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LIEUT. F

LECTURE

ON

SUBMARINE BOATS

AND THEIR APPLICATION TO

TORPEDO OPERATIONS.

BY

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PREFACE.

In this lecture I have endeavored give a general history of the science of submarine navigation; giving detailed descriptions [when I have been able to obtain them] of special apparatus designed for the purpose, and a general idea of others where my researches have not been so successful.

The greater portion of the information on this subject, which has found its way into print, is vague in the extreme; probably from the fact that it is a subject of very little interest to the general reader and only sought after by the curious, who, in most cases, would prefer the accounts of marvelous results attained rather than the dry detail of the mechanical devices necessary to obtain them. As regards the lack of other sources of information, both in times past and present, it may probably be ascribed either to illiteracy on the part of the inventors or a desire of keeping their knowledge to themselves.

An effort has been made throughout the greater portion of the lecture to follow something of a chronological order in discussing the various inventions; but the attempt has not always been successful, and it is hoped that the defect may be partially remedied by the Appendix, which contains a number of other facts pertaining to the subject which have come to my notice while in search of information, but which could not well be inserted in the body of the lecture itself.

LECTURE.

Roger Bacon, who lived in the 13th century, mentions submarine vessels amongst the other marvels which he enumerates. "Moreover," he says, "instruments may be made wherewith men may walk in the bottom of the sea or river without bodily danger; which Alexander the Great used, to the end that he might behold the secrets of the seas; and these have been made not merely in time past, but even in our days." Again, in another place, he says: "We have seen and used in London a warlike machine, driven by internal machinery, either on land or in water; and succeeding years have shown us a vessel which, being almost wholly submerged, would run through the water against waves and wind with a speed greater than that attained hy 'Celonibus Londinensibus expeditissimis,'" [the fastest London pinnaces.]

At the seige of Tyre by Alexander, according to Quintius Curtius, the defenders are said to have protected the foot of their walls, on the sea face, by huge blocks of stone, intended to prevent the approach of the boats of the Macedonians, on which were mounted their catapults and other engines; and in endeavoring to remove these obstructions the assailants were much annoyed by workmen under water, who came out from the city and cut their cables. At the same time other submarine workmen hindered the attempt of the Macedonians to connect the city with the main land by taking away the dike from underneath the water as fast as stones were added to it from above.

The pleasures of Antony and Cleopatra have also rendered celebrated the divers of Egypt. According to Plutarch, the two lovers were frequently engaged in fishing in the waters of the Nile, on which occasions Antony secretly employed the services of a submarine assistant, who from time to time attached a fish to the line of his master. The success of Antony was a matter of great concern to Cleopatra, who could not conceal her annoyance, till one day, discovering his secret, she also employed a diver, who, on the next occasion, attached a large salt fish to the line of Antony, who drew it from the water amidst the laughter of the surrounding courtiers.

It is stated by some writers that a corporation of fishermen existed in ancient Rome who used a submarine armor in their daily avocations, and it is also asserted that a corps of military divers was attached to the army, and on board each ship of the navy were one or more men who were accustomed to this kind of work.

However mythical these statements may be, a circumstantial account of the principle of the diving-bell occurs about the year 1540, when it was demonstrated in the presence of Charles V and his court at Toledo, in Spain, by two Greeks, who descended into the water in a large inverted kettle loaded with lead at the rim with a burning light and came up dry, having the light still burning.

William Bourne, of London, proposed a plan for submarine navigation in 1578; but the earliest detailed attempt is that of Cornelius Debbrel, who, in 1624, during the reign of James 1st of England, constructed a submarine boat to carry twelve rowers besides passengers. He is also stated to have discovered a liquid which had the property of restoring air when it became impure by breathing; but he died before his plans were perfected, and his secret died with him. Somewhat later another contrivance was invented by an Englishman, which consisted of a strong leather sack so prepared as to contain about half a hogshead of air and to be airtight. It was constructed in such a manner that it exactly fitted the arms and legs and had a glass window in the front part of it. When the inventor put on his apparatus he could not only walk on the bottom of the sea, but could enter sunken ships and recover goods. None of these inventions, however, were generally known or understood even during the time of their existence. Few other applications of these demonstrated principles seem to have been attempted until 1683, when William Phipps, a Boston ship carpenter, persuaded King Charles II of England, to furnish him with a ship and a diving-bell apparatus of his own invention to search for a rich Spanish ship which had been sunk in six or seven fathoms of water off the coast of Hispaniola. The first attempt was unsuccessful, but on a second trial in 1687 he succeeded in raising treasure to the amount of $200,000. He was knighted on his return to Europe.

Up to this time in inventions of this description the bell was hoisted to the surface with great frequency to obtain a fresh supply of air; but in 1715 Dr. Halley contrived a method of supplying air to the bell while at the bottom by lowering to it barrels of air by means of weights, and the vitiated air was let off from the bell through valves in its top. Numerous minor improvements were made in the bell within a few years, but this clumsy mode of supplying the air still remained in use until 1779, when Seaton, the engineer, applied the air-pump to forcing down the air; which method is still in use. These improvements [as well as those in submarine armor for single operators, the history of which I have not sketched, as being rather more foreign to my subject] were, however, confined to the more convenient manipulation of a vessel, which, though under water, is still a fixture, or at least can only move along the bottom, as in Sear's diving-bell and others of like nature.

Little was apparently done from Debbrel's time in the way of propulsion till 1771, when David Bushnell, of Connecticut, first suggested the idea of attacking a vessel underneath the water, and constructed a submarine boat capable of accomplishing the desired object. There is no drawing extant of this remarkable invention that I am aware of, and the accompanying sketch (Plate I) I have made from the different descriptions given of the apparatus. If not exactly accurate, it will at least give a tolerably correct idea of its general appearance.

The external shape of the vessel bore some resemblance to two upper shells of a tortoise joined together, and it floated in the water with the tail down, while the entrance to the vessel was at the opening made by the swells of the shell at the head of the animal. The inside was capable of containing the operator and air sufficient to support life for half an hour. The vessel was chiefly ballasted with permanent lead ballast, A, besides which a mass of lead, B, of about 200 lbs., could be let down forty or fifty feet below the vessel, and thus served as an anchor as well as enabling the operator to rise suddenly to the surface of the water in case of accident. A water-gauge, C, showed the depth by means of a piece of cork with phosphorus on it, which floated on the water within the gauge, while a compass, D, marked with phosphorus, directed the course of the vessel above and underneath the surface. An oar, E, formed on the principle of an old-fashioned screw, was fixed in the forward part or edge of the boat. Its axis entered the vessel, and on being turned in one direction propelled the vessel forward, but being turned in the other propelled it backward. An oar, F, placed near the top of the vessel and working on the same principle as E, enabled the operator to move upward or downward, after having once established approximately an equilibrium. A rudder, G, at the after edge of the boat, was made very elastic and might be used for sculling.

The entrance to the vessel was elliptical, and so small as barely to admit one person. It was surrounded by a broad elliptical iron band, H, the lower edge of which was let into the wood. Above the upper edge of this iron band was a brass crown, I, resembling a hat, which shut water-tight upon the iron band, being hung to it with hinges, so as to turn over sideways when opened. In the crown were three round doors, J, J, one directly in front, and one on each side, large enough to put the hand through, and, when opened, they admitted fresh air; their shutters were ground perfectly tight, and were hung with hinges. There were likewise several glass windows in the crown for looking through, and for admitting light in the daytime. There were two air pipes, LL, in the crown, and a ventilator, M, which drew fresh air through one of the pipes, and discharged it into the bottom of the vessel, the impure air escaping by the other pipes. The valves X, X opened automatically, when they came out of the water, and closed as soon as they re-entered it.

When the operator wished to descend, he placed his foot upon the lever of the valve N, by which means he opened a large aperture in the bottom of the vessel, allowing the water to enter the tank O O, until a sufficient quantity had been obtained to cause the boat to descend very gradually. He then shut the valve. The water could be discharged from this tank by the brass force pump P, and when the vessel leaked, the bilge could be pumped out by a similar pump, Q. A firm piece of wood was framed parallel to the conjugate diameter, to prevent the sides from yielding, and it also served as a seat for the operator.

The aperture under the Kingston valve N was covered by a perforated plate, and everything within the boat was brought so near to the operator that he could find anything in the dark, without turning either to the right or left.

In the fore part of the brim of the brass crown was a socket with an iron tube passing through it. At the top of the tube was a wood

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navigation was being made in England by a man named Day, who constructed a vessel of 50 tons burden, to go under water. He never made but one successful submersion, however, as on his second attempt, in 1794, the vessel remained at the bottom. After this date little seems to have been done until the time of Fulton, who went to Paris in 1797 and laid his plans before the Directory, but they were refused. He then made a model of his proposed submarine boat, which the Directory approved of to the extent of ordering a commission, which reported favorably upon it. The Minister of Marine, however, refused the necessary facilities and assistance. After three years Fulton offered his services to the First Consul, who appointed a committee consisting of Volney, Monge and Laplace, to examine his inventions. They reported favorably, and in March, 1801, a sum of 10,000 francs was appropriated to make the necessary experiments. Thus encouraged, Fulton constructed a plunging boat, furnished with two parallel screws, which served for propulsion and steering horizontally, while a screw working on a vertical axle effected the movements of ascent and descent.

With this boat the inventor experimented at Havre and Brest; but it seems that little was accomplished with it, as he shortly afterward constructed, at Paris, a second boat, larger and better than the first, and which carried on its stern the name "Nautilus," in letters of gold. The new boat had ribs of iron and sheathing of brass. It had the form of an ovoid, very elongated, and was nearly six feet in diameter. At one extremity was a hole, with a rim or collar, to take a water-tight cover, and near the middle of the boat's deck, in a fore and aft line, was a narrow channel, intended to receive a small mast, which could be raised and lowered by a hinge. In the interior were ranged the handles of oars, shaped like a screw, to produce a motion of translation. A reservoir, into which water was introduced, caused the boat to dive at will, and a force-pump to drive out the water caused her to rise.

Near the end of June, 1801, the Nautilus was first tried in the Seine, near the Hotel des Invalides. Fulton, with one sailor and a candle, went under water in his boat and remained 20 minutes, emerging at some distance from the point of disappearance. In a few moments he again disappeared, and came up at the point of first starting; after which he made sail and manœuvered for some time on the surface. On the 3d of July, Fulton, accompanied by three men, went down in the harbor of Brest to the depth of 25 feet, remaining for an hour, and on the 24th of July he replaced his candles, which consumed too much air, by a stout glass dead-light in the top of the boat, which afforded him sufficient light to read his watch at a moderate depth. On the 26th he experimented under canvas. The boat carried a jib and mainsail, and it took but two minutes to furl sail, strike his mast and disappear beneath the surface. The speed under water was 1 metre per second, (about 2 knots per hour;) the boat handling well, and the compass working as perfectly as on the surface. On the 7th of August he carried down with him a strong spherical copper tank, capable of containing enough compressed air to last for 8 hours. The longest time that he ever remained under water, however, was four hours and twenty minutes.

With this boat he was able to blow up a small vessel in the harbor of Brest, by attaching a torpedo to her containing 20 pounds of powder. He also attempted to blow up an English man-of-war, but when he was on the point of attaching his torpedo the vessel moved away, and he could not find her again.

Notwithstanding his undoubted successes, the French Government was not disposed to offer him any further assistance, the principal reason being, it is asserted, in consequence of the opinion of Napoleon, that the boat operated too slowly when under water. Fulton, therefore, visited England, where, meeting with a like want of encouragement, he afterwards came to America.

This boat, though not as convenient as Bushnell's for the manipulation of a single individual in attacking a vessel in a quiet harbor, may be considered as a step in advance in the general science of submarine navigation, since it carried a supply of compressed air and a larger number of people.

It is said that at the time of Fulton's death he was engaged in the construction of a large diving boat named the "Mute." This vessel was to be 80 feet long, 22 feet wide and 14 feet deep, while its walls were 1 foot thick, and the deck was covered with iron plates. The Mute was intended to navigate usually on the surface, but on approaching an enemy it could sink itself quickly, just keeping the rail awash. A small cylindrical port-hole in a pilot-house would then enable the officer of the watch to put his head above the deck and steer the ship. Her complement was fixed at

100 men, a part of whom turned a large paddle-wheel, (probably some sort of feathering arrangement,) by means of a crank. Being at a depth of 6 or 7 feet, no noise would be made; hence the name of Mute. No masts or sails were to be used, and it was intended to utilize the vessel at night, in roadsteads and harbors, to destroy an enemy by means of its submarine battery. It is very probable that Fulton also intended to apply steam to this boat.

In 1809 there was constructed in France, by two brothers named Coessin, a small submarine boat which was intended to carry nine men and was to be used at Havre for carrying sulphur cloths, which it was designed to attach to the bottoms of the English vessels for the purpose of burning them. I have seen no account, however, of its ever having been actually used.

During the war of 1812 various special torpedo boats were invented, some of which had the power of diving and remaining under water a short time. The general appearance of most of them was said to be similar to that of Bushnell, and one is described in Niles' Register as being chased by the English and escaping by means of her power of diving "like a porpoise."

The next most interesting invention of this description [from an historical point of view] was that of an Englishman named Johnson. His boat was built in 1821 and was 100 feet long. It was intended to be used in an attempt to rescue Napoleon from St. Helena; but the death of the Emperor on the 5th of May, 1821, put an end to the project. A few years later Johnson navigated under the waters of the Thames in a submarine boat carrying several passengers.

In 1825, M. de Montgéry, a French naval officer, proposed a submarine war vessel, a section of which is shown in Plate II, Fig. 1. This vessel was named the "Invincible," and was to be 86 feet long, 23 feet beam, and 14 feet deep. The deck was furnished with two hatchways for ingress and egress, in the covers of which were placed large dead lights. The bowsprit could be rigged in and the masts were hinged, so that they, with all rigging and sails attached, could be stowed in a groove or channel on the spar deck when wishing to dive. The interior was furnished with a gun deck, below which were various compartments, some for munitions and others for the admission of water; the latter were to be filled by opening valves when it was intended to sink, and were freed by force-pumps when wishing to rise. Horizontal movement was obtained by a wheel worked from the poop and three paddles on each side, and the vessel was to be armed with rockets, as mentioned in a previous lecture, and with quick fire, to be forced under water by means of pumps. This vessel was never built.

In 1854, James Nasmyth, an Englishman, proposed a form of boat to be almost completely immersed and resembling a gigantic mortar. Plate II, Fig. 2. This mortar was to be charged with a huge bomb cylindro-spherical in shape, and fired by a percussion arrangement on contact with an enemy's vessel.

In 1859 a submarine boat was exhibited in London by an American named Delaney, of which the following is a vague description: The boat was egg-shaped, in transverse section, and diminished nearly to a point at each end. There was a rudder at one end of a hollow shaft, and the axis of a screw propeller passed through the shaft. There were two iron tanks in the interior, and one had air forced into it by a pump. A pipe with a cock communicated to the other tank, which contained water and had another pipe and cock opening outboard. The engineer of the boat, by forcing water into or out of the second tank by means of the air in the first, was enabled to raise or lower the boat in the water. She was propelled by steam, and provision was made for purifying the air; but how these two latter results were to be accomplished is not stated.

In the early part of the war the United States Government constructed a submarine boat for the express purpose of blowing up the Merrimac. Its inventor was a Frenchman, to whom the Government paid $10,000 for his machine and entered into an agreement with him by which he was to operate the vessel against the enemy under command of an officer selected by the Navy Department. This boat was built at the Washington navy yard of boiler iron, treble riveted, in the form of a cigar, 35 feet long and 6 feet in diameter. She was to be sunk by admitting water into a watertight compartment, which extended along the entire length, and raised on expelling the water by means of two force pumps. The weight of sixteen men was required to sink her when the water compartment was full, and she was propelled by sixteen oars, eight on each side, each constructed on the principle of the webbed foot of a waterfowl, the blade being formed of two pieces hinged together. With these oars a speed of 2½ knots per hour could be obtained on the surface. A row of thick glass "dead lights" admitted light to the interior.

The boat was provided with a chemical apparatus for the manufacture of oxygen, and another containing lime and having a bellows attachment, by which the air was to be forced through it for purification. Owing to the disappearance of the inventor neither apparatus was ever tested, it being generally considered a swindle. Nothing was ever accomplished with the boat beyond a few experimental trips to the bottom of the river; but it is said that a part of the Frenchman's design was to emerge from the boat in submarine armor, and, having attached a torpedo to the vessel underneath which the boat was submerged, to return to the boat and leave the torpedo to explode by its own machinery.

About the same time, a Frenchman named Villeroi constructed, in Philadelphia, a plunging boat of 35 feet in length and 44 inches in diameter, (Plate II, Fig. 3.) Its motion was obtained by means of a screw three feet in diameter, and the introduction of water for submersion was effected by a pump, through tubes of gutta percha.

Near the end of 1863, an American named Alstilt is said to have constructed, at Mobile, a submarine boat, of which, like that of Villeroi, only a drawing, (Plate II, Fig. 4,) and an unsatisfactory description has been obtained. It was made of sheet iron, and was 65 feet long, with a deck near the centre, which divided it into two parts. Above the deck was the machinery, compressed air and gear for working two rudders, while below were a number of compartments for water, coal, &c. The propulsion was effected by a screw, put in motion by a steam engine and two electric engines. When moving on the surface, the lower compartments, forward and aft, were filled with air, and steam was used to drive the propeller; but on the appearance of an enemy, the boat was to plunge beneath the water by filling the tanks with water, instead of air, and thus increase the specific gravity of the boat, the fires being hauled at the same time, and the electric engines put in operation. The pilot remained in the pilot-house forward, which was furnished with large dead lights, while the remainder of the vessel was supposed to hold itself at a depth of three feet below the surface of the water.

In 1863, Rear Admiral Bourgois, of the French Navy, launched at Rochefort a plunging boat, (Plate III,) which is said by French authorities to be far superior to anything of its kind that has ever been constructed. Its form is that of a great fish or cigar, flattened on one-third of its circumference. It measures 44.5 metres in length and 3.6 metres in height, its draught of water being 2.8 metres when on the surface. Its stern is furnished with a screw, a vertical rudder, and two horizontal ones. It contains an engine of 80 horse-power, driven by compressed air, and a large number of reservoirs, in the form of tubes, in which air is compressed to twelve atmospheres. Immediately below the air reservoirs are placed others for the reception of the necessary water to sink the boat, the water being driven out on occasion by admitting the compressed air. In addition, the boat is provided with a mechanism by the aid of which a portion of its back or deck can be detached, and become, at the same moment, a life boat for the crew, composed of twelve me n This boat was launched in May, 1863, from which time till February, 1874, she was made the object of a series of experiments, both in the river Charente and in the open sea. The trials were, of course, said to be very successful. It is difficult, however, to ob tain reliable information pertaining to any government invention in France, and the great success of these trials may perhaps be doubted.

Von Scheliha, in his Coast Defence, refers to the model of this submarine boat, which was on exhibition at the Paris Exposition, in 1867, but which no one was allowed to approach for examination. His description of the boat itself is as follows: "The boat is entirely built of iron, and is about 140 feet long by 10 feet deep, and 25 feet beam. The deck has a top about 70 feet long by 7 feet wide, and 4 feet high. The boat is propelled by a screw, about 7 feet in diameter, which is placed, in the ordinary way, between the rudder and stern post. The screw is driven by a pair of inclined engines, the motor being compressed air. Twenty-one copper cylinders, with rounded ends, serve as receptacles for the air, which is compressed to about 200 lbs. per square inch. These cylinders connect with the supply pipe of the engines, and with another pipe, by which the crew is supplied; they contain about 130 cubic metres of air. A small pump, worked by compressed air, serves to fill or empty a water tank at the bottom of the boat, and there is also an apparatus on board, of which it is said that by means of it the boat may, with a single turn of the hand, be immediately lowered or raised from or to the surface. This is probably some apparatus capable of taking in or discharging a large amount of water very quickly. The top of the deck forms part of the pilot-house, and is provided with a glass window; it has also four man holes similar to those in steam boilers, through two of which the crew enter the boat.

"The middle part of the top is bent to the shape of the life-boat, which is secured by screws reaching to the interior of the top. This life-boat is constructed similar to the large boat, and perfectly air tight; it is about 25 feet long, 6 feet wide, and 3 feet deep, and has four man holes, two of which fit exactly over two man holes in the top part of the deck, serving as a means of communication with the large boat; the other two are on the sides of the life-boat, and are probably intended for the passing out of oars.

"The steering apparatus consists of one ordinary rudder and two horizontal ones, about seven feet long, moving on the same axis, near the stern. A small screw, moving on a vertical shaft above the boat, is intended to increase the speed with which she may be raised or lowered. A torpedo spar is provided, which is an immovable tube, about 14 feet long, and to it is attached a cast-iron torpedo, to be fired by electricity; its insulated wire leads to the pilot-house, where the battery is located."

Von Scheliha also states that "it is said that the French have experienced great difficulty in steering this boat when immersed." This is not to be wondered at, when one considers the difference of shape of the upper and lower portions.

Of the submarine boat which destroyed the Housatonic, I have been able to obtain but a limited description. It was built of boiler iron, was about 35 feet long, and was manned by a crew of 9 men, 8 of whom worked the propeller by hand, while the remaining man steered the boat and regulated her movements beneath the surface. She could be submerged at pleasure to any desired depth, or could be propelled on the surface, and in smooth still water she could be exactly controlled; the speed being about 4 knots, while the length of time under water without inconvenience to the crew was half an hour. It was intended that she should approach any vessel lying at anchor, pass under her keel and drag a floating torpedo after her, which would explode on striking the bottom or side of the ship attacked. This was not, however, the manner in which she was used in attacking the Housatonic; the torpedo was then attached to the bow of the boat, and from the shock of the explosion she probably filled, as she was found by a diver after the war to be lying on the sand with her bow pointing in the direction of the hole in the ship's side, which the torpedo had made. It is probable, too, from the fact of her being in sight from the deck of the Housatonic for some two minutes before the explosion occurred that on this occasion she was merely used as an ordinary cigar boat, and no attempt made to submerge her at all.*

It is said by Sarrepont that in 1864 a Spaniard, named Narciso Monturiol, constructed a submarine boat, to which he gave the name of "Ictineo." After a long series of experiments, crowned with success, a national subscription was opened in Spain to recompense the inventor, and a royal decree put at his disposition the material of the navy yards for the production of a boat of large dimensions on his plan. The new Ictineo was launched in the fall of 1864; but all experiments with it have been kept secret, and all that is known to the public is that the boat is entirely covered with a sheathing of brass, that the hatches or lookouts are capable of great resistance and will sustain the most violent shocks, and that there deadlights are defended by a species of orbit like those sunk in the skulls of animals.

The same author also states that in 1865 a mechanic of Stockholm invented a submarine boat, and one was also produced by a Frenchman named Deschamps, which, besides the usual apparatus for taking in and discharging water, is provided with a pump for expelling the vitiated air, while another pneumatic apparatus draws in fresh air from the surrounding water. (?) For working without the boat the operator passes his arms through openings to which are attached rubber sleeves.

After the war the first submarine boat which gained any notoriety in this country was the "Intelligent Whale." (Plate IV.) She is 26 feet long by 9 feet deep; made of boiler iron about ½ inch thick, and has one center and two bilge keels of heavy timber. Propulsion is effected by a four-bladed screw, driven by four men at the cranks. * * Two small copper tanks (S, S) contain air under a pressure of 600 pounds per square inch. Two large tanks

* In the course of the various attempts made to use this boat she sunk four times, destroying the lives of thirty-two out of thirty-six men who formed the four crews.

(E, E) contain water for sinking the boat, and communicate both with the air-tanks and with the water outside of the boat. H is a rudder, and I, I are fins for controlling the motions of the boat in any direction when under way. A is an iron cupola, having bull's eyes in it for the look-out. A compass to indicate the course, a water-gauge to show the depth, and an air-gauge for showing the pressure of air in the boat, are also provided. At F F are square gates, which can be opened when required. The entrance is a circular opening at J. Two 15-inch shot are fitted, one at each end, for anchors; the cables are wire rope, and the windlasses work in water-tight boxes at T T. An apparatus is also provided for spraying water through the air when it becomes foul, and thumb valves are also supplied in the top of the boat for allowing the foul air to escape. The water-tanks are filled, for sinking the boat, by opening a valve, and can be emptied by pumps, or the water can be forced out by compressed air being let in.

This boat will hold 13 persons, and has been tried in the Passaic river with that number on board. Her speed is about 4 knots, and she functions as follows: To sink, let the water into the tanks E, E, till the boat passes slowly beneath the surface; the four men then work the cranks and propel the boat, the man at the look-out working the fins and steering. Having arrived at the proper position, if on soundings let go anchors; let air from tanks S, S, into the boat until the air-gauge shows a pressure greater than the pressure shown by the water-gauge at that depth; then open one of the gates F, F. A man in the submarine armor then passes out of the boat carrying an electric torpedo, the wires of which pass through holes in the side of the boat. Having placed his torpedo underneath the vessel, he returns, and the torpedo is fired by a battery within the boat. Wishing to rise, the gate F is closed, communication is opened between the air and water tanks, and the water is driven out, causing the boat to rise.

The United States Government had intended purchasing this boat and an instalment of the price was paid; but a difficulty arising as to the ownership of the boat nothing was done, and she lay at the Brooklyn navy yard for several years. A trial was at length ordered in 1872, and a board of officers assembled to report upon it. The result was a complete failure. A superior boat could probably be built for one-fourth her purchase money.

In 1869 Passed Assistant Engineer John W. Kelley, U. S. N., submitted plans for the construction of a submarine boat. He proposed a cigar-shaped vessel, to be propelled either by steam or by hand. In using steam he proposes to bottle it up at a pressure of near 200 lbs. per sq. in.; then to draw his fires, and he thinks he will be able to run at high speed for about half an hour before his engine gives out. In running by hand, he calculates that four men will be able to propel it at a rate of about three knots per hour. The vessel is to contain air enough to last the crew for half an hour, and it is to be steered by a rudder and fins, being also provided with a water chamber and pumps for effecting changes in the specific gravity. The boat is intended for using torpedoes, which the inventor proposes to throw out from tubes placed in different parts of the hull; some pointing ahead, some astern, and some on each side; the propelling force being a blow from a stout elliptical spring. There is no method proposed for purifying the air or of supplying fresh air without coming to the surface.

In 1869 also, Dr. Barbour, of New York, submitted plans for a submarine boat, the main features of which are represented in Plate V. The boat is about 22 feet long, 3 feet wide, and 5 feet deep, [outside measurement.] She is to be constructed, however, in a peculiar manner. A, A′ are upright cast-iron vessels, firmly bolted together and communicating with each other and with two conical cast-iron vessels, B, B′, which are bolted to them as shown. The outline of the vertical section represents a heavy wrought-iron band, flattened along the top and bottom of the boat, where it is firmly secured to the cast-iron vessels. At the bow and stern it is flattened in the opposite direction to a thin edge. T, T, T are wrought iron tubes of a capacity of about eight cubic feet, and are secured, between the wrought iron cut-water and the vessel B′, in the lower half of the bow. The spaces between the iron vessels, pipes, &c., &c., are to be filled in with wood, and the whole boat then covered with copper. The shaft is a tube 3 inches in diameter, having a thrust bearing at the after end of the vessel, B, and the propeller is surrounded by guards. A pair of oscillating engines, of eight-inch stroke, (not shown,) connect with the main shaft by gearing and extend outside of B into the vessel C. The rudder is a double fish tail, moving on a ball and socket joint at D; at the four corners are attached wires which lead through sheaves at *b*, *b*, and thence through the end of the hollow shaft to the wheel at E. This wheel works on a ball and socket joint, so as not only to move the perpendicular rudder, but also the horizontal one, the wires being connected with the spokes, which are pulled fore and aft instead of revolved. Two fins, H, H, on the sides of the boat, assist in elevating and depressing when the boat is in motion. Lead ballast is placed in the spaces at the bottom of the boat as shown, and the corresponding spaces, I, I, I, at the top of the boat, contain vessels which are to be filled alternately with air or water for controlling the buoyancy. The man-hole for entrance is at the top of the vessel, A′, where there is also a small sliding cylinder, K, which shoves up a few inches above the boat, having dead-lights in its sides for the purpose of observation. Other dead-lights are to be placed in different parts of the boat, and a water gauge is used to show the depth at all times. The motive power is derived from liquid ammonia or carbonic acid gas.

As regards the atmosphere, the inventor remarks as follows: "The occupants of the boat are to be entirely independent of the external air. A hundred or a hundred and fifty cubic feet of oxygen can be forced into two cubic feet of tube space by my pumps in a few minutes, and this amount will supply the two men, together with a light, for from 8 to 10 hours. The gas is permitted to escape into the boat as required by fine capillary tubes, using one or more according to the pressure. The impurities of the atmosphere thrown off by the occupants are to be taken up by means of absorbents. A small wooden keg, mounted on axles formed of two pieces of tube, partly filled with a solution of potash, and is entirely filled with fine shavings, such as are used for mattresses. A rotary blower passes a continuous stream of air through the upper part of this keg, from which it passes through a vessel containing chloride of calcium. Every half hour or so this keg requires to be revolved on its axle a part of a revolution, so as to present to the current of air a fresh surface of the shavings and to dissolve the carbonate of potash from those which were at the top. This single operation, together with the requisite supply of oxygen, will keep the atmosphere in its normal condition for any length of time." The inventor states that he has tested his apparatus and theory for hours by hermetically sealing himself up in the shell of a steam boiler, and always with success.

For war purposes, the inventor proposes to secure in the top of the boat a number of nitro-glycerine shells, X, X, X, with buoyancy imparted to them by means of an outer casing. A fine wire cable is coiled under each, one end of which connects with the fuze in the shell, and the other passes through, and is attached to, a thumb-screw on the inside of the boat. There are two operators required to manage the boat; one in A, who attends to the engine; the other in A′, who steers and handles the torpedoes. In an attack, the boat is to pass under the enemy, and while there, the operator in A′ detaches one of the shells by turning its thumb-screw. The shell rises under the vessel, and the operator, who retains the end of the wire in his hand, can make contact with the battery, when he feels the shell strike. No boat of this description has yet been constructed, and if attempted it would probably require a large number of alterations in the original plans.

In 1872, plans were received here of a submarine boat, submitted by Mr. Rowell, of Wisconsin. His description and drawing are both indefinite, but a general idea may be gathered from the following: The shape is that of a cylinder with conical ends, Plate VI [omitted,] the cylinder being 17 feet long and 7 feet in diameter, while the total length of the boat is 34 feet. On the upper side of the cylinder is a turret seven feet long and two feet high, open at the bottom. In and under the turret sit the operators. The conical ends of the boat serve as chambers for a supply of compressed air, and have a capacity of about 450 cubic feet, the air being used to drive a small engine, which works two propellers—one at each end of the boat. Adjustable weights, *x x*, travel upon a rod parallel to the axis of the boat, by means of which it is intended to change the direction; the boat is also supplied with vertical and horizontal rudders [not shown.] No arrangement for torpedoes is made. Mr. Rowell's boat may be said to present little that is new, while the objections to it are numerous.

We now come to the Phillip's submarine boat, (Plates VII and VIII,) which I have reserved to a later portion of the lecture than that to which it belongs chronologically, from the fact of its being the most complete invention of its kind with which I am acquainted.

The inventor launched his first boat on the waters of Lake Michigan, in 1851; it was cigar-shaped, 40 feet long and 4 feet in greatest diameter, and in the course of a few years he so far perfected his arrangements for purifying the air, &c., that on one occasion he took his wife and two children with him, and spent a whole day in exploring the bottom of the lake; he also had a 6-pdr. gun mounted in this boat, and with it descended, and fired shot up through the bottoms of hulks that had been anchored for the purpose. His plans may be generally described as follows: The vessel is to be cigar-shaped, though this may be modified according to circumstances, being careful to preserve, however, in all cases a circular cross section, which is necessary, in order to give the required strength to resist compression when at a great depth, as well as to make her steer with equal facility in all directions. The longitudinal section may be that of a cylinder in the middle and of an ellipsoid at each end, or the ends may be ogival. The internal arrangement of the boat is as follows: Water tanks, W, W, W, (Plate VII,) run fore and aft of the cylindrical portion of the boat, on each side of, and underneath, a midship passage way; they are of sufficient capacity to submerge the vessel, when they are partly filled with water, or to raise her when they are empty, and the remainder of the vessel full of water. Each tank has a cock [not shown] connecting it with the external water, all the cocks, except the centre one, being worked by a single rod; there is also a cock on top of each tank for permitting the air to escape from it into the air space [or country] of the boat, and a pipe with a cock [not shown] connecting it with the compressed air cylinders A, A, A, which are arranged along the skin of the vessel, just above the water tanks.

At C is a lookout or cupola capable of sliding up and down, and underneath is the wheel and compass. O is an air pipe capable of sliding down in a socket, so as to come wholly within the boat; but when slid up, as in Fig. 2, it enables the occupant of the boat to receive fresh air when still about four feet under water. R, R, are rudders for lateral steering; no diving rudders or fins being used, as all vertical motion may be effected by the admission and discharge of water. F, F, are anchors worked by small windlasses. The bow of the boat works with a hinge, so as to be removable at pleasure, [in several of the inventor's designs the whole forward compartment is made movable,] the object being to facilitate the use of tools outside the boat. Abaft this false bow is a bulkhead, through the centre of which works a ball and socket joint, and through this ball a sleeve; through the sleeve, properly constructed, saws, chisels, augurs, &c., can be worked at pleasure. At T, T, are other apertures for the use of a greater number of tools, while around the universal joint in the bow are dead lights to facilitate the work when not at a very great depth. The whole body of the boat is provided with dead lights as shown, but when very deep in the water a peculiar lamp, constructed by the inventor, is used.

The purification of the air is effected as follows: Along the top of the water tanks runs a pipe [not shown] connecting with the air pump, S, and at intervals along this pipe hang pieces of hose terminating in rose heads, *v, v, v, v, v,* &c. The air pump is also connected on the suction side with a pipe opening into the country of the boat, and by working the pump the foul air in the boat is drawn in and forced through the pipe in the top of the water tanks and out at its only openings, the rose heads, *v, v, v, v, v,* &c. This causes the air to be disseminated through the water in fine particles, which rise in bubbles to the surface, and is thus washed free of its carbonic acid, which is absorbed by the water. The air thus passes again into the country through the vent cocks in the tops of the tanks. The inventor has found this method of treatment sufficient to keep the air respirable for ten hours when three or four occupants were in the boat, thus enabling them to use the compressed air solely for working the boat, tools, &c., and moreover always have the air for breathing at the normal pressure of the atmosphere. As soon as the water in the tank becomes foul it it forced out by compressed air and fresh water admitted.

The boat is kept at any given depth by an apparatus in the middle of the boat which works automatically, and whose position is indicated by the letter *d*, in Fig. 1, Plate VII; the gate of the center tank of the boat being at D. Plate IX [omitted] illustrates the principle of this ingenious arrangement, and its operation may be thus explained. If all the tanks except the one in the center of the boat be filled with water it will bring her top or back just awash. Wishing to sink still deeper, the outboard cock I, in the center tank (Fig. 1, Plate VII) is opened, and, the water rushing in, the boat begins slowly to sink beneath the surface. The apparatus in Fig. 1, Plate IX, then functions as follows: The tank A, with its hollow ball and sealed shaft, forms the index of depth; the shaft working airtight through the top of the tank. C is a sleeve secured at pleasure to the shaft by the thumb-screw F. The arms L and E work in a slotted joint upon this sleeve. The two B's are sectional views of the same tank, [the center one in the boat,] in which A is enclosed, communicating with it by H, H. The interior tank, A, determines the depth of submergement, the gate D being wide open, by the action of the water pressure upon the ball and shaft. If, for instance, the desired submergement be indicated by the number 20 upon the shaft, the sleeve is moved till 19 appears just above, and is secured in that position by the screw F. This operation first levels the arms L and E, the instant effect being to open the valve I, and by giving egress to the air to admit water into the tank B. The increased volume of water and decreased one of air in B causes the boat to descend. Meanwhile the pressure due to the increased depth compresses the air in A, and by the forcing in of the water through H, H, elevates the ball and shaft and contracts the angle of L and E till I being closed the valve K is opened and compressed air admitted in such volume as to expel any superfluity from B through D. Thus the reciprocal action of the valves I and K will regulate the depth of the boat.

Besides suspending the boat at any given depth, the inventor has also devised an apparatus for keeping it on an even keel, so that it will always be parallel to the surface, and the moving of weights from one end of the boat to the other will not disturb its equilibrium. Its exact position is not shown in the smaller drawings, but the principle is shown in Fig. 2, Plate IX, [omitted,] which illustrates the action of the one fitted to the after part of the boat. The ball S, with its shaft, hangs in the after part of the country like a pendulum; the tank P and valves L and Z being very near it. If the bow descends the ball deviates from the perpendicular and opens the valve L, which allows the air to escape and more water to enter the tank, while a similar apparatus at the bow causes water to be forced out of its tank by compressed air at the same instant. If the stern descends, the valve Z is opened instead of L, and allows compressed air to rush in and drive out the water, while the bow apparatus reciprocates as before. Their united action keeps the boat on an even keel, or rather it always has its longer axis parallel with the surface.

The propeller is two-bladed, and usually worked by hand. In his original boat the inventor gained a speed of 4½ knots per hour by this means, with two men at the cranks. He has, however, devised a steam-boiler to generate steam under water for driving an engine continuously. This plan is shown in Fig. 1, Plate VII, though it has never been tried practically. The boiler is an upright one, and is shown in the after part of the boat. The smoke-stack has an elbow init, and in one arm of the elbow a valve, J, which prevents the ingress of water. The fire-box is made perfectly tight; the shute by which coal is passed in being closed by a cylinder (L) across the end of it. This cylinder has a hole in the upper side of it, into which coal is passed; the cylinder is then turned round until the hole in the upper side corresponds with the hole in the end of the shute, when the coal slides into the fire-box, the shute being kept perfectly tight during the whole operation. M is a poker working through a ball-and-socket joint. K is a pipe leading from the compressed-air cylinders to a perforated pipe under the grate, and in this pipe, at the point K, is a valve, the stem of which connects, by a rod and suitable crank-arms, with the stem of of the valve J. When on the surface the valve J falls open from its own weight, closing, at the same time, the valve K, and the draught of the fire can be regulated by opening suitable orifices in the ash-pit. As soon, however, as the boat sinks the water rushes into the chimney and closes the valve J; this, however, opens the valve K, and the compressed air, rushing into the fire-box, passes up the chimney with sufficient force to open the valve J and force back the water, thus causing the fire to draw artificially. This arrangement is very ingenious, and theoretically it would probably work, but it would seem that in practice the apparatus would heat the entire boat so much as to render the air within it unendurable to the operators.

The air-cylinders which contain the large supply necessary for the different operations of this boat are about 8 feet in length and 13 inches in diameter, made of ¾-inch iron, riveted, and the seams brazed. In these the inventor claimed that he could "put up" a pressure of 500 lbs. per sq. in. by a small two-cylinder air-pump worked by himself.

Plate VIII shows a form of Mr. Phillips' boat designed for war purposes. The construction is generally the same as that in Plate VII, except that the diameter is about one-eighth the length instead of about one-tenth, and the upper part is heavily plated for protection against grape and small arms. Underneath the cupola is the wheel. At C is the recess for torpedoes, which are placed in an opening in the cylinder underneath, the cylinder being then turned till they pass up through a corresponding opening in the bottom of C.

At H is a submarine gun working through a ball-and-socket joint, the muzzle passing snugly through the ball, and when run in after firing the port is closed by a slide running through the ball in a direction transverse to the port-hole. At E is a rocket to be fired just along the surface of the water, as described in a previous lecture, carrying with it a torpedo, F, which it picks up on its discharge by means of a hook, which catches in a ring at the end of a rope coiled down over the head of the torpedo. The torpedo is provided with a pair of diving fins, and when the rocket, which carries a large bursting charge, strikes and explodes, the torpedo dives and bursts under the bottom of the ship attacked. The chambers which contain the rocket and its torpedo both work on the ball and socket principle, the loading-hole being on the after side. In the forward part of this boat the inventor has also made arrangements for working numbers of saws and other tools for clearing away obstructions.*

The inventor of this submarine boat has also a complete wrecking system, comprising armor, camels, &c., of his own invention, which seem generally successful in their application. The subject, however, is rather foreign to the matter before us, and I will, therefore, merely state that his general plan is to sink his boat far enough under water to be beyond the influence of waves, and then to anchor her, bow and stern. A hatch is then opened in the bottom, and the armor, capable of withstanding the pressure 1,000 feet deep, descends to the scene of the sunken wreck, with its double-channeled hose. The man in the armor then drills holes in the bottom of the

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* Owing to the obscurity of the descriptions of this boat that have been furnished to this station, I am unable to state with accuracy whether the rocket torpedo, the gun and the recess torpedo are all applied to one boat or not. The drawings furnished show the rocket torpedo in one boat and the recess arrangement in another, while the gun is in a separate drawing, which represents it as mounted in a section of the heavily plated back or top of a submarine boat. The descriptions to which I have had access make no distinction whatever, the impression being given that all three belong to the war boat.

wreck for securing the camels, which are lowered in a collapsed state from the boat. After it is secured the camel is inflated from the boat, and the man in the armor proceeds to secure another, &c., &c.

I have stated that Mr. Phillips' invention dates back to 1851; this, however, only applies to the construction of a submarine boat; the minor improvements and inventions have been perfected from time to time since then. The inventor is now dead, and the plans, without adequate descriptions, however, were sent here in the early part of 1870 by a gentleman, named Blatchford, of New York.*

In February, 1875, Mr. Holland, of Paterson, New Jersey, submitted plans for a submarine boat, (Plate X,) to be operated by a single individual, and therefore to be as small as possible.

Its length is 15½ feet, breadth 1½ feet, and depth, exclusive of the projection on top, 2 feet. She is nearly square in section, with parabolic lines, and calculated for a speed of 5.8 knots per hour on the surface, and three knots per hour when wholly immersed.

The boat is divided into three compartments, and in the centre one, to which water is freely admitted, sits—or rather reclines—the operator, who is dressed in a diver's suit. The motive power is a propeller, 18 inches in diameter, to the shaft of which are connected suitable gears, so that the operator can give the proper motion, by means of treadles, as shown. Both the forward and after compartments are reservoirs of air for breathing purposes; the former to contain a sufficient supply for ten minutes' respiration at the normal pressure, while the latter contains a sufficient quantity, under pressure, to last from 1½ to 4 hours. The two reservoirs are connected together by a pipe and cock, and each has running through its centre a diaphragm of oiled silk, with slack enough in it to lie against either top or bottom, but, at the same time, effectually to divide the reservoirs into two distinct parts.

Respiration is to be effected in the following manner: Over the mouth and nostrils of the operator is to be fitted a respirator, to which two pipes are attached [not shown.] One of these pipes

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*I have been told that Mr. Phillips, who was a shoemaker by trade, met his death in a wooden boat constructed on his principles. He descended in Lake Erie, near Buffalo, and as the boat never re-appeared, it is supposed that he accidentally got too deep, and the boat was crushed by the pressure of the water.

leads to the forward reservoir above the diaphragm, and the other to the same reservoir below the diaphragm, and each is fitted with a valve, one weighing one ounce and the other weighing two ounces, opening in opposite directions—the heavy one being in the pipe of exhalation, and the lighter one in the pipe of inhalation. The pipe from the after reservoir of the boat enters the same compartment of the forward reservoir as the inhalation pipe, while to the other compartment is connected the section of a small air pump, shown in dotted lines in Fig. 1. This air pump is connected to the treadles, so as to be worked by them, and is of such size that it will draw from its compartment above the diaphragm, and expel from the boat, at each stroke, as nearly as possible the quantity of air breathed during that time. A gauge, connected with the forward reservoir, and placed in front of the operator, indicates the pressure there at all times. By opening the cock in the pipe leading from the after reservoir, the air is intended to be admitted continuously under the diaphragm in the forward reservoir, from whence it is drawn through the inhalation pipe to the lungs of the operator, passing back again through the exhalation pipe to the portion of the reservoir above the diaphragm, and from thence overboard, by means of the air pump.

The submersion of the boat is to be effected by means of a tank (not shown) located underneath the gear-wheels, and capable of containing 65 lbs. (1 cu. ft.) of water. When this tank is full the boat will sink, but when partially empty the boat will rise. It is emptied by directing the delivery of the air-pump through it. Underneath the boat is a rudder, to be worked by a tiller attached to the forward end of it by means of a pin, which works through a slot in the bottom of the middle chamber. No diving fins are used, but to effect the same object the operator has two heavy plates of lead connected together, which he can move forward or aft.

The torpedoes are five in number, each containing 30 lbs. of explosive, and divided into three parts to be secured together as shown in Fig. 5. The forward compartment contains a rocket composition and an exploding rod. The center one contains the charge, while the after one fills out the contour of a spindle of revolution, which is the shape of the whole. The parts of the torpedoes are stowed separately in the boat, the middle compartments of each being just abaft the operator, while the ends are in the top of the boat. How

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and it is possible that when the impure air from the boat is forced through the water, as in Mr. Phillips' plan, the water not only washes away the greater part of the carbonic acid and animal impurities, but that more oxygen may be added [as is claimed by Mr. Blatchford] from the oxygen already dissolved in the water. This, however, is not very probable, since the impure air only bubbles through the water and is not completely dissolved in it.

In consequence of the large size of the Phillips boat and the small number of occupants, it is likely that his process keeps the air sufficiently washed from carbonic acid and animal impurities to be respirable at the end of nine or ten hours, although the quantity of oxygen in it is actually less than at first. To my knowledge his process has never been tried in a boat of small dimensions, when the good and the bad qualities of it could be equally demonstrated.

Theoretically, the air in a submarine boat ought to be kept theroughly pure by, 1st, having an absorbent for the carbonic acid, [like quicklime properly arranged;] 2d, an apparatus for generating oxygen or tanks containing it; and 3d, an apparatus for generating ozone [which Dr. Barbour's plan lacks] whenever wanted to convert the animal impurities into carbonic acid and water. Such an arrangement would purify the air of a boat of any size, although from Mr. Phillips' experience it would seem that his method is ample for the size of boat that he recommends, viz: from 10 to 75 feet in length; and it has the special advantage of merely requiring the mechanical manipulation of a pump, which is always ready to function, and avoids the introduction into the boat of chemicals, which must frequently be renewed.

The science of submarine navigation is likely to be one of great importance in connection with the torpedo operations of future wars, both for attacking vessels and for entering harbors and destroying submarine mines and their connections, provided the present partial disadvantages connected with the use of diving boats can be successfully overcome. These disadvantages seem to lie in the present imperfect solution of the problems of light and speed. The problem of speed would not appear to be so important as that of light; but it is great enough to require that some substitute should be found for manual labor, and at present liquid carbonic acid gas would seem to be the most efficient motor, though in the future the electric engine will probably prove the most suitable. The problem of light-

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of lead, weighing 2,000 kilograms, and intended to counterbalance the tendency to roll or list produced by the propellers. There are two propellers—one at each end of the boat—of 7.6 meters in diameter, and having 9 steel blades, 4 of them being smaller than the others, so as to be constantly submerged whether the boat is riding light or not. The anchors are cylindrical castings, weighing each 1,000 kilograms; they stow in tubular openings in the bottom. Major Daudenart advocates vessels of this description to be used for war purposes as follows: "They should be supplied with slender observatory tubes fitted at the bottom with photographic apparatus, by means of which the appearance on the horizon, and all subsequent movements of other vessels would be recorded and rendered manifest to those within without the necessity of rising to the surface."

The Prussians are said, by Captain Bourelly, writing in 1872, to be in possession of three torpedo boats very nearly resembling the one built at Rochefort by Admiral Bourgois. They are of iron, about 20 metres long by from 2 to 2.5 metres diameter. In the forward end is the apparatus controlling the rudder, above which, in a higher portion, is a sight-hole 26 m. m. square, which enables the pilot to see ahead. The chimney is small and low, and situated in the after part of the trunk and a double plating protects the chimney and deck. The crew consists of three or four men. These boats use petroleum as fuel, which burns without smoke or sparks. The center of the boat contains the engines of destruction, though how they are worked is not known. The vessels are to be used at night, and are painted a grayish color. Three others of the same kind are shortly to be built.

[As an instance of the latitude with which some of the accounts given by foreign writers are to be taken, and of the allowance which must be made for a disposition to magnify facts, I may state that since last delivering this lecture, in September, 1874, I have learned, on undoubted authority, that the foundation of the above description of Bourelly (and others) consists of the following facts:

The boats used by the Prussians during the late war were not submarine boats, but simple launches. They were of iron, about 50 feet long by 7 feet beam, and very low in the water, the deck being rounded over like a whale-back. Just forward of the middle of the boat was a low pilot-house, with small glass windows in front.

The operators, of whom there were three or four, stood on a deck below the pilot-house. Abaft the pilot-house was a low smokestack, and beneath this the engine and boiler, separated by a bulkhead from forward. Abaft the boiler the whole after part of the boat was partitioned off into a chamber into which the exhaust of the engine was led, so as to make no noise.

An attempt was made in these boats to use petroleum as fuel, but it was abandoned and Welsh coal substituted. A speed of 7½ knots could be obtained; but at this speed the water boiled up aft and made some noise, while at a lower rate the boat was perfectly noiseless when moving through the water. The torpedo arrangements consisted of an iron socket, having forked legs, which hinged on each side of the bow abaft the stem, so as to have vertical motion only. Into this socket was fitted a wooden spar about 13 feet long, to which the iron torpedo was lashed, [this operation had to be performed alongside of a dock.] A small bowsprit with a sheave in the end was provided for a topping lift, which led to a reel on the deck below the pilot-house. The electric machine for firing the torpedoes was also located on this deck. These boats, of which there were three, were painted gray, and the operators were completely hidden under the whale back, which covered the entire boat.

An experiment to test their qualities of invincibility and silence was made at Wilhelmshafen by the Prussians. On a dark night one of their largest iron-clads, lying out in the harbor, was directed to blow her whistle and make other signals at the first sign of approach of the torpedo boat. In spite of their utmost vigilance, however, the boat was actually alongside before any one perceived it.]

APPENDIX.

The diving bell is first mentioned by John Taisnier, who was born at Hainault, in 1509.

Diver's armor is mentioned by Vegetius, in 1532.

In 1692, John Williams invented a species of diving bell of which a drawing is still to be seen in the Roll's Chapel, in England.

In 1692, also, Papin wrote to Leibnitz concerning a submarine boat invented by himself. It was to be moved by oars at the side and could be cause to rise or sink by pumping air into or out of internal vases. It had a mercurial water gauge, was steered by a rudder, and lighted by glass windows. Air for respiration could be pumped in through a tube by a "Hessian pump, that is to say, a rotary flyer with vanes;" the vitiated air escaped by another tube, while a third enabled the operator to attack an enemy's ship.

About the same time, or a few years earlier than Papin's machine, an Italian named Borelli invented a diving dress very similar to the one at present in use. He also describes a submarine boat of his invention having bags, open to the exterior water, from which the water could be squeezed when wishing to rise. It was to be propelled by oars at the side, and also a flexible broad-bladed oar at the stern, by the vibrations of which the boat would be moved forward on the same principle as a fish swims by vibrating his tail.

In 1693, a patent was granted in England to John Stapleton for a diving dress, a submarine boat, and a method of "defecating" or purifying the air after breathing; hardly any description is, however, preserved.

In 1722, some experiments are said to have been made by Dirnis, of Bordeaux, an account of which is given in the "Journal of Encyclopedique," of August, 1772. From this we learn that his machine carried ten persons a distance of five leagues, below water, in the bay of Biscay, and that it remained below for four hours and a half.

From the time of Fulton up to the present, several patents have been taken out in England for submarine inventions; but none of them seem to have been much experimented with or to have had much success. In 1805, John Schmidt and Robert Dickinson invented a sort of diving machine which was to be moved by oars working at its lower edge. In it the carbonic acid generated by respiration was to be absorbed by a caustic alkali. This is noticeable as being the first time, apparently, that this means was used for the purpose.

The next English patent was granted in 1854, to J. H. Johnstone, for a vessel, invented by Messrs. Payerne and Laninal, with several interior compartments. The propulsion was to be effected by a steam engine whose fuel was a "chemical composition."

The following year Casimir Deschamps and Charles Vilorcq patented a machine called a "free diving boat" to be propelled by a screw turned by hand. Its chief peculiarity consisted in an arrangement for an electric light at the top.

In 1859, a submarine boat was invented in England, by J. M. Mason, in which the chief peculiarities are specified as consisting in the compression of the air before descent, and its increased compression by means of the generation of carbonic acid gas within inflatable rubber bags.

A few years ago a boat was patented in England by Mr. Merrian, an American. The boat is ovoid in shape and consists of several compartments in one of which the crew can work, while the others are used as reservoirs of compressed air. The bottom is a heavy cast-iron plate in which are several doors. Forward is a bar with suitable gearing for attaching a torpedo without going out of the boat.

About the same time another foreign patentee took out a patent for a boat consisting of two concentric cylinders between which water was to be admitted.

W. Bauer, of Munich, in 1853, invented a submarine boat which was to be driven by a gas engine. The air was to be supplied from above by pipes. In the sides were holes with water-tight sleeves, (as in Williams' invention, in 1692,) through which the arms of a man could be thrust for doing work outside the boat. The same inventor, in 1866, patented a submarine vessel capable of a certain amount of independent motion by aid of a screw propeller, but it is intended to be let down by chains from a ship.

In the division of Sarrepont's book, which is devoted to America, he states that a few years ago a Mr. Roeber built at Newark, N. J., a cigar boat 9 metres long and $2^{m}.15$ diameter. The shell of the boat, which was of sheet iron, contained a chamber capable of accommodating six or eight men, of which number two or three were sufficient for turning the handle of the propeller. The inventor also furnished his boat with many coils or rolls of electric wire of a length of two or three miles, for the purpose of keeping up communication with the shore. The same inventor designed the plans of another boat of a similar description except that it was to be $22^{m}.86$ in length and was intended to carry an offensive torpedo by means of a spar which rigged in and out through a sleeve in the bow.

The latest foreign invention in the field of submarine navigation, of which I have been able to obtain a definite account, is that of M. Toselli, which, although not exactly a submarine boat, is still not a diving bell, but something between the two, and is intended to be used for torpedo purposes in times of war. It consists (Plate II, Fig. 5) of a cylinder of boiler iron 40 inches in diameter and 10 feet high and is divided into four compartments. The bottom division A, contains lead, and serves to hold the vessel in a vertical position. B can be filled with water by opening a cock communi-

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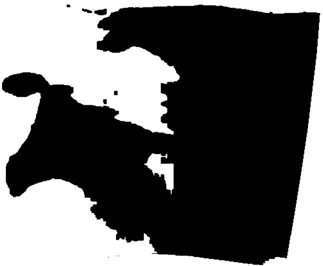

Francisco; but I have as yet failed to find a satisfactory account of it and so far it has, I believe, never been used under water. It was launched in the latter part of December, 1874, but on the trial trip, no attempt was made at submergement on account of some neeessary alterations required in the ballast; it was said, however, to function well on the surface. As in the case of most inventions of this nature, its construction has been carried on with the utmost secrecy, and the following account is the best I have been able to obtain.

The boat is 11 feet long, and 4 feet deep, with 4 feet beam, and is described as resembling a miniature monitor with a hexagonal instead of a round turret on deck. But that which might be mistaken for a turret, is simply a manhead or trunk. The main hold, which extends from the centre of the boat to the stern, is almost entirely taken up with machinery of the most complicated description, leaving but little space for the occupant. A forward hatchway opens into a cistern which will hold forty gallons of water, introduced and expelled by means of a force pump inside the boat and under control of the operator. The water passes in both instances, through a hole perforated amidships under the keel, and carried through a small rubber hose to the cistern.

When the operator desires to sink his vessel, he fills his cistern with water, which takes her down by the head, and when he wishes to ascend, he empties his cargo of water below, and the boat comes up bows first. The manhead or trunk is three feet long, and from one to two feet wide. It is closed over with a hatch cover, held down inside by two iron claws which are secured by two iron rods. A slight pressure on these rods in a given direction instantaneously loosens the claws and the hatch cover springs open. In this way the inventor proposes to escape from the boat should anything go wrong while below, with his machinery. The manhead has five small apertures for light, four of the six sides and the top having a window of French plate glass. On either end of the manhead, extending upward several feet, are two wrought iron rods, intended to facilitate the escape of the operator in case of danger, who uses them to force himself from his place. To the after rod is connected by a number of strands of wire, a contrivance which resembles a steam whistle. It is made of three sections of gas-pipe, telescoped into each other, surmounted by a cap. In the second section of the pipe is a tumbler, connected with a screw on top, which is attached to a wire below, at the command of the operator. This tumbler makes the upper section air-tight. It moves up and down within the pipe and the operator can, by means of it, expel through the water the foul air from the boat. (?)*

The steering apparatus is the essential feature of the invention. The screw consists of two blades and looks like the arm of a windmill. It is controlled by a snake shaft. This shaft or chain is made of peculiarly

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* This apparatus is probably intended merely to function like the air-pipe O in the Phillips boat, Plate VII, to enable the operator to obtain fresh air when several feet below the surface.

shaped brass links, so fitted together as to permit it to be twisted in any conceivable direction. The revolutions of the fans are governed by this shaft, and by complicated machinery, specially prepared for the purpose, the fans are thrown to any desired angle, and revolved by the snake shaft. The external machinery, at the stern, is used to change the position of the propeller, which is thus also used as a rudder, and the operator can, at pleasure, shift his directing and propelling power to any point of a sphere. In this vessel everything is at the command of the operator, from his position in the centre of the boat. On either side of him two small wheels, attached by ropes to arms fitted on the shaft of the propeller, enable him to throw the apparatus into gear on the right or left, and a similar wheel in front of him is used for bringing it back to a central position. The propeller is worked by treadles, like the pedals of an organ, and by hand levers, like those of an invalid's chair. A single turn of the controlling wheels brings the propeller to any desired angle, and the levers and pedals are so arranged that the boat can be worked backward or forward with equal facility. The anchoring apparatus is said to be complete and easily worked.

DESCRIPTION OF PLATES.

Plate I.

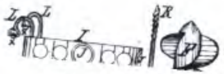


Plate 11.

Fig. 1.

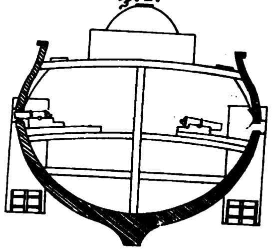


Fig. 2.

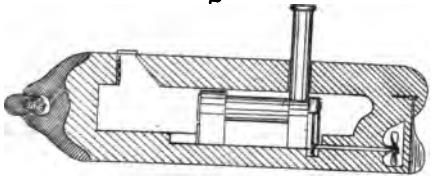


Fig. 3.

Fig. 4.

Fig. 5.

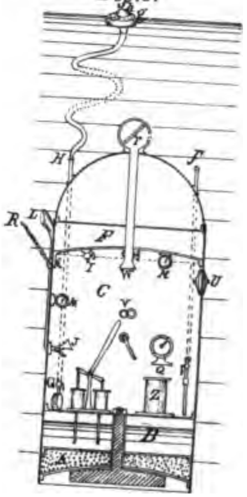
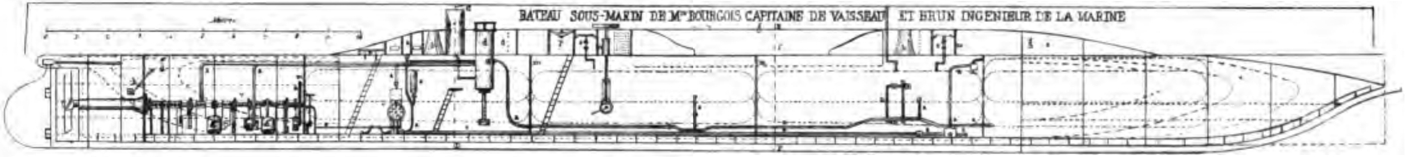


Plate 111.



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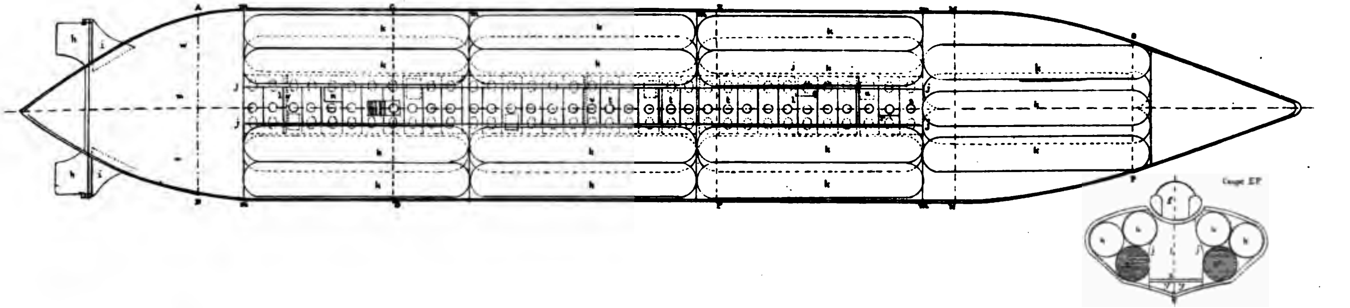

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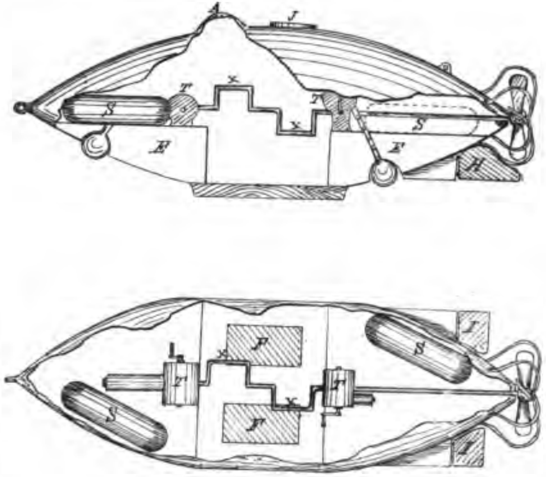
Plate IV.



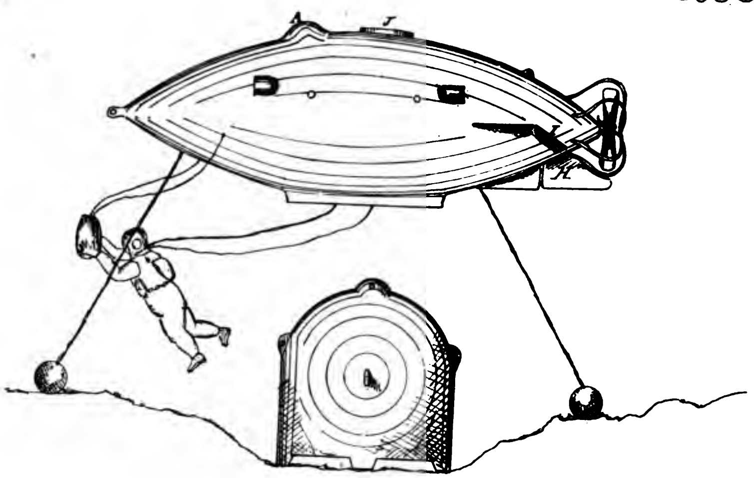


Plate V.

Fig 1.

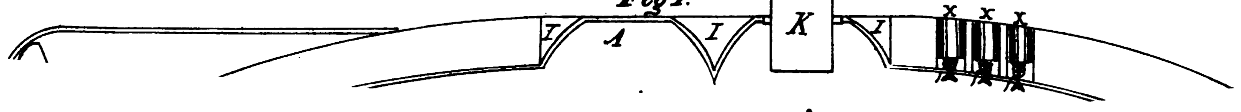


Plate VII.

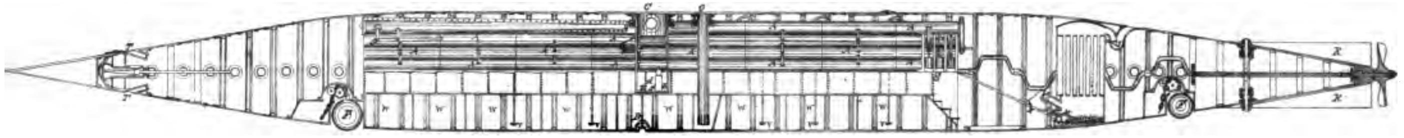
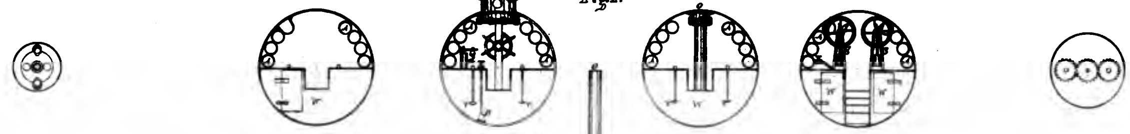


Fig. 1.



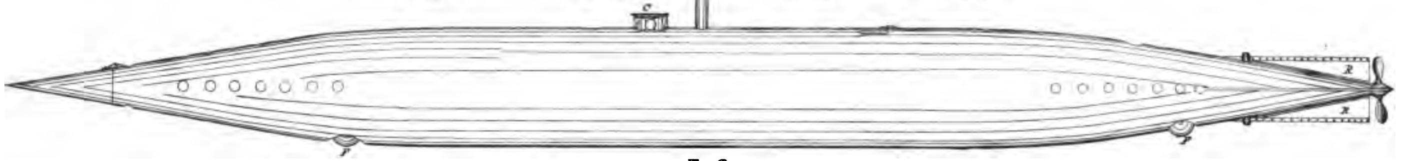


Fig. 2.

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Plate VIII.

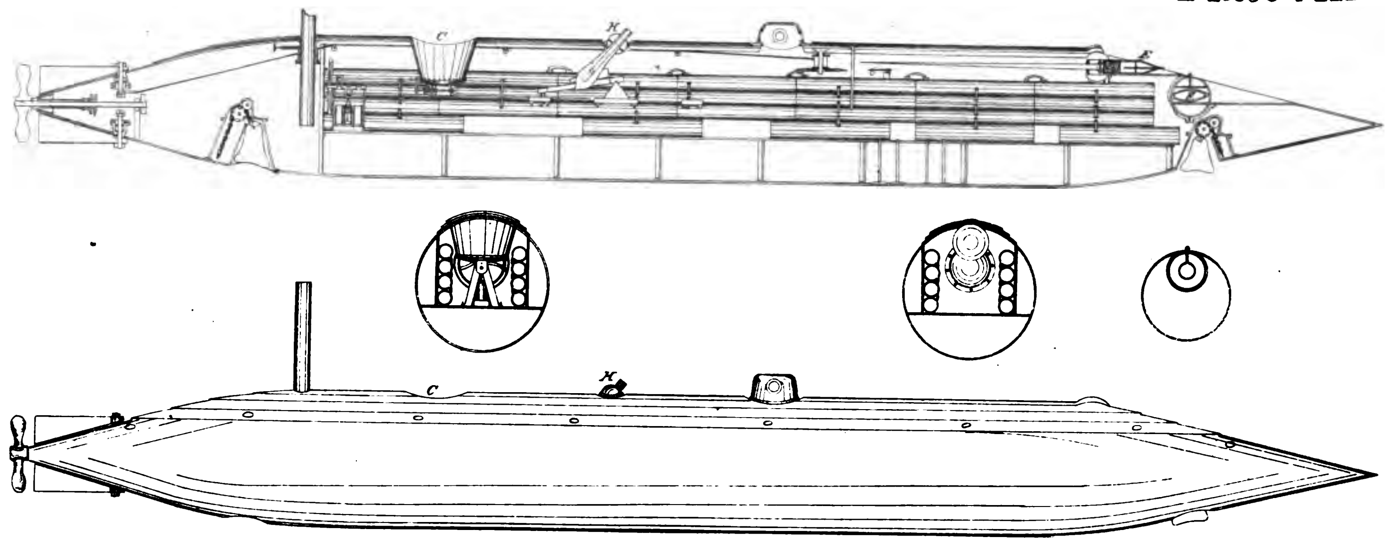

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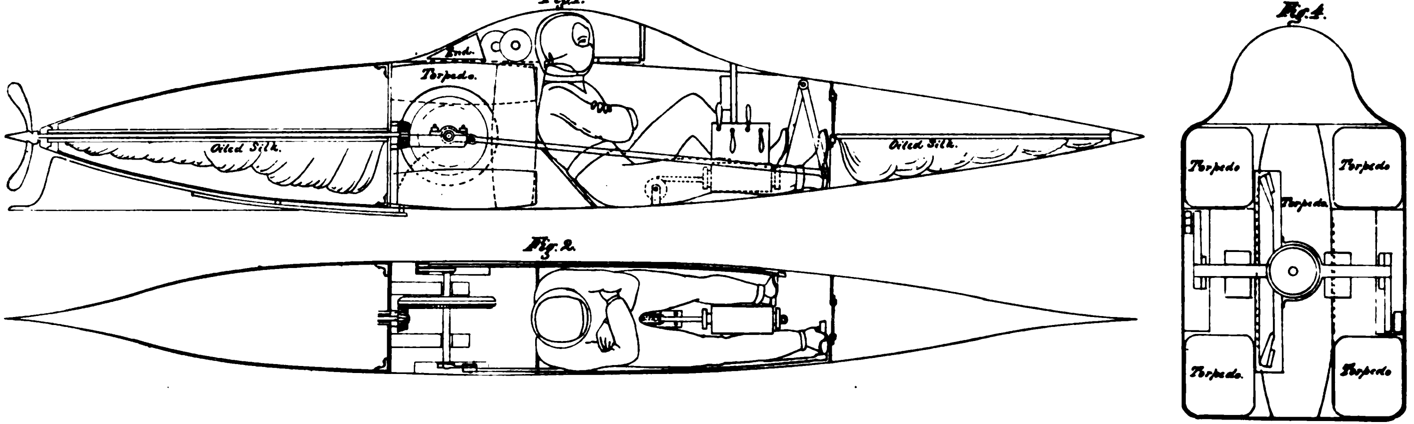
Plate X.

Fig. 1.

Fig. 2.

Fig. 4.



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