronicle. It is being exploited by the Subsurface Torpedo-boat Company, and we are likely to hear more about it very shortly.[2]

L. Vucasinovich

This gentleman took out a patent for submarine torpedo boats on December 22nd, 1902.

1 From an article by Herbert C. Fyfe, in the 'Naval and Military Record' of August 14th, 1902.

2 See Addenda.

PART IV

THE 'LAKE' SUBMARINE BOATS.

THIS young inventor (he is well this side of 40) has made his name famous through the exploits of his marvellous submarine explorers. Mr. Simon Lake, to whom I wrote asking for some information, kindly sent me a charming booklet entitled 'The Argonaut; her Evolution and History,' and it is this compact little work that I have reproduced below. The first part is a short survey of the life of the astute American, and it is interesting as showing the early date at which he conceived the remarkable vessel, which through the evolution of time has become the 'Argonaut.' In June, 1901, a Company (the Lake Torpedo Boat Company) was formed for the designing and building of submarine torpedo boats and pleasure craft. At this present moment it has one or more vessels in hand for the U.S. Government. Its Directors are:

President: Simon Lake.

Secretary: S. T. Champion. *Treasurer:* Lebbeus B. Miller.

Committee: J. H. Rothert, William T. Malster, H. J. Ely, J. C. Lake.

The head offices are at 11, Broadway, New York, and with such men as those mentioned above (Mr. Miller is head of the Singer Manufacturing Co., Elizabethport, N.J.; Mr. Malster is President of the Columbian Iron Works and Dry Docks Co., Baltimore, Md.; while Mr. Rothert is a noted Capitalist) possessing not only ample capital but an extraordinary amount of business capacity and sound common sense, this newly formed Syndicate will not long be an unknown quantity, and we shall shortly hear more about it.

SUBMARINE NAVIGATION

SIMON LAKE, INVENTOR OF THE 'ARGONAUT.'[1]

Possibly the greatest achievement of this inventive age is the 'Lake' submarine boat by means of which the bottom of the ocean may be traversed and explored as well as its surface. In the first place, the inventor of this wonderful vessel has successfully overcome all the difficulties of navigation beneath the surface of the water. He has produced a ship which is a marvel of mechanical skill and one which actually goes to the bottom and moves rapidly about, responsive to the will of its commander, and, besides, it can be put to a variety of practical uses.

Equipped with the necessary machinery and appliances for propelling the vessel, for providing compressed air for its passengers and for lighting its way beneath the waves, the 'Argonaut,' as the new vessel is called, is ready at all times for a trip to the bottom of the sea. It can be employed in searching for sunken wrecks and in securing the valuable cargoes or treasures which were buried with them. It can be used in finding hulls that are intact and in raising them to the surface, while in the rôle of a torpedo boat it would prove a most valuable acquisition to modern navies, as well as for service in coast defence.

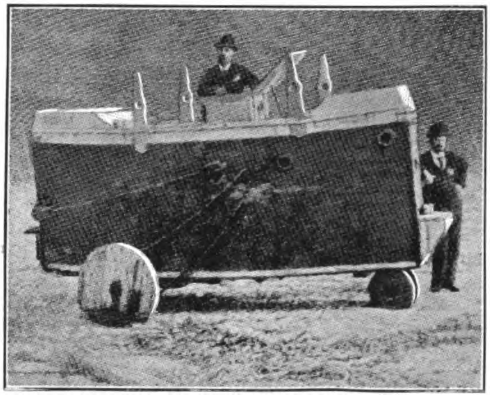
The problem of submarine navigation is not esentially different from sailing through the air. As long as a vessel is propelled upon the surface it moves in the same plane, turning right or left, advancing or going backward, as the case may be. But the moment the ship is submerged motion may be in any plane, in any direction, at any angle; hence difficult problems relating to equilibrium, trim and control of the action of the vessel arise, and as yet no boat has been invented that could be depended upon to sail rapidly through the water midway between the surface and the bottom. In the 'Lake' boat, however, all these difficulties are met by going directly to the bottom and shaping the course, as on the surface, in one plane. As a result a hitherto insuperable obstacle has been eliminated by very simple means.

The inventor of the first successful submarine vessel is Simon Lake, born in Pleasantville, N.J., September 4th, 1866. He

1 From the 'American Shipbuilder,' February 9th, 1889.

sprung from Welsh stock, the ancestor coming from that country in the seventeenth century and locating in New Jersey The family has been identified with industrial and other interests in that State for many years, the grandfather, Hon. Simon Lake, from whom the inventor was named, being the original owner and promoter of the famous sea-side resort known as Ocean City, N.J.

Simon Lake has been at work upon his invention since he was fifteen years of age. When not more than ten years old chance threw that wonderfully interesting book, Jules Verne's 'Twenty Thousand Leagues Under the Sea' in his way. He read it through, and the impression left upon his mind remained, took shape and grew until it is now embodied in



CLI. SIMON LAKE'S FIRST SUBMARINE

one of the most remarkable inventions of the nineteenth century. Mr. Lake tried many experiments and worked along many lines of investigation before he hit upon the simple plan and apparatus which composed the completed craft.

Young though he was, he laboured patiently on in secret until his plans were perfected and until all his tests had been made. Finally, in 1895, they were given to the world, and his first boat was built at Atlantic Highlands that year. This was comparatively small and was constructed for the sole purpose of proving the feasibility of his plan. But machinists and engineers were slow to accept the proof until their own eyes beheld the plans, and capital laughed at the idea as being Utopean and chimerical. It was not until William T. Malster, President of the Columbian Iron Works and Dry Docks Co., of Baltimore, Md., became interested in the undertaking that daylight gleamed through the clouds of difficulty which beset the young inventor's way. But the launching of the 'Argonaut' and its behaviour on successive trial trips has removed all doubts as to the success and utility of his new submarine boat.

The 'Argonaut I'

The picture shows the 'Argonaut Jr.' She was built in the winter of 1894. In 1893 Mr. Lake gave up his other business in Baltimore, Md., came to New York and opened an office in the Cheeseborough building, remaining several months in an effort to enlist capital in his enterprise. He had plans for a boat about 80 feet long and 11 feet in diameter which he hoped to build; but as the cost of such a vessel would be about $75,000, he was unsuccessful in raising the required capital, investors not being found who were willing to put up that amount on an experiment.

Plans a large vessel

This boat Mr. Lake expected to call the 'Argonaut' as the *Argonaut* is the name of an animal that lives in the sea, that either creeps about on the bottom, swims between the surface and the bottom or comes to the surface, sets a tiny sail and skims over the seas. This animal is more commonly known as the 'Portuguese man-o'-war.'

The first sailors of which we have any historical record were also called *Argonauts*, and this is a common name given to the pioneers of a new region who go in search of gold. As the 'Argonaut' was to be capable of crawling along on the bottom, swimming beneath, or sailing on the surface, and was also to be a pioneer in the unexplored regions of the bottom of the sea, as well as a gold-seeker, Mr. Lake thought the name peculiarly appropriate. Being unable, however, to raise the required capital to build the 'Argonaut' as he wished, he decided to construct a smaller craft capable of substantiating some of his claims.

Dimensions

He went to Atlantic Highlands, N.J., where the 'Argonaut Jr.' was built during the winter of 1894-5. She was only 14 feet long, 4½ feet wide and about 5 feet high. She was built (principally by himself) of yellow pine timber, double thick, painted with coal-tar, and was propelled on the bottom by turning a crank on the inside of the boat which operated the driving wheels.

The compressed air was stored in a soda-water tank, and the air compressor was only a plumber's hand-pump. The diving armour was one he himself made out of canvas and painted to render it impervious to water. The air supply was conducted through a piece of common wire-wound garden hose.

This boat was designed to stand a maximum pressure corresponding to a depth of only 20 feet, and it was never intended to do more with her than to submerge in shallow water and travel around on the bottom to show that she was easily managed and to open the door of the diver's compartment while submerged to prove that the water could be excluded, a sufficient air pressure being maintained therein for the purpose.

Trials

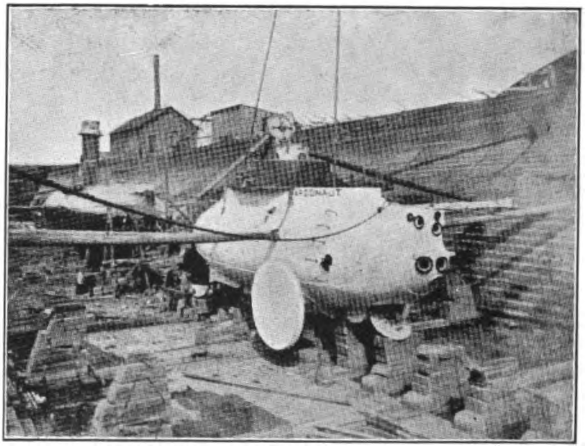
She was experimented with during the months of July and August in 1895. Three men, Messrs. Lake, S. T. Champion and B. F. Champion, of Atlantic Highlands, N.J., were submerged in her at one time for 1 hour and 15 minutes at a depth of 16 feet, and during the submergence the door was opened and articles lost or thrown overboard from the dock were recovered through the open door.

On the strength of these experiments, which were witnessed by many of the prominent people of Atlantic Highlands, N.J., capital was subscribed toward building a larger boat to further demonstrate the principles involved, and the Lake Submarine Company was organized for that purpose in November, 1895, but owing to the difficulty in raising sufficient funds to build the proposed larger boat Mr. Lake designed a smaller one, the 'Argonaut,' now of international reputation, which was built by the Columbian Iron Works and Dry Docks Company, of Baltimore, Md., in 1897.

'Argonaut II'

The 'Argonaut,' which was only 36 feet long and 9 feet beam, was fitted with a 30 horse-power engine, a dynamo, an air-compressor, a search-light, water ballast pumps (both power and hand), etc., the apparatus necessary for successful submarine navigation; but in such a small vessel there was, of course, little accommodation for the crew, and no carrying capacity, yet five men made a cruise in her during 1898 of over 2,000 miles in the Chesapeake Bay and on the Atlantic Coast, travelling both on the surface and submerged, and over all kinds of bottom, and put her through every test which could be suggested to demonstrate the practicability of living and travelling successfully under water.

She was finally brought to New York in December, 1898, after thoroughly proving her seaworthiness by being out in the storms of October and November of that year, in which over 200 vessels were lost along the coast.



CLII. THE 'ARGONAUT II'

During the winter 1898-99 Mr. Lake made plans for enlarging her, and also for adding some further improvements he had invented, which would give her great additional buoyancy while on the surface, increased deck room and much more fuel-carrying capacity. This was an entirely new departure in submarine boats, and removed the principal objection naval men have had for submarine vessels, the 'Argonaut,' with this improvement, being as well adapted for comfort as any surface vessel of her dimensions. In all other submarine boats, as soon as there is any sea at all, it is necessary to go below and close one's self up tight, as they have so little freeboard and no deck.

She was taken to the shipyard of the J. N. Robbins' Dry

Dock Company in Brooklyn, N.Y., during 1899, for enlargement and alterations in accordance with Mr. Lake's recent plans, and left there December 28th, 1899, for Bridgeport, Conn., where she has recently been completed (July, 1900), and additional demonstrations given which still further show her practicability as a submarine navigator, and prove also that vessels of her type must be a great commercial success even in recovering such cargoes as coal, as will be shown later.

Improvements effected

As reconstructed, the 'Argonaut' is as buoyant on the surface as other surface vessels of her size and is much more stable. The additional length also gives room for sleeping quarters for the crew, so that she is now capable of making a continuous sea voyage of about 3,000 miles, and affords accommodation for a crew of eight men.

PRESENT DIMENSIONS AND EQUIPMENT.

The length over all of her superstructure is 66 feet, and her beam is 10 feet, the circular portion which must resist the pressure of water, being 56 feet long and 9 feet beam. The upper superstructure fills with water when submerged and is not required to resist the water pressure.

She has a 60 horse-power White and Middleton gas-engine to propel her when on the surface or on the bottom, run the arc light dynamo, the main air compressor, water ballast pumps, power hoisting, etc., also a 4 horse-power engine for incandescent lighting, raising the anchor weights and running a small air compressor.

She carries sufficient air supply for a submergence of forty-eight hours, without surface connection. With a surface connection she can remain submerged for an indefinite period, determined only by the amount of fuel and supplies on board.

She has a diving compartment in the bow, through which the divers can readily pass out or in when on the bottom (no water entering the boat while the door is open), and a search-light in the bow, which lights up the pathway in front of her as she wheels along over the bottom. She is also fitted with telephones throughout, so that conversation can be carried on between the divers and their tenders, with different parts of the boat, with the surface or with the shore.

HER PERFORMANCES.

The 'Argonaut' soon after her completion at the shipyard of the Columbian Iron Works and Dry Dock Company, in 1897, made numerous descents in the Patapsco River at Baltimore, where her first public trials took place, and were witnessed by thousands of people.

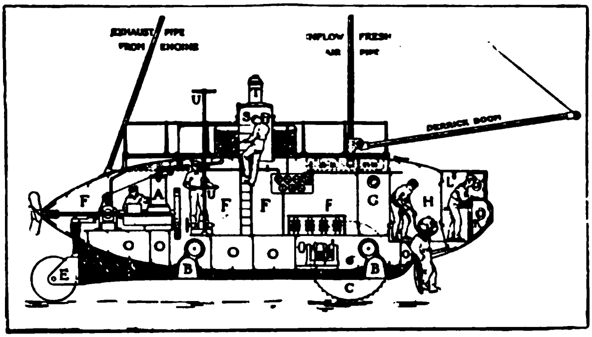
On December 16, 1897, a press trial was given and twenty-two representatives of the leading papers of New York, Philadelphia, Chicago, Baltimore and other cities made a short descent in her (one lady among the number). The first trip was of one and one-half hour's duration. The second trip was of about four hours' duration, when the diver was sent out of the diving compartment and the submarine brought to the surface with him standing on the deck. Reference to Fig. CLV. shows at H the diver's compartment, with the door at the bottom, and the diver passing out. The water is prevented from entering this compartment by air pressure, which is supplied from the compressed air tanks, and while the door is open is kept at the same pressure as that of the water outside.

During February and March, 1898, she made numerous descents in the same vicinity, and on January 6, 1898, the first telephone message ever sent from a submarine boat under water was sent by Mr. Lake from the bottom of the Patapsco River to the Hon. Wm. T. Malster (then Mayor of Baltimore City) at his office in the City Hall. Mr. Lake afterwards called up the President of the Chesapeake and Potomac Telephone Company in Washington, D.C., and other parties in Washington, Baltimore and New York, thus proving conclusively the practicability of a submarine boat being submerged, and, although her location was unknown, capable of communicating with the shore.

After further trips in the smooth waters of the Patapsco, it was decided to put her through more severe tests in the Chesapeake Bay and possibly in the Atlantic Ocean itself. Consequently on May 19th, 1898, Mr. Lake, with a crew of four men, left Baltimore for an experimental cruise down the

Chesapeake Bay. She made numerous descents on her way down the Bay, and travelled over all kinds of bottom, some of which was sc soft that the divers would sink nearly up to their waists when leaving the boat. Other bottoms would be found to consist of hard sand in which the wheels made no impression. She was run up and down hills and across dredged channels, and it was found that she could be readily maintained so nearly buoyant that these gradual ascents and descents made no perceptible difference in the power required to propel her. It was also found that she would mount over any obstacle that she could get her bow over. In one place bottom was found very much resembling shelled corn.

CLIII.



LONGITUDINAL SECTION OF THE LAKE SUBMARINE BOAT 'ARGONAUT'

A, Gasoline engine, thirty horse-power, which supplies all the power used in moving and operating the boat. BB, the two anchor weights used in sinking the boat. C, one of the two driving wheels. E, rudder and guiding wheel. FFFF, the "living-room," in which are placed the engine and all the other machinery and apparatus for operating the boat. G, the air-lock: it affords passage to and from the diver's room without reducing the air-pressure. H, the diver's room, whence free passage is secured into the sea. K, bow compartment where the search-light is placed. L, the forward lookout compartment. MM, gasoline tanks. NN, compressed-air reservoirs. OOOO, water-ballast compartments. PP, permanent keel. PQ, drop keel. R, dynamo. S, conning tower. 1, binnacle. The compass in this binnacle is in direct view from the outside steering gear; but from the conning tower it is read by reflection U, outside steering gear. In general form, the "Argonaut" is cylindrical, or cigar-shaped, with a very bluff bow and a pointed stern, and is thirty-six feet long.

One of the favourite pastimes of the trip was to sit in the diving compartment with the divers' door open, and with a short-handled crab net in hand, pick up oysters or clams as she travelled over the bottom.

She visited Norfolk and Hampton Roads, where she made her headquarters for some time and made numerous descents in the vicinity. She went out in the Atlantic Ocean in July and made a trip along the bottom about five miles south-east of Cape Henry Light. Here the bottom was found to be as hard and smooth as a macadamized road and the ideal bottom for wheeling along in a submarine automobile.

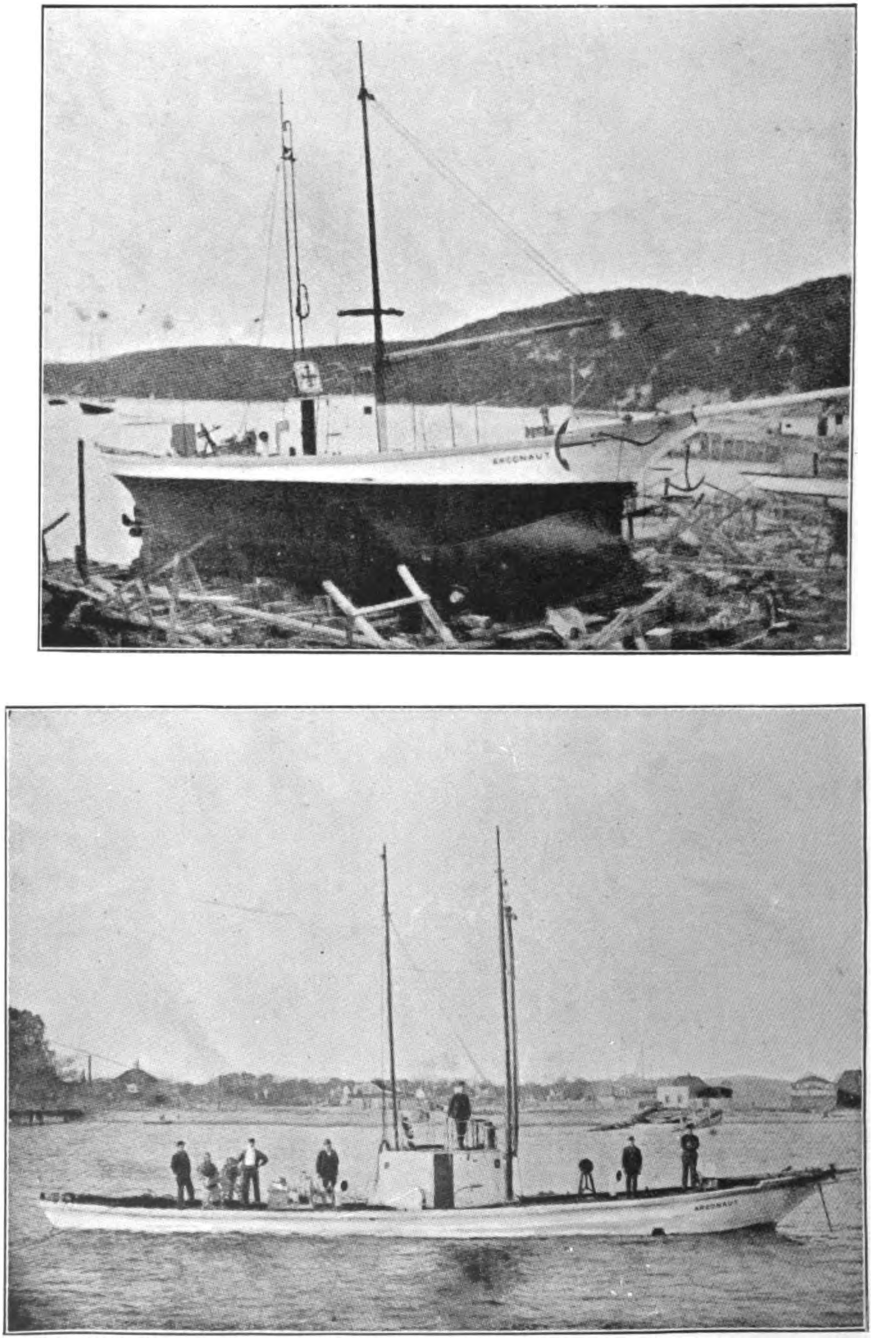
On this trip she was accompanied by the tug 'Annie' of Norfolk, and while the 'Argonaut' was on the bottom a severe squall suddenly came up and raised quite a sea in a short time—so severe that when the 'Argonaut' came to the surface the tug was rolling her rails under. Yet while beneath the water the effect of the storm was not felt at all. In fact, the crew of the 'Argonaut' were very much surprised when they returned to the surface to find the conditions so changed. This trip occupied over two months, during which time she travelled over 2,000 miles under her own power, and demonstrated that as a submarine the 'Argonaut' was a great success, proving beyond question the correctness of the principles involved.

One of the important changes in construction which suggested itself to Mr. Lake as a result of this trial was the enlargement of the boat so as to provide sleeping accommodation for the crew and another the addition of a superstructure and deck, which would give her more buoyancy when on the surface, to enable her to ride the seas instead of having the seas wash over her, as they did formerly when the water was rough, at times waist deep.

On her return to Baltimore, Mr. Lake commenced making plans for enlarging her, to embody these features. She was in the meantime taken to New York—this also under her own power and *unescorted*. The course she covered from Baltimore was up the Chesapeake Bay to Chesapeake City, through the canal to Delaware City, down the Delaware River and Bay to Cape May and from there a run of 120 miles on the ocean to Sandy Hook where she also made several descents, and thence to New York, where she was finally taken to the John N. Robins Dry Dock Company at Brooklyn for enlargement, under contract to be completed by June 1, 1899.

Owing to the press of Government work that came in after the contract was made, the Dry Dock Company did not complete her in the time specified, and it was not until about January 1, 1900, that she could be taken away from the shipyard, and even then in an unfinished condition.

From there she went to Bridgeport, Conn., where she has



CLIV.-CLV. 'ARGONAUT II.'

remained until this writing, getting her equipment completed and undergoing further tests in Long Island Sound to demonstrate the value of her additions and to prove her efficiency in a commercial way.

This company in the meantime also had built a small experimental freight boat (another of Mr. Lake's inventions), which was capable of being towed out and submerged alongside a wreck, loaded and afterwards brought to the surface with its load. This freight boat, like the pressure resisting portion of the 'Argonaut,' is cylindrical in form, and is made air tight. It is provided with air and water valves and connections, by which, when on the surface and the loading place is reached, the air is allowed to escape, and water to enter the boat to submerge. When on the bottom the diver removes the hatch cover, the boat is loaded, the hatch cover is replaced, compressed air from the 'Argonaut' is applied through the air valve and by it sufficient water forced out to render the boat with its cargo again buoyant. The advantage of this system is that the work of loading the freight boat can be carried on wholly beneath the surface and independent of surface conditions, as there are only a few days in the year when a surface vessel at sea can be loaded, owing to the wave motion, etc.

Recently several different parties have spent a considerable time searching for a barge loaded with coal, said to have gone down in the vicinity of Bridgeport Lighthouse. The information as to the position of the barge was indefinite, and the searchers failed to find it. Provided with a wreck finder, invented by Mr. Lake, the 'Argonaut' took up the search, and in less than two hours and with no additional information discovered the barge. This result was due to the very great efficiency of the 'Lake' invention as compared with the method of conducting searches previously in general use.

She then towed the submergible freight boat out, sunk it alongside the wreck and in seven minutes after removing the hatch cover and getting the suction and discharge pipes of her pumping apparatus arranged, transferred from the wreck to the submergible freight boat more than eight tons of coal. The hatch was then closed and the water forced out by the admission of compressed air, and in five minutes thereafter the freight boat came to the surface with its load. This provès conclusively that even on such cargoes as coal there is a great field for this class of boat. The recovery of coal at the rate of one ton per minute would mean a very profitable enterprise indeed, as the coal can readily be disposed of within 25 cents per ton of its market value, and there are hundreds of thousands of tons that can be found with the wreck finder as easily as this, sufficient to keep numerous submarines and submergible freight boats busy for years to come. If this gives a profit on coal of from $1,000 to $2,000 per day, as the work done by the 'Argonaut' shows, how much greater will it be on wrecks containing bullion or specie, or such cargoes as pig-iron, copper, block-tin or on the general cargoes with which our coast is strewn!

On July 10 and 11, 1900, two parties of business men from Bridgeport, Conn., took a trip on the bottom of Long Island Sound. The first day there were twenty-two in the party, who remained submerged four hours. The second day there were twenty-eight, an exceedingly large party for so small a boat, yet they all reported no unusual sensation during the time they were submerged. Dinner was cooked and served below, the diver was sent out of the boat and brought them souvenirs from the bottom through the open door. The majority of those present availed themselves of the opportunity to go into the diver's compartment and see the door opened and how the divers leave and enter the vessel. The submergible pontoon, with its load of coal, was brought to the surface in their presence.

This practically completes the disclosure of the purpose for which the 'Argonaut' was built and verifies the claims Mr. Lake made years ago when he started out to introduce his inventions to the world—viz., that he could build a vessel that would be:

Capable of being submerged to any desired depth and raised again at the will of the operator;

Capable of being propelled either on the surface or on the bottom, as required; and

Capable of searching the bottom thoroughly and locating wrecks.

From these vessels divers can pass from the interior to the exterior and back again when on the bottom as readily as one can pass into and out of a house. They will also be operating under the eyes and within the hearing of others, and in case of emergency can receive immediate assistance.

Divers are not subjected to the strain of a boat jumping upon the seas, to variable air pressures or to the currents carrying and entangling their life lines. They also have the advantage of light in their operations and machinery at hand for their assistance.

The crew can live in these vessels comfortably for days at a time during submergence under substantially normal atmospheric conditions, and operations on wrecks can be carried on by night as well as by day, as easily in storm as in calm.

With these advantages many of the operations in raising vessels and removing cargoes can be performed from the interior of the boat by means of special appliances, which have been devised for the purpose.

These vessels will prove invaluable in laying foundations for piers, breakwaters, docks, lighthouses, bridges and locks for canals. They will also be invaluable for removing obstructions such as rocks, shingle, etc., from the entrances to harbours, all the drilling operations being capable of accomplishment in an ordinary atmosphere.

1.—Submarine Wrecking.

This is a business that has received very little attention in this country, most of the companies confining themselves wholly to surface work such as lightering the cargoes from stranded vessels and pulling them off again or towing disabled ships into port.

Mr. I. J. Merritt, Jr., of the Merritt and Chapman Wrecking Company, the largest concern of this kind on this side of the Atlantic, is quoted as saying in an article published in 1894: 'The Atlantic Coast is strewn with wrecks that would offer rich returns to the wreckers if they could be recovered. But they cannot by any means be known to the wrecking science.'

A reference to the Government Wreck Chart is a verification of his statement, as there are shown the names and approximate location of hundreds of sunken vessels that have been lost during the short time the Government has attempted to keep any record of where the vessels have gone down.

With Mr. Lake's inventions it will be possible now to recover many of the sunken cargoes, and where they have not been down too long, the vessels themselves may be raised.

The yearly total loss of vessels and their cargoes is appalling. Lieutenant-Commander Richardson Clover, while chief of the Hydrographic Office of the United States Navy, in his published report of February 20, 1893, says: 'The most reliable statistics show an average annual loss of 2,172 vessels, with 12,000 lives, in the commerce of the world. The estimated value of the vessels and cargoes lost is about $100,000,000' (per year).

It is almost a disgrace to the enterprise of Americans that there has not been an adequate apparatus for saving much of this valuable property lost along our coast. Millions of dollars worth of vessels, property and cargo have been lost in the last few years, among which, directly in sight of New York, right in the harbour, in fact, were two or three fine steamships, that were finally blown up for old junk, not even their valuable cargoes being saved.

During our recent war with Spain, several fine cruisers and battleships—the pride of the Spanish people—were allowed to rust away, although some of them were not injured to any great extent. Had proper wrecking apparatus been at hand they could have been recovered and become valuable acquisitions to our fleet.

During the November storms of 1898 over 200 vessels were lost along the North Atlantic Coast, a great majority of which might have been saved with proper apparatus.

The losses are not confined to the ocean alone. The 'Marine Review' of June 6, 1895, gives a list of vessels lost in the Great Lakes in one month alone which amounted to over one million dollars.

A proper plant for recovering the cargoes from these sunken vessels would consist of: One or more submarine boats with derricks, hoisting apparatus and wrecking pumps, submergible pontoons or freight boats for receiving the cargo and for attaching to the side of the sunken vessels in raising them, wreck finders and tug boats.

To go into the business of lightering the cargoes from and removing stranded vessels would require additional apparatus, estimates for which will be cheerfully given to interested parties.

Captain Reginald Humphreys, R.N., says, in regard to the action of the sea on vessels and merchandise:

'Wooden ships, after being sunk, are very rapidly covered with a marine growth, which forms a sort of lime deposit and preserves the wood, in some cases for several centuries,' etc. Its effects on merchandise are not so destructive as one might imagine. We are informed by one of the underwriters of New York, who had charge of the salvage operation on the 'Oregon,' 'that bicycles were brought up from her hold that had been in the water over four months, and yet looked as bright as the day they went down; also silks, the outer folds of which were only injured.'

Some wines that had been recovered from a vessel sunk about fifty years brought $75 per bottle at auction. Gold and some other metals, glass and precious stones are never affected.

The following are a few of the articles which will not be affected for a long time: Silver, gold, platinum, pig-iron, and other metals and metal products; rubber, steel, earthen and crockeryware; wines and other bottled products, cotton in bales, fine woods, marble, glass products, machinery, tin plate and leaden products, jewellery and precious stones, hemp and jute products, paints and oils in casks and cans, preserved meats and vegetables in casks and cans, hides, wool, coal, ores, and thousands of other articles of commerce.

2.—Recovering Gold from River and Seacoast Bottoms.

It is generally known that where the rivers which run through gold bearing countries empty into the sea there are to be found rich deposits of gold, caused by the gradual erosion through countless years of rocks bearing the gold.

These deposits are washed down the mountains in times of freshets, and hence into the sea, where it settles as soon as it reaches deeper water. Several locations are known along our Western coast where these deposits are very large, the most notable of which are the Cape Nôme districts.

This section is without doubt the greatest gold bearing district known in the world to-day. Thousands of people have gone there during the past year many of whom have reaped rich rewards, as the sands along the seashore are found to be very rich in gold in some localities panning as much as $4,000 to the ton. Anywhere along the beach for a distance of many miles $25 per ton may be panned out, and the further out they can get into the sea the richer the deposits are found.

Millions of dollars have already been taken from these beaches by the simple hand rocker with which two men cannot wash over one ton a day. The beach is covered by thousands of people, and thousands more are going by every steamer. It is estimated that 25,000 people have started there during the past two months (May and June, 1900), with the inevitable consequence that the great majority will find the claims taken up and that they are too late. But in this locality there is one section that is not taken up, and that is the richest of all. It lies under water near the shore, and submarine boats of the 'Argonaut' type, with a crew of submarine divers and machinery especially fitted for the work, can handle such sands as are found in the Cape Nôme districts at the rate of about one ton per minute separating the gold therefrom. Truly a marvellous proposition, but capable of proof to those who investigate the capabilities of boats of the 'Argonaut' class. This offers an unparalleled opportunity for great wealth to a company that will build and operate some of these boats on the Pacific Coast.

Vessels equipped for this class of work will cost $50,000 or upwards, depending on their size and equipment.

In addition to the 'Nôme' District other localities are known where it will pay enormously to have submarine boats recovering the gold under water.

3.—In the Coral, Pearl or Sponge Fisheries.

In this class of work these vessels would prove invaluable. More work could undoubtedly be performed in one day than in a month with the present crude system. These fisheries are growing in importance every year. The shell of the mother of pearl oyster brings about $200 to $1,000 per ton. and single pearls are frequently found which realise as much as $5,000. London alone imports about 3,000 tons of mother of pearl shells every year.

Our new possessions in the Phillipines should offer excellent opportunities for large returns to a company organized to operate a few of these submarine boats in the Sulu Sea and other territory surrounding the islands, as the pearl oysters are found in abundance in these waters.

Cuba and Porto Rico, as well as Florida, also offer excellent opportunities for sponge fishing. The sponges bring from $1.50 to $3 per pound.

One expert on sponge gathering says:—'With one of these boats the catch would amount to more in one day than it would be possible to get with a surface vessel in a month.'

The boats to engage in either the pearl or sponge fishing would be very small, and would work in connection with a lay boat to receive their daily catch, and on which the crew could sleep. These small boats could be built for about $5,000 each, and in numbers perhaps for less.

4.—In Laying Submarine Foundations.

In laying submarine foundations, piers, docks, breakwaters, lighthouses, or removing rock or débris from the entrance to harbours; equipped with a derrick to handle heavy stone, masonry could be laid under water, almost as readily as on land, all the lifting and placing of the stone being done by power operated from the interior of the vessel, the diver having only to guide the stone in place. In rock drilling a large diver's compartment would be arranged in the bottom of the boat, so that men could operate their compressed air drills, the same as they would in the upper air.

5.—As Scientific and Pleasure Boats.

What would prove more interesting to scientific men or men of wealth than a cruise among the fishes, with an opportunity to view submarine life in its natural element? There would be a constant panorama of new and beautiful submarine scenery.

There could be seen submarine plants with which, in some localities, the ocean bed is carpeted, to which would be added the zest of chancing upon a valuable treasure ship.

It would pay to have a submarine boat at every seaside resort to take parties out for a short trip to some near-by wreck.

PRINCIPLES OF THE 'ARGONAUT' TYPE OF SUBMARINE VESSELS.

The 'Argonaut' radically differs from all previous types of submarine vessel in several important particulars, all of which are thoroughly protected by basic patents.

FIRST, and probably the most important, is her method of travelling submerged. In all previous efforts to travel under water, the attempt has been made to travel between the surface and the bottom. This has been found a very difficult problem, as navigation beneath the surface in this manner is very much akin to aerial navigation. Every mariner knows how difficult it is to steer a straight course on the surface. Then how much more difficult must it be to steer accurately beneath the waves. On the surface the vessel can vary from a straight course only in two directions—either to the left or right—as she is held to the one plane (the surface of the water) by her buoyancy and weight, but as soon as she takes a position between the surface and the bottom all these conditions are changed, and the steering problem is a difficult one indeed. She can go up or down, to the right or left, or in any other direction. Eddies and currents take possession of her at times, and it is exceedingly difficult to maintain absolute equilibrium and perfect control of the fore-and-aft trim owing to the shifting of water ballast, the crew moving about, etc., and the navigator cannot see clearly where he is going, as she is like a surface vessel in a fog, and currents may carry her far out of her course, so that they are compelled to come to the surface at frequent intervals to correct it.

This latter type of vessel, commonly called 'diving boats,' is the kind that have been previously experimented with in both this and foreign countries. Over 125 of them have been built in the last quarter of a century at the expense of millions of dollars, and none of them have been put to any practical use. All the experiments with them have been made in smooth and shallow waters, and have mostly been carried on in secret, so that it is difficult to ascertain if they have accomplished even what they claim to have done, which at best is scarcely more than Fulton did with his 'Nautilus' nearly 100 years ago.

The 'Argonaut' is evidently quite different from any of these 'diving' craft. *She is a true submarine vessel, and can go under water and remain there for days at a time, and travel as accurate a course as when on the surface*, as she goes direct to the bottom or water bed, and uses that as her guiding medium, travelling over it as an automobile does over the surface of the earth in the upper air.

She has no perfect trim or equilibrium to maintain, as she can be navigated over the bottom with a weight exceeding her displacement by one pound to one ton, an ample margin, and the crew can move about as freely as they choose without fear of her making one of those fatal headfirst dives to the bottom that some of the older types of submarines have done.

She can steer as straight a course when submerged as when on the surface, owing to her resting on the bottom with sufficient weight to prevent her being carried out of her course by the currents, and consequently can maintain a more accurate course than a surface vessel, as she travels over a medium which is not constantly changing like surface waters.

SECOND.—Another important feature is in the ability of the crew to *readily leave and re-enter the vessel when submerged*. This is also one of her distinctive features not possessed by other submarine craft, and one of paramount importance, as without this capability she would be like other submarine vessels, without an occupation excepting in times of war. With it, she is capable of opening up almost a new world in under-water exploration and work.

THIRD.—*She is capable of supplying the submerged crew with an abundance of pure, fresh air.* All other submarines are compelled to depend on compressed air for breathing purposes.

The 'Argonaut' also has a compressed air supply to draw upon in case of necessity, through injury to her surface connections or when her ventilating machinery is closed down. Ordinarily the vessel is as well ventilated when submerged as when on the surface through two flexible tubes extending to the surface and their ends supported above the water by a buoy, or, when in comparatively shallow waters, by pipes, their upper ends extending above the surface.

The importance of this feature on the health and spirits of the crew is obvious. This also permits the use of the gas engine for propulsion under the surface, instead of employing an electric motor and a series of expensive and unreliable storage batteries.

FOURTH.—Still another feature is the combination of the submarine with the surface vessel, the necessity for which was developed by Mr. Lake's trip in the 'Argonaut' previous to its enlargement, in the rough waters of the Chesapeake Bay and on the Atlantic Ocean.

This combination of the two vessels in one elevates the submarine vessel from the ranks of a purely harbour or smooth-water craft to the ranks of the cruiser capable of undertaking long voyages, in which the crew may travel as comfortably as in any surface vessel, with ample deck space and living quarters.

There are numerous other important features covering construction, safety appliances, method of recovering cargoes, etc., but as they are mostly auxiliary we will not consider them here.

The above four cardinal principles are the features that have raised the submarine vessel from the position it has occupied for the past 100 years to an every-day, practical working machine.

'EXPERT OPINION OF THE 'ARGONAUT' TYPE OF VESSEL.'

Chas. H. Haswell, the eminent consulting marine, mechanical and civil engineer, author of 'Haswell,' the engineers' handbook, and formerly Engineer-in-Chief of the United States

Navy, after giving a thorough review of the principles involved, sums up as follows:—'In conclusion, I am of the opinion that the design is capable of embracing the operation of a submerged torpedo projector, as distinguished from a simple torpedo exploder, and that it presents greater facilities for wrecking and laying foundations in deep water than any yet attained.'

The report referred to was written in 1894, and the success achieved by the 'Argonaut' has proven the correctness of this celebrated engineer's opinion.

Hon. Wm. T. Malster, president of the Columbian Iron Works and Dry Dock Company, of Baltimore, Md., and builder of the cruisers 'Detroit,' 'Montgomery' and 'Petrel,' and numerous torpedo boats and other craft, was also one of the early engineers to recognise the value of vessels of the 'Argonaut' type, and predicted that such vessels would be successful both for purposes of war and commerce.

Rear-Admiral Philip Hichbourn, Chief Constructor of the United States Navy, in a recent article, says:—'The 'Lake' boat gives good promise of efficiency.' He then describes her method of operating, and says a boat of her type fitted with a true submarine motor, might be very valuable for the attack of a mine field.

Numerous other engineers and mechanical experts, naval officers, etc., have given the highest kind of indorsement, but space is too limited to publish them, as also the indorsement from wreckers, etc., of which we have many. We quote extracts from a few of the latter only:

Capt. Louis H. Timmons, formerly with the Baxter Wrecking Company, and also the Merritt Wrecking Organization, in describing his experience of twenty-two years in the wrecking line, says in part:—'The difficulties and dangers to be overcome are so great by the present system, that very few men are in the business. The work that is done is principally in inland waters, and even there, by present methods, only about 20 per cent. of the loss is recovered; and on the Coast where the great losses occur the percentage of recovery is so small as to be hardly worth mentioning, owing to the difficulty encountered by the waves, as diving becomes exceedingly dangerous when the boat on the surface that contains the pumping apparatus, tenders, etc., is bobbing around on the seas.

'As an illustration:—The last job I worked on was with the 'Merritt's' in getting the 'Markomania' off the beach in United States of Columbia, South America. We were on that job eight months, and during that time the weather was such that we could perform only twelve days' work, and even then we lost four of our crew by drowning.'

He says:—'I consider especially valuable your system of searching the bottom in locating wrecks, as I have been engaged for months with various companies in searching for vessels known to have been lost even in inland waters, the location of which was approximately known, some of which we never did succeed in finding. The method of operating your boat is entirely practical, and I consider it perfectly safe, and I believe that in performing work on sunken vessels at sea work can be carried on every day in the year, while with the present system, if we succeed in getting three or four days in every month—even in summer—we consider that pretty good, and in winter it is never attempted.

'I consider it will be the means of recovering untold wealth that, with the present appliances, is too hazardous and expensive to attempt.'

Mr. W. H. Dwyer, of Philadelphia, writes:—'I am so favorably impressed with the possibilities of your system that I should like to engage with you as a diver. I was trained for diving by the United States Naval Training School for deep water work. I have worked at a depth of 150 feet, and can stand a pressure of 75 pounds to the square inch without feeling any bad effects from it. I do not doubt but that I could work in depths from 160 to 170 feet by preparing myself (physically) beforehand. I worked for the Merritt Coast Wrecking Company, on the steamship 'Oregon,' in 130 feet of water, taking out cargo. I worked last for the Midford Salvage Company, New York.

'You mention in your list of treasure ships one of which I have been searching already, though under great difficulties. I refer to the Baron De Brake, lost in Delaware Bay in 1792. She could be located very easily with your boat.

'As I have been diving for nearly twenty years, I have had practical experience in all kinds of work, both in bright and dark waters. Hoping you will be pleased to give me a place on your staff of divers, etc.'

EXTRACTS FROM EDITORIALS.

In references to possibilities of boats of the 'Argonaut' type.

'Klondyke is nowhere.'—*New York Herald.*

'By Mr. Lake's invention, man is likely to gain a more complete control of one of the great elements than ever before.' —*Baltimore American.*

'The 'Argonaut' should open up new fields of submarine research.'—*Baltimore News.*

'Lake's submarine boat causes Jules Verne's 'Nautilus' to be a far less fantastical creation than it was hitherto supposed to be. The 'Argonaut' has duplicated every important feat of the imaginative craft except that of speed.'—*Baltimore Herald.*

'According to the unanimous opinion of all present, the 'Argonaut' proved herself a wonder, and Mr. Lake's invention may bring about a revolution in wrecking methods.'—*New York Maritime Register.*

Jules Verne, author of 'Twenty Thousand Leagues Under the Sea,' in special cable to the *New York Journal* from Amiens, France: 'While my book, 'Twenty Thousand Leagues Under the Sea,' is entirely a work of the imagination, my conviction is that all I said in it will come to pass. A thousand mile voyage in the Baltimore submarine boat is evidence of this. The conspicuous success of submarine navigation in the United States will push on under-water navigation all over the world. If such a successful test had come a few months earlier it might have played a great part in the war just closed. The next great war may be largely a contest between submarine boats.'

It will probably be of interest to have a detailed explanation of the 'Argonaut' from the inventor, and I have therefore extracted the following from McClures Magazine.[1]

'My own submarine boat, the 'Argonaut,' is quite different

1 'McClures Magazine,' January, 1899; 'Voyaging under the sea,' by Simon Lake.

from any other thus far projected or constructed. All previous attempts have been to design a boat to navigate between the surface and the bottom; but the results have been, as a rule, unsatisfactory, owing to the disturbing influence of waves and currents, as well as the difficulty of maintaining trim and equilibrium. These craft should more properly be called diving boats. They are intended to be steered by vertical and horizontal rudders or vanes (as in the 'Nordenfelt,' 'Gymnote,' 'Holland,' and 'Peral' types) placed in various positions, but generally near the stern, or by changing the angle of the propellers, as in the 'Goubet,' 'Baker,' and 'Tuck' types.

When it is desired to submerge such boats, they must first be very accurately balanced, so that the bow and stern are exactly alike. Then the vessel must be in equilibrium with the water; that is, she must weigh no more, no less, than the water she displaces, under which conditions the theory is that she can be guided through the water like a fish; but here the difficulty arises. Man has not, nor can he have, the training and instincts of fishes, and he cannot compete with nature in her own domain. With a navigator carefully trained to the business, a vessel might possibly succeed in navigating the deep to some extent in this manner; but it still remains, I think, somewhat of a question. All mariners know how difficult it is to steer an absolute straight course on the surface; then how much more difficult is it to steer a straight course beneath the waves?

On the surface the vessel can only swing to the right or left. She does not go up in the air, because she is held to one plane by her weight; neither does she go down, because she is held to the same plane (the surface of the water) by her buoyancy; therefore, the rudder is able to control her. But below the surface all these conditions are changed. Every wave imparts an up-and-down motion to the particles of water beneath it, and, consequently, affects the course of the submarine vessel. Currents run in a variety of directions, and as soon as the screw or propelling mechanism starts in motion, it effects the equilibrium and trim of the boat. If one of the crew moves either forward or aft, the trim is affected, and all these things tend to elevate or depress the bow of the boat or affect her course; and as she can go either to the right or left, or up or down, or, indeed, in any direction, there is scarcely any limit to the difficulty of holding her securely to an appointed course under the surface of the water. Either she will be ducking down and running her bow into the bottom of the sea, or bobbing up again to the surface.

But with the 'Argonaut' we experience none of the difficulties above recited. By referring to the accompanying skeleton sketch, her principles will be readily understood.[1]

The hull of the vessel is mounted on three wheels. Of these, E is the rudder, for surface steering, and is also the guiding wheel when the vessel is running on the sea bottom; and C is one of the supporting and driving wheels, of which there are two, one on each side. B B are two anchor weights, each weighing 1,000 pounds, attached to cables, and capable of being hauled up or lowered by a drum and mechanism within the boat; O O O O are water ballast compartments contained within the boat; H is the diver's compartment, situated forward, with an exit door opening outward in the bottom; while G is an air-lock.

When it is desired to submerge the vessel, the anchor weights B B are first lowered to the bottom; water is then allowed to enter the water ballast compartments until her buoyancy is less than the weight of the two anchors, say 1,500 pounds; the cables connecting with the weights are then wound in, and the vessel is thus hauled to the bottom, until she comes to rest on her three wheels. The weights are then hauled into their pockets in the keel, and it is evident that she is resting on the wheels with a weight equal to the difference between her buoyancy with the weights on the bottom, and the weights in their pockets, or 500 pounds. Now, this weight may be increased or diminished as we please, either by admitting more water into the ballast tanks or by pumping some out. Thus it will be seen that we have perfect control of the vessel in submerging her, as we may haul her down as fast or as slow as we please; and by having her rest on the bottom with sufficient weight to prevent the currents from moving her out of her course, we may start up our propeller or driving wheels and drive her at will over the bottom, the same as a tricycle is propelled on the surface

1 See Fig. CLIII.

of the earth in the upper air. In muddy bottoms we rest with a weight not much over 100 lbs.; while on hard bottoms, or where there are strong currents, we sometimes rest on the wheels with a weight of from 1,000 to 1,500 lbs. Thus the effect of currents and wave motion and the maintenance of trim and equilibrium are not factors in the successful navigation of the vessel; in fact, navigation becomes surer than on the surface, as one is travelling in a medium which does not constantly change like the surface water from the effects of winds, waves and currents. When the divers desire to leave the vessel, they go into the diver's compartment, located in the forward portion of the ship, and close the door communicating with the living quarters. This door closes on rubber packing, and is air-tight. Air is then admitted into the compartment from compressed air reservoirs, until the pressure of air equals that of the surrounding water. The bottom door may then be opened, and no water will come into the boat, as the pressure of air contained within the compartment offers an invisible barrier to its entrance, and the divers may pass in and out as frequently as they please.

The 'Argonaut' is fitted with a White and Middleton gasolene engine of thirty horse-power, which operates the screw, the driving wheels, the dynamo, the air compressors, anchor hoists, and derrick-operating machinery. She is provided with two Mannesmann steel tubes, in which sufficient air may be stored, with what is contained in the boat, to last the crew for twenty-four hours without obtaining a fresh supply from the surface. In the 'Argonaut,' however, and probably in all such craft used for commercial pursuits, as a usual thing, there will be a connection with the surface, through which a constant supply of air may be drawn, either by the masts, as shown in the views, one of which supplies air to the interior of the vessel, the other being utilized as an exhaust from the engine, or through suction hose extending to a buoy on the surface. While the engine is running, there is about fifty cubic feet of air flowing into the boat per minute; and when the engine is closed down, there may be a flow of air maintained by an auxiliary blower, so that it is possible to remain below for days, or even weeks, at a time.

The course is directed by an ordinary compass when on the bottom, and it is found that the needle responds as quickly and is as accurate as when on the surface. Notwithstanding the fact that the 'Argonaut' is quite a small vessel, a crew of five men have lived aboard her during an experimental cruise extending over two months, during which she travelled over 1,000 miles under her own power, partly on the surface and partly on the bottom. The trip was made to demonstrate the practicability of vessels of her type travelling on various kinds of bottoms; also to demonstrate her seaworthiness and capabilities in searching the bottom, in working on sunken wrecks, finding and taking up submerged cables, etc. We have been out in some pretty rough weather, and found that she was perfectly seaworthy. Of course, being so small and of such weight, the seas at times would wash clear over her decks. This, however, caused no inconvenience to those below, as her stability was such that she would roll or pitch very little, even though the seas were breaking over her in great volume. We have been cruising on the bottom in rivers, in Chesapeake Bay, and beneath the broad Atlantic. In the rivers we invariably found a muddy bed; in the bay we found bottoms of various kinds—in some places so soft that our divers would sink up to their knees, while in other places the ground would be hard, and at one place we ran across a bottom which was composed of a loose ground resembling shelled corn. Out in the ocean, however, was found the ideal submarine course, consisting of fine grey sand, almost as hard as a macadamized road, and very level and uniform.

During this trip we investigated several sunken wrecks, of which there are a great many in Chesapeake Bay and on the coast adjacent thereto. The vessels we boarded were coal-laden craft and of themselves not of much value; but the coal would pay handsomely for its recovery, which could be readily accomplished with the proper equipment. We found one old wreck said to have gone down 40 years ago near the mouth of the Patuxent River. There was nothing in sight except a few timbers and deck beams, and these were nearly consumed by the teredo—a boring worm—which completely honeycombs any timber it may attack. We pulled up some of the planks of this vessel, which had a numerous growth of oysters, mussels, and several kinds of submarine vegetation clinging to them. The portion of the timbers not eaten by the teredo was found to be almost as hard as iron and thoroughly impregnated with the dark blue mud in which the hull lies buried. After the timbers were hauled to the surface, in sawing them in two, we noticed a very strong odour of yellow pine, and so learned that they must be of that wood, though they were as black as ebony. Toad fish had evidently found this old wreck a congenial habitation, and when the diver's hand comes in contact with the slimy back of one of these horrible-looking, strong-jawed, big-mouthed fish, he pulls it back pretty quickly. The piece we pulled up had within it three of these fish, which had taken up their abode in portions of the timber that had been eaten away, and one was a prisoner in a recess which, evidently, he had entered when small and had grown too large to get out. In a wreck near Cape Henry, fish were very numerous, principally bass and croakers, though two or three small sharks were seen in the vicinity.

It might prove interesting to copy one day's experiences from our log-book. This day we submerged for the purpose of discovering how much weight was necessary to prevent the current from moving the 'Argonaut' in a strong tideway (Hampton Roads), and also to discover if there was any difference in starting our machinery again under water after it had been shut down for several hours. I copy verbatim from the log-book under date of July 28, 1898.

Submerged at 8.20 a.m. in about 30 ft. of water. Temperature in living compartment about eighty-three degrees Fahrenheit. Compass bearing West-north-west, one quarter west. Quite a lively sea running on the surface, also strong current. At 10.45 a.m. shut down engine; temperature eighty-eight degrees Fahrenheit.

After engine was shut down, we could hear the wina blowing past our pipes extending above the surface; we could also tell by the sound when any steamers were in the vicinity. We first allowed the boat to settle gradually to the bottom, with the tide running ebb; after a time the tide changed, and she would work slightly sideways; we admitted about 400 pounds of water additional, but she still would move occasionally, so that a pendulum nine inches long would sway one-eighth of an inch *(thwartship). At 12 o'clock (noon) temperature was eighty-seven degrees Fahrenheit; at 2.45 p.m. the temperature was still eighty-seven degrees Fahrenheit. There was no signs of carbonic acid gas at 2.45, although the engine had been closed down for three hours and no fresh air had been admitted during the time. Could hear the whistle of boats on the surface, and also their propellers when running close to the boat. At 3.30 the temperature had dropped to eighty-five degrees. At 3.45 found a little sign of carbonic acid gas, very slight, however, as a candle would burn fairly bright in the pits. Thought we could detect a smell of gasoline by comparing the fresh air which came down the pipe (when hand blower was turned). Storage lamps were burning during the five hours of submergence, while engine was not running.*

At 3.50 engine was again started and went off nicely. Went into diving compartment and opened door; came out through air-lock, and left pressure there; found the wheels had buried about ten inches or one foot, as the bottom had several inches of mud. We had 500 pounds of air in the tanks, and it ran the pressure down to 250 pounds to open the door in about thirty feet.

The temperature fell in the diving compartment to eighty-two degrees after the compressed air was let in.

Cooked clam fritters and coffee for supper. The spirits of the crew appeared to improve the longer we remained below; the time was spent in catching clams, singing, trying to waltz, playing cards, and writing letters to wives and sweethearts.

Our only visitors during the day were a couple of black bass that came and looked in at the windows with a great deal of apparent interest.

In future boats, it will be well to provide a smoking compartment, as most of the crew had their smoking apparatus ready as soon as we came up.

Started pumps at 6.20, and arrived at the surface at 6.30. Down altogether ten hours and fifteen minutes. People on pilot boat "Calvert" thought we were all hands drowned.

We spent some time with Hampton Roads as headquarters, and made several descents in the water adjacent thereto; we were desirous of making a search for the cables which connected with the mines guarding the entrance to the harbour, but could not obtain permission from the authorities, who were afraid we might accidentally sever them, which would, of course, make their entire system of defence useless. It was, therefore, necessary for us, in order to demonstrate the practicability of vessels of this type for this purpose, to lay a cable ourselves, which we did, across the Channel leading into the Patuxent River. We then submerged, and, taking our bearings by the compass, ran over the bottom, with the door in our diving compartment open, until we came across the cable, which we hauled up into the compartment with a hook only about four and one-half feet long; and we could not avoid the impression that it would be a very easy thing to destroy the efficiency of the present mine system. And how many lives might have been saved, and millions of dollars besides, had our navy been provided with a craft of this type to lead the way into Santiago, Havana, or San Juan, off which ports squadrons were compelled to lie for weeks and months, owing to fear of the mines!

I have frequently been asked my sensations on going beneath the water—whether I had any fear of not being able to come up again and whether it did not require a lot of courage. I usually reply that I have always been too busy and interested for fears or sensations, and that it does not require any courage on my part, as I am so thoroughly satisfied of the correctness of the principles upon which the 'Argonaut' is constructed and the strength of the structure as to have no doubts or fears of any kind; but I do think it requires courage on the part of those who do not understand all the principles involved and who simply trust their lives in my hands. Quite a number of people have made descents in the vessel, but in only one or two instances have I seen them show any signs of fear.

In one instance, during our trials in the Patapsco, several gentlemen were very importunate in requesting the privilege of making a descent the next time we were to submerge. They were, accordingly notified when the boat was to go down. At the appointed time, however, some of them did not appear, and of those who did, not one at the last would venture. I have no doubt had we made the descent at the time they made the request all would have gone; but thinking about it for a couple of days made them change their minds.

On another trip, we had a college professor on board who could not exactly understand how our men could get out of the boat. I told him to come into the diver's compartment and I would explain it to him. Accordingly he reluctantly, as I thought, entered the compartment, which in the 'Argonaut' is a little room only four feet long and a little wider. After closing the door, I noticed that the colour was leaving his face, and a few beads of perspiration were standing out upon his forehead, and had he been anyone else than a professor, or, possibly a newspaper man, I would not have gone any further with the experiment. The door, however, was closed and securely fastened. I then opened the valve a full turn, and the air began to rush in with a great noise. He grabbed hold of one of the frames, and glanced with longing eyes at the door we had just entered. I then turned off the air, and said, 'By the way, Professor, are you troubled with heart disease?' He said, placing his hand over his heart, 'Why, yes, my heart is a little affected.' Remarking, 'Oh, well, this little depth will not hurt you,' I turned on the air again after saying to him, 'If you feel any pain in your ears, swallow as if you were drinking water.' He immediately commenced swallowing, and during that half minute or so we were getting the pressure on I believe he swallowed enough to have drunk a bucketful of water. After getting the desired pressure, I stooped down and commenced to unscrew the bolts holding the door which leads out into the water. Our professor said, 'What are you doing now?' I answered, 'I am going to open this door so you can see the bottom.' Throwing out his hands, he said, 'No, no. Don't do that, I would not put you to that trouble for the world.' However, about that time the door dropped down, and as he saw the water did not come in, the colour returned to his face, and he exclaimed, 'Well, if I had not seen it, I would never have believed it!'

What Submarine Vessels will do for the Human Race.

The object hitherto sought in building submarine vessels has been to provide a new appliance for carrying on war; and all naval authorities agree that if a successful torpedo boat of this type can be built, there is no means known to naval science to prevent the destruction of any squadron afloat. Viewing them from this point, submarines will undoubtedly be one of the greatest agencies ever known for the promulgation of that universal peace so much desired by all people who love their fellow men and who would rather see international differences settled by arbitration than by the sword. When every nation with a seacoast has among its defences a number of submarine torpedo boats, it will be worse than folly to think of invading its territory from the sea. No transport ships would dare approach its coast-line and attempt to land an army if a number of these little destroyers were known to be prowling about the vicinity. In all probability the fear they would inspire would be so great as to break down the nerves of the best disciplined navy. Men can stand up and fight an enemy whom they can see and at whom they can strike, but to be in a position where they do not know at what instant—whether asleep or awake—without any warning whatever, they may be blown into another world, will inspire such terror that no one could long endure the strain.

Had the Cubans been provided with one or two of these little craft, Spain would never have invaded and laid waste their beautiful territory with her army of 200,000 men.

Consequently Cuba would have been in the position which all countries should be in, that the majority of the inhabitants could have managed their own affairs without interference from outsiders.

Warfare, however, is only one feature of their usefulness. While submarine torpedo boats will, in all probability, in future wars between maritime nations, destroy millions of dollars worth of battleships, cruisers, etc., yet the submarine wrecking boat will undoubtedly recover from the bottom of the sea many times the value of the vessels lost in war. Of the cargoes, treasures, and vessels lost in the merchant service, the aggregate amounts to over one hundred millions of dollars per year, according to the official report of Lieutenant-Commander Richardson Clover, Chief Hydrographer of the United States Navy; and as the loss has been going on for many years, the wealth lying at the bottom of the ocean transcends the fabulous riches of the Klondyke. One authority said many years ago:—'There is every reason to believe that the sea is even richer than the earth, owing to the millions of shipwrecks that have swallowed up many a royal fortune.' Fortunately, the majority of the great losses occur in waters in which it will be practical to operate with submarine boats of the 'Argonaut' type. By referring to our coast-lines, it will be found that the bottom is principally composed of a hard, white or gray sand, and is very uniform. The depth increases as you leave the shore at the average rate of about six feet per mile, and the bottom forms an ideal roadway. Of course there are depths in the ocean which man's eye can never behold. The pressure would be so great that it would crush anything except solid metal; but within certain limits, exploring the ocean bed, the writer believes, will become in the near future, almost as common as travelling on the surface.

In addition to their great value in the wrecking business, submarine vessels will be of immense service in the coral, sponge, or pearl fisheries. These fisheries are principally carried on by native divers, who become so expert that they can remain under water for a minute or so, during which time they may get a handful of shells or a sponge. They can make but a few dives a day, and can operate only during fair weather, and there is also great danger from sharks, which usually abound in great numbers in the waters where the pearl, sponge, or coral is found. What an immense harvest the submarine could recover here as she went wheeling along over the bottom. With the door open in the diver's compartment, the choice specimens could be picked up with a rake only four or five feet in length, without leaving the boat, or the divers could be sent out clad in their armour, and could search the bottom for a couple of hundred feet on either side of the ship. Then, again, in laying submarine foundations for breakwaters, piers, lighthouses, etc., it would only be necessary to equip one of these vessels as a derrick, and dump the stone overboard in the vicinity in which it is desirous of operating. As the boat may readily be run backward or forward, and the derrick may be swung to the right or left, the stone could be picked up, and carried and lowered into place as the diver should designate, he alone guiding it to its resting-place.

Then, what would prove more interesting to scientific men or men of wealth than a cruise among the fishes and a view of submarine life in its natural element? There would be a constant panorama of new and beautiful scenery. There you would see the submarine plants, the sportive actions of the denizens of the deep, the beautiful corals, shells, and flowers with which in some localities the ocean bed is carpeted; and to this would be added the zest of probably running across a valuable treasure ship. In fact, it would be the most interesting exploration men could make.

The following account of some further trials of the 'Argonaut II.' are interesting.

The result of Mr. Lake's visit to Washington was to attract official interest to his project. When the discarded submarine boat 'Plunger' was being built at Baltimore some years ago the same works constructed and turned out for work, within a year, the submarine boat 'Argonaut.' The boat was cruising in the waters of the Chesapeake when war with Spain was declared, and for hundreds of miles she travelled along the bottom of that body of water. The mine fields about the approaches to Fort Monroe were then heavily planted and Mr. Lake asked permission of the military authorities to disconnect one of their mines and thus prove the practical usefulness of the craft for countermining work. His application was refused, but he took his own way to convince them.

He submerged his craft near the Government landing and so remained for hours. So in that time the diver could have destroyed a dozen or more mines. Not content with that, Mr. Lake took his boat out beyond the Capes and, toward dusk, with all but his sighting hood submerged, ran up through an unsuspecting fleet of sailing vessels. All the while the searchlights from the fort were flashing inquiring beams upon the incoming schooners, but not once did the lights pick up the 'Argonaut.'

Heretofore, Mr. Lake has made no effort to travel between the surface and the bottom, but in his new boat he has planned for just that sort of performance. To accomplish that he uses four big hydroplanes, two for each side, that steer the boat either down or up. These hydroplanes, or rudders, are placed near the water-line well forward and well aft and act in concert. Instead of pointing the vessel's head either up or down when rising or submerging, they force her up and down on an even keel. This feature does away entirely with the dangerous tendency to dive, characteristic of all other submarines heretofore built. It is also asserted that the boat will have more stability than most submarines.

To cause the boat to submerge it is necessary only to fill certain divisions of the bottom, and to make the craft rise again to the surface the same tanks are quickly discharged by air pressure. There are certain reserve tanks designed to be filled as the torpedoes are discharged, in this way maintaining unchanged the total weight of the boat when submerged. There will be many safety devices which will automatically control the diving depth of the boat, either by working the hydroplanes or relieving the boat of weight by driving out water from the submerging tanks or by bodily releasing a large section of the solid metallic keel.

It has been found in all submarine boats of the sub-surface type that navigation was tantamount to steering in a dense fog, and the moment the boat's bearings were lost the navigator was likewise adrift.

With the 'Lake' boat, when running on the bottom, this difficulty is removed, for, unaffected by the currents, the boat's hold upon the water floor keeps her in a direct course, even though the navigator be absolutely in the dark. Mr. Lake has found his compasses to work with satisfactory accuracy when once compensated, and all that is necessary is for him to take his bearings before sinking, following that course by compass when on the bottom.

For scout work it is intended to have stations well off the coast to which the boats could repair and by making connection with telegraphic cables sunk there communicate at once with the shore. It is not generally known, but it is possible to keep within soundings of 150 feet, the maximum diving depth of the boat, off our coast at distances of from fifteen to seventy-five miles. With an advance guard of submarine picket boats it would be possible to establish the most effective blockades with the minimum of expense.

To connect with the cable the boat by cross bearings would locate the spot, lower its two anchors and slowly draw itself down to the junction box. The diver would then go out, complete the circuit and communication could at once be held with the shore. By rising to the surface just so that the armoured sighting hood was clear the boat could observe every movement of the enemy until well up, directing the station ashore as to the speed and compass bearing of the approaching foe, and then if discovered sink completely out of sight in three seconds.[1]

Besides the peaceful 'Argonauts' Mr. Simon Lake has designed submarine war-vessels. The following is an extract from the 'New York Sun.'[2]

A few weeks ago Mr. Lake submitted to the Navy Department carefully worked-out plans for submarine boats of three orders; a small kind that could be carried by a battleship and used as a picket boat; a larger type for coast defence work, and a still larger order for cruising purposes, having a radius of action of thousands of miles. The result of Mr. Lake's interview with the Board of Construction will be the building of a boat of the coast-defence type to be tried in competition with the submarine boats now being built for this Government.

The boat Mr. Lake is about to build will be nearly 90 feet long and will have a surface speed of 12 knots and a totally submerged speed of 7 knots; in the semi-submerged state she will be able to do ten knots. On the surface, the craft will be driven by a couple of gasolene engines, and when running beneath the water she will be propelled by a dynamo supplied from storage batteries. This same dynamo, driven by one of the gasolene engines, will charge the batteries. Mr. Lake estimates that enough electricity can be stored in his batteries to give the boat a submerged radius of action of fifty miles. He estimates that his 90-foot vessel will have a cruising radius of 1,000 miles upon her usual fuel allowance. As the boat is designed only for off-shore work, that is more than ample.

By way of armament, the boat will carry two one-pounder rapid-fire guns in the deckhouse, so arranged in bell-and-socket joints that they can have a considerable train yet be water-tight, and for torpedo service she will have three torpedo tubes, two forward and one aft, and a reserve of two more

1 'New York Sun,' August 4th, 1901.
2 'New York Sun,' August 4th, 1901.

torpedoes, for each tube will ordinarily be the storehouse for a torpedo. The discharge of the torpedoes from the tubes will be effected by compressed air, and the pointing will be done by bringing the whole craft to bear upon the target.

It will be possible to keep the boat submerged two days, if necessary, there being reserve air enough, under high pressure, in the air flasks for that purpose. Mr. Lake has found, from previous experience, that his boats were actually cooler when sealed up and submerged than they were when open and being ventilated from the surface. The boat is propelled by twin screws, which, besides the advantage of reducing the risk of total disablement, have a corrective force tending to maintain the lateral stability of the vessel when running between surface and bottom.

On the bottom, the boat will travel upon two big wheels placed in the keel, one forward and one well aft.

When not running on the bottom, these wheels will be drawn within the vessel. The usual lateral steering will be done by a big balanced rudder at the stern.

Should she wish to attack, all she need do would be to cast loose the sealed end of the cable, raise her anchors and have at the enemy. If the approaching foe were light craft or torpedo boats, this coast-defence submarine could effectively use her two one-pounder guns on them, and that while presenting only the target of her tower. At night, against such small craft, it would be better for her to do that than to waste her torpedoes; and the boat is so designed that should this part of her hull be damaged it can be completely cut off from the body of the boat, while navigation could be carried on from below. When doing normal cruising work, circumstances, the boat will travel on the surface.

The New York paper had not, however, got hold of the whole truth. The following extract from the 'Engineer' of December 12th, 1902, describes the 'Protector' as the boat mentioned above has been named, and compares it to the Holland vessels.

'The accompanying illustrations show the submarine torpedo boat Protector, which was launched on November 1st, at Bridgeport, Connecticut. In our issue of October 6th, 1899, we published an account of the Argonaut, a boat of substantially similar order to the Protector, which, in turn, was a modified copy of the older boat of the same name built in 1897. During the early days of the Spanish-American war, the Argonaut, in her original form, was cruising in the waters of the Chesapeake, hunting for wrecks, and, to prove her usefulness for military work, application was made for her to be allowed to countermine or disconnect, by stealth, some of the torpedoes in the mine fields abreast Fortress Monroe, Virginia. For good and sufficient reasons, permission was refused, but Mr. Lake established his record nevertheless. One afternoon, her commander determined to run right upon the mine fields, and to anchor, unobserved, in the midst of the large fleet of coasting vessels moored just beyond. Taking his bearings when about three miles distant, he submerged the boat until the sighting-hood on the conning-tower was just above water, while the ventilating pipes which the boat then carried were high above the surface. It was nearing sunset when he started, and a short while afterwards the sun dipped and the searchlights on the fort began to sweep the whole area of approach, but while the lights picked up every ordinary craft of any size whatever, still they failed to discover the approaching Argonaut. After an hour's run, she stopped right in the midst of the vessels, rose to her cruising trim, and anchored right under the fort's guns. The military authorities were thoroughly surprised. A day later, the Argonaut submerged at the same spot, and cruised around the bottom for some hours. In that time the diver could just as easily have disconnected half the mines in the near-by fields.

'The Argonaut and the Argonaut No. 2 have, so we understand, cruised hundreds of miles on the ocean bed along the Atlantic coast, and though they have experienced all sorts of weather, we gather that at no time has either been in tow or under convoy. Since 1900 Argonaut No. 2 has, it is said, more than paid for herself by the wrecking work which she has done in Long Island Sound in recovering valuable cargoes long since lost and forgotten.

'The Protector, as will be seen from the engravings, is not cigar-shaped, like almost every other submarine torpedo boat, and the reasons are the result of her builder's experience in waters disturbed by heavy seaways. Photographs of the cigar-shaped boat while under way awash show them labouring, even in smooth water, with the weight of water bearing down upon their turtle-backs. With a displacement rapidly decreasing after the major longitudinal axis is submerged, the tendency is to 'bury' in a seaway, and this fault becomes no less serious when submerged, for it has been discovered from experiments made with the Argonaut that the heavy ground swell after a storm reached a depth of five or six fathoms in effect, and has a tendency to beat down upon a submerged craft. The Protector, like her prototype the Argonaut No. 2, has a ship-shaped hull, which consists inwardly of a cigar-shaped body, with the ship-shaped formed superstructure rising above without. In the ship-shaped superstructure are placed the air tanks and the gasoline storage. This effects a double end. In the case of the air tanks it tends to lower the centre of gravity, while with the gasoline tanks outside the main body of the boat an element of added safety is secured in case of their leakage. On the deck, amidships, is placed an elliptical conning-tower, and above that rises an armoured sighting-hood. With deck awash, the conning-tower is nearly all above water, while for closer observation the boat is submerged to the armoured sighting-hood, three seconds' time, it is said, being required to effect the change. With the sighting-hood above water, the boat has, it is stated, a reserve buoyancy of only a few hundred pounds, so that total submergence when under way can be effected quickly by the operation of the hydroplanes at the sides in line with the guards. In addition to the hydroplanes, there is a third rudder aft for vertical control, and, of course, one for horizontal direction.

'To travel on the bottom, all that is said to be necessary is to effect total submergence, when the boat, on reaching the water-bed, will settle upon her two travelling wheels—one forward of the other on the keel line. These wheels are so arranged that they have considerable vertical play, and they are housed to some extent within the body of the keel when not in use. They are raised and lowered by pneumatic lifts, which, when the boat is running on the bottom, tend to act as buffers against the effect of a heavy ground swell. For anything but very moderate submergence the builder recommends that the boat be drawn down to the water-bed. To effect this the boat carries two pyramidal weights, or anchors, weighing 1,000 lb. apiece. These weights are usually housed within the keel, and are connected to power drums by wire rope. When the point of submergence is reached, and the boat is designed to work to a depth of 150 feet, these weights are lowered, the buoyancy of the boat is reduced to that of the awash condition, and then she is bodily hauled down. The object of this is to prevent too rapid a descent. Another

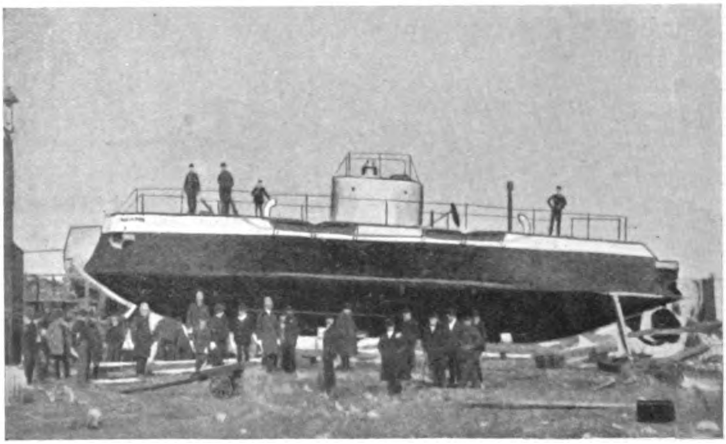
By favour of the 'Engineer.'

CLVI. STERN VIEW OF 'PROTECTOR'

reason for this mode of submergence is that it is possible to take accurate bearings, and sink the craft in this way within a few feet of any chosen point. For running between the surface and the bottom, the boat has to depend upon the lateral hydroplanes and the vertical rudder at the stern. This is the only experimental feature about the new boat, for the others of this type ran only on the surface or on the bottom—not in between. The boat carries a heavy cast-iron keel, a large section of which can be dropped at will in case of accident on the bottom. The conning-tower when submerged is said to exert a considerable righting moment, so that the double effect of the conning-tower and the disposition of the weights and the heavy keel is to keep the craft on a level keel. In the Argonaut No. 2, upon which the present Protector is an advance, this stiffness was so pronounced that it was found, when running from the general water-bed into a deepened channel, that the boat sank only when the stern cleared and then she went down on a level keel. When submerging under way, it is anticipated that the weight of the water on the hydroplanes will force the boat down on an even keel, and that there will be no danger of a sudden plunge, or dive, should any of the crew move forward.

'The boat is 65 feet long, over all, has a maximum beam of 11 feet, and a submerged displacement of 170 tons. She has twin screws driven by two gasoline engines of 250 horsepower applied direct to shafts. For submergence runs, she carries storage batteries, with capacity equal to 100 horsepower. The batteries can be re-charged while the boat is running under her gasoline engines. There is said to be ample space for a crew of six, folding berths, like the bunks in an American sleeping-car, being provided for that purpose, and turned up out of the way when not in use. The engines are placed to the sides of the boat, leaving a passage way between them. The surface speed is estimated at 11 knots, and the submerged at 7 knots. The fuel tanks hold 1,400 gallons of gasoline. Enough air is carried in the tanks in the superstructure, at a pressure of 200 lb. to the square inch, to last, it is estimated, for a submergence of sixty hours. Forward of the living space there is the diving compartment, by which access can be had to the sea when the boat is on the bottom. In this compartment is carried a telephone, which connects with the other parts of the boat, and which can also be connected to an outside line. The object of this latter use is for off-shore picket service. It is proposed that boats of this type shall be sent well out to sea, where the bottom is still not more than 100 feet below—on the Atlantic coast of the United States this ranges all the way from 5 to 20 miles—and when an enemy is observed in the offing, after having marked his apparent speed and direction, sink to a junction box, send out the diver, and make direct telephonic connection with the shore. By gradually increasing the air pressure in the diving compartment, during the interval of hauling down, it should be possible to bring the diver to the point of pressure needed without danger.

'The offensive work of the boat is centred in three 18-in. Whitehead torpedo tubes—two in the bow and one in the stern. The torpedoes will be carried in the tubes, and water ballast will replace their discharge. In making an attack the bow tubes will be fired just after submergence, while the after tube, should the bow torpedoes miss, will be fired after the boat has passed under and beyond the target and upon rising. This is to be effected without the need of the boat turning in its flight.



By favour of the 'Engineer.

CLVII. BROADSIDE VIEW OF 'PROTECTOR'

'The wheels of the Protector have a central blade, intended to bite into the bottom, which, on the Atlantic coast, is generally hard sand, and to keep the boat true to her course. Cyclometers are to be geared to the travelling wheels to check distances. Where the bottom is muddy and soft the pressure, it is said, can be easily regulated, and it was found with the Argonaut No. 2 that she would travel easily, the wheels burying but 6 inches in mud in which the diver would sink up to his waist.

'The Protector has, so we understand, been built with the direct understanding of competitive trials between her and the Holland type of boat, and the results will be looked forward to with interest. To the engineer and the naval man the following comparison of elements is instructive: while the safety appliances and the means of escape for the entire crew through the diving compartment in case of total disablement—using patent helmets for the purpose, are advantages that mean much for the maintenance of *morale* in time of danger.

The Protector.	*Holland Boats.*
Length over all, 65ft.	Length over all, 63ft. 4in.
Breadth of beam, 11ft.	Breadth of beam, 11ft. 6in.
Displacement afloat, 115 tons.	Displacement afloat, 105 tons.
Surface buoyancy, 55 tons.	Surface buoyancy, 15 tons.
Engine horse-power 250, applied direct to shaft.	Engine horse-power 160, less a considerable loss due to driving indirectly through gearing.
Battery capacity, 75 horse-power for four hours.	Battery capacity, 70 horse-power for four hours.
Twin screw.	Single screw.
Hull, sufficient strength to submerge 150ft.	Strength of hull approximately the same.
Armament, three Whitehead torpedo-firing tubes.	Armament, one Whitehead firing tube.
Means of submerging, three. Admitting water ballast, submerging with the use of hydroplanes, and hauling down to the bottom or to any desired depth by anchor weights.	Means of submerging, two. Admitting water ballast, and driving with horizontal rudders.
Means of coming to the surface, four. Discharging water ballast by either compressed air, power, or hand pumps; by the hydroplanes, when under way; by lowering the anchor weights, and by releasing the drop keel.	Means of coming to the surface, two. Discharging water ballast, and use of horizontal rudders when under way.
Fuel-carrying capacity, 1400 gallons.	Fuel-carrying capacity, 850 gallons.
Speed (estimated), 10 to 11 knots.	Speed (estimated), 8 knots.

The Protector.	*Holland Boats.*
Submerged speed (estimated), 7 knots.	Submerged speed (estimated), 7 knots.
Means of travelling on the bottom.	
Submerges on a level keel.	Dives by the bow at varying angles.
Gasoline fuel carried in superstructure where escaping gas or leakage would not injure crew.	Fuel, gasoline, carried in tanks in the living quarters of the boat.

'It will be understood, of course, that in the foregoing comparison the claims made for the Protector have yet to be substantiated when she is far advanced enough to make trials. Her builder, Mr. Lake, seems to be confident that he is not claiming too much for her, and he says that his boat will embody the following extra advantages:—

'Means to enable divers to leave and enter the vessel while submerged; automatic and positive maintenance of trim; means to measure distance travelled when submerged; invisibility in a semi-submerged condition; capability of steering long and correct courses; automatically controlling depth of submerging; means for cutting cables and for mining and countermining purposes; a water-tight superstructure affording deck space and sufficient buoyancy to make her seaworthy and also afford space for storage of fuel, air tanks, etc.; automatic drop keel and other automatic features to prevent submerging below a safe depth; ample officers' and crews' quarters with cooking and sleeping facilities; provision for escape of crew in case of partial disablement of vessel while submerged.'

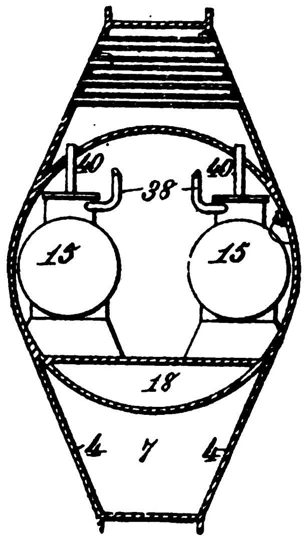
I have not yet finished the account of Mr. Lake's inventions. His latest is best described in the words of his specification, from which also the illustrations have been taken.

This invention relates to submarine vessels and is particularly designed for navigating in water covered by surface ice, and has for its object, first, to provide a submarine boat with means for engaging the under side of the ice or the water bed to furnish a sliding contact therewith, and to combine with such means, means for ballasting the boat in such a manner that the contact between the boat and the bottom of the ice or the water bed may be reduced to a minimum; second, to provide the boat with a vertically adjustable guide or guides projecting from the boat and adapted to engage the surface ice or the water bed and guide the vessel over the uneven surface thereof; third, to provide a traction wheel adjustably arranged with relation to the hull and adapted to engage the under surface or the ice or the water-bed at pleasure, and means for rotating the said wheel to propel the vessel; fourthly, to provide improved means for supplying air to and exhausting it from the interior of the boat and the engine; fifth, to provide improved means for rendering harmless, back explosions of the engine; sixth, to provide novel torpedo devices for blasting the ice, blowing up ships and the like; seventh, to provide means for affording an exit from the boat through the ice; and lastly, to provide certain other features ot invention hereinafter referred to.

The hull of the vessel is preferably of the usual double-conoidal form and possessing sufficient strength to resist the pressure of water at ordinary depths. It is provided with the usual water ballast tanks or compartments and means for admitting and expelling water from the same, the tanks and their connections being so proportioned and arranged as to permit the necessary adjustment of the trim and the variation or destruction of its buoyancy, in order to suit the various conditions under which the boat is designed to be operated.

The hull is provided externally upon the top and bottom with longitudinal runners to contact with the under surface of the ice, as when running thereunder in buoyant condition, or upon the water bed, as when the buoyancy is wholly destroyed by suitable manipulation of the water ballast tanks. The upper and under sides of the hull are also provided with wells in which are pivoted vertically swinging arms provided, each at its free end, with a traction wheel operated by suitable driving mechanism, as a chain and sprocket wheels connected with a shaft actuated by means within the hull for propelling the boat, the lower of such arms being made buoyant, and both of said arms being thrust and sustained in their outer operative positions by mechanism contained within the hull. The upper traction-wheel-carrying arm, when released, is automatically returned by gravity to its well, while the other traction arm is similarly adapted to be returned to its inoperative position by its buoyancy.

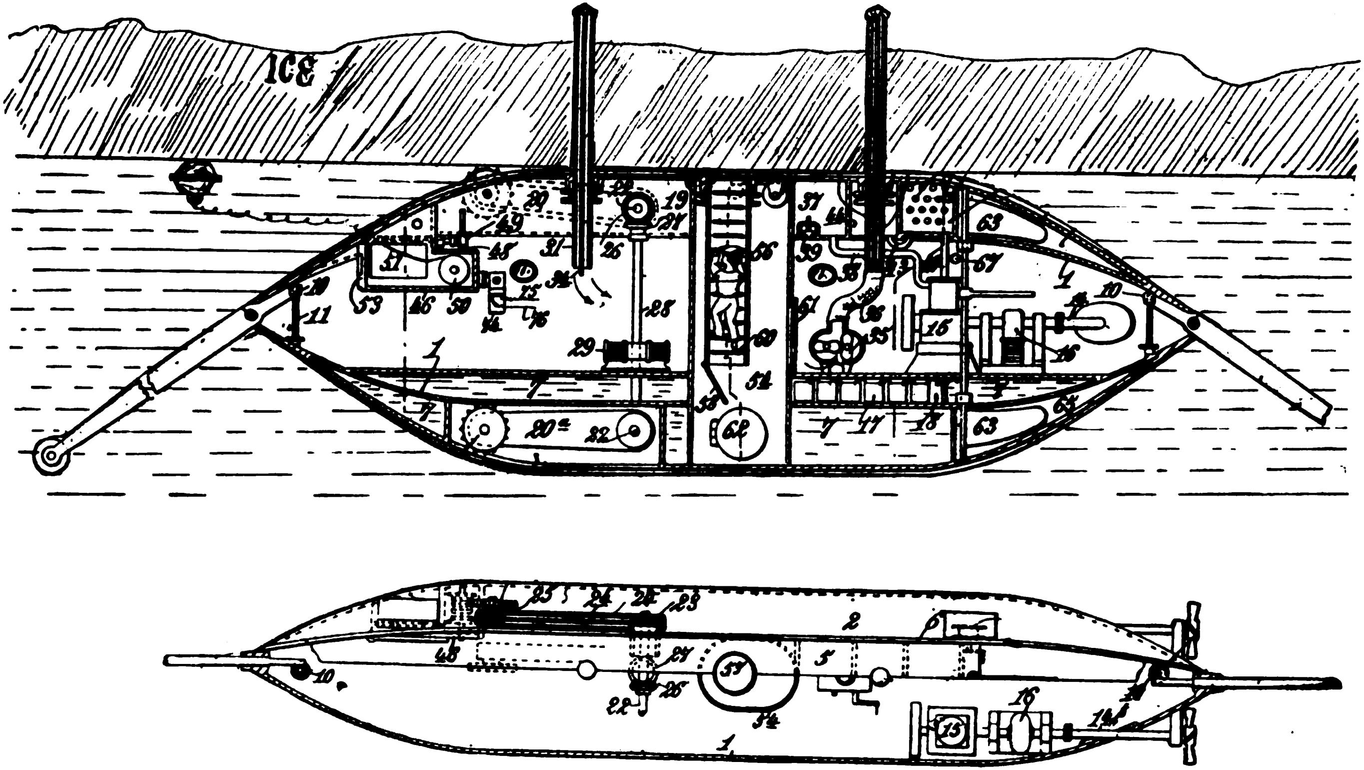
To enable the boat to readily pass over or under obstructions while maintaining a given direction of motion, deflecting arms are pivoted to one or both of its ends to swing in a vertical longitudinal plane beyond the same, and are held rigidly at a given upward or downward inclination by means of an adjusting and sustaining device operated from within the vessel, the outer ends of such deflecting arms being provided each with a guide-wheel; whereby the contact of either of such



CLX. SECTION OF LAKE BOAT

arms or their guide-wheels with obstructions at the level at which the boat is travelling, will cause the latter to be deflected bodily upwardly over a submerged object or downwardly under a floating obstruction, as an ice-field, its trim being maintained meanwhile by the suitable adjustment of the water ballast tanks.

The hull is further provided at the top with stuffing boxes, through which are adapted to be thrust two hollow drill rods telescoped through the upper wall of the hull so as to be



CLVIII.-CLIX. SIMON LAKE'S LAST SUBMARINE

vertically moveable and opening at the lower ends into the interior of the vessel, valved points or cutters being provided on the upper ends of said drill rods and provided with means for operating their valves from within the hull, so that, after holes are bored through the ice by means of the drill points or cutters, the upper ends of the hollow drill rods may be opened to afford, respectively, an inlet and an outlet for communication between the interior of the hull and the atmosphere above the ice.

The boat is further provided with a compartment for the reception of a buoyant torpedo and has a door for normally closing said compartment water-tight and means for opening said door from the interior of the hull to permit of the escape of the torpedo, a drum being also arranged in the said compartment carrying an electrically conducting cable connected to the torpedo and provided with means whereby said drum may be operated from within the vessel to control the torpedo; whereby an opening may be made in a field of ice for the ascent of the occupants of the boat to the surface by first releasing the torpedo from its compartment, then backing the boat to a safe distance, and finally exploding the torpedo by means of an electric current through the cable connection from the boat to the torpedo, after which the boat may be again moved forward to a position directly under the hole thus formed in the ice.

In cases wherein it is unnecessary for the boat to come to the surface, a hole may be blasted in the ice of such size only as to permit the use by the occupants of its tubular hatchway vertically and telescopically arranged in the upper side of the hull and provided with a suitable hatch for normally closing the upper end of said hatchway water-tight.

When an explosive engine is employed to furnish power for manipulating the boat, its exhaust is preferably connected with an external condenser which is in turn connected with a chamber surrounding the lower portion of the outlet pipe formed by one of the said hollow drill rods, which latter has a lateral hole or port adapted to communicate with said chamber. The raising of such outlet pipe to brings its lateral hole or port within the exhaust chamber surrounding said pipes operates to open communication between the same and said chamber to permit it to lead away the products of combustion of the engine.

To avoid any injurious consequences from back explosions of the engine, its inlet pipe is connected to an air supply tank whose inlet passage has a check valve through which the engine draws its air supply from the interior of the boat. The back explosions of the engine thus operate merely to close the check valve thereby preventing the escape of the products of combustion into the boat.

When it is desired to propel the boat during submergence, or to recharge a series of storage batteries such as is usually provided in boats of the present general type, communication with the atmosphere may be established, when the boat is not running under a field of ice, by means of two sections of flexible hose coupled at the lower ends to suitable nipples, the one tapped directly into the side of the condenser and the other into the wall of the vessel at some adjacent point, the upper ends of said hose being provided with automatically closing valves to exclude water, and supported by a float upon the surface with their normally open extremities exposed to the atmosphere.

THE FRENCH SUBMARINE BOATS.

'SUBMARINES.'

Although the active interest of the French Government in submarine navigation dates back theoretically to the experiments conducted by Bourgeois and Brun with the 'Plongeur'[1] practically it began with the remarkable invention of M. Goubet.

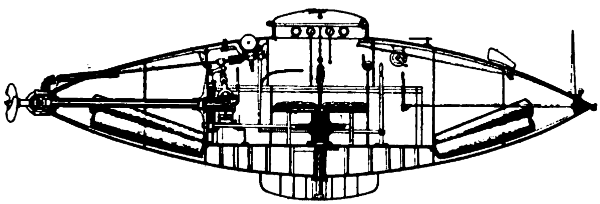
'Goubet I' The 'Goubet I.' was built in 1885 at Paris and has the following dimensions:

Length over all	5m. 16.404 feet)
Height at centre	1m. 78 (5.8399 feet)
Extreme beam	1m. (3.2809 feet)
Weight of hull	1,450 kilos (1 ton 8 cwt. 60 lbs.)
Safety weight	300 kilos (661.38 lbs.)
Total displacement	1 cubic metre 80 (64.317 cubic feet)
Capacity of water tanks	0 cubic metre 30 (10.6 cubic feet)

1 See pp. 44-53.

The stability of the 'Goubet I.' is maintained by the action of a weighted pendulum fitted to a small exhaust pipe in such a manner that an inclination of the vessel one way or the other forces water from the forward to the after tank or vice-versa according to the direction in which the movement is made. Thus the moment the boat dives, water is sucked up from the forward reservoir and ejected into that placed astern. These stability tanks are never empty even when the vessel is in a light condition, as the quantity of water they contain is very small. For submerging large tanks are filled until the buoyancy has been overcome to the required degree. A careful study of the appended plan will aid my descriptions:—

The motive power is electric, the dynamo being of the Edison type; this motor is used for working all the various mechanisms, pumps, etc., contained in the interior. The



CLXI. THE 'GOUBET I.'

electric current is supplied by a system of Schanshieff batteries placed in the bows of the boat.[1]

The safety weight solidly fixed to the bottom of the boat by a clamp, in such a way, however, that a slight twist of a handle would cause it to detach itself when the submarine would at once rise to the surface. This weight adds greatly to the stability of the boat when submerged.

The armament consists of a torpedo which would be fixed to the hull of a hostile vessel and, when the submarine had drawn off to a safe distance, it would be exploded by electricity. The conning-tower, by which also the crew enter the vessel, is fitted with stout lenses, which are also provided with obturators so that in the event of a glass breaking the water would instantaneously be excluded from the interior.

1 Maurice Gaget in 'La Navigation Sous-Marin' says the batteries were by Stichetline.

The screw, placed in the stern, is moveable in every direction and hence all rudders are dispensed with. The crew, consisting of two, sit back to back on the air reservoirs which contain compressed air for respiration.

This first Goubet boat is a failure, being unable to keep its depth properly, and a straight submerged run has been found absolutely impossible.

'Goubet II' The second vessel [1] built by M. Goubet differs very little from his first, except in size, and the one description will therefore do for the two. The 'Goubet II.' was ordered by Admiral Aube on September 12th, 1886, and built at Cherbourg, the launch taking place in 1889. Her dimensions are:

Length over all	8m. (26.247 feet)
Diameter	1m. 85 (6.0697 feet)
Material of hull	Bronze
Safety weight	1½ tons
Weight of hull	5 tons

The hull is one inch thick in the middle of the boat and should withstand enormous pressure. The propeller is driven by a Siemens' Road Car motor, weighing 190 kilos, and working at 9 ampères and 48 volts. The weight of the hull is five tons and the detachable safety keel weighs 1½ tons. The speed is about 5½ knots the radius being 25 knots. The following description of this vessel is interesting: [2]

'Submarine boats being the subject of the day, I accepted with avidity the chance offered me to visit the 'Goubet II.' moored in the basin of the St. Ouen Docks. To tell the truth, I was going to see the 'Goubet II.' to ease my conscience, having still in mind the experiment at Cherbourg (in May and June, 1891) judging from which it would appear that this vessel, though of a special and improved type, was very imperfect and far from fulfilling the desiderata of the partisans of submarine warfare. I returned convinced, on the contrary, that we had in this boat, setting aside the

1 In August, 1899, it was reported that M. Goubet was to make experiments at Toulon before a Special Naval Commission with a new and improved type of submarine vessel.

2 Translated from an article by M. Emile Duboc in 'Le Yacht,' February 18th, 1899.

'Zédé,' a second satisfactory solution of the problem which just now occupies us. That it may be perfected, I agree, but I consider, that we have in our hands a serious engine of warfare, easy to construct, robust, by no means expensive and capable of carrying out at a future date and with the same success the experiments in submarine attack recently effected by the 'Gustave Zédé' against the 'Magenta.'

'Before going further I should like to bestow a word of praise on the eminent engineer after whom the 'Zédé' is named, and who, backed up by Admiral Aube, constructed the 'Gymnôte' which is considered a good model upon which to experiment and through which to elucidate the as yet unknown factors of the problem. The name of Commander Darius who has contributed greatly by his essential perfective endeavours to a practical solution must not be forgotten. As for M. Goubet already noted for many years for his various mechanical inventions, notably the Goubet joint, all of which he perfected before turning to submarine navigation, I will leave it to the reader to judge of him by his work.

'His first submarine, tried at Cherbourg, was ordered by the Navy. The Commission decided that on certain points it left much to be desired. It was therefore thrown on the hands of the inventor who far from being discouraged constructed a model of larger dimensions than the first and profiting by the acquired experience, endowed it with perfected organs and mechanisms which did away with the faults of his primitive endeavour. Such was the origin of 'Goubet II.' into the interior of which we are about to enter.

'When we get on board the dome is open and the vessel is emerged about 0m. 50. The interior aspect is very attractive and very simple. It is all painted white and seats of varnished indiarubber, covering the accumulators, are placed to port and starboard. In the centre, close to the tube of the conning-tower, is placed a wheel by which the rudder is worked, or rather a steering wheel by which the propeller is moved. The shaft of the screw is articulated with that of the motor by a Goubet joint in such a manner as to allow of the boat performing evolutions in any direction. All about the dome are placed glasses, thanks to which one is able to inspect the horizon when on the surface. The 'Goubet I.,' 5 metres in length, was founded in a single piece of bronze; the 'No. II.' is founded of the same metal in three sections, closely fitted and perfectly water-tight.

'The thickness of the centre portion is 2½cm. The two end portions diminish in thickness to 15mm. Beneath such a thickness of a metal impervious to the attacks of the constituents of air and water, one feels quite safe. It is a fact that once the boat fell into the sea from a height of 5 metres whilst being hoisted by a crane, and yet no damage whatever was done. This perfect cohesion of the sections and these enormous resisting powers to crushing forces are not only to withstand the exterior pressure which reaches as high as 1 kilogram per square centimetre but also that the hull might be protected against the rapidly changing pressures which are exerted on the exterior.[1] It is with submarines very much the same as with boilers, and as is well known, these latter deteriorate very rapidly unless an even pressure is maintained; with a submarine the rivets work loose, the joints warp and give and a small leak of water is the result; quite sufficient to completely upset the stability of the boat.

'Against all these dangers the 'Goubet' is fully secure. She is absolutely water-tight and stiff and is safe from all deformation to depths as great as 300 metres (circa 985 feet).

'My position is forward. I am comfortably seated on a seat in the form of a horse-shoe and find within my reach: 1st, a pair of oars which are moved by turning a vertical axle, and of which the palettes fold up when coming forward for a stroke; 2nd, on either hand a cock for letting water into the ballast tanks; 3rd, at my feet two fly-wheels between which is a lever for working a double-ended suction pump. According to the direction given to the fly-wheels, one can expel either the vitiated air, or the ballast water.

'Lastly, in the stern, which is reserved for the engineer, is the motor, a large tank for water in case a sudden dive were a necessity and an electrically worked rotary pump. Besides these there are the same mechanisms as in the bows, only more powerful. In addition there is an apparatus con-

1 The form of the 'Goubet' assures a maximum of resistance. It is reckoned her hull could withstand a pressure of 150 atmospheres, i.e., sink to a depth of 1,500 metres (4921.34 feet) without serious risk.

cerning which I must give no details; a new apparatus applied for the first time in the 'Goubet II.' for the purpose of maintaining the vessel at an even depth when in motion submerged. We will call it the 'automatic immersion regulator.' As with the main motor it is electric, the current being supplied by a battery of accumulators.

'The entrance hatch is closed. We are going to submerge. The water cocks on both the port and starboard sides are open. We can hear the water running into the ballast chambers and yet the stability is in no way affected. The surface of the water mounts up the look-out glasses, the needle of the manometer is slowly moving. The top of the conning-tower is awash. The water cocks are turned off. Immersion is complete and we remain motionless in an equilibrium. The cocks are again open for a moment, to allow of a glass of water to enter the tanks and the new position of equilibrium is at 10cm., beneath the surface. This (the surface) divides the view of the optical tube pushed out above the dome in two equal lengths just as in the cylinders of a telescope. The vision seen is very clear and yet we are only showing a half of the prism which forms the top of the optical tube. It is about the size of half a five-franc piece.

'We remain in this position for some ten minutes; I move from my place several times and placing my eye to the optical tube perceive that the upper lense is always divided in two by the surface of the water. We are masters of submersion almost to the millimetre.

'Suppose this equilibrium to be disturbed and the vessel approaching the surface, the opening of the water-cocks a second will place us in our first position. Suppose we sink, a stroke of the lever which I have close to my hand will expel a little liquid and the manometer will show us we are again at the appointed depth. When in motion the manœuvre is the same. The operator keeps his eyes on the manometer as a helmsman keeps his eyes on the compass; he steers over 5 metres of depth as the pilot steers to a degree of the card. In motion it is not any more difficult, the same causes, expulsion or introduction of water, produce the same effect.

'It is in this way that the experiments were carried out at Cherbourg; but it was perceived that the man to whom the submersion was entrusted became tired out with the constant attention required and that is why M. Goubet devised the electric automatic submersion regulator, which is more powerful than the manual machines, and which above all things, is instantaneous in its action.

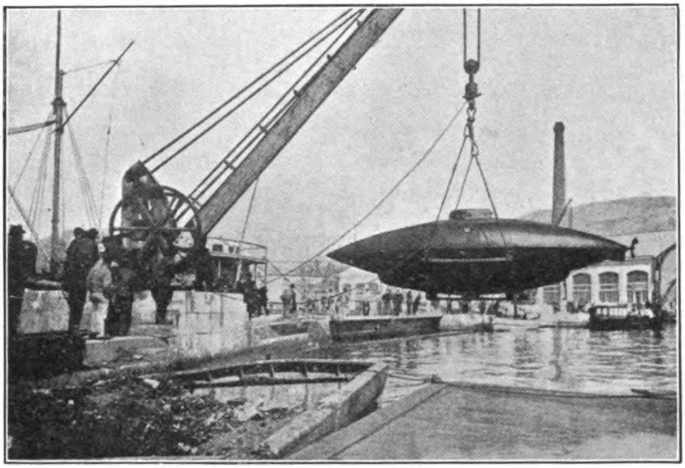
'In the 'Goubet I.' at Cherbourg, during one of the experiments, a hydrostatic tube burst and a rush of water into the hull resulted. The crew, composed of two quarter-masters of the Navy took prompt action; the safety weight attached to the keel was unclamped and the boat bounded suddenly to the surface as though shot by a spring. The 'Goubet II.' which is 8 metres long has a safety weight of 1,500 kilos.

'I have now explained everything connected with the methods of immersion and emersion when still and in motion. One can see that they are very simple. I now arrive at the chief quality of the 'Goubet,' namely, the stability in diametrical and longitudinal senses. This is due to a stability of enormous weight (1,500 kilos of safety weight and about 200 litres of water ballast, besides an interior ballast of 700 kilos of lead, which is all accumulated in the central section of which the thickness reaches, as we have seen, 2½cm.). Added to this is a horizontal collar fixed all round the boat and 60cm. wide (at the greatest width) which besides preventing rolling and being caught up in obstructions, in no way hampers its freedom for evolution. One can now see why the 'Goubet' is so little affected by interior movement of members of the crew. An enormous inertia is opposed to every inclination. It is firm as a rock and possesses an extraordinary stability of platform even on the surface.

'As regards offensive powers, it is formidably armed, possessing as it does on each side, and fixed in tubes supported by the collar, an 18-in. White-head torpedo, which is set in motion by a lever worked from the interior.

'I ought to add that I have seen the boat carry out evolutions on the surface with the greatest ease, with the optical alone and even submerged in the St. Ouen basin, which is 20 metres wide by 600 long, in dirty water with but little depth, this augmenting the difficulties of navigation since the slightest contact with the bottom would cause the vessel to rebound above water, a thing that has never occurred.

'I therefore consider that the 'Goubet II.' can navigate submerged at a constant depth, a quality denied the 'Goubet I.' by the Commission appointed at Cherbourg, who, however, in my opinion attached too great an importance to this one quality. The question to be settled is to know whether the engine in question could approach an enemy who was cruising along the coast for the purpose of bombardment, remaining the while practically invisible and invulnerable and under these conditions to torpedo her. Here is the experiment which must be carried out to-day with the enlarged and more perfect 'Goubet.'



CLXII. THE 'GOUBET II.' BEING HOISTED OUT

'The 'Goubet' is granted the capability of being able to remain motionless at any desired depth, but it is denied that of keeping the depth when in motion, a feat only possible to the submarines constructed on the principle of the 'Zédé' with a continuous flotability and a horizontal rudder. But theoretical calculations are oftentimes contradicted by experiment.

'In conclusion I respectfully desire to draw the attention of the Minister of the Marine to this new submarine which forms the subject of my article. It would be as well to appoint a commission either at Cherbourg or Toulon to make an official examination.

'Perhaps they might then be persuaded to construct an even larger vessel on the same plans; but such as it is, having cost 150,000 francs, and capable of being constructed in three months, the 'Goubet II.' with a weight of hull of only 5,000 kilos, can be easily transported on the deck of a large steamer to Bizerta and all our Colonies for which it would prove, as well as for our home ports, a unit of defence to be seriously reckoned with.'

This ends M. Duboc's interesting account and so complete is it that little remains to be added. On April 13th, 1890, experiments were carried out at Cherbourg which although of much interest would take too long to describe in detail.

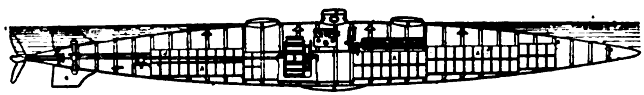
Briefly, they consisted of a course which took the submarine beneath the keels of five torpedo boats, rounded several buoys, ran into an English merchant steamer, the 'St. Margaret,' cut the wire of a dummy mine and fixed the propeller of a steamer in such a way that it could not be turned. These experiments were fairly satisfactory but the 'Goubet' boats all found a difficulty in keeping their depth when submerged and could besides never make a greater speed that 5-6 knots even on the surface of the smoothest water and this is of course totally inadequate for modern requirements. One quality, however, they possessed to a remarkable degree—stability. So stable are the 'Goubet' boats that when submerged in a rough sea the flagstaff projecting above the surface never shows the least trace of oscillation, and movements of the crew do not effect the equilibrium in the slightest degree. The power of remaining in a constant equilibrium is also very remarkable and one not possessed by any other submarine vessel. This last capability, however, is of very little practical utility. The success of M. Goubet's inventions, however, so moved the Russian Government that orders (so it is stated) were given for 300 of these vessels, the hulls to be built in Russia and the engines and mechanism to come from France. How many of these, if any, were ever laid down or completed I have been unable to ascertain, but taking into consideration their value as war-vessels, it would really not be of any great importance.

The 'Goubet II.' was purchased in the summer of 1901 by a M. Maire for frs. 14,000.[1]

1 See Addenda

The plans of the 'Gymnôte' were primarily conceived by that talented engineer M. Dupuy de Lôme, but his untimely death prevented his putting them into execution although he had almost completed his designs. Several years later M. Gustave Zédé, an intimate friend of Dupuy de Lôme, and a retired Naval engineer, took up the study of the subject which had been so suddenly terminated by its originator. He added many modifications to the primary designs and presented the completed plans to Admiral Aube, Minister of the Marine. When one considers how keen a partisan of submarines the Naval Minister had always been, and the fame the designer M. Zédé had already gained, it was not extraordinary that the plans should be accepted with avidity and the project adopted without delay. 'Gymnôte'

Tenders were called for immediately and the construction of the first submarine for the French Navy was intrusted to La Société des Forges et chantiers de la Méditerranée, of



CLXIII. PLAN OF 'GYMNÔTE'

which company M. Zédé was a director. This fact was of great importance in that it allowed the inventor to personally supervise the construction of the vessel.

The 'Gymnôte' was launched in September, 1888, and has the following dimensions:—

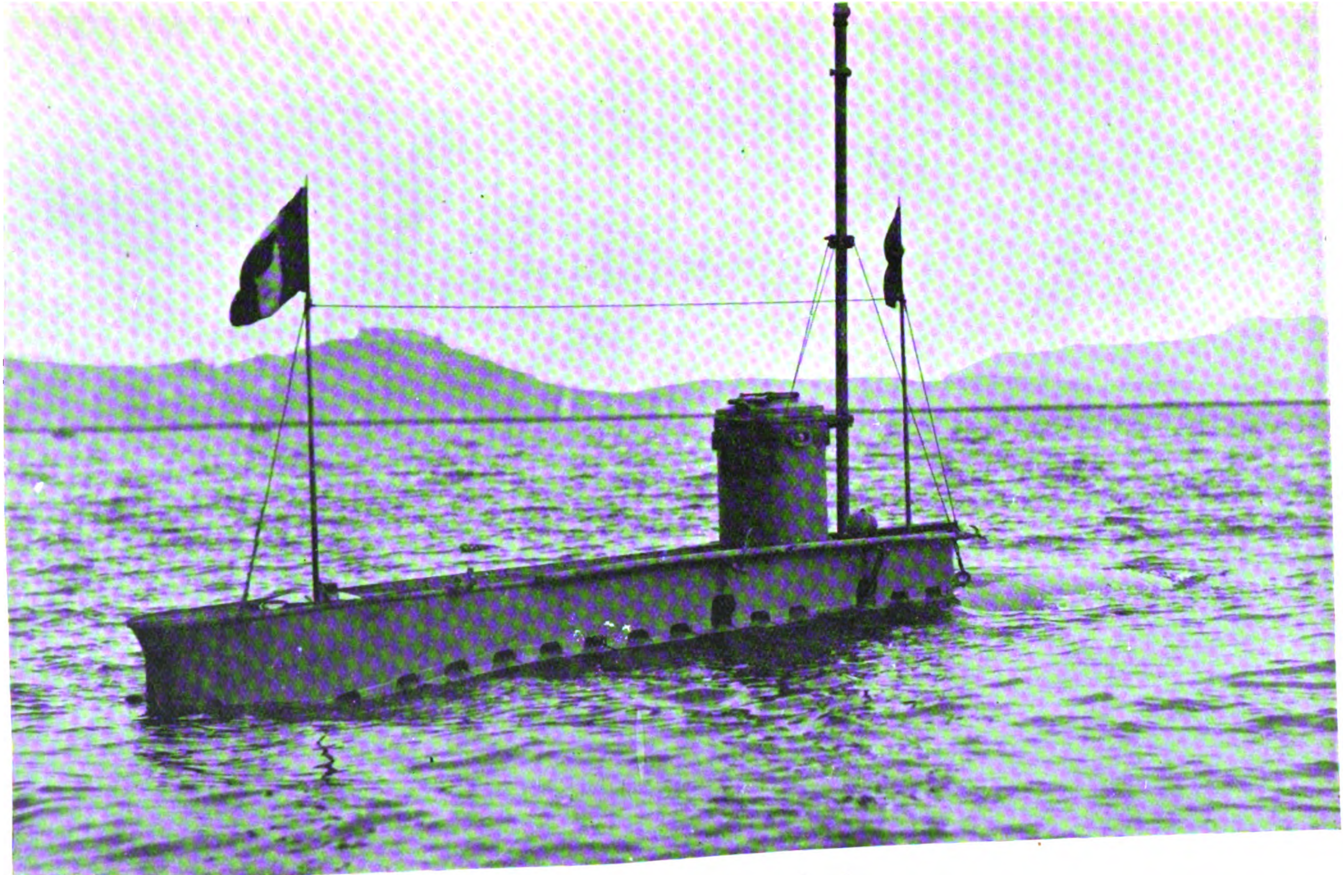
Length	17m. 20
Extreme diameter.....................	1m. 80
Displacement	30 tons

In shape the 'Gymnôte' is cylindro-conical, the hull being uniform and symmetrical on either side of a line drawn through the centre from stem to stern. The frame consists of 31 spherical hoops strengthened by longitudinal braces; on this frame is laid the sheathing of steel plate having a thickness of 6mm. in the centre reduced to 4mm. at the extremities. Pigs of lead are placed on either side of the keel line serving in two specially made tanks, to regulate the draught and to be used as safety weights in case of necessity. A narrow platform or deck provided with manholes at either extremity, is placed on the superior upper side. In the centre of this platform, resembling the dorsal fin of a gigantic whale, is found a small conning-tower of om. 50 in diameter, furnished with lenses by which the officer in charge may see the route to be steered. Immersion is obtained by the introduction of water into three reservoirs, two of which are situated one at either extremity, and the third in the centre. The reservoirs at either end are intended to maintain an even longitudinal plane and to preserve the stability when submerged. These three reservoirs are filled by the opening of air-cocks and emptied by compressed air or by means of a Behrens' rotary pump worked by an electric motor. Diving is effected by the horizontal rudders placed in the stern. Steering in the horizontal sense is effected by ordinary vertical rudders placed in a similar position to the two horizontal ones, i.e., just abaft the propeller.

A straight course is preserved when making a submerged run, by means of a compass connected to a gyroscope, each counteracting any tendency to false movement on the part of the other. Despite all precautions, however, the compass is much affected by the surrounding metal and the amount of electric current in operation on every side, whilst the gyroscope (although much improved) has proved a very capricious and untrustworthy servant. For seeing, two distinct apparati are provided; a twin-mirror optical tube and a périscope. Of these the first has given the best results.

Propulsion is obtained by means of a propeller 1m. 50 in diameter and rotated by an electric motor having a force of 55 H.P. constructed especially to the designs of Com. Krebs and capable of giving the 'Gymnôte' a speed of 8 knots an hour. This motor will be fully described under the heading 'Motive Power.' The current is supplied by 564 accumulators constructed by Mm. Coummlin, Desmazures et Baillache, each cell weighing 17 kilos 500, and having a combined weight of 9,870 kilogrammes. The speed of the motor at full power is 280 revolutions a minute. The following short extract re her trials is not without interest:—

'Aux expériences que l'on fit devant le préfet maritime



CLXIIIa. PHOTO OF 'GYMNÔTE'

de Toulon, le 24 Septembre, 1888,[1] le Gymnôte se comporte assez bien ; les essais de vitesse et de stabilité donnèrent de très bons resultats ; il pouvait évoluer dans tous les sens sans trahir sa présense devant les nombreuses Commissions qui étaient venues assister à ses éxpériences. Mais ce que l'on ne put obtenir et que personne ne pouvait se rendre compte, c'est qu'il ne lui fut pas possible d'obtenir un équilibre parfait entre deux eaux. En effet, les divers mécanisms ne s'obtenaient plus automatiquement et se faisaient à la main, de là une suite de montées et de descentes, que l'on n'arrivait à corriger que très difficilement.'[2]

This vessel was at once told off as a training ship for those who were desirous of taking up submarine navigation, and consequently her crews and commanders are being constantly changed. She has been captained by Lieutenants Baudry de Lacantiniere, Chéron, Darriens and many other well-known officers, and is at present in commission under Lieutenant Voisin. Naturally as an experimental boat she has undergone many changes, and it is doubtful if more than the hull remains of the original 'Gymnôte.' The Coummlin-Desmazures accumulators have been changed for some by Laurent-Cély of 'La Société des Metaux.' The French Naval Officers as a whole were at once favourably impressed with the result of the experiments carried out by this vessel and are to-day keener on submarine boats than our juniors are on commanding torpedo boats or destroyers. In fact the feeling for submarine boats has become a serious craze. The following notes about the 'Gymnôte' may be interesting:—

She was laid on the stocks in the arsenal of Mourillon (Forges et Chantiers) near Toulon on April 20th, 1887, and constructed under the care of her inventor M. Romazotti, (a first-class sub-engineer who later designed the 'Gustave-Zédé') and Capt. Krebs the designer of her motor. Her launch took place on September 24th, 1888, and her first trials on November 17th of the same year. There is some discrepancy about the date of her first trial, but November 17th is probably correct. The motor weighs 2,000 kilos, and

1 There is some doubt about this date.

2 Forest et Noalhat, Vol. I., p. 203.

(according to Pesce) has a power of 52 H.P. The crew consists of either 4 or 5 men including the commander. On the surface the speed is 10 knots which can be kept up for 45 knots, or 83 kilometres, while at 6 knots the 'Gymnôte' has a radius of 220 kilometres. Submerged the maximum speed is between 7 and 8 knots.

An amusing incident is recorded about the 'Gymnôte.' M. de la Porte, the Reporter of the French Naval Budget, with the object of informing himself on naval matters, was engaged on a series of visits to the principal French ports. In October, 1899, he arrived at Toulon and expressed a wish to make a trip in the submarine boat 'Gymnôte.' His desire was, of course, acquiesced in, and the 'Gymnôte' was ready to start when it was discovered that M. de la Porte, who is a very big and corpulent man, could not be got on board. The hatches which give admission to the 'Gymnôte' are exceedingly narrow and it was quite impossible for M. de la Porte to pass through them.

The armament of the 'Gymnôte' consists of two tubes each capable of discharging a torpedo of 335mm. (14 inches) calibre. The latest conning-tower of the 'Gymnôte,' for in common with many other parts her conning-tower received alterations, is collapsible like a Venetian lamp, and is so arranged that when it is completely doubled up the top of the conning-tower is level with the deck. The new Laurent-Cély battery is composed of 204 elements of five plates weighing 30 kilos each. It is, like the first, divided into 6 elementary batteries of 34 couples, grouped by twos in quantity and 17 in tension. The range of action at a speed of 8 knots is now 32 miles and at a speed of 4 knots 100 miles. The motor has a serious drawback. Trimmed to the stern of the boat, its stern bearing is inaccessible, and it cannot be repaired in place; the mode of rolling up the armature does not easily allow of inspection and the removal of defects of isolation when they are produced; finally, the mode of excitation does not permit the immediate stoppage of the armature.[1] We will now leave the 'Gymnôte' and go right on to the 'Gustave Zédé,' which if not so good a boat as the 'Gymnôte' at the start has finished up decidedly the best of the two.

1 The last few notes are from the 'Naval and Military Record,' 13th September, 1900.

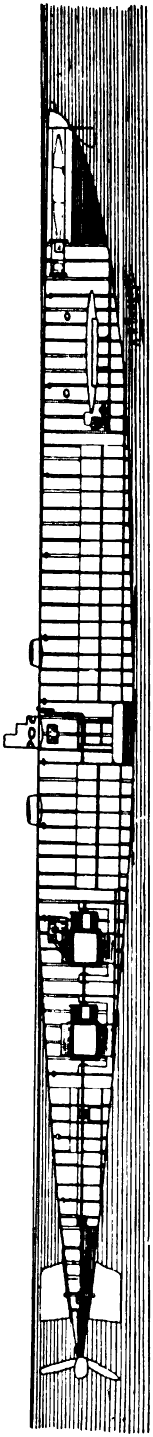
In 1890 M. Barbey, Minister of the Marine, ordered the construction of the famous 'Gustave-Zédé,' to the designs of Engineer Romazotti. She was laid down at Mourillon's Yard at Toulon under the name of 'Sirène,' but during her construction the inventor of the 'Gymnôte' died, and desiring to pay a last homage to his memory, the largest submarine boat in the world had her name changed to 'Gustave-Zédé.' 'Gustave-Zédé'

The 'Gustave-Zédé'[1] was launched on June 1st, 1893, but defects were discovered as soon as she entered the water, and it was many years before the submarine carried out trials that were in any way successful. Her dimensions are as follows:—

Length	48 metres 50 (159 feet)
Diameter	3 metres 75 (12.3033 feet)
Displacement	266 tons

In shape the 'Gustave-Zédé' differs considerably from the 'Gymnôte.' Although cylindro-conical, the form of the latter boat is dissymmetrical, the stern half is in shape symmetrical like the first vessel but at the bows the keel line rises to meet the deck, almost to the water-line when the vessel is awash. A glance at the plan will make my meaning clearer. The framework consists of 76 hoops connected by longitudinal braces; on this are laid the plates of Roma metal, of which the whole hull is constructed owing to its immunity from deterioration by the action of the sea. As in the 'Gymnôte' the upper deck is flattened from quite near the bows to 50 feet from the stern, and in this deck are two entrance hatches and the conning-tower. The means of immersion and regulation of stability when submerged are identical to those employed on the 'Gymnôte' and do not therefore require re-explanation. Instead of one reservoir in the centre, however, the 'Zédé' has two. The water is expelled from the tanks by compressed air obtained through the action of two Thirion pumps each worked by an electric motor. The pumps also supply the air necessary for respiration and for the discharge of the torpedoes. Diving and steering are managed

1 The original cost of the 'Gustave-Zédé' was 600,000 frs., but this sum has since been much exceeded.



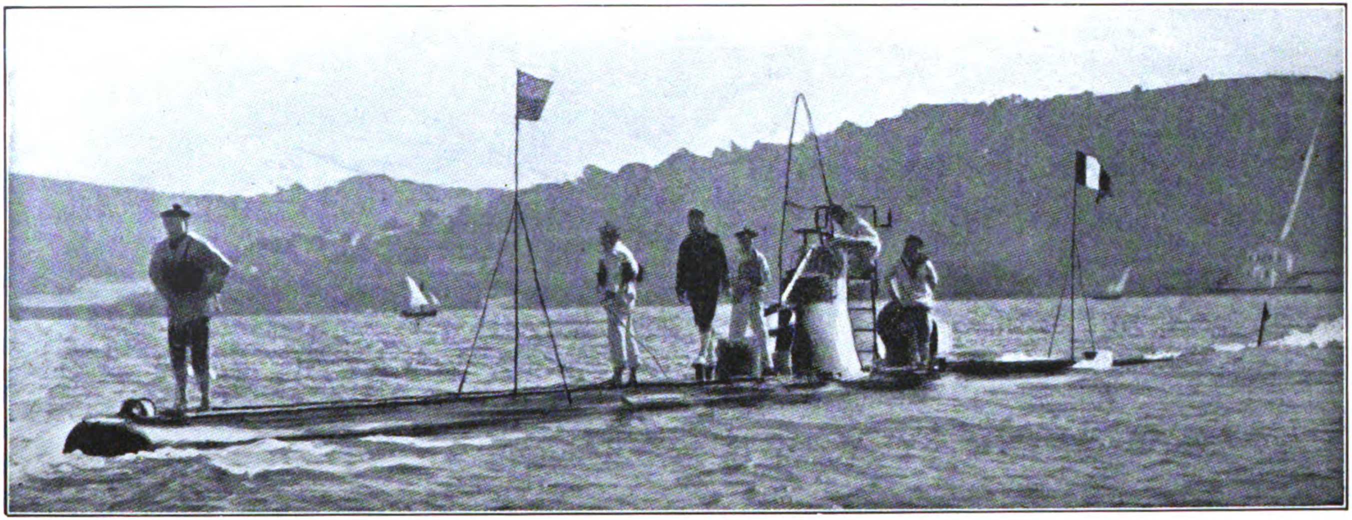
CLXIV. PLAN OF 'GUSTAVE ZÉDÉ'

on the same principle as that employed by Gustave Zédé in his boat, the rudders being in a similar position just forward of the propeller.

The propeller which projects from the stern point, is rotated by two electric motors connected to the same shaft; these motors, which were built by Sautter Harlé, have an independent power of 360 H.P. and a combined strength of 720 H.P.[1] They are six pole motors of the Thury type with separated excitation. They can be coupled singly or together to the propeller shaft to which they give 250 revolutions a minute. The power is stored in a battery of accumulators by Laurent-Cély; this battery, composed in the first place of 720 elements, weighed 130 tons, the combined weight of the motors is 27 tons. At the maximum power the two armatures are coupled in quantity under 300 volts and 1,800 ampères for the above mentioned speed of rotation.

On account of defects in the accumulators 18 months was lost. For in the battery of 720 elements with 29 plates each, an electrical power was collected such as had never before been experimented with, and it naturally required most expert operators to attend to it. After a few days satisfactory work, however, short circuits were produced through the formation of pellicules of lead peroxyde which fell into the tanks. It was then decided to isolate the plates (which were reduced to 27) with magnets, the positive plates being covered with a magnetised lining. When the new battery had been installed on board the charging current was put on with the result that the stern of the submarine was almost blown to pieces and destroyed, a violent fire breaking out showing the impossibility of using such batteries. The only remedy was to reduce the cells by one half, and at last after nearly two years of scientific muddling the 'Gustave Zédé' was able to go on her first trials; but her fine designed speed of 15 knots was now only 8 knots an hour. Another difficulty now cropped up. After being on the vessel a short time, her crew were all taken violently ill owing to the free discharge of large quantities of acid vapour throughout the hull. This matter was, however, speedily set right and with her wings clipped and reputation

1 Forest and Noalhat, pp. 297-299.



CLXV. THE 'GUSTAVE ZÉDÉ' RUNNING AWASH

at zero the largest submarine boat the world had yet seen started to vindicate her character.

But after her first trip, any remaining faith in her possessed by the French nation was shattered, and it was only a chance that the 'Gustave Zédé' is not now on the scrap heap. For the moment she lost her buoyancy the submarine became unmanageable and her course had so much in common with the switchback that her poor crew were unable to keep their feet and were hurled hither and thither. This improved a little when they became accustomed to the eccentricities of their craft, but even then the 'yaws' were between 14 and 18 metres, or 46 to 60 feet. These variations she accomplished in long swift swoops and all the endeavours in the world would not keep her on a straight course for more than a few minutes at a time. The uneven torpedo-like course of the 'Gymnôte' had been the cause of much comment and the much greater length of her big sister only accentuated the faults she had herself displayed. This 'yawing' although not dangerous where a sufficient depth of water existed would be absolutely fatal in a harbour or when wishing to pass under a ship which would of course be a frequent occurrence.

After these preliminary trials many drastic changes were made. The batteries were removed and a new set of elements of greater capacity was installed, so that the multiplicity of the couplings and connections was much reduced. The canvas conning-tower with which the vessel had been supplied was also removed, a metal tower tapering off fore and aft being substituted. The movement of the Thirion pumps for regulating the water ballast was modified and lastly a new system of diving rudders was fixed, these being brought up to six in number, two forward, two in the centre, and two in the stern, i.e., three on each side of the vessel. With this new system of rudders the trials began again and to the surprise of every one, that which had been put down as an absolute failure, proved a brilliant success, for the stability was now almost perfect, and the speed had increased to 12 knots on the surface owing to the change of accumulators. When travelling with the top of the conning-tower just above the surface, the rest of the hull being submerged three feet, the vessel could be made to manœuvre in any direction with perfect ease and surety. The difficulties which had beset the 'Gustave-Zédé' at the outset had been resolutely faced and after nearly four years of increasing labour, been overcome. The 'Gustave Zédé' is a credit to the genius of France not so much for 'being' as for the way in which apparently insuperable difficulties were met and pushed aside.

The metal conning-tower has a height of 1m. 50 and is fitted with a périscope constructed by the firm of Sautter-Harlé. This périscope has an outer diameter of 364mm.; a total field of 27 degrees of which 20 degrees are above and 7 degrees below the horizon; an angle under which the upper part of the point of convergence of the rays can be seen of 3 degrees, a reduction of 1/9th and a distance from the image to the emerged part of the apparatus of 1 metre. The image obtained is examined by a rather complicated process by means of an eye-glass.[1] This périscope has proved almost a failure, the image obtained being very distorted and indistinct. There is also an optical tube fitted. The gyroscope and compass are used here as in the 'Gymnôte' for giving the course but both are untrustworthy, the compass especially since it is in a position where the magnetic attraction is unevenly distributed. The hull of the 'Zédé' is luckily of non-magnetic metal.

The armament consists of 3/18-in. White-head torpedoes, one of which is carried in the solitary tube in the bows. The opening of the discharge tube is closed with a tightly fitting conical cover and this is removed just prior to firing the torpedo. The rush of air through the tube forces out the water that has penetrated owing to the cap being open, and another torpedo can thus be inserted without the fear of getting flooded by a sudden inrush of water.

The experiments carried out by the 'Gustave Zédé' since her re-construction have been many, and all have been instructive as showing what a submarine can and cannot do. The best known of her trials is that in which she torpedoed the 'Magenta' in Toulon Harbour. The following account of the attack by that talented naval student M. Lockroy is full of interest.[2]

1 'Naval and Military Record,' September 13th, 1900.

2 'La Defense Navale,' E. Lockroy, Paris, 1900.

'Exercice d'attaque du *Magenta* par le *Gustave Zédé*.

'Les trois cuirassés 'Magenta,' 'Neptune,' 'Marceau,' tirent sur le 'Gustave Zédé' avec leurs pièces moyennes et légères.

'L'exercice commence au signal à 3h.17. La torpille est lancée à 3h.28. La durée de l'attaque et du tir est donc de 11 minutes.

'La torpille dont la trajectoire est oscillant attient le 'Magenta' dans la verticale de la tourelle avant bâbord. . . .

'Le 'Gustave Zédé' a plongé à 3h.20 pour la première fois. A partir de ce moment, il a émergé cinq fois. La plus longue apparition a duré 1 minute 30 secondes. La plus courte 30 secondes.

'La défènse connaissait la position initiale du sous-marin, ce qui était pour elle un avantage considerable.

'Dans chaque exercice, le 'Gustave Zédé' ne montrait que son kiosque.'

This concise account of the attack is of especial interest as showing that the successful firing of a torpedo is possible without disturbing the equilibrium of the submarine discharging it. That the attack was successful is borne out by the statement of the commander of the 'Gustave Zédé' who wrote to M. Lockroy as follows:

'Aux termes de la dépêche ministérielle du 19 novembre, 1898, l'expérience devait porter principalement sur la possibilité d'utiliser l'appareil militaire du bâtiment et, à ce point de vue, il semble qu'on a constaté l'exactitude de l'opinion émise par la commission d'essais, dans sa séance du 3 novembre, 1898.

'Si une escadre ennemie se présentait au large de Toulon ou tenait un coup de main contre les îles d'Hyères, le 'Gustave-Zédé' sortirait et aurait des chances de réussir à torpilles un ou plusieurs des bâtiments ennemis.'

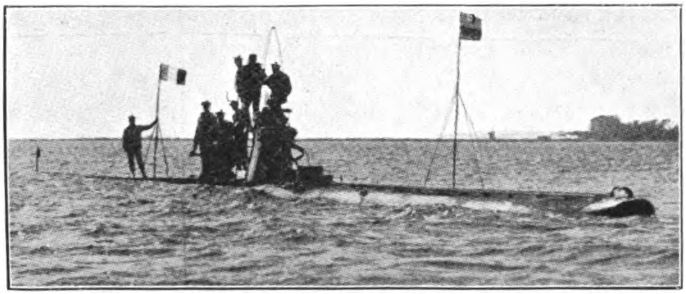
No commander could speak in such terms unless he felt confidence in his vessel and I do not think his confidence is exaggerated, for I was myself a witness of the trials of the 'Gustave-Zédé' and was so struck by the undoubted success of the manœuvring that from a disbeliever in the new arm, I have become an enthusiast. The ease with which the various evolutions were effected was astonishing, no sudden swerves or dives marring the even and steady course of the vessel.

At a later trial the 'Magenta' was again torpedoed whilst steaming at 10 knots an hour, a really remarkable performance. The 'Gustave-Zédé' which is attached to Toulon, made a trip to Marseilles, a distance of 41 miles, at an average speed of 6 miles an hour. The sea during this passage was very rough, but nevertheless it was accomplished without accident and without aid from the tug 'Utile' which accompanied her, and on arrival she had still more than enough power to take her back again to Toulon. We now come to the culminating experiment of the 'Gustave-Zédé,' namely, her successful employment during the French Naval Manœuvres of 1901. The details, however, of this occurrence are so mixed that fact seems to be hopelessly involved with fiction. On the evening of July 2nd the submarine, followed at some cables length by the Government tug 'Utile,' left Marseilles, without the pilot-service, whose look-outs are stationed on the quay, being able to perceive her or signal her departure. On Friday morning she appeared off Corsica and sinking beneath the surface evaded detection until she rose again to make observations in Ajaccio Harbour in the centre of the fleet and not 200 yards from a battleship. The battleships were just leaving the harbour and according to a despatch [1]—'the presence of the submarine was not suspected until a curious shock was sustained and a white furrow was perceived on the surface of the sea. Then, two hundred yards away, a black cylinder, which was the optic tube of the submarine, was noticed. This sudden and unforeseen attack, which had been so skilfully conducted by Lieutenant Jobard, aroused general enthusiasm. . . . . It appeared on the surface a few minutes afterwards, and saluted by light guns of the 'Charles Martel' and 'Jauréguiberry' it plunged again, but in crossing the course of the 'Jauréguiberry' too near that battleship, it exposed itself, to certain destruction. The 'Jauréguiberry' had to veer to the left to avoid this. In conformity with the plan and with reality the submarine was then pronounced to have been destroyed.'

But for the price of one battleship, twenty or more submarines can be built!! And brave and patriotic men ready to die for home and glory are never wanting. We must always

1 'Le Temps.'

remember this. The following is translated from another French paper:[1] 'The 'Gustave-Zédé' had not been perceived by any of the coast signal stations, although the sea was calm and the pilot-steamer 'Sentinelle' went out to meet the tug 'Utile' without suspecting that the submarine was immersed near at hand, navigating under water. Its presence was shown above the water only by the tiny tricolour flag, the size of a sheet of paper, just above the surface. The 'Gustave-Zédé' entered the port and was moored at the quay among the other vessels without its presence being detected save by reason of the little flag. She was towed part of the way by the 'Utile,' at least, so it was rumoured, but even so there is no doubt she successfully torpedoed the 'Charles Martel.' Her claim on the battleship was disallowed, however, as Ajaccio



CLXVI. ANOTHER VIEW OF 'GUSTAVE-ZÉDÉ'

was considered an impregnable harbour. This last claim has no value from a strategical point of view, since the mere fact of one telling a future enemy that Portsmouth, for example, is impregnable will not keep hostile submarines from entering, or trying to enter the harbour. On July 29th the 'Gustave-Zédé' attacked and torpedoed the 'Bouvet' with M. M. Waldeck-Rousseau and Lanessan on board. This attack, however, was undoubtedly prearranged, and this being so, it is of little or no value. Still the 'Gustave-Zédé' has settled one thing which has been the subject of much dispute for a long time, namely, that it is perfectly possible for a submarine in a state of practical

1 'Le Petit Journal.'

nullity as regards buoyancy, to discharge a torpedo without disturbing the equilibrium. Also the value of submarines just on the surface has been ascertained; even when quite close the 'Gustave-Zédé' was almost invisible and presented so small a target that it would require a gun crew trained by Captain Scott to hit it, and such crews are rare in our own Navy unfortunately, but luckily are still less common in the Navies of foreign Powers. Experiments were made also to discover what colour was most suitable for war purposes, and after many trials a grey-blue has been decided on, and it is probably owing to the manner in which this tint harmonises with the water that the 'Gustave-Zédé' owes much of her invisibility.

It was also remarked that except on very calm days (in which case a slight eddy is discernible) the progress and direction of the submarine cannot be discovered by movements on the surface—a matter of great importance. The 'Gustave-Zédé' is commanded by Lieutenant Jobard.[1]

Morse'

The 'Morse,' the third of the French submarines, was almost as long in the plan stage as her elder sister the 'Gustave-Zédé' was in the experimental stage, for although proposed in 1895, it was not until 1897 that any progress was made with her construction. She was designed by Engineer Romazotti, to whom also the 'Gustave-Zédé' owes her existence, but is an undoubted improvement on that vessel. This is only natural since *experimentia docet*, and when so novel a project as the construction of submarine boats is entered upon, it is too much to expect the first essays to be crowned with complete success. The 'Morse' was built in Cherbourg Dockyard and launched on July 5th, 1899. Her dimensions are as follows:

Length	36 metres (118.11 feet)
Diameter	2m. 75 (9.0224 feet)
Displacement	144 tons[2]

The shape of the 'Morse' is analogous to that of the

1 Her first commander in 1893 was Lieutenant Provensal.

2 According to 'Le Yacht' of August 17th, 1901, Forest and Noalhat give displacement 140 tons; M. Gaget says 145 tons; Laird-Clowes, F. T. Jane and Lieutenant Armstrong give it as 146 tons, which is probably the *real* displacement.

'Gustave-Zédé,' the contour being dissymmetrical. The framework consists of 75 hoops strengthened by longitudinal crosspieces; the material of the hull is Roma bronze. Submersion is obtained by four tanks situated and manipulated as in the 'Gustave-Zédé.' Indeed, the 'Morse' differs very little from the earlier vessel, and it is not worth my while recounting the various details common to both. The compression pumps, optical tubes, aerating apparatus, diving and steering mechanism, entrance hatches, etc., are all identical to those fitted in the 'Gustave-Zédé,' but, of course, on a reduced scale.

One important difference is the motor. Only one motor is fitted and its H.P. is 360. It is of the Thury six-pole type with separated excitation, the main current being furnished by a battery of accumulators manufactured by the Société des Metaux; the excitation is obtained through the medium of a 100 volt. battery constructed by the same firm. The speed on trial was 12.3 knots or .3 knots over that designed,—a most creditable performance. The revolutions of the propeller per minute are 250 as in the 'Gustave-Zédé.' The radius of action is estimated at 120 miles at 6 knots. In common with all the French submarine boats a detachable lead keel, serving as safety ballast, is carried.

The crew of the 'Morse' comprises an officer and eight men, and at the present time (September, 1901) she is commanded by Lieutenant Morillon and is attached to Cherbourg. Her cost was 648,000 francs. It was proposed at one time to give her two means of propulsion, but the project fell through. Her trials were in every way satisfactory and her final trials took place on July 19th, 1900, before the President of the Republic.

The armament consists of one torpedo tube and three 18-in. White-head torpedoes, one being carried in the tube ready for firing.

The following is an account of an attack by the 'Morse' on the gunboat 'Cocyte.' On Monday, July 23rd, 1901, Admiral Fournier, Inspector-General of Mobile Naval Defence, ordered the submarine 'Morse' to start from Cherbourg at 3 o'clock in the afternoon for Havre, a distance of seventy-two miles. This was the first voyage of any importance that the 'Morse' had undertaken, and she accomplished it without any untoward incident, steaming on the surface at an average speed of 9 knots. Lieutenant Morillon had had orders to attack on reaching Havre, the armoured gunboat 'Cocyte,' which was anchored in the roadstead. He arrived off Havre at night-time, and plunging, entered the harbour submerged and managed to successfully torpedo (?) the gun-boat without being discovered. The 'Morse' then came to the surface and was recognised by Admiral Fournier who was present on board the 'Cocyte.'[1]

'Lutin' Class

Of this type there are four,—the 'Lutin,' 'Farfadet,' 'Korrigan,' and 'Gnôme.' They were all laid down simultaneously at Cherbourg on September 27th, 1899.

The 'Farfadet' was launched on the afternoon of May 17th, 1901; the 'Lutin' a few months later; the 'Korrigan' in January, 1902; and the 'Gnôme' on July 24th, 1902. Their dimensions are as follows:

Length	41m. 35 (135.67 feet)
Diameter	2m. 90 (9.5141 feet)
Displacement	185 tons

The single screw is to be rotated at 250 revolutions by a single motor and the trial surface speed is 12.25 knots whilst the maximum submerged is 9 knots. The current is supplied by a battery of accumulators. The hull is of steel and not of Roma metal like the 'Gustave-Zédé' and 'Morse.'

The armament consists of four torpedo holding apparati, fixed to the outside of the hull. The crew will consist of an officer and eight men. Lieutenant Desvoyod is at present in command of the 'Farfadet.' The four vessels of this class were built to the designs of Engineer Maugas. They are to have a radius of 200 miles at an economical speed and 25 miles at full speed. The cost of these vessels is reckoned at

1 According to some accounts three (?) torpedoes were successfully fired whilst a correspondent in Havre wired to say that 'the attempt made by the submarine 'Morse' last night did not succeed owing to the state of the sea. The swell prevented any torpedo from being fired.' The 'Courrier du Soir' commenting on the attack said 'All the science of the Admirals will fail to persuade the general public that such results can be disregarded, and that the immediate construction of a great number of submarine boats is not most urgently necessary for national defence.'

800,000 frs. each, or £32,000. They will all be in commission long before this is in print.

'Français' Class

This class includes two vessels, the 'Français' and 'Algérien'; they were paid for by a national subscription organised by 'Le Matin' at the time of the Fashoda dispute and are almost identical to the 'Morse,' having a few additional improvements. They were laid down at Cherbourg in 1900; the 'Français' was launched on January 29th, 1901, and her sister on February 15th of the same year. The 'Français' is commanded by Lieutenant Dartige du Fournet, the 'Algérien' by Lieutenant Tadié, a young officer whose researches into wireless telephony have already made him famous. They have the following dimensions:

Length	36 metres (118.11 feet)
Diameter	2m. 70 (8.8578 feet)
Displacement	146 tons

These two vessels are improvements on the 'Morse,' of which vessel, except for a few minor modifications, they are exact copies. Their hulls are of steel. Their cost is £32,972.

'Alose' Class

In 1900 the French Minister proposed 8 submarines in his programme, but a reconsideration of the number changed this total to twenty. These newest submarines of which very few details are known are only half the size of their immediate predecessors. Their dimensions are:

Length	23m. 50 (77.101 feet)
Beam	2m. 26 (7.4148 feet)
Depth	2m. 41 (7.9069 feet)
Displacement	68 tons
Speed	8 knots
Complement	4 men and 1 officer
Cost	365,400 francs (£14,616)

Ten of these, the 'Alose,' 'Anguille,' 'Bonite,' 'Dorade,' 'Esturgeon,' 'Grondin,' 'Perle,' 'Souffleur,' 'Thon,' 'Truite,' are being built at Toulon. Of the others, 6 are being built at Rochefort and 4 at Brest. Their names are:—'Castor,' 'Loutre,' 'Ludion,' 'Lynx,' 'Méduse,' 'Naiad,' 'Otarie,' 'Oursin,' 'Phoque' and 'Protée.' All these will be finished by 1903

Romazotti Besides these there are three others on the stocks. One has been designed by Engineer Romazotti and is to cost 499,400 frs. (£19,976); this vessel is building at Cherbourg.[1]

Maugas A second is due to M. Maugas, the designer of the 'Lutin' class, and for this vessel 779,300 frs. (£31,172) has been set aside; M. Maugas' boat is being constructed at Rochefort.[1]

Bertin The third boat, which has been assigned to the arsenal of Toulon, is due to the genius of M. Bertin, the well-known Chief Constructor to the French Navy. His vessel, which according to all accounts is to revolutionize naval warfare (as indeed, all submarines have been intended to do) is to cost the large sum of 924,300 frs. (£36,972).[1]

It is rumoured that it will much resemble the 'Narval' being similar in dimensions to that vessel. The departure from the usual type consists, we are told, in the abandonment of the mixed mode of propulsion and the substitution of compressed air for electric accumulators. The new vessel is equipped with an engine driven by alcohol, which, with compressed air, furnishes the motive power.

The air is contained in reservoirs under a pressure of 100 atmospheres. When the boat is on the surface, or when there is no danger of its presence being perceived by the enemy, the air is allowed to escape directly into the water, and comes to the surface in a series of little bubbles similar to those produced by the White-head torpedo during its course. As, however, these bubbles leave a wake which would reveal the presence of the submarine and would make an excellent target for artillery, the alcohol engine only is used when the vessel is submerged during hostile operations. As all these boats are being built experimentally with a view to discovering the most efficient type, their completion and subsequent trials will be awaited with much interest. With these three eminent engineers all doing their very best a satisfactory solution of the all-absorbing subject should shortly be discovered. We have not yet come to the end of the French submarines for before the next financial year is ended 31 more will have been laid down. When I say that this large number has already

[1] See Addenda.

been allotted to the various yards it will be seen that this is no mere projected programme but a solid fact.

Rochefort is to receive Q 43-50 = 8 boats.

Cherbourg will have to build Q 51-60 = 10 boats.

Toulon must construct Q 38-42 and 61-68 = 13 boats, making a total in all of 31.[1]

Besides these there are rumours of a large vessel being built secretly (and secrets with reference to submarine boats can be kept, as witness our own five 'Hollands') in Toulon Dockyard, but although I have done my best to discover whether there is any truth in the rumour or not, up to the present my efforts have been unavailing.[2]

But putting all rumours aside we find that France will at the beginning of 1904 be the possessor of a fleet of 63 or including the two 'Goubet' boats, 65 submarine boats,—a truly formidable flotilla. And we have not yet spoken of the 'submersibles.'

SUBMERSIBLES.

The French submersibles were the direct result of the competition opened in 1896 by the Minister of the Marine, with a view to obtaining the designs of a perfect vessel. Any boat of which the plans were sent in had to concur with the following conditions:

Maximum displacement—100 tons.

Speed—The highest compatible with the size of the vessel

Armament—One or two 18-in. torpedo tubes.

The motive power, shape to be given the boat, and all component parts and details to be left to the discretion of the inventor.

Any design sent in had to be planned with a view of carry-

1 Eight of these are to be of an improved 'submersible' type.

2 M. Pelletan has just ordered the construction of two submarines of a new type, but whether they are from the 'liquid air' designs of M. Pictet, a protégé of M. Pelletan, and a clever Swiss engineer, I have been unable to find out.—AUTHOR, January, 1903.

ing out an extensive programme, which I reproduce in full from the statement of M. Lockroy. [1]

Programme D'Experiences.

1st.—Essai de résistance de la coque.—Le bateau sera immergé à une profondeur de 20 mètres (immersion comptée depuis la surface de l'eau jusqu'à la génératrice supérieure du bâtiment) et restera plongé pendant 3 heures. Au bout de ce temps-là, il ne devra être constaté avec de jauges appropriées aucun affaissement appréciable de la coque, laquelle sera aussi absolument étanche.

2nd.—Expérience d'habitabilitè.—Immersion à 10 mètres de profondeur pendant 8 heures, après laquelle il sera constaté que le personnel embarqué n'a nullement été incommodé de ce séjour prolongé dans un espace clos.

3rd.—Plongée au repos.—Le bateau devra s'immerger et se maintenir à une profondeur constante de 6 mètres pendant une heure, au moyen d'un dispositif automatique auquel pourra se substituer rapidement une manœvre à main; le maintien de l'immersion se fera automatiquement pendant la première demi-heure, à la main pendant la second. Les écarts en hauteur ne pourront pas excéder 20 centimètres de part et d'autre du plan d'immersion.

4th.—Essai de vitesse.—Cet essai se fera dans les conditions normales des bâtiments, le long d'une base mesurée et à la vitesse maxima prévue.

5th.—Plongée en marche.—Le sous-marin devra effectuer un parcours dans l'eau de 5 milles, à la vitesse minima de 7 noeuds à une immersion constante de 6 mètres; les écarts en hauteur pendant la plongée ne pourront pas être superieurs à 0m. 50 de part et d'autre, ce qui revient à accorder au sous-marin, comme plan d'immersion, une tranche horizontale de l'mètre d'épaisseur. Dans toutes les expériences de plongée, les profondeurs seront relevées par un enregistreur d'immersion.

6th.—Plongée en marche à une immersion de 0m. 50.—Pendant cette plongée, le sous-marin aura à évoluer autour de

1 'La Marine de Guerre,' Edouard Lockroy, Paris, 1897, extracts from pp. 341-345.

nombreux bateaux et obstacles accumulés sur sa route, entrée et sortie de passes étroites, etc.

7th.—Essais de plongées successives.—Marche pendant 4 heures à la vitesse de 8 noeuds pendant la première et la deuxième heure, plongée d'un quart d'heure; deuxième plongée de même durée entre la deuxième et la troisième heure. Enfin, dans la dernière heure, series de courtes plongées de 5 minutes, separées par des intervalles à émersions variables. Toutes ces plongées devront se faire instantanément, sur signal fait par la commission d'expériences.

Pendant tous ces essais, les conditions d'habitabilité du bâtiment devront être aussi parfaites que possible; il sera constaté si les hommes de l'équipe out eu à souffrir.

8th.—Plongée après dépense des 5/6es de la force motrice. —Après avoir dépensé au point fixe les 5/6es de son approvisionnement de force motrice, le bâtiment fera une plongée en marche d'une demi-heure, dans les conditions du paragraph 5.

9th.—Lancement de torpille au repos.—Le bâtiment, étant immergé au repos à 6 mètres, lancera une torpille sur un but placé à 400 mètres; la torpille ayant été réglée au préabable ses écarts ne pourront pas dépasser 10 metres de part et d'autre du but.

10th.—Lancement de torpille en marche.—Un but étant mouillé, le sous-marin devra lancer sur lui sa torpille, à la fin d'un parcours de 3 milles affectué sous l'eau à l'immersion de 6 mètres; faculté lui sera donnée pendant le parcours, de revenir deux fois à la surface, la durée des émersions n'excédant pas une minute. La torpille sera lancée à 400 mètres du but, le bateau étant à son immersion, au moment de 'feu.'

Conditions General.

11th.—Expériences de stabilité et de roulis.—Les plans seront établis, pour l'ensemble, à l'échelle du 1/10 pour les details, à des échelles suffisantes pour l'éxecution. Tous ces plans seront cotés.

Des mémoires annexés à ces plans donneront tous les renseignements nécessaire; description, calculs de déplacement et de stabilité, coefficient d'utilisation, etc., etc., en un mot, tout ce qui sera de nature à rendre le projet clair et précis.

Ces plans ou mémoires ne porteront ni signatures, ni date, mais une devise, laquelle sera reproduite avec la signature de l'inventeur, la date et la lieu d'envoi sur une pièce justificative mise sous pli cacheté déposé en même temps que les plans.

Ces plis ne seront ouverts que par le ministre, après examen complet et définitif des projets.

Les officiers et ingénieurs de la marine désireux de participer à ces concours seront soumis aux mêmes règles et addresseront directement leurs projets au ministre, dans les mêmes formes indiquées plus haut.

Chaque projet devra contenir un devis estimatif du prix. Ce prix servira de base au marché à passer avec l'inventeur, au cas où son projet serait jugé digne d'être exécuté.

La Marine se réserve le droit de prendre, dans le divers projets, les organes de détail pouvant présenter un réel intérêt et de les utiliser sur un projet definitif.

Si les résultats du concours fournissent des projets dignes d'appeler l'attention, des primes pourront être accordées par le ministre à un ou plusieurs d'entre eux.

Tous les projets devront parvenir au ministère de la Marine avant le 1er avril, 1896, au plus tard, et porter comme addresse : 'Monsieur le Ministre de la Marine. (Concours de sous-marin).'

Never has a document produced such vast changes in an organised department as the one above wrought in the consideration of naval power. The thoughts of all nations at once turned to the absorbing question of submarine navigation and the result of the competition was awaited with much interest. The names of the principal competitors soon became known, and with such men as Laubeuf, Maugas, Romazotti, Philipeau, Drzewiecki and Forest in the lists, a result of the utmost importance was only to be expected and at the close of the examination of the designs (of which some 47 were sent in) the plans chosen were those of M. Laubeuf ; the oil engines of M. Forest and the torpedo launching apparatus of M. Drzewiecki were also taken. Amongst others to send in plans was M. Turc, a young French officer, whose proposal I notice

CLXVII. THE 'NARVAL' STEAMING ON THE SURFACE under the year 1898, and M. Seuchet, commandant of the Gendarmerie.

The following prizes were apportioned:

M. Drzewiecki, 2nd prize, 5,000 frs.; M. Forest, 3rd prize, 3,000 frs.; M. Philipeau, 4th prize, 500 frs. Messieurs Romazotti, Darriens, Chéron, Maugas and Laubeuf all received gold medals. A few words concerning some of these designs will be found under the year 1897. The number of designs—and valuable designs—sent in for this competition, surpassed the most sanguine expectations of the Minister of the Marine and it is a pity his excellent example is not copied over here, where, alas, inventors are a drug on the market, and consequently other nations lead,—we follow,—the very reverse to that which should be the case.

The 'Narval,' the first of the 'submersibles proper,' designed by M. Laubeuf, presents so many new features that in all the history of submarine navigation, there is no vessel that bears to it the very slightest resemblance. For this competition M. Laubeuf received a gold medal and a handsome sum of money, and he well deserved it. The dimensions are as follows: 'Narval'

Length	34 metres (111.55 feet)
Beam	3m. 75 (12.3033 feet)[1]
Displacement (light)	106 tons
Displacement (submerged)	200 tons

The 'Narval' is double hulled; the inner hull is cylindro-conical as with the 'Morse,' and it is of such a thickness as can stand considerable outward pressure. The outer hull is of thin plates and takes the form of an ordinary torpedo boat. Between these two hulls, the water is allowed to circulate freely when submerged. The great length of time required in filling this skin is one of the great faults of the 'Narval'; it takes at least 20 minutes to sink.

The propulsion is mixed, there being a steam engine for the surface and an electric motor for navigation submerged. The steam engine is of the triple-expansion type by Brûlé et Cie and developes 250 I.H.P. on the shaft. The boiler is tubular

1 M. Gaget gives the beam as 2m. 40; but this is an error, or perhaps he means beam of inner hull.

and was constructed by Adolphe Siegle; five liquid fuel furnaces supply the heat, heavy petrol being injected. On trial a speed of over 11 knots was obtained. The electric motor is supplied with power from a 158 element Fulmen battery of accumulators. The speed submerged is about 8 knots.

The boiler weighs 3,000 kilos, or 12 kilos per I.H.P. furnished by the engine. The evaporation of water per hour is 70 kilos, or 14 kilos of water per square metre evaporates for every kilo of oil used. The 'Narval' has the following radii of action:

Surface. 252 miles at 11 knots 23 hours steaming.
624 miles at 8 knots 78 hours steaming.
Submerged. 25 miles at 8 knots.
70 miles at 5 knots.

The hulls are of steel, the outer one being pierced with a number of holes to allow the water a free entrance. The 'Narval' can navigate in three different positions:

1st.—On the surface like an ordinary torpedo boat;
2nd.—As a submersible torpedo boat, with only the funnel and conning-tower showing;
3rd.—Completely submerged as a submarine boat.

The 'Narval' was built at Cherbourg and launched on October 26th, 1899. Her armament consists of four Drzewiecki holders fitted with 18-in. torpedoes. Her present commander is Lieutenant de Cacqueray.

The most important trial to which the 'Narval' has as yet been subjected, was the run from Cherbourg to St. Malo and back. At 1 o'clock on Thursday, May 22nd, the 'Narval' left Cherbourg for a 40 hours' trial. The sea was very rough, there being a strong north-easterly gale blowing, and the 'submersible' reached St. Malo at 5 o'clock on Saturday morning, although there had originally been no intention of entering this port. Although this was not quite in accordance with the prescribed programme, the 'Narval' navigated for 40 hours without stopping, covering a distance of 260 miles at a speed of 6.5 knots an hour. During this time she dived for several hours and twice filled her accumulators. On returning to Cherbourg the four torpedoes, carried on the flanks, were fired with complete success. This experiment was certainly very favourable and the French Government have a right to consider it a brilliant success.[1]

'Triton' Class

Besides the 'Narval,' France has four other submersibles in commission. These are the 'Triton,' 'Sirène,' 'Silure,' 'Espadon.' They have all been built at Cherbourg and have the same dimensions as the 'Narval,' but these for convenience I am repeating.

Length	34 metres (111.55 feet)
Beam	3m. 75 (12.3033 feet)
Displacement	106 tons (light)
	200 tons (submerged)
Cost	£24,700 each

The 'Triton' was launched on Saturday, July 13th, 1901, and is commanded by Lieutenant Boulain.

The 'Sirène' was launched on Saturday, May 4th, 1901, and is commanded by Lieutenant Moysan.

The 'Silure' was launched on October 29th, 1901.

The 'Espadon' was launched on August 31st, 1901, and is commanded by Lieutenant Wolf.

These vessels differ so little from the 'Narval,' that it would be mere repetition to give a detailed description of them. It is sufficient to say that they are improvements on their prototype in this much that whereas the 'Narval' takes anything from 20 to 30 minutes to submerge, the 'Triton' class do so in 6 to 9 minutes, a distinct advance towards ultimate perfection. In the eight new boats which will shortly be commenced, this time is, however, to be reduced by one half.

With the submersibles the French submarines end for the present; there are rumours, however, of a marvellous invention being constructed at Toulon which is to revolutionize modern naval warfare, but these 'disturbers of the universe' are now so common that we need take little notice of them. It will be seen by the above that France has long passed the experimental stage in the matter of submarine boats, and that all other nations, except perhaps the United States, will have a

1 Extracted from 'Le Yacht,' June 8th, 1901.

lot of lee-way to make up before they can expect to equal the strength of our Gallic neighbour.

The following is a short resumé of the French submarines and submersibles:

DATE	NAME OR CLASS	NUMBER	DISPLACEMENT
1885	Goubet I	1	1 ton 8 cwts.
1886-1896	Goubet II & III	2	5 tons
1888	Gymnôte	1	30 tons
1890	Gustave Zédé	1	266 tons
1894-1897	Morse	1	144 tons
1899-1901	Lutin	4	185 tons
1900-1901	Français	2	146 tons
1901-1902	Perle	20	68 tons
1902	X Designed by Romazotti		168 tons[1]
1902	Z Designed by Maugas		202 tons[1]
1902	Y Designed by Bertin		213 tons[1]
1902-1904	Omega	31	301 tons[1]
1899	Narval	1	106 tons
1901	Triton	4	106 tons
1902	Aigrette	2	172 tons[1]
	Total	73	

including the three Goubet boats

THE BRITISH SUBMARINES.

The following appeared in the estimates for 1901-1902:

A1—A5 'Five submarine vessels of the type invented by Mr. Holland have been ordered, the first of which should be delivered next autumn.

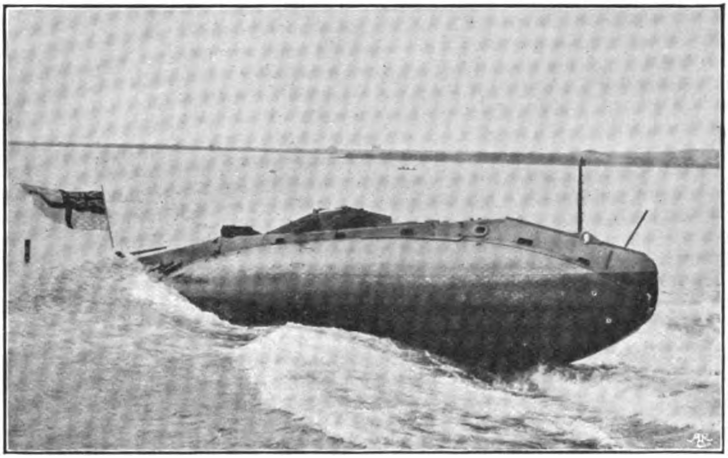
'What the future value of these boats may be in naval warfare can only be a matter of conjecture. The experiments with these boats will assist the Admiralty in assessing their true value. The question of employment must be studied, and all developments in their mechanism carefully watched by this country.'

These vessels were laid down with the utmost secrecy in the latter part of 1900 and every vessel had been on the stocks five months before anyone outside the works and the

1 See Addenda

Admiralty knew of their contemplated construction. Their dimensions are as follows:[1]

Length over all 63 feet 4 inches, beam 11 feet 9 inches, with displacement when submerged of 120 tons. One torpedo expulsion tube is formed at the extreme forward end of the boat, and four of the 18-in. White-head torpedoes are carried, the gear being arranged so that the torpedo may be discharged with the boat stationary or running at any speed, and when the vessel is awash or submerged. The scantlings of the hull have been designed to withstand the pressures consequent on submergence at a depth of 100 feet from the surface, the double bottom tanks being utilised for ballast and storing



By favour of the 'Navy and Army Illustrated.

CLXVIII. LAUNCH OF THE FIRST BRITISH SUBMARINE

purposes. Ingress and egress are through a conning-tower of armoured steel 4 inches thick and 32 inches in external diameter, fitted with observation ports. The propulsion of the vessel awash is by a gasolene engine with four single-acting cylinders water-jacketed, actuating pistons of the trunk type, with long surfaces, the connecting rods being attached direct to the pistons. The inlet and exhaust valves are of the poppet type, and are in the cylinder heads, the levers by

1 By permission of Lieutenant A. Trevor Dawson, of Vickers, Maxim, Limited.

which they are operated being actuated by hand, mounted by sleeves keyed to the cam shaft running alongside and near to the top of the cylinder. The cam shaft makes one revolution for every two of the main crank shaft, and the motion is transmitted by two pairs of skew gears through a vertical shaft. The electric ignitors are actuated by eccentrics also from the cam shaft; the moveable and fixed electrodes are fitted with platinum points. There being four cylinders it follows that there is an impulse for each revolution, and the speed may be varied from 200 to 300 revolutions per minute, giving a maximum power of 190 B.H.P. The boat has one propeller with four blades and the speed awash is expected to be 8 knots. Fuel is to be carried for a radius of 400 miles at this speed. Propulsion when submerged is by an electric motor, which, like the gasolene engine, drives the shaft from the propeller through gearing with clutch connection. This gearing enables both gasolene engine and motor to be at a lower level than the shaft, which is on the centre line of the boat. For diving the boats are fitted with horizontal as well as vertical rudder, while at the same time a simple system of automatically arranging the disposition of water ballast is fitted to overcome any lack of horizontal stability consequent upon the diving action. Automatic means are also provided for determining the angle of diving or rising to the surface, and to obviate submergence to excessive depths. At the same time hand gear for most purposes is fitted.

These five vessels, all of which are afloat, were built at Messrs. Vickers, Sons and Maxim, Barrow-in-Furness.

H.M. Torpedo Gunboat 'Hazard' was specially commissioned by Captain R. S. H. Bacon, D.S.O., an expert torpedo officer, to act as 'mother ship' to the submarines. On this gunboat also is a son of the present Secretary to the Admiralty, who has always taken a great interest in wireless telegraphy and torpedo work.

The programme to be carried out by the first boat finished was as follows. A surface run of 10 knots at full speed and then a submerged run of 2 knots at the same speed, at the end of which run a torpedo was to be discharged at a target 150 feet long by 16 feet deep, the upper edge of the target being awash and placed at right angles to the course. During the submerged run the boat would only be permitted to come to the surface three times before firing the torpedo and the duration of each appearance was in no case to exceed one minute.

Submarine boat 'No. 1' was launched on October 3rd, 1901, 'No. 2' on February 21st, 1902, 'No. 3' on May 9th, 'No. 4' on May 23rd, and 'No. 5' on June 10th of the same year.

As a foster-ship for this strange squadron, the third-class cruiser 'Latona' has been commissioned, and in her the crews of these subaqueous craft will take up their lodging.

Whilst the last three of the five ordered in the Naval programme were still on the stocks, a sixth, designated 'No. 6' was laid down. A6—A9

This vessel, about which it is very difficult as yet to obtain details, is apparently nothing more than an elongated Holland, being 100 feet instead of 63 feet 4 inches in length.

Her engine power has been vastly augmented, and during a preliminary trial,—for she is already afloat, having been launched on July 9th, 1902,—she attained a surface speed of over 15 knots. This constitutes a record for the modern vessel, unless one includes the unsuccessful 'Nordenfelt' which came to so untimely an end off Denmark.

Now again three more are being built, of the 100 foot class, so that by the end of 1903 England will possess no less than nine craft of the most advanced type.

There is one fault in the British 'Hollands,' however: the interiors are filled with pieces of mechanism that might easily be dispensed with. What struck me especially on board the American boats (the author had an opportunity of inspecting several at Long Island in October, 1902) was the wonderful amount of space—or elbow room—they possessed, which must make a great difference to the comfort of those managing the boat during trials.

Submarine boat 'No. 1' was put through an important series of trials in Barrow docks during April, 1902. She first underwent surface tests with the view of ascertaining the results attending the erection of a brass conning-tower, which was originally composed of steel, as well as a new steering wheel, now fixed to the boat close to the tower, which can be worked from above and below alike. These improvements, it is understood, proved highly satisfactory. This was the first time the craft had been entirely under water. She proceeded at a slow pace along the dock, and was seen to sink at the bow and then suddenly disappear from sight, a few inches of the periscope only being visible. The sinking was executed in the space of a few seconds. There were five persons on board and the vessel was submerged for over two hours, the crew feeling not the slightest inconvenience. This preliminary test gave the greatest satisfaction, the boat behaving admirably at a depth of about 9 feet.

A noteworthy feature of the test was her excellent diving propensities, which for three days were put to the severest trials. In this respect it is intended the boat, on sighting its object for 'destruction,' shall immediately dive down, first of all as far as the small conning-tower, in which position she can travel if necessary for a distance of 400 miles. When within suitable range—say about 2,800 yards—she goes completely below the surface, a lookout being kept by means of the periscope, which reflects down into the boat any objects ahead, when she is under to the depth of about 10 feet.

It was expected that this operation could be accomplished in a very short time, and the exhaustive tests of 'No. 1' boat have shown the surmise to be quite correct. In fact, the boat, after submerging to the tower, suddenly disappeared, and then came again in sight some yards distant with remarkable rapidity, the diving being continued at intervals, for several hours at a time, without any perceptible hitch.

Seven persons were on board the submarine, and the vessel repeatedly ran the length of the dock submerged a few feet below the surface of the water. The trials were accomplished in a remarkably short time, the submerging not taking more than six seconds, while the ascent to the surface was made in a very little longer time. The operations were continued for some time, the vessel being kept on a straight course. The steam launch 'Cayzer,' with Admiralty and other officials on board, was in attendance.

These tests having proved successful, the boat was taken out into the Irish Sea, escorted by the tug 'Furness,' on board of which were divers ready for instant action in case of accident. All went well with the submarine, and it is reported that her open-sea trials, which took place off the west coast of Walney Island, were successful. The vessel was submerged to a depth of 15 feet and ran 6 miles under these conditions. She remained off Walney Island until late in the evening waiting for the flood tide, upon which, attended by the tug, she returned safely to Barrow.

A few words as to the trials of the British boats. It would be mere repetition to quote all these in full, since they corresponded in detail almost exactly to those of the American vessels, which have been given very fully elsewhere.

Captain Cable, who has made some 2,500 descents in vessels of the 'Holland' type, came over here especially to initiate some of our experts into the mysteries and to teach them the various tricks of submarine boats.

He had apt pupils, and they speedily learned to control their novel craft with great skill, if not with the finesse of the master hand of Captain Cable.

The speed realised on the surface was between 9 and 10 knots, in all cases exceeding that required by contract. The mere fact of having a new order for four additional boats proves that the distrust and *laisser-faire* policy of 'the powers that be' in Whitehall have given way to confidence and energy. Captain Bacon has been appointed Inspecting Captain of submarines.

In May, 1901, a report was current that the Admiralty had ordered two more 'Holland' boats of an improved type and on a large scale. These were to be built at Sayville, Long Island, U.S.A.

This rumour I can positively assert is nothing but a fabrication of the paper that promulgated it.

It has also been stated in official quarters that a tenth submarine boat is actually on the stocks in a private yard in England, the vessel being built to the designs of an English inventor, whose name has not transpired.

The author, despite repeated inquiries, has been able to find no trace of this vessel, and its existence is denied in official quarters.

THE AMERICAN SUBMARINE BOATS.

As some doubt exists as to the real number of submarine craft possessed by the U.S. Government, the following list is appended that any such doubts may be removed. They are of two classes, the 'Holland' and 'Adder.'

Class	*Holland*	*Adder*	
No.	1	7	
			1901
Date of Launch	1896	Adder -	July 22
		Porpoise -	Sept.
		Shark -	Oct. 19
		Mocassin, Grampus, Pike	1902 Feb. 1
		Plunger -	1902
Length	53-ft. 10-in.	63-ft. 4-in.	
Beam	10-ft. 3-in.	11-ft. 9-in.	
Submerged Displacement	$74\frac{3}{10}$ tons (salt water)	120 tons (salt water)	
I.H.P., Oil	45	160	
I.H.P., Electricity	50	70	
Surface Speed	8 kts.	8 kts.	
Submerged Speed	7 kts.	7 kts.	
Contract Price	$150,000	$170,000	

The shell of the old 'Plunger' is lying denuded of all its fittings at Cutchoque, Long Island, N.Y., the 'Plunger' mentioned above having been built to replace it.

The 'Fulton' is the private property of the Holland Company. The other vessels often erroneously named as belonging to the U.S. Government are the 'Protector' (see the 'Lake' boats), the 'Moriarty,' the 'Burger,'[1] and the 'Baker.' These are all described in the general historical section. The first three, namely, 'Protector,' 'Moriarty,' and 'Burger' are being experimented with by the American Naval Department, but have not yet been purchased by it.

A detailed description of the 'Holland' boats is given in Part V.

1 See Addenda

THE RUSSIAN SUBMARINES.

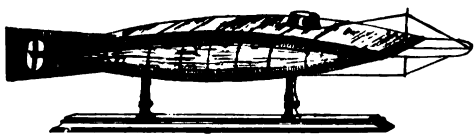
Russia, like France, has espoused the cause of the submarine for many years and there are at present building at Cronstadt no less than seven of these craft. Of these seven, five are from Russian designs, one is American and the seventh English. Very few particulars are obtainable concerning these boats, but such as I have collected are given below.

Kolbasiev and Kuteinikov

A model of this vessel, designed by Lieutenant Kolbasiev (or Kolbassieff) and M. Kuteinikov (or Kontoinikoff), a naval engineer, was tried at Cronstadt in July, 1901, with remarkably successful results, and a larger edition of the same type was at once laid down.

The length is 50 feet and breadth 4 feet (? probably incorrect), the displacement being 20 tons. It is being built in nine sections which when complete will be bolted together.

This boat has been christened the 'Petr Kochka.'



CLXIX. THE 'PETR KOCHKA'

Of these sections the three in the centre contain the machinery all of which will be electrical. According to the 'Daily Express' six propellers are to be fitted, but this statement may be accepted with reserve. The accumulators, which are of the Bari type, take up the best part of three more sections, the remaining sections being those at the extremities. These are cut away at the top and bottom and are fitted with planes for altering the elevation when submerged. In form this submarine resembles a cigar cut down the centre from end to end with a flat piece inserted between the two halves at both top and bottom. My meaning will be made clearer by a glance at the sketch above which I have copied from one published in the 'Daily Graphic' for August 1st, 1901.

The armament is to consist of two torpedoes placed in tubes pointing fore and aft and capable of being trained over a large arc. Another feature of this Russian submarine boat is an automatic safety mechanism which, should the vessel incline to the extent of 90 degrees, brings it back on an even keel immediately. This vessel was launched in June, 1902, and is at present undergoing its trials. It cost 50,000 roubles,[1] which cannot be considered exorbitant if it proves successful. On the completion of its trials it will be transported overland to the Black Sea for the defence mobile of Sevastopol. The other four submarines of Russian design are probably very similar to the one described above.

Of the American boat no details are available, but the English vessel under construction is cigar-shaped with two propellers, one at either end. Beneath the hull, in the centre of the boat is another propeller for drawing the vessel under water; all three screws are worked by electric motors, the current for which is stored in accumulators arranged as ballast. The great feature of this vessel, however, appears to be in quickness of diving in which particular it is far ahead of any other submarine (?). The armament consists of torpedoes for which tubes are fitted fore and aft, and the complement numbers five. This vessel, which is now launched, was built at the Neva Yard, St. Petersburg, and will have cost £10,000. I have a suspicion that there is some connection between this boat and one of the last inventions mentioned in my history,[2] so closely (according to all accounts) do they resemble each other.

By the time this book is in print more details concerning these Russian vessels will no doubt be known, but just at present they are shrouded in mystery and it is difficult to know what to believe and what not to believe. This much is certain that Russia has commenced to build submarine boats in some quantity, though exactly how many are in course of construction it is hard to say. Russia has during the past year been credited with having 20 submarines on the stocks,[3] but until further information is forthcoming, it is useless to enter into any idle speculation.

1 One rouble = 2/10, therefore 50,000 roubles = £7,500. A rouble is not now worth even 2/-.

2 See A. H. Argles' Submarine.

3 'Daily Express,' August 30th, 1901.

THE ITALIAN SUBMARINES.

Italy has during the last five years been paying a great deal of attention to the subject of submarine navigation. There are in service in Italy five submarines. One of these, the 'Audace,' has already been described in the historical section. The others are the 'Delfino,' 'Pullino,' 'Pino,' and 'Tritone.'

'Pullino'

The 'Pullino' is from the design of engineer Pullino of the Italian Navy and was built in 1891 at Spezzia. It was launched early in 1892. The dimensions are as follows:

Length	12 metres
Displacement	15 tons

The trials took place in April, 1892, and on the 29th of the month, four men remained submerged in her for five hours, at a depth of 4 metres beneath the surface. The boat being very small did not contain a large enough air supply during this time, and so compressed air carried in tubes was utilized, the vitiated air being ejected by means of an electric pump. Submersion was obtained by means of horizontal propellers, placed as in the early 'Nordenfelt' boats. During 1893 many experiments were made with this little ship, and in March, 1894, a dummy torpedo was successfully fired against the training-ship 'Maria-Adelaide,' lying at anchor in Spezzia.

'Delfino'

The undoubted success of this boat decided the authorities to build a modified vessel on the same lines, and an order for the 'Delfino' was given This submarine boat is considerably larger than its predecessor, as a glance at the dimensions will show. Immersion propellers are fitted as in the 'Pullino.'

The 'Delfino' has the following dimensions:

Length	24 metres (78.74 feet)
Diameter	2.9 metres (10.1 feet)
Displacement	107 tons submerged, 95 tons awash
Submerged speed	10 knots
Surface speed	12 knots
Cost	£12,000

The 'Delfino' was launched at Spezzia in 1894 and is propelled by electric motors of 150 I.H.P. She has been through the most successful trials and is capable of maintaining a submerged speed of 10 knots for several hours together, a feat impossible to all other submarines. The hull is cigar-shaped and is built of steel. The armament consists of two torpedo tubes, and compressed air is carried sufficient for twelve men for eight hours; a cleptoscope is fitted for steering when submerged.

The Cleptoscope of Laurenti and Russo, tried in the first place from the tower of the Italian Naval Ministry with the greatest success, is so I have been told by Colonel V. Cuniberti, infinitely superior to anything of the kind possessed by the French Government. The definition is clear and concise and with its discovery the value of the submarine has enormously increased. The Italian Government does not believe in the submarine, however, but in the submersible,[1] and experiments are being made to ascertain the possibility of constructing a submersible possessing only one motor,—an oil motor. Such a motor, invented by Colonel Cuniberti, has been tried with much success in torpedo craft and it works almost as well submerged as when on the surface. We shall shortly no doubt hear more about the Italian Government propositions for the future.

'Pino'

In the early part of 1902, experiments took place in the harbour of Genoa with a new submarine, to which the name of 'Pino' has been given, after its inventor. It is not intended for warlike purposes, but is fitted with a number of grappling appliances and a huge pair of tongs, the intention being to recover valuables lost by wreck or foundering. It is suspended from the surface either by a float or a ship, and receives its motor power, electricity, from the shore or the vessel supporting it. During some preliminary trials which took place before the Minister of the Navy, the 'Pino' sank to a depth of 50 metres.

'Tritone'

Concerning the fifth submarine at present afloat in Italy very little is known. The inventor is one Captain Guiseppi Ferrari, of the Italian Navy, and he asserts that his vessel can go from the mouth of Genoa Harbour to Comogli in 1½ hours under water. It has a length of 56 feet 8 inches, and

1 See remarks on an interview with Colonel Vittorio Cuniberti.

is stated to be very gracefully proportioned. The strictest secrecy is maintained as to the construction of the boat. It has been given the name of 'Tritone.'

'Laurenti'

In June, 1902, a sum of Lr. 800,000 was voted for the construction of a sixth vessel, a submersible. It has been designed by engineer Laurenti, and is being built at Venice. The surface speed is to be 14 knots, and the radius of action 2,000 miles, a great advance on any former types. A special feature is the armoured conning-tower. The motive power is supplied by an oil engine designed by Colonel Cuniberti. This vessel is to be launched this year.

By the estimates of 1903-1904 three more submarine vessels are to be built, but of what type is as yet unknown.

PORTUGUESE SUBMARINES.

Portugal has experimented with submarines in a tentative way for the last ten years.

The 'Fontes I'

The majority of the inventions brought before the Portuguese Naval Board have been of the 'submarine worker' pattern, but Lieutenant Fontes (or to give him his full name, Joao Augusta de Fontes Pereira de Mello) has proved an exception to the rule. His first vessel had no means of propulsion; its dimensions are as follows:

Length	7.29 metres
Over all length	11.35 metres
Diameter	2.03 metres
Immerged Displacement	16.8 tons (metric)

The body of the vessel was cylindrical and was as stated above, 7.29 metres long; the two cones, one at each end, made up the additional 4 metres. It was designed in 1888-89 and built in the latter year, being eventually launched on July 27th, 1890. Its trials are uninteresting, since, lacking means of propulsion, it was of no military value.

The 'Plongeur'

In 1890 Lieutenant Fontes designed a second submarine boat which seemed to embody some valuable new features, and orders were given for the construction of a vessel to his plans. This boat, named the 'Plongeur,' was launched in 1892. Its dimensions are:

Length	72.1 feet
Diameter	11.5 feet
Displacement	100 tons
Armament	4 torpedo tubes

The speed of the 'Plongeur' is 6 knots, the power being derived from accumulators, stowed so as to form ballast. Submersion is obtained by the introduction of water and steering by horizontal and vertical rudders. The trials of this boat are said to have been satisfactory but very little is known about it. In October, 1901, another model by the same officer was tried at Lisbon. After official tests of a severe nature, the Commission of Inquiry stated that this model showed itself superior to all foreign submarines. This result has caused great satisfaction in naval circles and it is probable that, taking into consideration the present prevailing enthusiasm, a larger type of this craft will be constructed.

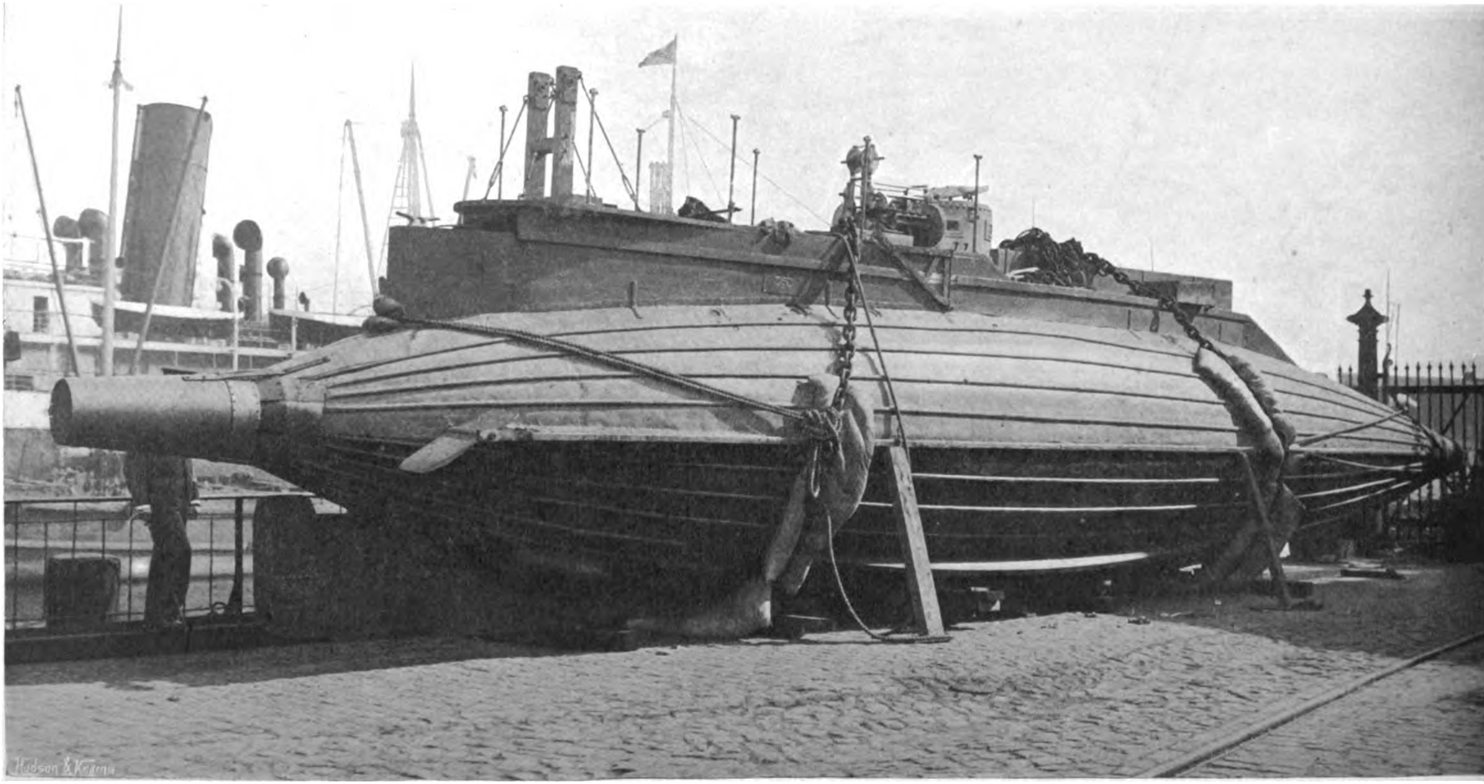
The 'Fontes III'

THE GERMAN SUBMARINES.

Although in Germany, as in England, the submarine boat has been the subject of much ridicule, its possible value in time of war has never been lost sight of.

It is perhaps not generally known that Germany has in reality, despite official protests, taken a very great and active interest in the development of this novel arm of warfare. In 1890 two vessels of the 'Nordenfelt' type were laid down under the titles 'U 1' and 'U 2' at Kiel and Dantzig. Their dimensions were as follows:

Length	34.85m.
Diameter	3.65m.
Displacement	200 tons
Surface Speed	12 knots
Semi-submerged	9 knots
Submerged	6 knots



CLXX. A GERMAN SUBMARINE, BUILT AT HOWALDT'S, KIEL

By favour of the 'Navy & Army Illustrated'

During submersion the enclosed steam was capable of driving them at full speed for two hours. On the surface they could steam at their maximum rate for twenty-four hours. They took between 70 and 80 seconds to submerge from the surface condition. On trial the surface speed obtained was 12.2 knots, semi-submerged 9.3 knots, and completely submerged 6.5 knots. These two vessels were attached to the torpedo fleets of Kiel and Wilhelmshaven and took part in the manœuvres of 1890.

The following year a third, 'U 5,' similar in design but somewhat smaller, was launched from the Howaldt Works. It had the following dimensions:

Length	30.85m.
Diameter	3.60m.
Displacement	180 tons
Surface Speed	16.3 knots (on trial)
Semi-submerged	13 1 knots (on trial)
Submerged	9.3 knots (on trial)

Full speed on the surface was maintained for one and a half hours. These vessels, despite their speed, did not give complete satisfaction, and different designs were called for and examined, to discover a more advanced and efficient type of submarine craft.

When, therefore, a lieutenant in the German Navy brought forward plans for a submersible torpedo boat, and when these plans had been received with favour by the various critics before whom they were placed, it was only natural that an immediate order should be given to construct a vessel to his designs.

The construction of this submarine was intrusted to the Howaldt Shipbuilding Yards at Kiel, and a few months after the first plate had been laid down, the vessel was put in the water. In shape it resembles a torpedo, having a length of 15 metres (49.213 feet) and an extreme diameter of 2 metres (6.5618 feet). The lower part of the hull is used as a reservoir for either compressed air or water, according to the position of the boat required.

In a preliminary trial of 3 hours, the boat remained almost motionless at a depth of 2 metres beneath the surface. The steering in both the horizontal and vertical sense is done by means of two horizontal and one vertical rudder. The motive power is electricity, the current being stored in accumulators of a special type. In the bows is a torpedo tube, this being the only means of offence; only one torpedo is carried and this is in the tube ready for firing.

This submarine boat was built at the expense of a society founded especially to test the value of the invention, the officer who designed it being a torpedo lieutenant, and one well acquainted with everything connected with the subject. In the latest trials, which have even yet not been concluded, the submersible remained submerged three hours carrying out various evolutions the while; the commission which was appointed to study these trials was, we are told, very well satisfied, and it is not unlikely that we shall shortly hear something more of this submarine boat.

Early last year (1902) a small submarine was constructed at the yard of Messrs. Schichau of Elbing. They received the order for its construction in the first week of April and it is already on trial.

At Elbing, too, also from a private yard, and also in April of last year, was launched a small model of a submarine boat which has executed some very satisfactory trials in the Bay of Hollenau.

THE SWEDISH SUBMARINE BOATS.

Sweden is one of the latest Powers to interest herself in submarine navigation, and two experimental vessels are being built in Government yards. The first is a modified 'Holland,' and has the following dimensions:

Length	65-ft. 6-in.
Displacement	120 tons
Surface Speed	10.5 knots
Submerged Speed	7-8 knots

The armament will be one torpedo tube, for which three 18-in. torpedoes will be carried.

The second, building at Stockholm, is from the designs of Herr Enroth.

The following is an extract from the 'Engineer' of July 13th, 1901:—

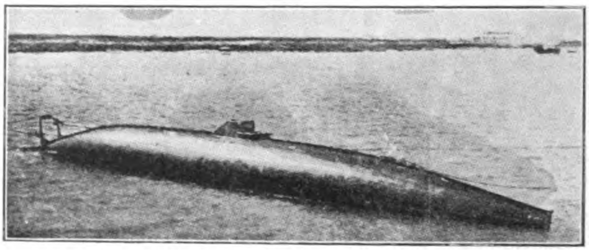
'It was announced recently that Herr Enroth, a Swedish engineer, had invented a submarine boat, and that he had offered his invention to the Swedish Government. Herr Enroth was entrusted with the construction of a 'Nordenfelt' submarine boat; he has conducted a great many experiments with this type of boat, and he is now regarded as being one of the leading experts in submarine boat building. At the French Submarine Competition in 1896 his ideas attracted special attention. At this moment Herr Enroth's plans are being considered by the Swedish Naval Commission, and it is believed that several boats will be built according to these plans for the purpose of choosing the type best adapted for the Swedish Navy. It is claimed by experts that the new type of submarine boat will be especially serviceable for coast defence. The following are the measurements of Herr Enroth's boat:—Length, 25 metres; 4 metres beam; and 3½ metres depth. Its displacement on the surface of the water will be 142 tons, and when submerged 146 tons. By the aid of two triple-expansion engines, which are each worked by a single screw, the boat will travel at the rate of 12 knots an hour above water and at 11½ knots an hour below water. Thus its rate of speed below water will exceed that hitherto attained by any submarine boat that has been tried and found to be practicable. For the purpose of driving the engines steam will be supplied by two water-tube boilers, and compressed air or steam will be used when the boat is below the water-line. Heat and air will be stored for at least ten hours, when the rate of speed is 6 knots an hour. Fore and aft there will be air chambers, in which air will be compressed at a pressure of twenty atmospheres. By pumping water either into or out of six cylindrical tanks the boat will be either sunk or raised, and it will take from twenty to thirty seconds to submerge. For regulating the depth at which the boat shall travel there will also be used horizontal rudders and hydrostatical pistons. The air that has been used up will be carried away through the cylinders which hold the screws. The build

Enroth

of the boat is of such a character that it will allow of its submersion to a depth of 60 metres or 80 feet. When the limit of depth has been reached an automatic safety apparatus comes into action and causes the boat to rise. The submarine boat will carry four 45-centimetre torpedoes, which will be arranged, two fore and two aft, in a longitudinal line with the boat.'

THE SPANISH SUBMARINE BOATS.

Spain has suffered in her attempts to solve the problem of submarine navigation from depletion of the National purse and a too frequent change of policy. Still, there are one or two inventions worthy the chronicling, foremost of which is of course the 'Peral.'



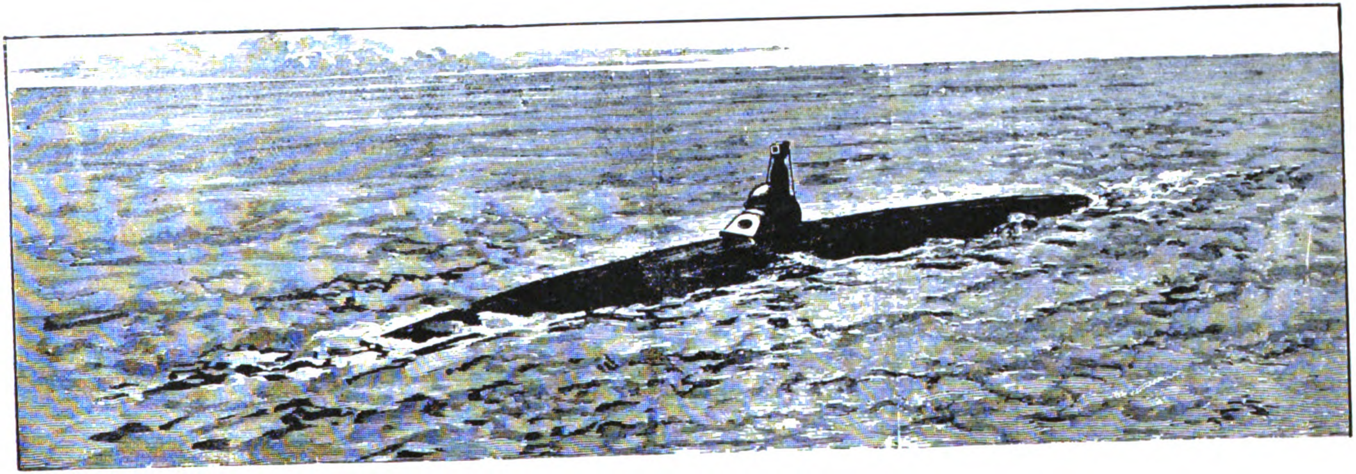
CLXXII. THE 'PERAL'

Don Peral

This vessel, the only one of its type figuring on the official Navy list of Spain, was launched at the Arsenal at Carraça on October 23rd, 1887.[1] For designing this vessel Lieutenant Peral (after whom the boat was named), received a title and a gift of 500,000 frs., and, considering the use that has been made of the vessel, the inventor undoubtedly got the best of the bargain.

The 'Peral' (of which the particulars are supposed to be a profound secret) has a length of 70 feet and a beam of 8 feet 6 inches. Its displacement is 87 tons; propulsion is obtained by means of two motors having an I.H.P. of 30 each (a horse-

1 Mr. Gaget says the 'Peral' was launched on October 25th.



CLXXI. THE 'PERAL' SUBMERGING

power of electricity is rather more potent than that of steam), while three auxiliary motors of 5 H.P. each serve to work the pumps, filling and emptying of reservoirs, and all other necessaries. These five motors are supplied with power from 600 accumulators.

One of the 5-H.P. motors is coupled to each of the sustaining propellers, of which there are two.

Air is supplied the crew by means of reservoirs and it is asserted that the amount carried would be sufficient for two days. This assertion cannot of course be credited.

Offensive power is given the 'Peral' by a torpedo tube in the bows from which Schwartzkopf torpedoes were to be fired; the ram was also to be used.

The interior is lighted by half a dozen electric lamps and a strong lamp is also fitted for lighting the bottom of the sea. This vessel was not tried until December 25th, 1889.

The following extract from the official report is interesting:

De Cadix, le 25 Decembre, 1889.

Au Ministre de la marine Espagnole.

'Le 'Peral' est sorti ce matin de l'arsenal de la Carraca; il a traversé la rade sans incident en faisant route sur Rota. En vue et à proximité de cette position il a fermé ses capots, rempli ses resérvoirs et s'est enfoncé à une profondeur de 9 mètres. Il a navigué ainsi pendant 16 minutes au moins faisant route au Sud-Ouest. Il est ensuite remonté sans s'arrêter à la surface puis il s'est bientot immergé une seconde fois constatant alors qu'il ne deviait pas sensiblement de la profondeur qui avait, été choise,—Les plus grands écarts étaient de 20 à 30 centimètres. Avant de rentrer il a parcouru la rade en tous sens et est revenu dans le port à 4 heures du soir.'[1]

Don Peral said after the trial that his vessel covered 4 miles during its submersion, i.e., it had an under-water speed of 15 miles an hour. A truly wonderful craft.

The last trial of the 'Peral' took place on June 28th, 1890, when an attack on the 'Cristobal Colon'[2] was planned.

1 'La Navigation Sous-marin,' Maurice Gaget, 1901.

2 The 'Cristobal Colon' was a fine well armed and well protected armoured cruiser of 6,840 tons displacement. She ran ashore on July 3rd, 1899, after escaping from Santiago de Cuba.

Particulars of this trial may be found in the United Service Gazette, June 28th, 1890.

Despite the powerful search-lights of the cruiser, the submarine boat managed to torpedo her without making its presence known. It approached as close as 12 yards without being seen. For this feat Lieutenant Peral had the honours showered upon him.

Yet with all the apparent perfection of this vessel it was never able to return to harbour without the aid of a tug. From the above description the real value of the 'Peral' can be pretty effectually gauged.

Anon

The Spanish Service journals gave considerable notice to the experiments carried out in 1898 with a weird and nondescript contrivance, the name of the inventor of which is unknown.

It was an enormous steel sphere so strongly made that there is no depth (?) to which it might not sink and yet bear the pressure easily. The diameter was 9 feet 9 inches, the displacement 10 tons and the thickness of the outer skin 4 inches. Sufficient air was carried to supply the crew of three men for 48 hours. The speed was 4 to 5 knots an hour, the propeller being rotated by an electric motor for which the power was carried in accumulators. An enormous screw was used for submerging and for preserving an equilibrium when beneath the surface and powerful search-lights cast their rays in all directions to enable the pilot to guide his boat amidst the various submerged obstacles. Should the accumulators fail, motion could still be obtained by means of pumps which sucked in and ejected water through various pipes, thus sending the vessel in any desired direction.

The uses to which this submarine boat, or rather ball, can be put are, we are told, numerous. Should it be necessary for a fleet to enter a harbour where mines were probably laid, the submarine would be connected by an electric wire to the leading ironclad and thus guide it safely between all obstacles, not only mines, but rocks and sand-banks. In the front of the submarine was a strong grappling iron, fitted at its extremity with sheers, by which wires connecting mines to the shore, and cables, could be cut. It could besides attach torpedoes to the bottoms of ships and having drawn off to a sufficient distance, unrolling the while a reel of insulated wire connected to an electrical key-board, the commander would press a button, and then—presumably—come to the surface and aid in rescuing the surviving members of the vessel destroyed.

In 1898, too, another anonymous craft was launched in Spain, and during 1889 this vessel carried out some very successful trials at Cadiz. The inventor, who resides at Cadiz, has offered his invention to the Government, but up to the present these worthy officials have not forgotten Don Peral and his submarine boat. Anon.

The great novelty of this invention is its means of propulsion, which is by clock-work. The crew consists of two men and from what can be discovered these poor fellows would be continually winding taut a gigantic watch-spring. The stability is perfect and it sinks with remarkable rapidity.

So have many other submarine boats!

Design for an Armoured Submersible.

I have several times expressed the opinion that the submarine boat of the future will in all probability be of the 'submersible' type. A careful study of the evolution of this class of vessel and of the sort of work they will be called upon to perform, has led me to think that they will eventually appear protected by armour-plating. The armouring of torpedo vessels is no innovation, the Japanese 20-knot torpedo boat 'Kotaka' having her vitals protected by 1-in. steel plates, whilst several of the latest French destroyers, of which the 'Mistral' is an example, are similarly defended.

The appended designs represent the future submarine as I imagine it. The most important and noticeable features of the 'submersible' I propose are the armoured deck and the large displacement. Now if we glance rapidly over the list of inventions that have been included in this history, we find that all but one or two of them, have been small boats, having displacements less than 15 tons. And how many of these small boats have been successful?—two only, the 'Drzewiecki' and the 'Goubet,' but the success of these two types is practically nullified by their lack of speed which has never exceeded 6 knots. On the other hand the really successful submarine boats, the 'Gymnôte,' 'Gustave-Zédé,' 'Morse' and 'Holland' are all vessels of some size, the 'Gymnôte' being the smallest with a displacement of thirty tons, and owing to this lack of size she is the least perfect of them.

That the 'Gustave-Zédé' was a failure for the first few years of her existence, was chiefly due to a desire on the part of the French Government to evolve a perfect type without having first gained the necessary experience by experiment. To use an Americanism, they 'bit off more than they could chew,' and learnt a lesson. But the scientific skill and mechanical ingenuity of our Gallic neighbours overcame all the primary difficulties and the final result is a credit to the genius of their constructors, and thus the largest submarine boat in the world is also very nearly the best.

Let me take a few parallel instances to show why this was inevitable. At the advent of torpedo boats it was an unwritten law that they must be as diminutive as possible in that their lack of size would prove the best defence against being sunk when under gun fire. But despite the ravings of the critics the torpedo boat has gradually grown in size and speed until it is almost impossible to draw the line between the largest torpedo boats and the smaller types of destroyer. From 12 and 15 tons the displacement has risen to 180 and even more, whilst the speed has increased accordingly, until 26-30 knots is the common designed velocity. With destroyers the case has been very similar; the 'Hornet' displaced about 250 tons and steamed 26 knots, whereas the 'Cobra' gauged about 360 tons, and had a speed of 36 knots,[1] whilst some of the new American 30 knotters have a displacement of 430 tons and an I.H.P. of over 8,000, and our latest vessels of the 'Exe' type are of 550 tons and 25.5 knots speed, with 7,500 I.H.P. There has always been a tendency to increase displacements, and although every additional ton is disputed and the policy of augmentation of weight condemned, the modern first-class battleships of all the chief naval powers displace over 13,000 tons, as compared to 10,000 tons of a few years ago. Thus the 'Benbow' built in the eighties is of 10,500 tons weight, the 'Nile' displaces about 12,000 tons; a few years more and we see the 'Royal Sovereign' class of 14,150 closely followed by the nine

1 The 'Cobra' was wrecked off Grimsby on September 18th, 1901.

'Majestics' with 14,900 and the 'Formidables' of 15,000 tons; lastly the two latest programmes provide for the construction of five immense ships displacing 16,500 tons, and who shall say that we have reached the limit?

In fact it has at last been recognised that to obtain a maximum of protection, speed and offensive powers, the size of the vessel must be augmented, whilst in torpedo craft the main unit of value is speed—and speed there must be even at the expense of increasing the bulk and thus adding to the size of target.

This applies equally to 'submarine' and 'submersible' vessels.

But to obtain this greater speed, greater engine power is necessary; this means more room, and consequently larger vessels. This sort of thing may go on indefinitely until the final phrase will be as different to the 'Gustave-Zédé' and 'Holland' as the cruiser 'Drake' is to the famous corsair 'Alabama.'

The vessel represented in the plans will therefore resemble the 'Gustave-Zédé' as regards displacement. It is essentially a 'submersible' boat and as such it will be chiefly employed in a semi-submerged state, i.e., the deck on a level with the surface. To protect it therefore while in this trim, all the exposed surface is plated with thin armour capable of keeping out all projectiles from the machine-gun bullet up to the 6 pr. shell. This plating is curved downwards to the sides much in the same way as the protective deck of cruisers, whilst from the bows it rises in the form of a turtle-back to just beneath the observation ports of the conning-tower, which is thus effectually protected up to that line. The conning-tower being more exposed will be plated with armour twice the thickness of that carried on the other protected parts of the vessel.

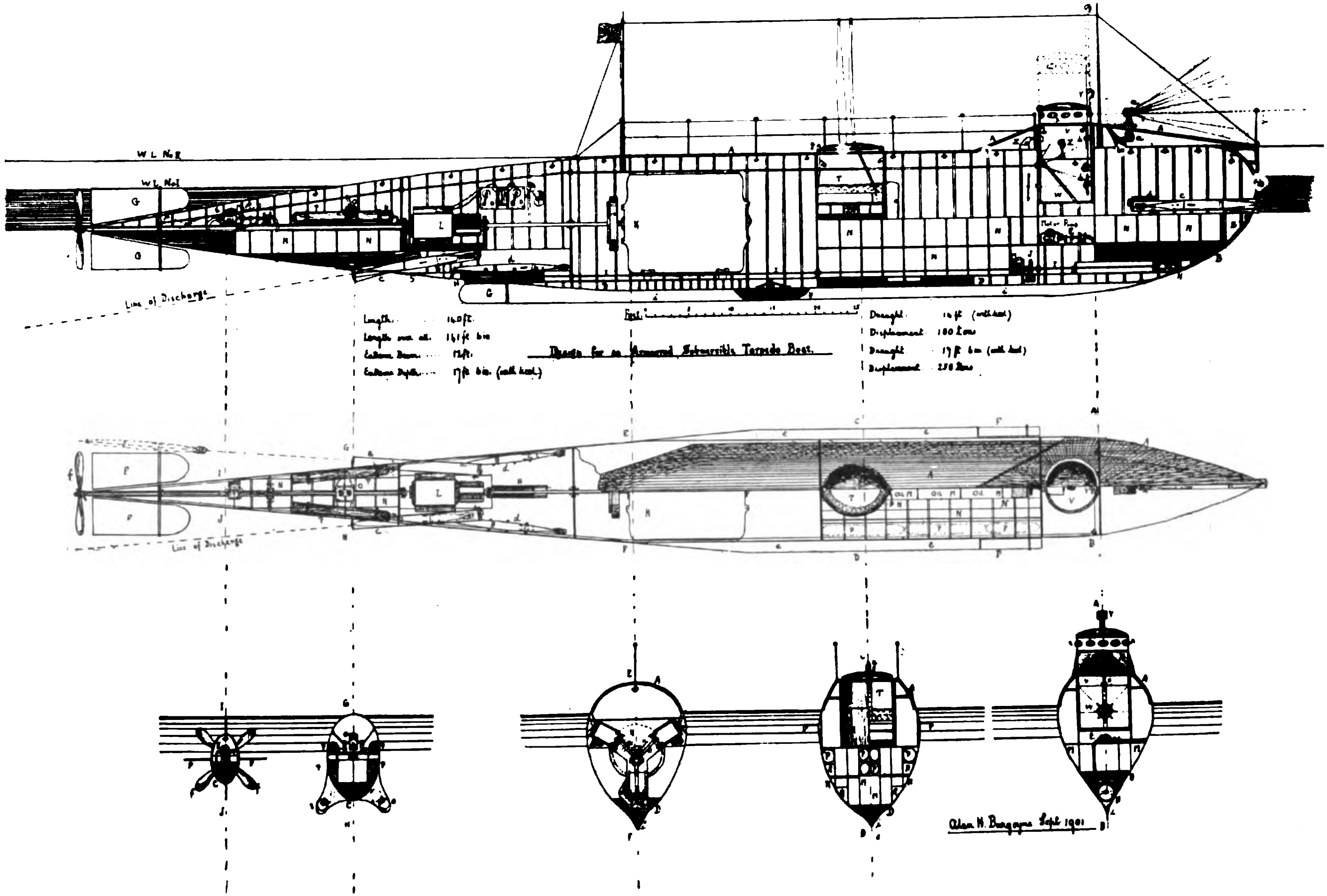
This armour will naturally be a great weight on the deck, and if the displacement were not large, the buoyancy and safety of the vessel would be much endangered in that the plating will be to a submarine what an excess of top-hamper is to a surface ship, and we know how much the French battleships suffer through carrying enormous military masts resembling lighthouses in their immensity. In this submersible boat, however, the weight of armour carried will (owing to the displacement) in no wise effect the stability when submerged nor the buoyancy and seaworthiness when navigating on the surface as an ordinary torpedo boat.

Submersion is obtained by the introduction of water into ballast tanks placed in convenient positions for the regulation of weight. These are filled by means of water cocks and emptied by pumps or compressed air. These pumps are of the Thirion type supplied to all French vessels, worked by electricity,—a pump which has been proved by experiment to be the best up to the present.

Stability when submerged is maintained by two distinct methods; firstly by horizontal rudders placed in the stern and worked by an automatic adjustment actuated by the longitudinal movements of the vessel, and secondly by the displacement of water in a pair of cylinders situated at either end of the boat. The pistons in these cylinders are connected by a rod running the whole length of the vessel, and this rod is so geared, that the simple movement of a lever will draw water in at one cylinder whilst expelling an equal amount at the other, thus altering the balance of the boat. It will at once be seen that by this means the perfect trim of the vessel can be accurately obtained.

The armament consists of three torpedo tubes, one forward in the bows and two others placed beneath the electric motor in the stern. For these, six 14-in. torpedoes will be carried, one in each tube ready for firing and three spare ones for reloading. The tubes are arranged in the method described, as being in the best positions for effectual service. The mode of attack would be as follows:—The vessel would approach the enemy bows on and when within range, fire the forward torpedo, after which she could either dive and rise on the further side of the ship attacked or else turn round and retreat the way she had come, in either of which cases the stern would be bearing and the after torpedo tubes could be fired to ensure the destruction of the hostile warship.

Now as to motive power: the proposed vessel being of the mixed propulsion type; an oil motor will be used for the surface and electric motor for use when navigating submerged. The oil motor is of the Forest Gallice type, having 18 cylinders



CLXXIII.-CLXXIX. THE AUTHOR'S PLANS FOR AN ARMOURED SUBMERSIBLE and an I.H.P. of 500. With this a speed of 14 knots should easily be obtained which is far in advance of that of any other submarine boat at present building.

This oil engine consists, as mentioned above, of 18 cylinders forming three radiating groups of six cylinders each, the angle that one group bears to another being 120. They all bear on the same shaft, and the power being equally distributed over an equilateral triangle, vibration is reduced to a minimum. This system permits of the size of the flywheel being reduced besides being especially suited to the development of high powers.

The electric motor will have a force equal to 200-250 I.H.P. which would propel the vessel at about 8 knots submerged. As, however, the chief value of this proposed 'submersible' will be when just on the surface, the motive power for use when under the water is not of the greatest importance, and high power engines will not be necessary.

The petrol for the oil motor is placed at various points of the vessel; these tanks are so arranged that as the oil in them is consumed, others fill with water to compensate for the loss of weight sustained. The accumulators for the storage of the electrical power are placed in the centre of the boat beneath a deck forming a longitudinal water-tight partition. These accumulators can be charged by utilising the motor as a dynamo, the oil engine being used for working it.

A radius of 500 miles is to be expected at an economical speed on the surface. The whole of the machinery is operated from the conning-towers.

Habitability is assured by a large supply of compressed air contained in cylinders fitted between the rows of accumulators; this air is liberated automatically by means of a weighted valve operated on by a pressure gauge. The vitiated air is expelled through tubes leading to the outside of the hull, though these would be closed when submerged. This compressed air can also be used in case of necessity to force the water out of the ballast tanks. These tanks are very much subdivided in order to avoid the surging forward of the water ballast when diving, since if this were to happen the equilibrium would be considerably disturbed.

The safety of the crew is adequately provided for. Firstly, there is a large detachable weight, cast in two portions, a part or the whole of which may be dropped in case of necessity, when the vessel will at once rise to the surface. Should, however, a fatal injury make the abandonment of the boat necessary, the crew would enter a specially designed cylinder placed in the centre of the boat. This cylinder is water-tight and contains sufficient compressed air to last half an hour; when the whole of the crew has entered and the door, which is of course water-tight, been closed, a catch is released and the cylinder by its reserve of buoyancy will rise at once to the surface, when the crew would trust to luck to being picked up by the vessel that had sunk them.

Two conning-towers are provided, one for use when navigating on the surface and another for use when submerged. The first of these is telescopic so that when scouting a more extended view of the horizon may be obtained. It is fitted with strong lenses which can be protected by sliding steel shutters. The second conning-tower is situated directly beneath the first, and can be more aptly described as a 'controlling' chamber. In front of it rises an extensible optical tube or périscope, for keeping a straight course when submerged and in (fine weather only) taking bearings without having to come to the surface. This, however, is so unreliable that a gyroscope, placed aft, will be looked to to prevent the vessel from deviating, by automatically turning the rudders in the direction that will again bring the vessel straight.

The vessel is further provided with three keels, one running along the bottom and one on each side. These side keels are fitted at the forward end with moveable planes to aid the rudders in diving. With these three keels rolling and pitching will be reduced to a minimum.

Diving is affected by the planes mentioned above and two horizontal rudders placed in the stern, whilst steering in the ordinary sense is managed by two rudders also in the stern, and an additional rudder of the ordinary type on the keel-line beneath the engine room.

The form of the hull differs altogether from that of any former submarine boat. Two-thirds of its length from the bows the shape recalls that of the French 'torpilleurs d'haute mer,' but after that it resembles a cigar, being an ovöid pointed cylinder. The torpedo boat bows will greatly increase the speed when on the surface.

The interior is lighted throughout by electricity supplied from the accumulators, whilst one or more searchlights can also be fitted should they be required; these matters are, however, of minor importance.

The following is a table of dimensions:

Length	140 feet
Over all	141½ feet
Extreme beam	12 feet
Depth	17 feet
Draught, W.L. No. 1	14 feet
Draught, W.L. No. 2	17½ feet

The following references to the letters on the accompanying plans may be found useful:

A Armour protection, B Forward ballast tank, C C After ballast tanks, D D D Central and Reserve tanks, E E Electric pumps, F F Horizontal rudders, G G G Rudders for steering in the ordinary sense, H H Hydrostatic cylinders for preserving an even keel, I I Rod joining pistons, J Motor for working rod, K Forest and Gallice oil motor, L Electric motor, M M Liquid fuel tanks. N N Accumulators, O Gyroscope, P P Compressed air cylinders, R R Oil compensator tanks, S S Torpedo compensator tanks, T Safety cylinder, U Safety weights, clamped one within the other, V Upper conning-tower, W Lower conning-tower, X X Look-out lenses, Y Optical tube, Z Z Compasses, *a* Swing searchlight, *b* Steering and torpedo aiming rod, C C C Torpedo tubes, *d d* Spare torpedoes, *e e* Side planes or lee-boards, *f* Propeller, *g* Rocket tube in safety cylinder, *h h* Steering wheels, *i i* Keel.

END OF VOL. I

ADDENDA

FRANCE :—

The *Times* of February 10th, 1903 contains the following: M. Jacob

The *Petit Var* states that on February 5th, experiments were made in one of the docks at Lorient with a new type of submarine boat invented by M. Jacob, first master artificer (mécanicien). Many naval officers and constructors were present. The little vessel was easily submerged and navigated, and the speed attained was remarkable. The boat is fitted with a tail very similar in appearance to that of a fish, which is worked by a motor and by which it is both steered and propelled. M. Jacob is also the inventor of another combination of rudder and propeller which can be used with his boat. Experiments have also been made with this invention.

'Omega' Class

This class, of which the number to be built has not yet been decided, will, as regards size, be a complete departure from all that have preceded them. The dimensions of the first of these submersibles—which has received the name 'Omega,'—are as follows:

Length..................	48m. 90
Beam....................	4m. 20
Draught.................	2m. 60
Displacement..........	301 tons
Surface Speed.........	16 knots
Submerged Speed....	11 knots
Armament..............	Two Torpedo tubes,
	Two Drzewiecki launching cradles

The complement of these large vessels will be two officers and eighteen men.

'Aigrette' Class

This class includes two vessels, the 'Aigrette' and 'Cigogne,' designed by Engineer Laubeuf, the author of the 'Narval' class. They are being built at Toulon and have the following dimensions:

Length	117 ft. 6 in.
Beam	12 ft. 6 in.
Draught	8 ft. 6 in.
Displacement	172 tons

These two vessels are, of course, of the submersible type.

Romazotti

Particulars of the large submarine building to the designs of Engineer Romazotti have recently been published:

Length	121 ft. 6 in.
Beam	10 ft. 6 in.
Draught	7 ft. 6 in.
Displacement	168 tons
Speed	10.5 knots
No. of Propellers	2

This boat, which has received the designation X, is to be completed by the summer of 1904.

Maugas

Engineer Maugas' design is for a somewhat larger vessel. It will have the following dimensions:—

Length	135 ft. 9 in.
Diameter	9 ft. 8 in.
Displacement	202 tons
Speed	11 knots
No. of Propellers	1

This vessel, known as Z, is also to be completed during 1904.

Bertin

The talented naval constructor Bertin has a heavier displacement still to his credit; Y is to be as under:

Length	142 ft. 8 in.
Diameter	9 ft. 9 in.
Displacement	213 tons
Speed	11 knots
No. of Propellers	1

This vessel is to be finished this year.

The 'Goubet II.' purchased by M. Maire has been transported to the Lake of Geneva, where it is used as a passenger boat for taking visitors for short submarine trips beneath the Rhône. The price of one journey is 25-frs: (£1) and each passenger is presented with a life insurance policy with the ticket. **'Goubet II'**

U.S. AMERICA:—

The Lake submersible 'Protector' maintained an average of 12 knots on her surface speed trials. **'Protector'**

According to the *New York Herald*, the construction of six submersible torpedo boats from the designs of Clarence L. Burger has been sanctioned by the Secretary for the Navy, and the inventor, who states that his design was approved by the Board on Naval Construction, announces his readiness to build the vessels as soon as the bill authorising the contract has been passed by Congress. The following is a detailed description of the type: **C. L. Burger**

The vessel consists of a cigar-shaped underwater hull, holding the machinery, torpedoes and torpedo tube, and the other vitals. This hull is suspended from a surface hull filled with cellulose, acting as a mere float, so as to provide vision, ventilation, buoyancy and seaworthiness. By the separation of the two hulls, by a fine shaped structure whose beam is only two and a half feet, the lower hull is protected from gun fire, and the displacement, it is held, is kept down so that high speed can be obtained.

A heavily-armoured conning tower for communication, observation and air supply rises from the submerged hull through the connecting fin, slightly above the surface of the hull of the water line. This armoured conning tower, in which the navigator stands and steers the boat, is said to be proof against all small guns, and is too small a target, in motion, for large guns to hit.

The vessel uses gasolene engines and air for combustion, and ventilation is supplied by blowers to the lower hull through the armoured conning tower.

Speaking of his vessel, the plans for which were prepared by Tams, Lemoine and Crane, naval architects, Mr. Burger said:—

'In addition to its other features, a remarkable fact about this vessel is that in a test of a model constructed in the navy yard at Washington, and tested under the direction of Rear-Admiral Bowles, Chief of the Board of Naval constructors, the boat attained a speed of sixteen knots an hour. The final plans of the boat were filed with the Navy Department on December 6, 1902, and it is in accordance with these plans that the six vessels will be built.

'Having a speed so greatly in excess of the ordinary manœuvring speed of fighting ships in battle or blockade, it is evident that a squadron of the boats would under cover of darkness, fog or the confusion of battle, and even in daylight, generally be able to get within range of and torpedo a fighting or blockading enemy and get away before getting into trouble.

'According to the bill, the price of each boat may not exceed $200,000.'

This description is full of interest and the trials of the first of these novel and ingenious craft will be awaited with expectancy; they seem decidedly practical on paper.

GERMANY:—

A Submarine of the Holland type is being built in Germany. It is said to be the result of Mr. Rice's recent visit to the continent; Mr. Rice is the President of the Holland Torpedo Boat Company.

GREAT BRITAIN:—

A Company under the Presidency of Admiral the Hon. Sir Edmund Freemantle was organized in 1902. It is intended to improve on the late M. Claude Goubet's designs, the patents for which have been acquired; the registered title of the new venture is the 'British Submarine Boat Company.' The endeavour will be to produce a small and efficient submarine capable of being carried on the decks of warships as is done at the present time with second-class torpedo-boats. An experimental vessel will be built this year in one of the many ship-yards along the banks of the Thames. The first board of directors consists of the following gentlemen:

Ad. Sir E. Freemantle
Col. W. F. Leese
Lieut. Carlyon Bellairs (late R.N.)
W. A. Casson Esq.
J. S. Allen Esq.
A. Hilliard Atteridge

Mr. Atteridge acted for many years as M. Goubet's British representative. The British Submarine Boat Company has offices in Chancery Lane, London, W.C.

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VOLUME I

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