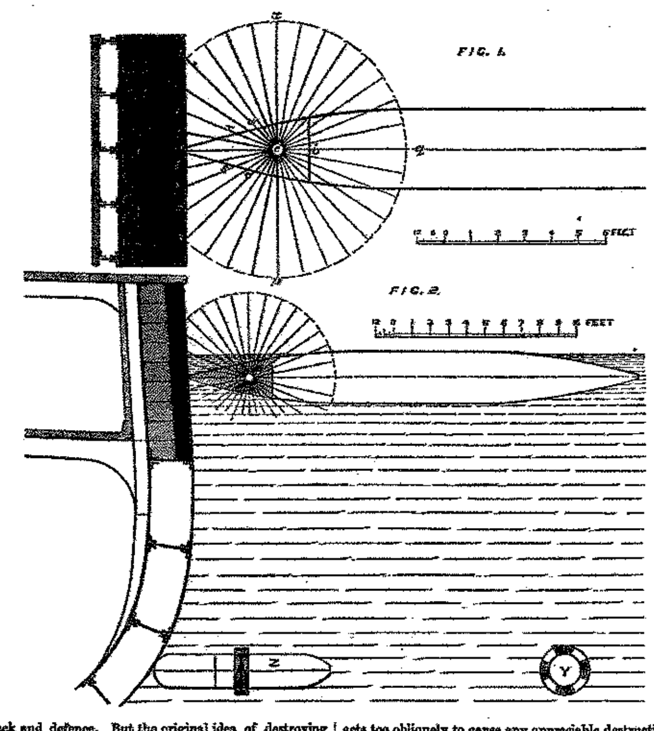
MOVABLE TORPEDOES.*

By CAPTAIN JOHN ERICSSON.

COMMANDER WILLIAM A. KIRKLAND, "one of the board ordered to inspect the Lay torpedo," states in his semi-official letter addressed to the *Army and Navy Journal*, that the said board has approved of the Lay torpedo-boat tested at Newport. The tone of Commander Kirkland's letter leads to the supposition that it had not been submitted to nor received the sanction of the board previous to publication; a supposition by no means implying censure on Commander Kirkland for the course he has seen fit to adopt. The manner in which the subject has been presented of course does not influence the important fact laid before the country, namely, that the board has approved of the torpedo-boat. In view of this approval on the part of the distinguished officers appointed by the Navy Department to investigate the matter, I propose to examine the leading features of the plan approved of, and at the same time correct the erroneous calculation and serious mistakes of Commander Kirkland, regarding my movable submarine torpedo.

Maritime nations have accepted the proposition that a successful introduction of a submarine structure capable of being propelled rapidly and directed with certainty under water, will compel a complete change of the present system



of attack and defence. But the original idea of destroying ships by explosive substances carried by rafts and similar structures floating level with the surface of the water has been long abandoned on account of their insufficient destructive power and the facility with which their approach may be prevented by the party attacked. Now, the torpedo-boat tested at Newport resembles the abandoned plan in its two main features, namely, that its approach may be easily prevented, and that the explosive substance is fired too near the water line, at a point where the armour of the assailed vessel presents the greatest resisting power. Commander Kirkland summarily disposes of this objection by the assertion that 500 lb. of nitro-glycerine "would either send the vessel and crew to the bottom by tearing out the side, or else would so crush her in as to render her abandonment a matter of healthy necessity to her inmates." As the utility of the torpedo-boat approved by the board of officers appointed by the Navy Department to inspect the same, depends altogether on the correctness of Commander Kirkland's assertion just quoted, the question of efficiency of the explosive charge applied in the bow of the boat demands serious consideration. Should it be found that the expected destruction is a mere visionary expectation, the country may at some future time witness failures attended by grave consequences. Let us, then, carefully investigate this subject.

Fig. 1 represents a sectional plan of the side armour of an ordinary European ironclad ship of the low freeboard type, and part of the top view of the hull of a torpedo-boat 26 ft. long and 3 ft. diameter, at the instant of contact with the opposing armour. A charge of 500 lb. of explosive matter of the same specific gravity as water, will occupy 4 ft. 7 in. in the line of the axis of a torpedo-boat formed as shown in our illustration; the distance of the centre of gravity of the charge, indicated at C, being 3 ft. 4 in. from A.

Before demonstrating what proportion of the explosive energy will be exerted against the armour plate, it will be necessary to point out that on igniting an explosive mass of spherical form, freely suspended in space, the resulting force acts in radial lines diverging in all directions from the centre of the mass, the energy diminishing nearly in the inverse ratio of the square of the distances. The pressure or elastic force of the exploding gas will, however, diminish inversely as the cube of the distance, since doubling the diameter of a sphere will increase its volume eightfold. Bearing these facts in mind, it will be perceived on a mere cursory inspection of Fig. 1, that only a small proportion of the charge of 500 lb. will be effective against the armour plate. It will be readily understood that since the explosion radiates with equal energy in all directions, the explosive mass beyond the vertical line, *x p*, in the opposite direction to the armour plate, will not exert any force against the same; hence the 250 lb. of the charge occupying the space beyond the line, *x p*, will produce no other useful effect than that of acting as an abutment to the other half; nor will the whole of the remaining 250 lb. be effective. Obviously the energy developed within the sectors defined by the arcs, *x d*, and *p n*, acts too obliquely to cause any appreciable destructive effect. The force acting in the direction of the radial lines, *c d*, and *c n*, will also be quite ineffective, owing to the great space between the charge and the armour plate. The distance, *c d*, being 4.4 times greater than *c w*, the energy of the explosion will be reduced in the ratio of 4.4×4.4 to 1; hence only one-nineteenth of the initial explosive energy will be brought to bear on the armour at *d* and *n*. Again, this greatly reduced energy has to overcome the inertia of the body of the water intervening between *w d*, and *o n*. The same argument applies to the energy acting through the lines, *c f*, and *c m*, which will be reduced in the proportion of 3.2×3.2 to 1; hence only one-tenth of the initial force of the explosion will be brought to bear on the plate at *f* and *m*. It must not be supposed that the water contained within the triangular spaces, *a*, *w*, *d*, and *a*, *o*, *n*, will act as a water ram, transferring the initial force of the explosion to the armour plate. The fact is that the explosion takes place so near the surface that the water contained within the spaces mentioned will be converted into spray, the inertia of whose particles will absorb much of the energy of the exploding gas without transmitting any destructive force to the armour.

In addition, therefore, to the diminution of energy resulting from the great distance between *c* and the points, *d*, *n*, *f*, *m*, &c., the inertia of the particles composing the spray tends to render the explosion harmless. Pursuing the investigation, it will be seen that not until we come to that portion of the charge contained within the radial lines, *c g*, and *c l*, can we show that the propagated energy is sufficiently intense to effect the opposing armour. But the explosive mass contained within these lines is only one-sixth of the entire charge, the mean distance from the armour plate being nearly 2 ft., while scarcely any portion of the charge is in actual contact. The power of nitro-glycerine, it is proper to observe, has been greatly overrated owing to its destructive effect when in actual contact. Let us also bear in mind that apart from the want of contact, the explosion of the charge contained within the lines, *c g*, and *c l*, will be distributed over a circular area the diameter of which extends from *g* to *l*, 2 ft. 9 in., hence dispersed over nearly 6 square feet of armour plate.

Moreover, it will be perceived on examining Fig. 2, which represents a transverse section of an ironclad ship of the type before mentioned, and side elevation of a torpedo boat 26 ft. long and 3 ft. in diameter, that owing to the absence of a column of water above the boat, and the presence of an unyielding resistance below the same, the exploding gases will be directed upward. The destructive effect of the explosion will thus be still further reduced. Obviously then, unless it can be shown by actual trial that our demonstration is incorrect, the Lay torpedo will prove useless as a means of defence against ironclad ships of war. Accordingly, before organising a new system of coast defence based on the conclusions arrived at by the experiment at Newport, the Navy Department will find it indispensable to test the efficiency of 500 lb. of nitro-glycerine, applied as intended in the torpedo-boat, against a floating target of large dimensions representing a ship's side protected by 12-in. thick armour. Of course, such a target must be backed by wood and an inner skin of plate iron, besides being braced in a manner that will give the same solidity and strength as that secured by the deck beams of an ironclad ship.

Before dismissing the subject of explosive energy, it will be necessary to call attention to the fact that the contents of the torpedo-boat bear so large a proportion to the mass of the charge, that if the boat be immersed in an unyielding medium, the explosive energy will be wasted by expansion to an extent rendering it wholly inefficient. The taper form at the bow evidently adds to the inefficiency of the explosion by reducing the volume of the explosive mass at the very point where the greatest destructive effect should be developed. Our space will not admit of entering into a demonstration on this subject; but I cannot omit adverting to the fact that, the energy of the explosion of detonating substances of great intensity acts through relatively short spaces; hence the great bulk of the torpedo-boat will be destructive to efficiency under all circumstances. The small dimensions of my movable submarine torpedo (shown at Z and Y in Fig. 2), which led Commander Kirkland to commit such extraordinary mistakes concerning displacement, stability, and power to resist the torsion produced by the rotation of the propeller, were dictated by the necessity of employing minimum bulk in order to insure maximum explosive effect.

Having thus established the unsatisfactory nature of the destructive power of the torpedo-boat, let us next consider the means adopted for propelling and directing the same. The unreliable character of the propulsive agent and the extraordinary complication of the mechanism applied within the torpedo-boat, will be best understood by a careful perusal of the following extract from the description previously published in the *Army and Navy Journal*:

"We shall not undertake, without the aid of drawings, to explain to our readers the somewhat complicated details of mechanism and arrangement. It will be sufficient to point out the leading features of the plan.

"The boat is divided into compartments. At the bow is the compartment intended for the explosive mixture. Next follows a compartment containing strong wrought-iron flasks filled with liquid carbonic acid. The pressure in these flasks is 600 lb. per square inch, but they are tested, when manufactured, to bear 1700 lb. They contain, when charged, about 400 lb. of acid. In the next compartment is the reel of wire cable, which is paid out through the bottom as the boat moves. This chamber is accessible to the water; but the tight bulkheads on either side prevent the entrance of water into either of the adjoining compartments, except in one place, where an adjusted cock, open while the boat is moving, and closed when she stands still, admits water into an iron water-bottom under the flasks of carbonic acid, at a certain rate, just enough to preserve the uniform flotation of the craft, which would otherwise rise further and further out of water as the wire cable was reeled off.

"Forward of this reel compartment is that in which the driving and steering machinery is located. This consists of two electric batteries, 'reducers,' for the carbonic acid gas, and a pair of oscillating engines. Still further forward is the mechanism for steering, which will be presently explained.

"The throttle valve is opened or closed by the operator on shore in this way: A current is made through one of the wires in the cable, having its ground connexions in a copper plate sunk in the earth near the battery, and a copper plate on the boat, in contact with the sea water. This current is conducted through a small electro-magnetic apparatus, in which it determines the movement, on the principle of the galvanometer of a central armature. When the current is reversed, the direction of this movement is reversed; and in this way the course of a strong current from one of the boat batteries is directed upon one of two helical electro-magnets. The movement here produced is exactly on the principle of the ordinary telegraph machine. It operates a valve admitting the high pressure gas behind a small piston, the movement of which opens the throttle valve proper. A reversal of the shore current changes the route of the local current, and in a similar way drawing the small piston back closes the throttle and instantly stops the engine. The apparatus for steering embodies a similar principle, only that the alternate action of the helical magnets is made through the change of a valve, to admit carbonic acid gas to one or the other of the two small pistons, the motion of which moves the rudder arm right or left, putting the helm hard 'up' or 'down.' When the steering shore current is not reversed, but interrupted altogether, the rudder assumes, by virtue of an ingenious arrangement, the medium position of 'steady.'

* From the American *Army and Navy Journal*.

"We have told how the gas is carried in liquid form. There is enough of it to drive the boat two miles. When it expands as vapour, a great loss of temperature is the result, and this might diminish the pressure seriously. This evil has been experienced in other carbonic-acid motors, in some of which the volatilisation of a part of the liquid froze the remainder, causing the pressure to cease altogether. It is counteracted in this machine partly by the large size of the wrought-iron reservoir or flask, partly by the method of conducting the gas past the reel compartment to the reducers, namely, through small pipes running along the outside of the shell, and thus exposing a large surface to the water, which imparts some heat to the gas within. The same end is facilitated by the use of the reducers. These are small flasks in which the gas is expanded before entering the engine. The pressure in the original flask is, as has been said, 600 lb. per square inch, but this is reduced before entering the engine to 96 lb."

Commander Kirkland cannot perceive that the mechanism thus described is at all complicated; "in fact," he says, "its great value is in its extreme simplicity." Now, the description informs us that two distinct motors are necessary to start the *third* motor which actuates the propeller; that other motors are required to operate the rudder, and that in order to make good the weight lost by paying out the wire cable, an "adjusted cock" has been devised for admitting water into the boat, opening while the boat is moving and closing when she stands still (a great mechanical achievement, experts will admit, provided this cock infallibly turns the right way at right time.)

Leaving out of sight the necessity of raising the torpedo-boat partially out of the water after an experiment, the duration of which counts by minutes; opening its hull, breaking certain joints, removing the exhausted carbonic acid flasks, replacing the same with other flasks, to be in turn attached to the receivers; again hermetically closing the opening in the hull and lowering the same into the water—leaving all this out of sight, and returning to the perusal of the description, we learn that owing to the great loss of temperature during the expansion the liquid in carbonic acid motors may freeze and the pressure cease altogether. This evil, it is stated, has been overcome in the torpedo-boat by the objectionable expedient of conducting the gas through small pipes running along the *outside* of the shell, in order that the gas within may absorb heat from the sea. In the face of such complication of mechanism, in which a defective joint, or an accident to the exposed external pipes, renders the entire structure useless, Commander Kirkland, one of the board ordered to inspect the Lay torpedo, says, that its great value is in its "extreme simplicity."

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

The following is the Address delivered by the President, Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S., &c., to the Members of the North of England Institute of Mining and Mechanical Engineers, at the meeting held at the Wood Memorial Hall, Newcastle-on-Tyne, on Saturday, the 1st inst.

Gentlemen,—The North of England Institute of Mining and Mechanical Engineers was, in its origin, a society limited in its scope to the discussion of subjects belonging to the practice of mining, and, especially, of coal mining. At that period, the working of coal and other minerals was carried on with less aid from machinery than at present, and the district in which the society is located, was not so distinguished as it now is for the practice of mechanical engineering in all its branches. Hence, the society, in its growth, has gradually assumed more and more of an engineering character; and my recent election, as your president, indicates that mechanical science is no longer regarded by the members as secondary, or merely subsidiary, to the practice of mining. But we must guard against this tendency of the engineering element to outgrow the mining element of this Institute. We must not forget that we are situated in the very heart of the coalfield which, more than any other, has rendered England pre-eminent as a producing nation, and that, notwithstanding the increasing magnitude and importance of the engineering works of this district, the raising of coal is still foremost amongst the industries of the North, both as regards the extent of the interests involved, and its importance to the general prosperity of the nation. For these reasons, although I come before you as the first president of this Society elected from the ranks of mechanical engineers, I shall, in this address, make coal the principal topic of my remarks, including, however, mechanical applications associated with its use, or involved in its production.

As I shall speak of coal in an economic as well as in a technical point of view, I cannot well avoid making some reference to its present excessive cost, because coal, like every thing else, must be governed in the extent of its application by its price in the market. In addressing an institution, so largely composed as this is of colliery proprietors, it is not an agreeable task to dwell on the evil of dear coal; but our Institution is not a commercial one, and I must speak of this subject, not as affecting individual interests, but as bearing upon mechanical art and national prosperity.

For many years past the consumption of coal has been increasing at the rate or about 4 per cent., per annum, computed in the manner of compound interest. We are all familiar with the cumulative effects of compound rates of increase; and it is easy to see that if the consumption of coal continued to advance at this rate, we should speedily arrive at impossible quantities. Thus, in 18 years our present enormous consumption would be doubled; in 36 years it would be quadrupled; and in 54 years it would be eight times greater than at present. It is clear, therefore, that our consumption has been increasing at a rate which could not possibly last. If nothing else was destined to arrest it, a failure of mining labour was inevitably approaching to have that effect; but a few years would probably have yet elapsed before the number of hands became inadequate to meet the required demand, had not the miners precipitated the event by restricting the hours of work.

The hours of mining labour in this district twenty-five years ago, were nine per day. At a subsequent date, they were reduced to eight, then to seven, and, finally, to six. Hither, the men have worked eleven days a fortnight, but it seems doubtful whether more than ten can now be worked, consistently with the very proper limitations of the recent Coal Mines Act, in regard to the labour of the boys. The full hours per fortnight, will, therefore, at the most, be sixty-six, or thirty-three hours per week of labour at the face of the coal; but as it is only the steadiest men that work full time, the average time will, of course, be considerably below that limit. I am not aware to what extent reduction of time has been carried in other parts of England; but we hear of the same policy of restriction either of time or output, or of both, being put in practice in all the important coal districts. I do not suppose that the average output, per man, has fallen off proportionately to the reduction of hours. The men work hard, even harder than formerly, while at their post; but it is impossible that so great a reduction of working time can have taken place without so lessening the output, per head, as to neutralise, in a great degree, the increase of production due to the numerical growth of the mining population.

Under these two conditions of increasing consumption and restricted labour, we have reached a point at which the demand has overtaken the supply. As yet, the deficiency cannot be great, for it has only very recently become apparent. Consumption does not advance by jumps; and we may assume that if a progressive increase of 4 or 5 per cent. per annum could have been maintained in the production of coal, a balance would still have existed between supply and demand. Though production has ceased to keep up with demand, it has not, so far as we can judge, actually receded, and it would, therefore, appear, that a small addition to the present supply would restore the equilibrium. But small as the deficiency must be, it is sufficient to create a sense of scarcity, and, as a consequence, to send up prices to a famine pitch.

The situation is a grave one, and the public has not yet fully realised how very grave it is. Taking the present consumption at 110 millions of tons (exclusive of exportation) and estimating the extra price to consumers at 8s. a ton over all, the annual loss to the community from the additional cost of fuel, amounts to 44 millions sterling. Had a Government tax of 44 millions been levied upon coal, in addition to existing taxation, the effect would have been regarded as utterly ruinous, not only in regard to its prodigious amount, but on account of its repressive effect upon every kind of production. Yet, it is a fact, that we are now paying the equivalent of such a tax, with this unfavourable difference, that the money does not go into the coffers of the nation. Whether it chiefly goes to coal-owners or coal-miners, is a question which I need not discuss; but I may observe, that the restrictive action of the men has benefitted their employers as well as themselves, and that the public are the only sufferers. Coal-owners have long been aware that limitation of quantity was the only effectual mode of raising price, but they have never been able, by their own action, to maintain a restricted production. At last their workmen have done it for them, and we see the result.

Whether the trade of the country will bear up against the heavy burden of dear coal, combined as it is with dearness of other products, arising from similar causes in other industries, is a question on which I shall not attempt to prophecy. It will be more to the purpose to consider what can be done to mitigate the evils under which the nation is now labouring in regard to the price of coal. It is vain to appeal for relief either to coal-owners or coal-workers. Self-interest is the ruling principle of trade, and it is visionary to expect that men will sell either labour or the produce of labour for less than the market price. However generous a man may be, he will not exhibit his generosity by selling an article below its value. Speaking, then, as one of the public and not as a coal-owner, I say, we must strive to economise the use of coal; speaking as President of an Institution of Mining and Mechanical Engineers, I say, we must endeavour to make up for the deficiency of human labour, by a more extended use of machine labour.

The waste of coal, both in domestic and manufacturing use, is a threadbare subject; but there never was a time when its consideration was of so much importance as at present. The small deficiency of supply, which is now so violently stimulating the market, would be just as effectually expunged by economising consumption, as by increasing production. If on the one hand, the mining population could easily, by a few hours addition to their weekly labour, restore the equilibrium between supply and demand, so on the other hand, consumers, taken as a body, could do the same thing, by discontinuing, in a small degree, those reckless habits of wasting coal to which they obstinately adhere.

The consumption of coal takes place under three great divisions, each absorbing about one-third of the whole produce: 1. Domestic consumption; 2. Steam engine consumption; and, 3. Ironmaking and other manufacturing processes. In the first two divisions the waste is simply shameful; in the third it is not so great, but still considerable, though in some processes, and especially in the smelting of iron, economy of fuel has been so diligently pursued, that there remains but little apparent scope for further saving.

I shall not dwell on the waste of coal in domestic consumption, as it is scarcely a subject for engineers; but the circumstances of the times are such as to forbid my passing it unnoticed. It is impossible to conceive any system of heating a dwelling more wasteful than that of sinking the fireplace into a wall directly beneath the chimney, which carries off the products of combustion. Nothing can be clearer than the advantage to be gained by merely advancing the fireplace a little into the room, and constructing it with proper heating surfaces, as in the "Gill stove," and in many other stoves acting on the same principle. There is no occasion to shut out the fire from view. Neither is there any difficulty about ventilation, since fresh air can easily be introduced from the exterior by a pipe delivering its supply against the heated plates, so as to temper the air before it enters the room. By this simple and unobjectionable departure from the conventional fireplace, the quantity of coal required to produce a given heating effect might easily be reduced to one-half, and still greater economy would be effected by the use of hot-water apparatus, which, however, has the objection of being too costly in first outlay to admit of very general application. For cooking purposes, also, the consumption of coal is in most houses equally extravagant, and I may add, equally inexcusable, since the means of prevention are attainable by the adoption of known methods and appliances for concentrating the heat upon the work to be done.

A more appropriate subject for the consideration of this Institution is the wasteful employment of coal for steam power. The steam engine is, at best, a very imperfect machine for utilising the mechanical power of heat, for in no case do we realise more than one-tenth of the theoretic effect of the fuel. But the difference in economy between our best steam engines and our worst is enormous, and unfortunately by far the most numerous class belong to the category of the worst. In the best kind of engines, the consumption of coal per horse power per hour is rather less than 2 lb., but there are thousands of steam engines in daily use which burn from 12 to 14 lb. per horse power. This excessive wastefulness arises from defects, both in the mode of raising the steam, and in the mode of applying it. Theoretically, 1 lb. of coal is capable of evaporating 13 lb. of water, but the conclusion arrived at on this subject by the late Royal Commission on the duration of coal, was that in practice 1 lb. of ordinary coal did not, on an average, evaporate more than 4 lb. of water. The causes of this deficient result are perfectly understood, and, therefore, cannot be excused by ignorance. They are, insufficient boiler surface to absorb the heat, insufficient steam space to allow of a complete separation of the steam from the water, unclothed boilers, and imperfect combustion of the fuel, arising from badly-constructed furnaces and from bad firing. The defects in the mode of applying the steam, or, in other words, the defects which belong to the engine, in contradistinction to the boiler, are equally well known, and equally remediable. The steam, to begin with, should be taken from the boiler at a much higher pressure than is usual. It should be admitted upon the piston at the full boiler pressure, and allowed to expand in the cylinder until its power is practically exhausted. The cut-off valves should be close to the ends of the cylinders, as in the Corliss arrangement, so as to leave the smallest possible amount of space between the valve and the piston when commencing its stroke. Finally, the cylinder should be steam jacketted to prevent its cooling during the expansion of the steam, and thereby causing condensation on the next admission of steam. Nobody disputes these requirements of a good engine, and yet how few engines there are in which these conditions are fulfilled. The responsibility, however, for this waste of coal lies more with the users than with the makers of steam engines. Old-fashioned engines are retained in use, partly on account of the outlay involved in replacing them, and partly from a dread of novelties and refinements requiring more care and delicacy of treatment than steam engines commonly receive. Even in replacing old engines, the repugnance to any increase of first cost, and the distrust of departures from long-tried patterns, powerfully tend to a conservation of antiquated types of steam engines.

As an encouragement to those who contemplate reforming their engine power, I may state what my own experience has been of the advantage of so doing. The engines and boilers originally applied at the Elswick Works, though representing a fair average of efficiency, were of the simple description then almost invariably used in factories. My firm, like others, was naturally averse to changing them, on account of the expense of so doing; but about two years ago they determined to begin the renovation of all their old engines by putting down, as a first instalment, two large engines of the Corliss pattern, to do the work previously performed by ten smaller engines. These two Corliss engines are now both at work. They have boilers of the best construction, and are fitted with various accompaniments favourable to economy of fuel, including Jukes's arrangement of mechanical firing. One of these engines uses 24 tons of coal per week, against 60 tons used by the engines it has superseded. The other appears to be doing equally well, but I have not the necessary data for making a similar comparison. Assuming the economy effected to be the same in both cases, the aggregate saving of coal amounts to 72 tons per week. The number of firemen required is also much diminished, and the general result is, that notwithstanding the enormous rise which has taken place in the price of coal, the required steam power is now obtained at a less cost than before, after allowing for interest on the capital expended.

Thus, then, the consumers of coal, as well for domestic use as for steam engines (under which two heads about two-thirds of our whole consumption are comprised), have it in their power to economise their use of coal to an enormous extent, without any diminution of effect. In metallurgical and other manufacturing processes there is also room for much saving of coal; but I must not extend my observations into that division of the subject. Speaking generally of coal consumption in all its branches, there can be little doubt that without carrying economy to its extreme limits, all the effects we now realise from coal could be attained with half the quantity we use. If a reduction to that, or any approximate extent, were effected, we should hear nothing more of scarcity or prohibitive prices for many years to come.

(To be continued.)

Baltimore Bridge Company.—This company has, since its organisation, built over 100 bridges and viaducts, measuring in length upwards of 9 miles, and containing 13,000 tons of steel and iron, in addition to several million cubic feet of timber and masonry. The company's list of bridges comprises one draw span 356 ft. long, and one viaduct in South America which is said to be the highest in the world. Details as to this viaduct, which occurs on one of the Peruvian Railways, were given in a recent impression of Engineering.

MOVABLE TORPEDOES.—No. II.*

By Captain John Ericsson.

Having in the preceding article on this subject (see ante page 107) called attention to the extraordinary complication of the mechanism, and the unreliable character of the motor employed by Mr. Lay, I now propose to consider whether his surface torpedo will be capable of reaching its destination when employed in broad daylight. Commander Kirkland thinks that a ship attacked would have no other certain means of preventing the approach of the torpedo than that of employing expert marksmen. But these, he says, "with carefully sighted rifles would have very little chance of making a bull's-eye on her, and even if struck, the very small angle which the direction of the shot would make with the surface would prevent its doing any damage." He then refers to "an improvement which has already been proposed and accepted," that of making the top plates of steel, an improvement which he apparently regards as insuring complete safety. The employment of ordnance against the approaching torpedo Commander Kirkland considers futile. He says, "the idea of depending upon heavy artillery for the preservation of the ship would be out of question, as taking too many chances." This view of the subject is by no means shared by the officers of the British navy. Captain Scott, in place of relying on "marksmen with carefully sighted rifles," has built a number of ingeniously contrived carriages for "torpedo guns," so arranged as to admit of any degree of depression, in case it should be necessary to fire down upon a torpedo boat when within a few feet of the ship. It will be well to bear in mind that we have no assurance from our opponents that they will not fire grape from their torpedo guns; a circumstance which calls for serious reflection on the part of the friends of the surface torpedo, who rely on Commander Kirkland's professional opinion. It will be readily perceived that the result of the diverging fire of grape-shot poured on the exposed top of the approaching torpedo boat, in place of establishing the correctness of the assumption that there is no chance of "making a bull's-eye on her," will prove that there are in fact "too many chances." This will be better understood by referring to our illustration, Fig. 1, representing a top view of the English turret ship Devastation, and the approaching surface torpedo, drawn to a scale of 100 ft. to the inch. A careful inspection of this illustration renders an elaborate demonstration unnecessary. Two light torpedo guns are applied at each end of the ship, and one in the middle, the former being pointed at different angles in order to produce an extended cross fire, as shown in the plan. The surface torpedo is represented in four different positions, each 30 yards apart. It is scarcely necessary to call attention to the fact that although the torpedo presents a very small target, endwise, the fire from the bow and stern guns commands the entire length of the torpedo's exposed hull; hence, owing to the number and diverging course of the shot, the top will infallibly be riddled. It would be waste of time to discuss this point at length. Our illustration and brief explanation has clearly shown that the idea of attacking ships by means of the surface torpedo in broad daylight, is based on assumptions so utterly fallacious that it merits no further consideration. A successful attack at night is, however, possible; but for such an attack we do not want the costly and complicated Lay torpedo boat with its tender wire cable, feeble motor, and ineffectual explosive magazine. A small decked wooden boat from 20 to 25 ft. in length, carrying the explosive charge in advance, some 15 ft. under water, propelled by a screw driven by an engine supplied with compressed air by means of my tubular cable, will be the most efficient instrument for night attack. A glance at our illustration, Fig. 2, drawn to a scale of $\frac{1}{48}$ in. to the foot, will suffice to give a distinct idea of the plan. The boat, as stated, is decked over, and immersed to within about 4 in. of the top of the deck. The motive engine of 15 horse power is located in the after part of the boat, actuating a four-bladed screw 3 ft. in diameter. The compressed air is conveyed to the propeller engine through the tubular cable, coiled round a reel a number of turns corresponding with the distance from the starting point at which the torpedo is intended to operate. Obviously it is immaterial whether the reel be placed in the boat (the original arrangement, not well adapted to torpedoes despatched from vessels in an advanced position), or on shore. When placed in the boat, the reel turns in an open well extending vertically through the hull. It will be evident that the paying out the tubular cable, which, when charged with air, has the same specific gravity as water, will not affect the line of flotation of the boat. As the detail of the arrangement will be minutely described hereafter, it will only be necessary to observe on this occasion that the reel on board of the boat becomes locked as soon as the air is shut off from the tubular cable, and the propeller engine thereby stopped. Consequently, by turning the shore reel (employed in all cases), a rapid retrograde motion may be given to the boat at any moment; or it may be hauled in at the same rapid rate, since the reel is actuated by the steam engine which compresses the air.

FIG. 1

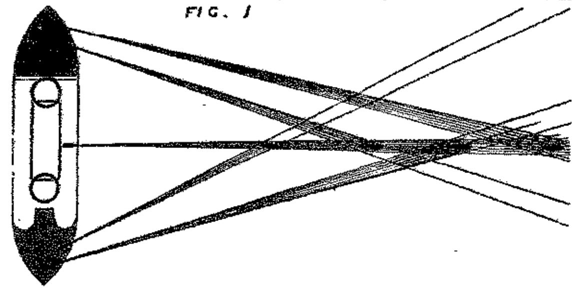
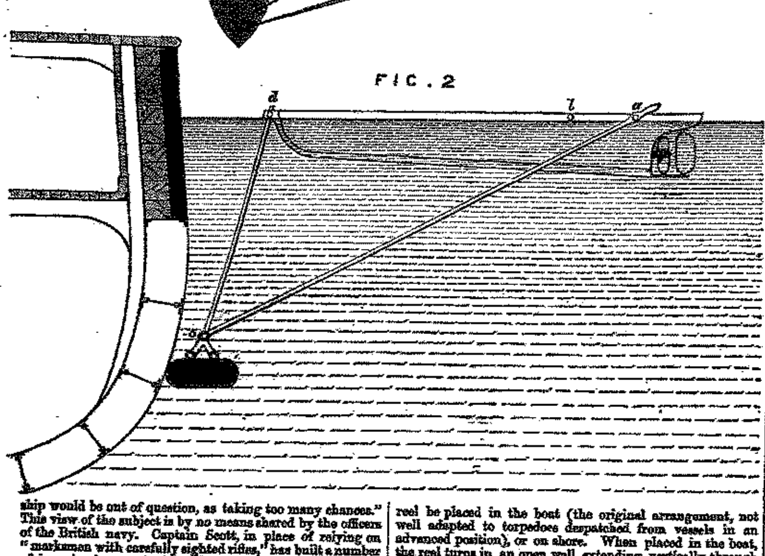


FIG. 2



The manner of carrying the explosive charge, contained in a cylindrical copper vessel having semispherical ends, will be readily understood by referring to the illustration. The advanced position of the copper vessel is regulated by two diagonal rods, a, c, one on each side of the boat, pins a and b being attached to the gunwale for that purpose. By means of the inclined rod, d, e, which slides in a square socket at the bow of the boat, the charge will be lowered to its position or raised. The superior efficiency of the charge applied far below the armour, as shown, compared with that of the Lay surface torpedo, requires no explanation; but it merits special notice that there is no empty space within the copper vessel, while the latter is entirely surrounded by an unyielding medium, excepting at the point in contact with the ship. Nearly the entire force of the explosion will, therefore, be directed toward the ship's hull, hence producing a terrific effect.

It is not intended in this article to describe the mechanism adopted for compressing the air which, by means of the tubular cable, communicates motive energy to the propeller of the torpedo. A brief explanation will, however, be necessary to dispose of Commander Kirkland's erroneous views on this subject. He states that "without fortifications to defend it," the necessary machinery would be exposed to destruction from the enemy's fire. Now, the *fact* is that, like the Moncrieff gun and carriage, which require no fortification, the mechanism necessary to charge the tubular cable, consisting of a common portable engine and boiler, together with the reel and air-pump, is placed in a hole in the ground less than 9 ft. square. "Landsmen" know that, in ordinary soil, such an excavation may be made in the course of 24 hours. Regarding attendance, any intelligent mechanic can operate the machinery referred to, whilst a few bushels of coal, or a few loads of wood, take the place of the chemical substances, the Bunsen cups, and the indispensible carbonic acid flasks, with their internal pressure of 600 lb. to the square inch. Can these materials and the electricians needed to operate the Lay torpedo gear be had as readily during war as coal or wood and mechanics of average intelligence? Mr. Lay states that he put 600 lb. of carbonic acid into his boat; yet this large quantity is consumed in less than half an hour. Now, 600 lb. of *coal* will develop fifteen horse power continuously during *ten* hours, when compressed air is employed in place of carbonic acid for propelling the torpedo. Another important question presents itself: Can the 25 ft. long torpedo, with its intricate mechanism, be built and transported as readily as a 20 horse power portable engine and boiler, covering a space of 7 ft. by 4 ft? Again, it should be borne in mind, with reference to the time necessary to obtain an adequate supply of such engines, with reel and air-pump, that such are the manufacturing capabilities of the country, that within eight weeks a supply from 500 to a 1000 machines of such comparatively rude description could readily be obtained. Commander Kirkland's apprehensions concerning the safety of these machines, which, as we have shown, so far from calling for "fortifications," require no other protection than that of being placed in holes in the ground, naturally suggests the question, in what manner is the cumbrous torpedo-boat to be handled within range of the enemy's guns? Evidently the fragile character of the wire which connects the internal mechanism of the boat to the electric apparatus on shore demands a degree of care and caution in handling wholly incompatible with the severe conditions inseparable from operating under the enemy's fire. It would seem, therefore, that the "fortifications" which Commander Kirkland erroneously supposes necessary for protecting the charging machine of the tubular cable can hardly be dispensed with in managing the torpedo-boat which he specially recommends on account of its independence of external machinery.

* From the New York *Army and Navy Journal.*

IRRIGATION IN SPAIN.

To the Editor of Engineering.

Sir,—In your issue of January 31st you published the second part of an article on "Contemporaneous Irrigation in Italy," in which reference is made to irrigation as practised in Spain. Having been many years resident in this country, and connected with the construction of irrigation canals here, the question treated of in your article is naturally very interesting to me, more especially under the aspect of the water duty that may be obtained in this country.

In designing or constructing a new canal no point is of such importance as the due apportionment of works to the amount of land that can be irrigated, and as in this, as in most other subjects, practical experience of what has been done is of the highest value, I trust I may be excused if I venture to ask you for a little space to show what has been and is the practice in Spain.

Spain, as is well known, possesses some of the most ancient irrigation works in the world, and, as is also well known to all who have studied this subject, there is no country where the economical management of water has been carried to such perfection.

I give below the actual water duty obtained on some of the most ancient and best-managed schemes in this country

Name of District.	Litres per 0'' per hectare.	Cubic feet per 0'' per acre.	Duty per cubic foot per second.
			Acres.
Valencia, from the Júcar	2.00	0.0283	35
Valencia, from Turia ...	0.86	0.0121	83
Gandia	0.80	0.0113	88
Murcia and Orihuela ...	0.74	0.0104	96
Esla and Henares ...	0.45	0.00635	157
Granada	0.29	0.00409	244

The land irrigated from the River Júcar, in Valencia, is chiefly devoted to rice cultivation—this accounts for the unusually large dotation of this district.

The Esla and Henares canals have only very lately been constructed, and until a larger experience has proved their powers, they can scarcely be taken as models of what can be done. Eliminating these districts we have those of Valencia, Gandia, Murcia, and Granada, representing the principal and most ancient irrigation zones of Spain, most of these works having been in operation from 800 to 1000 years.

Amongst these four districts, those of Valencia, Murcia, and Gandia show a remarkable uniformity of water duty; the mean term of the three being Gandia, which has a dotation of 0.80 litre per second per hectare, equivalent to 0.0113 cubic foot per second per acre, and a water duty of 88 acres per cubic foot per second.

The specially high duty of the Granada canals is accounted for partly by the much greater rainfall and more temperate climate enjoyed by this place, and partly because, from the