SUBMARINE WARFARE.

Captain Ericsson's Torpedo Invention—His New Method of Attacking Armored Vessels—A Revolution in Naval Warfare.

From Van Nostrand's Engineering Magazine.

In some recent letters from Captain J. Ericsson to the editor of "*Engineering*," the writer offers the following solution to the problem, "How to defeat monitors superior in thickness of armor to our own."

A heavy body of regular form, whatever be its specific gravity, projected laterally through the air, commences to fall from the instant of leaving the muzzle of the gun; describing during its progress a parabolic curve considerably fore-shortened, owing to atmospheric resistance. But a body of regular form projected under the surface of water or other fluid, in a horizontal or inclined direction, will move in a *straight* line, provided its specific gravity be equal with that of the fluid. In other words, a heavy body of any density whatever moving through the atmosphere, is inexorably under the influence of the gravitating force of the earth; while a submerged body, the weight of which is equal with its displacement, is not affected by gravitation. If put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a straight line until the motive energy which propels it becomes less than the resisting force of the surrounding medium.

Starting with these cardinal propositions, I entered, some twenty-five years ago, on the task of solving the problem of submarine attack, viz., the propelling or projecting below the surface of the water of an elongated shell containing explosive substances to be ignited when reaching some point under the bottom or bilge of an opponent's vessel. The most obvious method of carrying out the idea is that of projecting the elongated shell by means of some contrivance applied near the bottom of the aggressive vessel. Such a method I proposed to the Emperor of France in the month of September, 1854. The device consists of a long narrow chamber arranged near the bottom of the vessel, communicating with the sea and provided with a sliding valve at each end. The outer valve next the sea being closed, the shell is inserted in the chamber, after which the inner valve is closed and the outer valve opened. The means adopted for projecting or pushing out the shell is simply a rod connected with a steam piston. The forward end of the shell being provided with a suitable percussion lock fitted with a protruding trigger, it will be readily understood that when this strikes against an object, the lock, as in ordinary firearms, will cause the ignition of the charge within the shell. At close quarters such a method of attack will unquestionably be found very effective—indeed, infallible; but unless the opponent's vessel can be approached very near, it will prove abortive. Evidently, if the shell be projected in any direction not parallel with the line of keel while the aggressive vessel is in motion, a side resistance will be offered by the stationary water of the sea, which will divert the course of the missile the instant it is deprived of the guiding power of the chamber from which it is ejected. Currents will, from the same cause, change the intended course. It need scarcely be observed that, in addition to the difficulty of controlling the direction of the shell, the force imparted to the latter, whether steam or compressed air be employed, is insufficient to propel it to any considerable distance. In order to meet these serious practical objections, viz., that the shell cannot be propelled far enough, and that its course cannot be controlled, I have resorted to a device by which any desirable amount of propulsive force may be imparted irrespective of the distance traversed, and by which the course of the missile is under perfect control during its progress to the intended point. Persons of a mechanical turn of mind, in almost every country, have for a long time been engaged in contriving torpedoes to be propelled under water by independent motive power of various kinds, for the purpose of blowing up vessels. The Austrian torpedo, urged through the water by means of screw propellers actuated by compressed air, may be classed as one of this numerous tribe, the reported terrible nature of which has from time to time frightened naval constructors, and amazed some unmechanical sailors who have witnessed the trials, and found that the mysterious body actually can move under water. Proper investigation of the subject, however, exposes imperfections of the Austrian torpedo which render it, like all its predecessors, a mere mechanical toy. It should be borne in mind that atmospheric air compressed, so as to exert a pressure of only 300 lbs. to the square inch, weighs nearly two pounds to the cubic foot. Consequently, the amount of motive force which the torpedo is capable of containing will be found wholly insufficient for its effective propulsion; while the want of means for directing it to the desired point presents an in- contrived a torpedo that may be pro- superable objection. As stated, I have pelled with any requisite amount of force, irrespective of distance, the course of which is under perfect control, notwithstanding currents, and which may be directed with perfect certainty to an object in motion. In contradistinction to the term shell, applied to the structure of 1854, which was propelled alone by *vis viva* imparted, as before described, I propose to apply the term torpedo to the contrivance now to be considered.

It should be observed that nearly all attempts to propel bodies under water have been successful as regards maintaining a given depth. The self-evident device of applying a fin or horizontal rudder on each side, operated by a piston or elastic bag actuated by hydrostatic pressure, has been adopted in all. It readily suggests itself to the mind that an increase or diminution of draught, attended as it is with a corresponding variation of pressure, may be made subservient in changing the inclination, thereby establishing a tendency of the horizontal rudder, either to elevate or depress the torpedo during its forward motion. Thus, by a proper adjustment and application of the hydrostatic pressure, the torpedo may be made to move at any desirable depth below the surface of the sea. Nor has any difficulty been experienced as regards the instrument of propulsion in the experiments made since the introduction of the screw propeller. But the difficulty of procuring the requisite amount of motive force for actuating the propeller, and the absence of means for directing the torpedo, have in each instance defeated the object in view.

Before proceeding to consider the important question of guiding the torpedo, I will now briefly describe my method of obtaining the required power for actuating the propellers. A reel, of about six feet diameter, revolving on a horizontal axle, is applied near the bottom of the vessel. The torpedo is ejected, one end of the axle being supported by a hollow journal, while the other end enters a capacious air-vessel through a stuffing-box. The end thus inserted in the air-vessel is perforated longitudinally for a short distance and provided with an opening in the side at the point where the perforation terminates. A tubular rope, half an inch in diameter, composed of hemp and vulcanized rubber, is connected with this opening, and then coiled around the reel a certain number of times, and lastly, connected with the rear end of the torpedo. The air-vessel into which the perforated axle of the wheel enters being charged with compressed air (by means of force pumps worked by steam-power), it will readily be understood that the compressed air will pass through the axle, then through the several coils of tubular rope wound round the reel, and ultimately reach the rear end of the torpedo, where the rope is attached to the rotary engine which actuates the propellers. Accordingly the propulsion of the torpedo may be regulated by simply opening or closing the aperture of the perforated shaft within the air vessel. The rotation of the reel, consequent on the onward movement of the torpedo, obviously cannot interrupt the passage of the compressed air through the coils of the tubular rope; hence the supply of motive force will continue undiminished during the onward movement. The tubular rope being one-half inch in diameter in the bore, it will be found by calculation that a quantity of compressed air, sufficient to develop at least 10-horse power, may be transmitted through it during the progress of the torpedo, whether far or near the aggressive vessel. The arrangement thus described being sufficiently simple to be comprehended without entering into detail, it will only be necessary to state that the tubular rope, after leaving the reel under the deck, is made to descend through a vertical tube into the torpedo chamber, in order to prevent an entrance of water at the point where the rope passes out. Also, that two propellers are employed, revolving in opposite directions round a common centre—indispensable to prevent the torpedo itself from rotating when subjected to the powerful torsion produced by a single propeller actuated by the motive force which may be transmitted through a tubular rope of half inch bore.

I will now proceed to describe my method of guiding the torpedo, premising that the external casing which contains the mechanism and explosive compound is heavier at the bottom than at the top, in order to preserve a vertical position; and that, in addition to the fins for regulating the draught, the torpedo is provided with a vertical balance-rudder for directing the lateral course. The reel being 20 feet in circumference it will be seen that the tubular rope need only be coiled around it seventy-five times to admit of attack at a distance of 1500 feet, probably far enough, since the position of the aggressive vessel may be changed at all times with desirable rapidity.

The apparently absurd proposition to direct and change the course of the torpedo at will, on board of the aggressive vessel, without external aid, is solved by the following simple expedient:—A small elastic bag connecting the tubular rope with the induction pipe of the rotary engine, is attached to the side of the tiller of the torpedo's balance rudder. As the compressed air during its passage to the motor must pass through the elastic bag, the latter will expand and contract with every change of internal pressure. And as such change will depend on the quantity of compressed air admitted into the tubular rope, the expansion and contraction of the bag are evidently under perfect control. Now the power of this bag to resist internal pressure may be so proportioned that, when maximum pressure is admitted, the swelling of the bag will cause the tiller to move 20 deg. to port; and when the pressure is reduced 25 per cent., the accompanying contraction will move the tiller 20 deg. to starboard. Thus by admitting more or less air through the tubular rope, thereby changing the dimensions of the elastic bag, the tiller will assume any desirable angle within 20 deg. on either side of the torpedo's centre line.

Accordingly, the direction of the torpedo will be as completely under the control of the hand which admits the compressed air to the tubular rope, as if an intelligent directing power resided within the torpedo itself. Probably, no greater mechanical feat than this can be instanced. In smooth water, the telescope will enable the operator to trace the course of the torpedo by the copious formation of air bubbles on the surface of the sea. At other times, a small float attached by a string will clearly indicate the position; while at night, a small light in the float, seen only from the aggressive vessel, will inform the operator if the missile is on the right road to the intended point. It need scarcely be observed that the explosion of the torpedo will sever the connection with the tubular rope, which thus may be hauled in by turning the reel. Should the intended object not be reached, the admission of compressed air to the tubular rope should be shut off, and the torpedo hauled in, or sent out on a new errand.

The scope of the device, thus described, is, of course, limited; yet, had the Italians possessed it, the result at Lissa would unquestionably have been reversed. No harbor can be entered which is protected by it; nor would any amount of vigilance save vessels from destruction on an enemy's coast defended by it; the Hercules and Rupert, with their ponderous armor, would be as easily destroyed as the unarmored Inconstant.

In my recent letter to the editor of *Engineering*, it was admitted that the Devastation and Consort could steam up the Hudson in spite of our batteries and monitors. But small iron-clads of the monitor type without turrets, provided with the reel tubular rope, and torpedoes charged with 500 lbs. of dynamite, could sink Mr. Reed's breastwork monitors before reaching the Hudson.

As stated, the scope of this mechanical device is but limited. Fully impressed with this fact, my labors were early devoted to plans for carrying on submarine attacks by means of which the contest might be removed to the open sea. Before the close of the late war the problem was satisfactorily solved; and during the month of November, 1866, the leading features of a new system of naval attack were confidentially laid before the King of Sweden and Norway, the Swedish Minister of Marine, Count B. von Platen, and Commodore A. Adlersparre.

Let me add, for the information of your readers, that my object in giving an account of my labors connected with submarine warfare, is simply that of demonstrating the futility of encasing ships of war with huge masses of iron, and showing the absurdity of wasting millions of tons of coal in propelling weight which does not protect.

A NEW SYSTEM OF SUBMARINE ATTACK.

In the above communication I stated as a general proposition that a heavy body of regular form, of any density whatever, moving through the atmosphere, is inexorably under the influence of the earth's attraction, and therefore describes a fore-shortened parabolic curve during its flight; while a submerged body, the weight of which is equal with the weight of the water it displaces, is not affected by the earth's attraction; and that consequently, if put in motion under the surface of a quiescent fluid of unlimited extent, such a body will continue to move in a straight line until the motive energy which propels it becomes less than the resisting force of the surrounding medium.

In virtue of the first part of this general proposition, a heavy body may be projected in such a manner that the termination of its trajectory shall make any desirable angle, less than 45 deg., with the horizontal line, independently of the length of the chord of the trajectory. In other words, the body may be projected at variable distances over water, and yet strike its surface at any desirable angle. This important result is effected simply by varying the relative proportion between elevation and strength of charge. The second part of the stated general proposition is of equal importance. It points to the fact that the trajectory may be extended in a straight line under water, to any desirable distance, irrespective of the *speed* of the projectile. Accordingly, a shell may be projected from one vessel towards another within moderate ranges, in such a manner that it shall dip into the water at a considerable distance from, or close to, the vessel assailed, independently of the distance between the two vessels. Also that the shell may be projected at such an angle that this prolongation of its trajectory in a straight line, after contact with the water, shall strike the hull of the vessel assailed, at any desirable depth below the surface.

That a certain relation between charge and elevation enables us to project a *spherical* shot, with considerable accuracy, in such a manner as to strike the water at any desirable distance from an opponent's vessel, at angles with 15 degrees, will be admitted. Hence, if the torpedo be such that its extension in a straight line from the point of contact with the water leads to the hull of the vessel assailed, the latter will be hit—on condition, however, that the shot is not diverted on entering the water, and provided its *vis viva* be sufficient to overcome the resistance encountered during its passage through the water. These indispensable conditions, which apparently cannot be complied with, point to the difficulty of hitting a vessel below the water line. And if we suppose that the projectile is not spherical, another serious difficulty presents itself. An elongated body will not bend to the curvature of the trajectory, but retain during its flight the same inclination as the gun from which it has been projected; hence it will fall nearly flat on the surface of the water at the end of its flight.

Agreeable to our general proposition a regular body, weighing as much as the water it displaces, is independent of the earth's attraction; but there is another force which, notwithstanding the absence of any gravitating tendency, will cause a body of regular form moving under water to deviate from a straight line and rise to the surface. A cone moving in the direction of its apex and in the line of its axis horizontally, or on an incline, will, owing to the inertia and the nearly incompressible nature of water, more readily displace the column which rests upon and depresses its upper half, than the column from below with its lifting tendency. Consequently, the course of the conical body will be diverted from the straight line upwards, describing a curve nearly elliptical, and quite sudden, if the speed be great. A cylinder with semispherical ends will, from the same cause, ascend to the surface if moved in the line of its axis; while a body with flat ends will take a downward course, gradually increasing its inclination until at last the axis assumes a vertical position. Obviously, the lower part of the forward flat end encounters a greater resistance than the upper part; hence the lower half of the transverse section of the cylinder suffers an excess of retardation, which occasions the downward course described.

The question whether the apparently insuperable difficulties thus pointed out may be overcome by mechanical expedients has, as already stated, occupied my attention for a long time; and numerous experiments have been made to test the efficacy of devices resorted to on theoretical considerations. But it is not my purpose to enter on a description of these devices at present, on grounds that will appear hereafter. Accordingly, I will assume that the axis of the elongated projectile is so formed that its flight through the air is parallel with the trajectory, and that on entering the water the projectile is not diverted, but continue to move under the surface, with the same inclination it had on coming in contact with the dense medium.

It may be well to state that the elongated shell is charged with dynamite and provided with a percussion lock and trigger, to be actuated as described in my former communication relative to the self-acting torpedo.

It is well known that numerous plans have been suggested during the last few years for firing under water, for the purpose of piercing the hull of iron-clad vessels below the point protected by the armor. In several instances these plans have been carried into practice with the invariable result that the resistance of the water has been found so great, even at very short distances, that an ordinary wooden hull has proved to be impenetrable. The plan now under consideration bears no resemblance to these projects. In the first place, the attack is made at a distance; and, secondly, the force of the missile in reaching its destination need only be sufficient to actuate the trigger which causes the ignition of the explosive charge.

Apart from the theoretical considerations relating to the course of the elongated shell under water, the practical question of motive power to propel the same presents itself at the first step in the investigation. It is hardly necessary to observe that the force relied upon is the *vis viva* possessed by the shell on coming in contact with the water. Before estimating this force it will be proper to call attention to the fact that my new system, to be effective and a practical success, does not call for attack at a great distance, provided the vessel from which the missile is projected has greater speed than the vessel assailed, and at the same time adequate protection against his artillery. No reason whatever can be assigned why the attack should not be successful, and the destruction of the vessel assailed as certain if the distance of 500 feet were the limit, as if a range of 5000 feet better suited the new system. It will be inferred from this explanation, that although there is no physical obstacle to an increased range, the plan proposed contemplates attack at distances not much exceeding 500 feet, unless the sea be very smooth.

The *vis viva* of a shell 15 inches in diameter, of such a length that it displaces 500 lbs. of water, may be readily estimated if we suppose the charge of powder in the gun to be so regulated that the shell will enter the water at the rate of 400 feet per second; thus, $400^2 \div 64 = 2500 \times 500 = 1{,}250{,}000$ ft.-lbs. A cylindrical body 15 inches in diameter, with semi-spherical ends moving at a rate of 50 ft. per second under water, requires a constant motive force of somewhat less than 400 lbs. Assuming, then, that, the shell passes through 120 feet of water, we have a resistance of 120x 400=48,000 ft.-lbs. to overcome. The motive force, it will thus be seen, is more than 24 times greater than the resistance; hence no doubt can be raised as to the adequacy of the motive power furnished by the *vis viva* of the shell. It should be observed that the resistance is very great at first, and that the speed of the shell diminishes in a very rapid ratio; but it would be futile to present a formula expressing the ratio of speed and resistance, since the *form* of the body is the chief element in the calculation. Suffice to say, that while the resistance against a blunt body is so great that it can hardly be overcome, one provided with a sharp point enters the water with much facility, even at the rate of 400 feet per second. The passage of the shell through the water will, therefore, be sufficiently rapid to reach the desired object in proper time.

With reference to the gun, it should be borne in mind that the very low speed of the shell, and the consequent small charge of powder needed, render heavy metal unnecessary. Besides, slow burning cake-powder contained in cellular cartridges will be employed for the purpose of checking rapid ignition, and in order to sustain an uniform pressure during the discharge. The guns are loaded from below, and for that purpose so arranged as to admit of being depressed 60 deg. Gun carriages are dispensed with, the trunnions being suspended by adjustable pendulum links secured under the turret roof. The recoil is checked by buffers attached to the turret wall in rear of the breach.

I feel called upon to state, that loading guns below deck, as here shown, was planned by me, and drawings representing this method exhibited in New York several years before it was claimed by certain American engineers as their invention.

Respecting the safety of the charge in the shell from ignition during the discharge, it will be well to observe that efficient means have been devised to prevent such an accident. With reference to the *calibre*, it is evident that this system of attack calls for dimensions that will admit a shell of sufficient capacity to contain a charge which, by its explosion, will destroy a first-class ship of war built on the cellular plan. Nothing short of 300 lbs. of dynamite will suffice for this purpose; hence nothing less than 15-in. calibre will answer. The American and Swedish 15-in. guns are admirably calculated for the purpose, although they are unnecessarily heavy.

European savans, especially certain Swedish naval artillerists, who have criticised my advocacy of the 15-inch smooth-bore gun, will understand on looking into this matter why I have persisted in advising the Scandinavians to carry this large calibre in their monitor turrets as the most effective weapon against their powerful neighbors. Assuredly the Danes will have no cause to fear the Prussian Konig William or Friederich der Grosse, when their ports are defended by vessels armed with guns by means of which 300 pounds of dynamite may be exploded under the hulls of the intruders.

The turret, it may be briefly noticed, in which the light 15-inch shell guns are mounted, is composed of flat wrought-iron plates forming a square box, wide enough to accommodate the two pieces, suspended, as already stated, by pendulum links secured under the turret roof. A massive central shaft of wrought-iron supports the square box, on the plan adopted in the monitor turrets. The vessel designed to carry the rotating square box with its light shell guns is a mere iron hull crammed with motive power, in order to insure a higher speed than that of existing iron-clad ships of war. The midship section is triangular, and the bow raking. The overhanging sides and deck are heavily armored.

Permit me to add, that I intend to make a formal offer, under certain stipulations, to furnish, at my own cost and risk, a swift screw vessel provided with a pair of 15-inch smooth-bore guns, and the necessary apparatus for sinking, by submarine explosion, a vessel of the average draught of the iron-clad fleet of England, while such a vessel is being towed at the greatest speed possible, or performing whatever evolutions her owner may choose, with the distinct understanding that the attack shall not be made at a less distance than 500 feet. Accordingly, it has not been my purpose, on this occasion, to enter into a full description of my new system of submarine attack. It may be well, however, to define clearly what the scheme is intended to accomplish. If a first-class swift iron-clad ship, say the Devastation, unassisted by other craft, will meet in open water a vessel constructed agreeably to the new system, it is contended that the latter will sink the breastwork monitor in spite of her guns and impregnable armor, and notwithstanding evolutions designed to avoid the submarine missile.