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Friday, June 2, 1882.

REAR-ADMIRAL W. HORTON, C.B., in the Chair.

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## ON THE DEFENCE OF HARBOURS BY SUBMARINE MINES.

By Lieutenant CHARLES SLEEMAN, R.N.

It is with the greatest diffidence that I venture to read a paper this afternoon on any component part of that vast and comparatively developed subject of torpedo warfare, and most certainly should have offered so to do, had I not received a very flattering and encouraging request from the Council of this Institution to prepare a similar paper at the end of 1879, when I was on the eve of departure for China, and therefore unable to comply, and had I not also received valuable assistance from many able authorities on torpedo matters.

The magnitude of my subject, and the short space of time at my disposal, will only allow of a mere cursory glance at most of the details of harbour defence, and but little more at those of submarine defence, which really constitutes the main feature of my paper, and it is on these latter details that I look for some clear light to be thrown by the discussion which I hope may be invoked by to-day's work.

I will here mention that, with the exception of Captain Lushington's lecture on "Naval Blockade," and the one on "Torpedo-Boats" by Mr. Donaldson, there has been no paper read at this Institution on any of the various branches of torpedo warfare since 1875, and some half-a-dozen since its foundation.

The various items constituting a system of defence for harbours, rivers, mouths, &c., may be broadly classified as follows:—

1. Fortifications.
2. Vessels of war.
3. Guard and torpedo-boats.
4. Submarine defence.

The sheer impossibility of preparing a paper which should contain an adequate treatment of each of these items, in a manner worthy to be presented to a scientific naval and military audience such as is usually gathered here, decided me not to even attempt a general diagnosis of the first three of those items, but to devote my paper to the last but not least important of them, namely, "*Submarine defence*."

I think it best to mention here that, on the completion of my paper, I shall, by the kind permission of Captain McEvoy, explain the manipulation of two of his many inventions, being his "*Single System of Torpedo Defence*," and his "*Submarine Detector*."

inventor is a gentleman who has devoted the greater part of his life to the invention and improvement of torpedo and other military matters, and who is well known to many of you.

In discussing the subject of submarine defence, it will be best, for the sake of greater clearness, to divide it into its constituent parts, these may be defined as—

- A. *Systems of fixed mines.*
- B. *Locomotive torpedo submarine boats.*
- C. *Submarine boats.*
- D. *Passive obstructions.*

In dealing with these points, I prefer to leave that one prefixed (A) until the last, constituting as it does the main feature of submarine defence, and therefore requiring special and close attention.

I will then first treat of—

B. *Locomotive torpedo submarine boats.*—This part may be further divided into *controllable* and *uncontrollable* boats; the former class being represented by the *Lay* torpedo-boat, the latter by the *Whitehead* or *fish* torpedo-boat.

These representative submarine weapons being well known at the time pressing, I will not attempt to describe them, nor enter into the question of their merits and demerits. With regard to the *Lay* torpedo-boat, I have authority for stating that it has been of late considerably improved, its speed having been greatly augmented, and its manipulation much simplified. I believe it is generally conceded that a *controllable* locomotive submarine torpedo-boat is the form best suited for the requirements of harbour defence.

Then I come to the question of—

C. *Submarine boats.*—Up to the present time no practical adaptation of this mode of progression under the sea has been wrought out though I am told of a submarine boat now under trial in Sweden that is to be a perfect success. It is to Russia that we should look for solution of this difficult problem; for there the matter has of late years received the closest attention, but as yet without any definite practical result. I confess to having very little faith in submarine boats ever being brought to that state of practical efficiency which is needed for the work they are intended to perform in connection with torpedo defence, such as the destruction of fixed mines and their cables, &c., owing to the insuperable difficulty of piercing the intense gloom of the surrounding matter, when proceeding beneath the surface of the sea. Of course if by the aid of electricity or other power this difficulty of vision be overcome, and also that of the motor for these craft to such an extent that it becomes a feasible and safe matter to start from a ship in the offing in one of these subaqueous craft, pick up the harbour entrance, and moving about at a considerable depth cut the *steel-wire* mooring ropes and *armoured* branch cables of the submarine fixed mines, then these craft will most certainly demand the bestowal of far more attention than I think they deserve as at present constructed and manœuvred. This brings me to question—

D. *Passive obstructions.*—This mode of barring a channel or other

entrance, either by the sinking of weighted ships, piles, frames, or other methods, will no doubt prove extremely useful in many instances. The action and construction of such obstructions are, I consider, sufficiently well understood as not to require any special attention in this paper.

I must here explain that the subordinate positions I have *seemingly* assigned to the foregoing particulars of submarine defence, is due to the short space of time apportioned to my paper, and not to any want of belief on my part of their *great value* under *special* circumstances.

I will now proceed with the important question of—

A. *Systems of fixed mines.*—By a system of fixed mines I intend to be understood all methods of submarine defence necessitating the employment of fixed or anchored mines, and such I consider to form the backbone and most important factor of any scheme of coast defence that may be devised; the question (A) may then be resolved into the minor ones of—

1. *Systems of self-acting fixed mines.*
2. *Systems of dependent electrical fixed mines.*

I will first treat of the systems considered under section (1); these may be subdivided into *electrical* self-acting and *mechanical* self-acting fixed mines—the former including those whose firing agent is electricity—the latter those whose firing agent is mechanism.

The special application of a system of self-acting fixed mines for coast defence purposes is that of defending certain isolated and other portions of the defensive ground, where, for economy's sake or for some other cause, it is not necessary to advert to the dependent form of defence. The one great objection to any system of self-acting fixed mines is that the ground protected by them becomes a source of danger alike to friend and foe, and also the danger that has hitherto attended the planting and picking up of such mines: as regards this latter source of danger, so strongly condemned by Major Parnell in his lecture on "Coast Fortifications," where he says—"As for mechanical mines, they are hardly worth the mentioning, and are sources of danger to their employers rather than to those they are employed against," Captain McEvoy has, by some simple yet very practical improvements, I venture to assert, almost entirely expunged this objection. Were it not for the question of economy—the bugbear of all schemes of defence—I should advocate the entire *disuse* of self-acting fixed mines, and wholly depend on the dependent electrical fixed mines for coast defence, but as this economy question cannot be ignored, then this branch of submarine defence requires the most careful consideration.

Dealing first with the question of electrical self-acting fixed mines, we notice that but very few attempts have been made to devise anything practical in this line, for the reason, that where any system of electrical mine contains within itself the power of firing its fuse, an inherent risk of premature explosion must always, in a more or less degree, be present, and this source of danger exists, though in the latter in a minor degree, in the only two inventions of this kind that claim special notice, viz., the Hertz and the McEvoy systems of

electrical self-acting fixed mines. The former has been in use for some considerable time, especially by German torpedoists, and it was employed by the Russians on the Danube in 1877, when it was on one occasion successful, whilst the McEvoy system has been only lately perfected.

The Hertz system may be roughly described to consist of a mine case, on the head of which are screwed five lead cylinders, inside of these are placed five glass tubes containing chlorate of potash; beneath the lead cylinders, on the inside of the mine, are affixed five dry batteries: on either of the lead cylinders being struck by a passing vessel the glass tube is broken, and thus the battery rendered active and the mine exploded. This form of self-acting fixed mine I consider to be a most dangerous one, either to plant or to pick up; the latter fact I can vouch for, having had the unpleasant and dangerous task of clearing a part of the Danube in which some Hertz mines had been laid by the Russians. Its uncertainty I can also testify to, having seen one of the Hertz mines that had been torn from its moorings by the screw of a passing Turkish monitor, and drifted on to the bank of the river without exploding; one of its lead cylinders was considerably bent, but not sufficiently so to smash its glass tube. I was also once unwittingly anchored for some time over one of these mines, whilst on board the turret vessel "Hifsi Rahman," in company with the late Captain Manthorp, R.N., which we subsequently learnt from the Russian Officers they had attempted to explode by every means in their power, without, I am happy to say, succeeding.

Captain McEvoy's electrical self-acting fixed mine, a section of which is shown in the Plate, Fig. 1, consists of a small battery and a circuit closer placed within the mine case, also ingenious electrical arrangements for the prevention of premature explosions; as will be seen, he depends, for the action of his mine, on the contact of a hostile ship with the actual mine itself, and not with any particular excrescence. Captain McEvoy has not permitted me to exhibit this clever invention here; but I may mention that General Abbott, of the United States Torpedo Department, has ordered one of these mines for trial in America, as he considers it to be the most perfect one of its kind.

To eradicate the inherent danger I have before spoken of that exists in the ordinary electrical self-acting fixed mines, a system known by the name of the "sunken battery" was introduced. Here a set of five or more buoyant fixed mines containing circuit closers are connected with a voltaic battery, which is inclosed in a strong metal box, and sunk near its mines. This is an old idea, but it has hitherto failed, owing to the difficulty of obtaining a reliable battery; but with the present efficient state of the Leclanché this difficulty has been overcome. I will now proceed with—

*Mechanical self-acting fixed mines.*—Of these there are numerous and varied kinds principally devised by the Confederates, and of them the "Singer" falling weight invention has been more extensively used, and oftener successful, than any other species. Now this form of mine Captain McEvoy has taken in hand of late, and, I venture to

say, so improved it, that this mechanical self-acting fixed mine may now be considered as capable of supplying the want that has been long felt in submarine defence, namely, a mechanical self-acting mine that can be moored with perfect safety, whose action is certain, and that can be recovered with the minimum amount of risk. The original falling weight has been altered in shape and manner of resting on the head of the mine case. This new form of weight is prevented from falling off until a mine has been placed in position by a very simple mechanical contrivance; and to enable the recovery of one to be effected in perfect safety another arrangement has been introduced whereby, though the weight may be knocked off, yet the mine will not be fired. I am not at present at liberty to divulge anything further in connection with this newly improved mine, as it has not been patented. If the proper precautions be observed when carrying out the work of recovering self-acting fixed mines, such as waiting for smooth and dead low water, employing an experienced and careful boat's crew, and also using the submarine detector, there should be no danger or difficulty whatever in picking up the "McEvoy improved Singer self-acting mine;" and this I aver with the experience of one who possesses of such work with *unknown* self-acting mines.

I will now make some remarks on the subject of "Dumb Mine" or "Dummies." The reason originally advanced for the employment of such things was to increase the difficulties and tediousness attendant on any attempt that might be made by an enemy to clear space protected by fixed submarine mines. Now this should most decidedly be the only duty delegated to dumb mines, instead of what there seems to be a most pernicious tendency at the present time towards the use of dummies in the place of actual mines, and to trust the safety of a harbour entirely to moral in the place of real defence. There is no doubt a possibility of utilizing the moral effect of submarine defence for the purpose of deterring the attack of a hostile fleet, but to depend on the safety of any place by such means alone is, in my opinion, radically wrong, and is opposed to all the principles of real defensive warfare. I think it is hardly necessary to mention here, that were it England's misfortune to be drawn into a European war, then any of her opponents' harbours thus morally protected would soon fall into the hands of her fleet. This concludes my remarks on systems of self-acting fixed mines, the details of which want time prevents me from more fully discussing; not the less, I may impress on torpedoists in general, the great importance that attaches to this branch of submarine defence; for owing to the necessity of economy, electrical dependent fixed mines will be used as sparingly as is consistent in harbour defence, and their proper places supplied by the cheap self-acting mines, or possibly by the still cheaper dummy.

I now proceed to the study of section (2):—

*Systems of dependent electrical fixed mines.*—Of these, under certain circumstances, four different species have hitherto been employed; namely, the "ground" and "buoyant" fixed mines, and their combined with their circuit closers in separate buoyant cases.

The advantages claimed for any *ground* system of fixed mines are

the practicability of employing heavy charges, no liability to damage by the contact of passing vessels, and their certainty of position always secured.

Now, though none of these advantages may be possessed by the buoyant system of fixed mines—unless it be the latter one—yet owing to the uncertain and complicated operations attendant on the work of exploding a ground fixed mine at the exact instant of the hostile ship being within its destructive area, I prefer to depend entirely on the buoyant system for the protection of harbours by submarine defence; and I consider it most unadvisable and generally useless to employ the ground system of fixed mines. In the case of a mine charged with 500 lbs. of guncotton, and moored at its most effective depth, the radius of its destructive effect is, even with that large charge, only some 25 feet.

In the event of unforeseen circumstances rendering it impossible to use the system of buoyant mines, then I would rather trust to moral effect and self-acting mines than go to the trouble and expense of laying down a system of ground mines, necessitating the employment of any known method of observation firing, which at best can only be utilized at certain times.

I use the expression “known,” for Captain Watkins, in his lecture on “Range-finders” at this Institution,<sup>1</sup> mentioned the invention of a position-finder, which he stated was capable of automatically connecting up and exploding ground mines within less than 9 feet of vessels, moving at a speed of from 8 to 9 knots per hour. But, notwithstanding this invention, I cannot see any necessity that could arise where aught but the buoyant system need ever be employed, and thus I propose to do away entirely with the ground system of dependent electrical fixed mines, and also with those combinations of mines and separate circuit closer cases, and by so doing to adhere to one of the fundamental principles of torpedo warfare in all its branches, viz., *simplicity*, a principle, I venture to say, far too often overlooked.

My preference for the sole adoption of simple buoyant fixed mines in any system of submarine defence by dependent mines is based on the following grounds:—

I consider *firing by contact* to be the only truly practical and effective mode of carrying out submarine warfare, possessing as it does the needful elements of success for the destruction of a vessel, namely, the delivery of the whole force of the explosion, at the right instant, and in the weakest part; and, therefore, I regard buoyant fixed mines as wholly and solely contact-fired mines. Then, following out this reasoning, I fix the maximum charge of such mines at 100 lbs. of guncotton or other explosive compound, which amount is some 40 lbs. in excess of the charge considered necessary for the contact-fired Woolwich fish torpedo.

By thus limiting the charge and making the mines contact-fired ones, I obtain for the buoyant system the following advantages:—greater certainty of destructive effect; less expense of material;

<sup>1</sup> See Journal, vol. xxv, No. CXIII, page 765, *et seq.*



and simplicity in placing in position, as it is unnecessary to excavate each mine in the actual position assigned to it, as would be the case where any system of ground dependent electrical fixed mines is employed.

A buoyant mine such as I have described is shown in Fig. 2.

Then comes the question of "mooring" buoyant mines. This hitherto been considered a matter of great difficulty, and no doubt under certain exceptional circumstances, would prove a troublesome business. Most of the difficulties hitherto present in effecting mooring such a mine have been to a considerable extent overcome by the employment of a steel wire mooring rope, which prevents spinning round, and which would be found strong and pliant enough to ensure its being retained in its proper position under ordinary circumstances, the weight of the anchor having been carefully calculated according to the position of the mines, depth of water, flood tide, &c.

In exceptional cases a mode of mooring such as is shown at E might be adopted with advantage.

There still remains to be devised some practical method of recovering a buoyant mine at its normal depth in places where the rise and fall of tide is very great. Mooring groups of mines at different depths, increasing with their distance from the base of operations, rectifies, to some extent, this fault, but necessitates a considerable increase in the number of mines, and therefore in the cost of defence.

Another point in connection with the use of buoyant mines is the necessity of constructing them in such manner that they be rendered impervious to the constant ramming they would most probably receive from the passage of friendly vessels, if planted at the entrance of an important harbour; and the chances of accidents occurring from collision must be carefully guarded against by forming them of very tight compartments filled with cork, or some other method of rendering them unsinkable.

Having thus briefly discussed the various items of submarine defence, I will now treat the subject in its entirety; and to enable me to do this clearly and, I hope, effectively, I have prepared rough plans of a submarine defence of a river entrance and open seaport, both of which places will be probably recognized and familiar to many of my audience. I have preferred this method to the one usually adopted of creating a plan to suit the particular system of submarine defence under discussion.

Fig. 4 represents the plan of a system of submarine defence of what I term a "close" harbour, while Fig. 5 shows similar defence of what I term an "open" harbour. The former is of course more adapted to such a mode of defence than the latter one.

I will first take the case of the close harbour, Fig. 4. To the north is situated a large island, named Isle North, which it is impossible to circumvent by any but very light-draught boats, and therefore simply secured from rear attack. Flanking it is an extensive mu

To the west is another large island, Isle West, also secure from rear attack. Between these two islands flows a deep-water main channel, which is divided into east and west channels by the centre shoal and S<sup>1</sup> islands. The east channel ranges from three-quarters to a mile in breadth, the west channel from a quarter to three-quarters of a mile. Between the south-west mud flat and Isle West flows a shallow boat-channel about a mile in breadth at its widest part, but narrowing and shallowing considerably as it runs to the north. The average depth in the east channel is about 40 feet—ranging from 5 to 8 fathoms; in the west channel the mean depth is about 33 feet, whilst the depth of the shoal water to the south-west is from 13 to 3 feet, and on the centre shoal it is some 10 feet. The rise and fall of tide is about 4 feet and flows at the rate of from 2 to 4 knots per hour. The nature of the bottom is mud.

In planning the submarine defence of any harbour the points to be taken into consideration are—the object and importance of such defence, the assistance afforded by its natural formation and land defences, and the question of expense. And, going further into details, there would have to be considered—the number, position, formation, and class of the dependent electrical and self-acting fixed mines; also the question of the employment of locomotive submarine torpedo-boats.

In the particular case under review, the river, of which a sketch of the entrance is shown, leads to a most important town, possessing an arsenal and dockyard; and therefore the object of its defences, both land and submarine, would be the complete prevention of capture or of an effective blockade being established. Its natural formation lends great assistance to a work of defence, as the plan shows; and this is still further strengthened by the fact that a similar formation of narrow channels and high land is found about 10 miles further up the river, so that really the defence here treated of would only be considered as an advanced work.

First, as to the “fixed” mines themselves. The system of manipulating the dependent electrical fixed mines in this case, and also in that of the open harbour, would be the “McEvoy single main system,” Fig. 7; and, taking into consideration the depth of water, rise and flow of tide, “buoyant” fixed mines of maximum power would be used, that is, those containing a charge of 100 lbs. of some explosive compound. The “self-acting” fixed mines would be McEvoy’s improved Singer mine, containing only 50-lb. charges; and single moorings would be employed for both the dependent electrical and self-acting fixed mines.

Then as to their formation. By this I mean the shape or form in which the mines composing each group should be planted so as to reap the greatest advantages, such as—spreading over the largest space with greatest probability of success; simplicity in planting them and of laying out their branch cables; less chance of discovery by dragging on the part of the enemy. Now, considering carefully these points, I have preferred to adopt in the place of either circular, single line, or échelon, a triangular formation, whereby I contend the fore-

going advantages are obtained in a high degree. In Fig. 6 I have compared these four methods. The mines here are supposed to be planted at a distance of 600 feet apart, the two lines in the échelon case being 900 feet distant, which is the greatest space allowable. In calculating the spreading area of each formation to be its length multiplied by its depth, I roughly get, taking  $s$  as the area for the triangle formation,  $\frac{1}{2}s$  for the circular area,  $\frac{1}{3}s$  for the échelon area, and  $\frac{1}{10}s$  for the single line area.

Then for the probability of success. A ship steaming on to a group of mines of the triangle formation would be almost sure to strike one or other of them, which would not be so certain in either of the other formations, unless it be the circular one.

For simplicity in planting, &c., the single line is of course simplest, but next to it comes the triangle form.

Then as to the chances of discovery. Two or three mines in a triangle-shaped group being picked up by dragging would not at all be as sure an indication of the position of the remainder as would be the case were either of the other formations resorted to.

Then as regards the number and position of fixed mines. On the principles of submarine defence is, the prevention of serious damage to the first line of fortifications by the gun-fire of the enemy and the forcing and retaining as long as possible under a powerful cross-fire the attacking vessels when forcing an entrance. To do this the outer groups are planted as shown at A, B, and C, in Fig. 6. It would have been still more effective had I chosen to fortify the South, and consider that as the first line of land defence; but this would necessitate a great increase in the material, and consequently the expense of the defence, so I have only treated this isle as a look-out station, and as a place capable of affording a refuge for the gun-vessels and torpedo-boats of the defence. The station itself at S would be a bombproof, covered earthwork, carrying a few light guns, electric lights, &c., for the purposes of guarding and watching the groups of mines. And station S would be connected with fortification by the submarine telegraph cable C<sup>1</sup>, and by this cable its mines would also be fired when requisite, to render the place useless to the enemy.

Next comes the question of the defence of the different channels. The east channel, I calculate, would require at least 50 deep-sea electrical fixed mines, those in each group being placed 300 feet apart. The west channel might of course be effectually and simply blocked by planting it with self-acting fixed mines, but I have preferred to utilize this passage as a mode of egress and ingress for the vessel-boats of the defence whilst carrying out their special duties. The boat channel is rendered inaccessible by self-acting fixed mines laid down in the shoal water to the south-west. A boom obstruction combined with some few self-acting mines, would be prepared in readiness to further block the channel at its narrowest part, should the outer defences being forced.

The main and telegraph submarine cables, of which there are thirteen, are so laid that no crossing of them occurs, and with regard to the economy of the defence.

The shoal water round about Isle South is planted with self-acting fixed mines. These might with advantage be to a great extent supplanted by the dependent electrical system of fixed mines with 50.-lb. charges, and controlled from station S; but such would no doubt be considered too expensive.

Then we come to the subject of subaqueous batteries for the use of locomotive submarine torpedo-boats.

One battery might be placed to the south of Isle South, as at L, and its torpedoes manipulated from station S; another one, L<sup>1</sup>, off the work at S<sup>1</sup>, and controlled therefrom. The Germans are now experimenting with sunken batteries, containing six Whitehead uncontrollable torpedo-boats, starting them by some application of electricity; but the practical knowledge as regards the best mode of operating these subaqueous weapons has yet to be acquired, so I will not venture to further discuss them.

Having thus somewhat meagrely gone into the matter of the submarine defence of what I term a "close" harbour, I will now proceed to discuss the question of a similar mode of defence in the case of an "open" harbour, a rough sketch of which is shown in Fig. 5.

The actual harbour is comprised between forts F<sup>4</sup> and F, and is formed by means of a breakwater; the depth of water off the breakwater entrances, and at the outer (B) group of mines, ranges from 6 to 13 fathoms. The 5, 3, and 1 fathom lines are shown by the dotted lines. The strength of the current varies from 2 to 4 knots, and in this case a considerable rise and fall of water is met with, namely, some 20 feet at spring, and 13 feet at neap tide.

The nature of the dependent electrical fixed mines used would be buoyant ones of maximum power, and they would be specially moored somewhat after the manner shown in Fig. 3. The self-acting fixed mines would be similar to those used in the defence of the close harbour.

The distance extended by the outer line of submarine defence is upwards of 6 miles, and the groups of mines composing it are laid at some 2 miles' distance from the first line of fortifications. By the disposition of the dependent fixed mines, as shown in my plan, I hope to obtain what is the *sine quâ non* of such work, namely,—a maximum power of defence with a minimum of cost and of complication; and I cannot believe the capture of any harbour known to be so strongly fortified and supported by so powerful a submarine defence would ever be attempted, and thus the grand object of such a combination would be obtained, which is, the rendering of a port actually impregnable. The bombardment of the town and arsenals would have to be performed at a distance of 3 miles, and from seawards.

The dependent mines in this case are all planted as it were in the open sea, and thus any attempts made to damage or destroy them must be dependent on the state of the weather, and so would not be of so frequent occurrence, or stand so much chance of success, as would be the case in connection with a close harbour, where such

attempts would possess an important element of success, namely "smooth water."

The coast about this port is an extremely rocky and dangerous one, and therefore would not require a large number of self-acting mines as a flanking defence; also the fact of their having to be moored along the sea coast would militate to some extent against their use, owing to the possibility of some of the mines breaking adrift in heavy weather. I have shown in the plan a few of these mines placed along the coast, but the actual position and number of them will have to be determined by those more thoroughly acquainted with the peculiar exigencies of the situation.

This will conclude my necessarily very few brief remarks on the subject of a submarine defence of a close and open harbour, such have exemplified, and the only excuse I can offer for such a condensed treatment of an important subject is the vastness of the field I have attempted to cover in one short paper.

Until within the last few years, and even I believe at the present time, torpedo warfare has been looked on as something uncanny, too terrible. Now, the primary object of submarine defence is the safeguard of a harbour against the attack of a hostile fleet, and to maintain, that in the event of an enemy's ship being sunk in an attempt to force a harbour so protected, those responsible for the service being carried out should be held accountable for any loss of life ensuing from such a catastrophe, and not those responsible for such defensive means being resorted to. As a rule, it will be generally known whether any particular harbour is studded with fixed submarine mines or not; and should the slightest doubt ever exist as to that fact, it would in my opinion be a most foolish and reprehensible act on the part of any one to attempt to enter a port.

The popular delusion as to the resultant effect of an explosion of a submarine mine in contact with a vessel-of-war still, I believe, exists, which is, that the ship is blown into the air into small pieces, with total loss of her crew, while the actual effect with ships as at present constructed would be at the most the gradual sinking of the vessel caused by a large hole being made in her double bottom, and with but few casualties to the crew, they having ample time to get off in her boats.

Surely this cannot be considered as uncanny, nor yet one iota so terrible as those constant and dreadful bombardments between ironclads and ships usually ending so seriously for the crews, which have hitherto been so common a feature of maritime warfare; which the general adoption of submarine defence will to a great extent lessen, and thus the uncanny and too terrible torpedo under such circumstances be looked upon as really a *life-saver* weapon.

Notwithstanding the imperfection of the systems of submarine defence used during the American Civil War, yet even then we find Admiral Dahlgren writing: "I believe torpedoes to constitute

most formidable of the difficulties in the way to Charleston." But though some twenty years have elapsed since those words were written, and during this period submarine defensive material has been vastly and generally improved, and that in actual war submarine defence has been proved to be of immense value, yet we find Major Parnell writing: "Submarine mines do not, however, form material obstacles, and it is probable that their value is chiefly of a moral nature."

And yet another Officer, Captain Barrington, in his work entitled "England on the Defensive," though the author to some extent appreciates the value of submarine defence, says: "But torpedoes can only destroy or cripple the first line of attack, and when they have acted, the enemy can advance without further hindrance." Also Commander Barber, U.S.N., in an article on the progress of torpedo warfare, though he looks on fixed submarine mines as of immense utility as auxiliaries to other systems of defence, yet distrusts them to a great extent, on the belief that countermining and cable cutting will often prove successful; and also the general tenor of the remarks made *à propos* of the employment of torpedoes in the discussions here and elsewhere, is to the effect that torpedo warfare cannot yet be safely relied on, and therefore need not be seriously considered in matters of attack and defence. Now all this is, I venture to say, a great and radical misconception of the real value of submarine warfare, which should most certainly be eradicated at once from the minds of all naval and military men—especially of ours—who will, in the event of war, find the at present slighted and ignored torpedo of infinite value for defensive purposes, and I fear a terrible bugbear in all naval operations.

In the event of an organized invasion of England, which to judge from the numerous articles and letters published of late from the pens of some of the ablest of our naval and military Officers, would seem to be looming in the immediate future, we should have to depend for the safeguard of our numerous harbours, ports, inlets, &c. (which number, I believe, some 280), almost entirely on submarine defence—at any rate at the outset—that being the cheapest and most ready to hand of any defensive means; and this applies not only to England, but to all countries possessing any extent of sea coast.

One of the principal objects of an invading force would be an immediate descent on some known unprotected part of our coast, and there effect a landing; but if all the numerous places that must exist in a more or less unprotected state, when land defences and the presence of a fleet only are relied upon, possess a means of submarine defence, and a trained body of men to manipulate it, then the enemy would first have to wholly or partially destroy this submarine defence, before proceeding to the work of landing, thus occasioning at least a considerable delay, and affording time for our ships to arrive, with the probable result of the failure of the invading force at that particular attempt, and possibly the utter collapse of the expedition.

I trust no misconception may arise from anything I have said as to the value and importance of our Navy; but what I have intended to

express is the absolute necessity of submarine defence to enable splendid Navy being fully utilized, and affording it full opportunity to carry out the multifarious and onerous duties assigned to our fleet at the present day, and this with perfect immunity to us from invasion.

Then, again, the vast economy of submarine defence entitles it to that ground alone, to far greater importance and attention being given to it than is usually the case; and, as a proof of this economy, I mention that employing the "McEvoy single main system," for the dependent electrical mines, a sum of 1,500,000*l.* would allow a submarine defence of each of those 280 vulnerable inlets on our coasts, consisting of one-half of the whole material considered necessary for the defence of the close harbour.<sup>1</sup> Now this quantity might be taken as affording an adequate mean submarine defence for those 280 inlets.

In the method I have adopted of only employing small buoyant mines in a system of submarine defence, I do not see any need for complicating such a system by the addition of special fixed or other means for the prevention of interference with the defence by the enemy's boats; for if, whilst attempting to damage the defensive fixed mines, one of them be struck and short circuited, I should most decidedly not hesitate to fire that particular one; the probable effect of destroying the boats carrying out this work of destruction, or at any rate deterring a repetition of similar work, would be so doing it may be said that a mine is wasted, and caused in the line of defence; but by the employment of the single main system and small buoyant mines I consider it quite feasible and practicable to reinforce the submarine defence at any time, even in the presence of an enemy; provided that everything requisite for the accomplishment of such has been carefully and thoroughly prepared beforehand, and the submarine defence corps have been practically trained for this special service. This brings me to the question of the organization of a submarine defence corps. With us this is undertaken by the Royal Engineer Corps, but all the principal Continental Powers intrust the carrying out of this work to the Service.

Now the whole defence of any harbour must be a homogeneous work, if it be ever expected to successfully stand the crucial test of actual war, and therefore the old saying, "that those who plan the defence should also plan the torpedo defences," must be considered only partially correct, for the resultant plan of defence of an harbour should be the outcome of a joint committee of naval, artillery, and engineer Officers; and the actual execution of the submarine part of the defence should be placed entirely in the hands of the naval department; and this, I venture to say, must appear self-evident when it is duly considered what the details of such work consist of, and how infinitely more adapted for lighter, boat, and submarine work those are who, as it may be said, are born to it, than men

<sup>1</sup> See Appendix.

shore, as to all intents and purposes military men are. I trust it may not be conceived that I underrate the value and efficiency of the Royal Engineers, than which a finer or more important corps does not exist; but I do think that the work of the sea should be performed by seamen.

Then coming to the subject of the coast defence of the British Empire—a subject of vital import, involving as it does our immunity from invasion, the power of upholding our foreign prestige, and thus the preservation of peace to the Empire now and always,—submarine defence, if carried out in a thoroughly practical and real manner, and suiting the different means adopted to the peculiar exigencies of each particular place, will assuredly prove of immense benefit by enabling us to utilize to the full the power of our Navy. Of course, the principal naval ports, such as Portsmouth, Plymouth, &c., and strategic points such as Gibraltar, Malta, Hong Kong and others, are, or will soon be, amply provided with a means of submarine defence; but it is to the innumerable commercial ports, harbours of refuge, coaling ports, inlets, and open beaches which are to be found around our home and colonial coasts, many of which it might be absolutely requisite to securely protect, that I more particularly refer here, and in the safeguard of which submarine defence would prove of paramount importance. Captain Colomb in his Prize Essay of 1878 says—<sup>1</sup>

“If the enemy is to be kept at bay by a home defence of any kind, I should think that a cordon of coast torpedoes, fixed and locomotive, in the hands of a British volunteer force will do it,” in which I most cordially agree with him.

A volunteer torpedo defence corps should consist principally of the seafaring population of the different ports—men thoroughly accustomed to boat work, and possessing an accurate knowledge of the characteristics of the particular place to which they belong—and thus essentially adapted to the performance of the work of submarine defence. Little or no training would be needed for the greater portion of the force, as these men would have only the comparatively simple work of laying out the main and branch cables and planting the dependent electrical and self-acting mechanical mines. Then, having ascertained the number of men at each port it is determined to defend that would be capable and available for such service, a muster of them from time to time would suffice to secure their attendance when called on. The number, condition, and power of the steam tugs, launches, and lighters available at the different ports for the work of laying down the systems of submarine defence and guarding the same would, of course, have also to be ascertained and considered. At each port a few specially instructed members of the force would be needed for the work of manipulating and fitting up the system; no highly scientific training would be needed, but actual practical knowledge of the mode of working the instruments and batteries of the particular system that it is decided to adopt would

<sup>1</sup> See Journal, vol. xxii, No. XCIV.



have to be thoroughly taught. The plan and mode of defence is to be determined on beforehand, and all the material prepared in readiness for carrying out the same. The foregoing no doubt seems a makeshift and rough scheme of organization of a volunteer torpedo corps, but with the experience I have gained from carrying out similar work with Turkish and Chinese sailors who had had no previous training whatever, and not one of whom had ever seen much less seen, a torpedo, and whose language I was ignorant, I venture to say that a scheme based on those lines would prove a practical and efficient one.

The submarine defence I would propose to adopt with this scheme would be the simple buoyant dependent electrical fixed system, in connection with a simple method of single main cable or rheotome system, and the McEvoy improved self-acting mechanical fixed Locomotive submarine torpedo-boats, if used, should be entrusted to the regular force, and I believe a naval volunteer torpedo corps, carefully, and above all practically, matured, would—auxiliary—be to the Navy what the Volunteers are to the Army, than which no higher praise could be accorded it.

This concludes my paper, which, though it be terribly incomplete and far too concise, yet may, I hope, prove of some value in raising discussion on the many points I have been forced to leave untouched or only cursorily glanced at, in which, I hope, those gentlemen more able and capable of dealing with them may join and give the benefit of their vast knowledge and experience. I have only to offer you, Admiral Horton, my most grateful thanks for your presence in presiding, and to express the deep obligation I feel to my audience for the patient endurance displayed in listening to this has unavoidably been an incomplete and dry paper, and one of dogmatic opinions. As a result I can only hope that some of you may become imbued with the same strong opinion as myself as to the essential value and power of submarine defence.

I now proceed to describe Captain McEvoy's inventions.

I will first explain the mode of working the invention known as "The McEvoy Single Main System."

The title is intended to convey a system of submarine defence in which a number of mines are controlled and fired through a single cable of any length, but containing only one core or path for the electric current to traverse, which current enables all the various modes of firing and tests connected with any system of submarine mines to be accomplished. Hitherto, for this work, it has been necessary to use a separate core or path for each mine.

The principal object of this invention is the combination of simplicity of manipulation with great economy.

The single main and multiple main systems are shown and compared in the Plate, where Fig. 7 represents the former, A the shore instrument and J the junction box, inside of which is placed a sea or rheotome instrument; and Fig. 8 represents the latter, T the test-table, S the shutter arrangement, and J' the junction box.

The advantage of the former method over the latter in point of simplicity and paucity of connections is obvious from the plate, being as 1 to 2; and this advantage is still more patent when we take the case of the connections in a torpedo-room from which a number of mines—say fifty—are controlled. In this instance, using the McEvoy system, there would be only 5 main cable and 35 other connections giving a total of 40. While using the multiple cable system there would be 7 main cables, necessitating 49 connections, which, with the 63 other wires, makes a total of 112, or as 3 to 1 in favour of the McEvoy system.

Then another advantageous feature of this method is that due to the lightness per mile of its main cable, weighing as it does one-third less than the multiple main cable per mile, thus making the laying-out of such a work far more handy, requiring less time, and less expense further, the gain in economy by the use of the McEvoy system owing to the extreme comparative cheapness, namely, as 1 to 4, of its main cable, which constitutes the chief item of expense in submarine defence is yet another very important feature to be considered; and in the matter of the foregoing points of vantage on the side of the McEvoy invention, no one, however biased or prejudiced, can take exception thereto.

Before explaining the mode of manipulating this invention, it will be necessary to state, in general terms, the requirements of a perfect single main cable system:—

1st. Its manipulation must be simple and practical, and not requiring the services of a skilled electrician.

2nd. It must be certain in all its actions.

3rd. It must be capable of firing either at will or by contact.

4th. It must be able to denote the electrical state of each mine by comprehensible and easy tests at any time.

5th. It must afford certain indications of any severing or damage of either main or branch cables.

6th. It must denote the number of any mine exploded or struck.

7th. It must afford indication of the sinking of any mine.

8th. There must be no possibility of a switch or key being left in its wrong position.

[Note.—Then followed a general explanation of the system.]

Having thus shown you the capabilities of this invention, I will mention, and I hope overrule, the few objections that might be preferred against it. The sea instrument is of course the main objective point:—

1st. It may be thought to be too delicate an instrument to be placed under water, and in a position difficult of access, and on which the working of ten submarine mines depends.

Twenty or even ten years ago these objections might have been made with some show of reason; but nowadays, with the practical knowledge that we have of the satisfactory working of intricate pieces of mechanism under an excessive strain—such as telegraph and other instruments—no one would think of entertaining any objection to the adoption of an electrical instrument solely on account of its

apparent delicacy of construction. I say apparent, for it can be so to those who are unaccustomed to manipulate such instruments. Now, this sea or rheotome instrument of Captain McEvoy's, with a very much simplified adaptation of the Wheatstone A B C telegraph instrument, would, on actual service, have to stand comparatively little work—probably not more than four series of tests each. This instrument, and a similar one I had with me in China, have been often subjected in one day to far more work than would be the case with one of them on actual service in the course of a month of ordinary work; and yet we have never had occasion to remove the lid of the instrument case, for repairs or other matters, though the one used in China have been hard at work for many months.

Next, as to its being placed under water. This is, I venture to say, a very simple matter, involving merely the construction of separate brass boxes, or more if it be considered necessary, one for the other, both watertight, and capable of resisting a pressure of water, varying according to the depth at which it would be placed. The work, with the present perfection of all mechanical details, is easily and practically attainable.

2nd. It might be thought that owing to electrical leakage the balance may not work satisfactorily, and therefore uncertain results are afforded, after a group of submarine mines has been planted for a considerable length of time. Now, this fault caused by leakage, which I have greatly exaggerated, would be easily remedied by merely increasing the power of the signal battery, by the addition of a cell or two: for the failure of the signal current, which is supposed to be kept at a normal strength, to correctly swing the test needle, is due to its current, or a portion of it short circuiting through points of leakage.

This completes the explanation of this clever invention, which has been adopted by several foreign Governments, and I trust I have favourably impressed you with its power and practical usefulness for submarine defence; any way, I believe you will concur with me in declaring that it deserves a fair and honest trial.

Captain McEvoy supplied one of his original sets of instruments to the Chatham torpedo authorities in 1879, but he has not had the satisfaction of receiving an expression of opinion as to the merits or demerits of his invention; the Chatham authorities do not embrace all the late improvements.

This particular set of Captain McEvoy's system is adapted for a group of 10 fixed mines. Now, it has been often urged that it is too great a number of mines to be manipulated by one set of instruments and dependent on one main cable, and that also a far too great gap would be formed by the loss of one such group through the discovery of its main cable by the enemy.

Take the case of the close harbour in Fig. 4—here 100 deep-sea fixed mines are estimated for its defence, necessitating 10 sets of instruments, and 10 main cables. If only 7 mines composed the group, then to obtain a similar defence there would be required 7 sets of instruments and 14 main cables; and in the case of

groups, 20 sets of instruments, and 20 main cables would have to be employed, and I do not think the exponents of the reduced group system would consider the advantages claimed for it to be attained by the use of a greater number than 5 mines for each group: then by substituting the reduced or 5 mine group system for the 10 mine system, it is evident that far greater time is required for the work of laying out the defence, the cost is nearly double, and the simplicity of the work much impaired by the increased number of main cables and instruments; also the chances in favour of a main cable being discovered by the enemy are exactly doubled, therefore, weighing carefully the advantages and disadvantages of the two systems, I think it will be generally agreed that the 10 mine group system is by far the preferable one.

In conclusion, I will proceed to explain the very latest of Captain McEvoy's inventions. It is termed a "submarine detector," Fig. 9. It is constructed on the principle of the induction balance, and consists of an instrument box, small battery (which may be either a magneto or ordinary chemical battery), and the detector with its cable and box: this detector cable is composed of four insulated cores, and by an ingenious contrivance, the connection of these four cores can be made or broken by one movement. Within the instrument box is placed a set of induction coils, and a vibratory magneto-electric apparatus, the telephone in connection with which can also be laid in the box; the battery poles are always connected up, but the circuit can be broken or closed at will, by means of a small key; within the detector itself is placed a set of induction coils. The action of this invention is as follows:—the circuit being closed, and the telephone placed to the ear, a very distinct and regular increase of a humming sound will be heard on the near approach of the detector to any piece of metal however small, culminating on actual contact therewith. This invention, as may be easily understood, will prove of great value in an infinite variety of ways; as specially connected with submarine defence, it will be found of great use in discovering the position of submarine fixed mines—both dependent electrical and self-acting—also junction boxes, cables, &c., when it is required to recover the same.

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#### APPENDIX.

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The following is the amount of material that would be required for a submarine defence similar to that of the close harbour, Fig. 4, where Captain McEvoy's system of defence is employed:—

- |                    |   |   |
|--------------------|---|---|
| 10 sets of         | { | Shore instruments.                              |
|                    |   | Sea „   |
|                    | { | Junction boxes.                                 |
| 100                |   | buoyant dependent electrical mines.             |
| 100                |   | relay circuit closers.                          |
| 100                |   | anchors.  |
| $\frac{1}{2}$ mile |   | of steel wire mooring rope.                     |
| 22·44              |   | miles of armoured cable for the 10 main cables. |

- 20·5 miles of armoured cable for the 100 *branch* cables.
- 22·44 miles of steel wire rope for the 10 junction box tripping ropes.
- 24 10-cell Leclanché batteries.
- 4 Leclanché firing batteries.
- 139 self-acting mechanical mines.
- 139 anchors.
- $\frac{1}{4}$  of a mile of steel wire mooring rope.
- 7·34 miles of cable for 3 submarine telegraph cables.

The CHAIRMAN: There are gentlemen present who can tell us something of torpedo arrangements: perhaps some of them will be kind enough to make observations on the interesting lecture which Lieutenant Sleeman has given us.

Captain CURTIS, R.N.: I have seen and heard more about torpedoes here than at any other place in my life. Lieutenant Sleeman will excuse me if I try to touch upon the points of his paper as they appear to me. I conclude that these are not the awful weapons that they are generally supposed to be. Admiral Horton, now at Sebastopol when the Russians fired at him repeatedly. It appears to me that naval men should be the men to lay down torpedoes, and also to pick them up when they are being paid prize money for them when picked up before the enemy. Artillery men may say where they require them to be laid for the protection of a fort, but naval men, I consider that everything that has to do with the sea, seamen should be told off for. If Captain Spratt had been at that time a torpedo Officer, and it had been his duty to use this detector, I have no doubt he would have cut off the cable. We would run the risk of that. Then, again, at one point the mines appear to me to be superior to the floating mines, inasmuch as six or seven years ago I wrote to Captain Morgan Singer and suggested the idea of picking up the floating torpedoes. My idea was taken from the antennæ or feelers of a lobster. They are spars 50 feet long or so, with jaws of steel. One is at the end and the other arranged scissors-like, attached to a capstan, and you have a net at the jaws; and if you say the destructive effect of a torpedo is only 25 feet square area, you may easily have the beam 35 feet across your bows, and I presume should have vessels whose special duty it would be to precede the vessels attacking the fort to cut off the junction. Of course, if the torpedoes went off when they came up in the net some of the apparatus would be damaged; we should have several spare spars, &c., but that is a matter of little consequence, I imagine. We were speaking about torpedoes being moored at five or six miles off the fort, but I doubt they would be detected with these detectors. Then, I think, there would be no difficulty in picking them up in detail. That is where I see the weakness of torpedoes, and I think the torpedo that goes off by coming in contact with a vessel is certainly superior to any others.<sup>1</sup>

Colonel MALCOLM, R.E.: I came here to learn, not to talk, and I alone represent the Army side of the business, because, unfortunately, at the present moment the Royal Engineers are occupied with their meeting, which takes place only once a year, which I have run away from. I can only say that we have been working the Army pretty hard for the last twelve years, to my certain knowledge. I do not find torpedo defence quite such a simple thing as it appears on the table, but we do trust to a not inconsiderable extent to that moral power which the Army possesses, while he confesses to its influence, when he says, "In my opinion it is a most foolhardy and reprehensible act to attack a fort without a great deal of care." He also referred to Odessa, where people, to be brought through a mine, what we have every reason to believe, as he said himself, were chiefly dumplings stopped seven miles outside and passed in blindfolded. But how would that be at Liverpool, or in the great port of London? The business of torpedo defence is very simple on paper, but it is not quite so simple when you have got to defend the interests of this little island, which is so intensely commercial. I just

<sup>1</sup> NOTE.—That nation who has command of the sea, can lock his enemy out of his own port, by countermining with torpedoes, &c.

this question out, because, of course, we are very glad of any hints, and I have received some valuable hints myself to-day. I am in a position more or less confidential, and I do not quite know what I may say and what I may not; but taking the defence of these 280 inlets at  $1\frac{1}{2}$  millions of money, if we give them twenty more, and make 300 of them, it comes to 50,000*l.* per inlet, or 50*l.* each mine. What does that represent? Does that represent the mine cable, the mine cable and apparatus, the mine cable, apparatus, rooms, and boats, &c.? There are so many things that I am afraid that must be rather a *couleur de rose* estimate. As an old lecturer at Woolwich used to say, "Gentlemen, this is a large subject." Many points that have been shown here are not new, although they are so very pretty. The ability to render a number of mines active or inactive at will, for instance. With regard to what is called Captain McEvoy's single main system, I do not know from what year he dates it, but I myself propounded an exactly similar system as far back at least as the year 1872, of course with the very same objects that Captain McEvoy seems to have very successfully accomplished. We worked it for seven mines to a great extent; we could put 49 mines on one cable, but we found so many practical difficulties that do not appear on the lecture table, that the seven mines on the single core system have been given up. Captain McEvoy's rheotome system, we have been told, has been tried at Chatham, but as it is not the latest pattern according to the lecturer, certain defects have been discovered, so, although it is very highly thought of, it is not perfect enough to give complete satisfaction there. As for mechanical mines, of course we lay very great stress and importance upon them. There has been the very greatest difficulty in getting a mechanical mine to do all you want. You have to get a thing that will go off if you look at it, and that is perfectly safe to handle. That is not an article very easy to obtain, but there are certain mines at present under consideration and observation not mentioned by the lecturer which promise well, and it takes some time when you have got to deal with great pecuniary interests to settle upon patterns; because it is not only this country, but we have Colonial possessions, and so forth, to be looked after. We must satisfy ourselves to some degree. We are custodians of the public money, though we get little credit for it, and we must satisfy ourselves we have got a good thing. This cannot be done off-hand. Still, although we have been some years unsuccessful at it, we think we see light at last towards solving the problem, that difficult one of getting a satisfactory mechanical mine. To criticize a little, in that open coast system of defence, there is a very large opening between two and three, through which launches might go, and I fancy the whole of that upper line would be cut without the slightest trouble by the gentlemen from Portsmouth. That is supposed to be 13 or 14 fathoms. But in many places at that distance from land you get a far greater depth of water, then mooring your mines becomes a greater difficulty, and a three-fold mooring must be, I think, useless. There is one thing I am thankful to find, that there has been so good an attendance, and I hope Lieutenant Sleeman will succeed in impressing on the public the importance of submarine defence, in which, both actual and moral, I do believe firmly, and if we can get more money, I hope we shall be able to get on faster than we have done in the years that are past.

Lieutenant SLEEMAN: First, I will reply to Captain Curtis. He seems to think the weak spot of submarine defence is the fact that it is an easy matter to pick up and cut a main cable. Now, in all our principal naval ports and strategic points, such as Malta, Gibraltar, &c., and also our principal Colonial ports, it would be of very little use laying down a system of defence, unless that system were protected by guard vessels and boats; then it should be an almost impossible work for the attacking boats to get into a harbour and damage its submarine defence in the face of the guard boats and vessels, the guns of the forts, electric lights, &c. No main cable has in actual war ever been successfully got at and cut, though I think during some torpedo experiments at Spithead the attacking force did accomplish it, but that was what the Chinese call "play pidgeon" only. If you lay down mines, as you might have to do, in harbours where there were no land defences or guard vessels, you would simply place them there to prevent the enemy's vessels getting in, on the spec of there being no submarine defence; and also it would cause considerable delay and great trouble to pick the submarine mines up; for even in peace

time, and with every appliance to do such work, it is very troublesome and tedious. Now, I had to pick up self-acting mines at Sulina, on the Danube, during the Russian Turkish War of 1877-78, that I knew nothing of, not having seen the kind before. It was the Hertz mine. The first mine was found in a boat all ready for mooring. As I knew nothing of its manipulation, I had to set to work and take it to the bottom all the time expecting a premature explosion by clock-work apparatus or otherwise. Having diagnosed the mine, we set to work dragging, and though my boat's crew were composed of Turkish sailors, whose language I knew not, and who had never before seen a torpedo, and were in mortal fear of the mere name, yet five of self-acting mines were safely picked up. I mention this to show that under the most untoward circumstances it is not so very difficult a feat to pick up self-acting mines in *your own water*, and so I maintain that with Captain McEvoy's self-acting mechanical mine it would be perfectly easy and safe to lay down and pick up a number of them, by men accustomed to sea work. But it must be remembered that an attacking force would not be attempting to pick up mines, cut cables, &c., in harbours familiar to them, but in strange ports, which probably may never have been visited by them before, by which the difficulties of such a work are enormously increased. In the Turkish War it was found extremely difficult *even* to pick up the entrance to a harbour. Colonel Malcolm seems to believe a great deal in the moral effect. Now, moral effect would be important no doubt, for the trouble would be to distinguish between a moral and a real defence, and a harbour might be one which was thought to be only *morally* defended, instead of which it might be possessed of a real submarine defence, and the consequence of such a mistake would be somewhat serious to the attacking ships. I know the case of a harbour in the Black Sea about which the opposite supposition was accepted, that is, it was believed to be defended by torpedoes. Now, the late Manthorp Bey, not creditably reported, proceeded in one of the small Turkish monitors, and steamed round the harbour at a speed of eight knots, without exploding a torpedo, a pretty conclusive proof of the absence of any submarine defence there. Had his ship been blown up, not having taken any precautions to clear the harbour, he would have done a hanging. The result of this bold manœuvre was, that the Turks would not believe that such things as Russian torpedoes existed anywhere; and thus it came about that the Turkish monitor, "Hifsi Rahman," was anchored for some time in the Russian mine, as I have mentioned in my paper. Manthorp Bey, who was in charge, laughed at the idea of there being any Russian torpedoes in the branch of the Danube. Then, notwithstanding the fact of a Russian boat having captured a self-acting mine in it having been captured just previous to the Russian bombardment of Sulina, the Turkish Admiral ordered a steam-tug and gunboat to pick up the river and reconnoitre the enemy's fleet, the result being the destruction of the gunboat by one of these very same self-acting mines. The tug at the time of the catastrophe was some two miles in advance of the gunboat, but observing an explosion at once returned to Sulina, and left that same night for Varna wounded, it being impossible to induce the Admiral to send her up the river for the purposes of reconnoitring, which would have been perfectly safe, as the Russian torpedoes were evidently self-acting ones, and moored at a greater distance from the surface than the draught of water of the tug, which was only some ten feet. I mention this fact as a proof of the moral power of actual submarine defence, and how simple a matter it is to raise a torpedo funk. Colonel Malcolm also alludes to the expense of submarine defence. Of course in calculating the sum of one million and a half of money for the defence of the 280 ports, &c.,<sup>1</sup> I have run into the question of the expense of the labour, boats, &c., but I have calculated the cost of the actual torpedo material used for my close harbour, where 10 self-acting torpedoes, 100 electrical dependent mines, 100 circuit closers and anchors, 2 of main cable, &c., are required, which would give a total of 10,114*l.*; and 139 self-acting mechanical mines, &c., a sum of 13,467*l.*; then taking half the foregoing material for each of the 280 ports, and allowing a certain percent for the large quantity, I obtain the sum of one and a-half million before me:

<sup>1</sup> See Appendix.

which I think is a very fair estimate. In conclusion, I beg to thank you for your kind attention, and Admiral Horton for his acceptance of the chair at the late moment.

The CHAIRMAN: We have had a very interesting lecture, and heard opinion expressed from both the sea and the land, from the attack and the defence sides the question. I fear that one conclusion must be arrived at in which all here would concur, that it is an enormously expensive system to deal with. Colonel Malcolm knows more appreciatively the expenditure involved in it, and certainly the appears the advantage in the system advocated by Lieutenant Sleeman and Captain McEvoy, of economy in the use of a less amount of material; but the methods, the stations, the boats, must remain the same. At every station there must be a very large investment of capital employed, and whether we shall ever arrive at a satisfactory solution of the torpedo question is a matter which time can only solve. I was myself concerned in the initiation of the system, I forget how many years ago. In the year 1864 or 1865, I think, we began a Committee of Investigation, and as the thing is in the air. Lieutenant Sleeman has told us of certain experience of his which do not appear to have been successful. Further than that, I fear have very few remarks to make of any sort; but that he shows us a step in advance I think we shall all be prepared to admit. I had the pleasure of meeting Captain McEvoy, whom I knew many years ago, in the hall, and he told me this searcher his latest invention. It seems extremely ingenious, simple, and practicable, but beyond that, I do not know that we have had put before us much that is new except the simplicity of having one cable instead of a return circuit. I do not know the mechanism of the circuit closer, and that I fear we shall not have explained to us. I need not detain you further than to return our thanks to Lieutenant Sleeman.

Captain McEvoy: It has been at his own wish and desire that Lieutenant Sleeman has done me the honour to prefer my torpedo systems to others, and I am very much indebted to him, and beg to thank him for it, and in regard to which I am fully prepared to verify all the statements he has made as to the comparative efficiency and economy of my systems over others. I think we are all indebted to him for his interesting paper. My main object in rising was to say that it occurred to me that his explanation of some of the questions asked was not clearly understood: regards the application of this instrument to the permission to friendly vessels to pass over the mines at night. The apparatus is particularly applicable to that purpose, when it is set simply to give signals. It may again be set, so that the mines may fire themselves. It is arranged again that any mine may be picked out separately from all the others, and fired by observation. When it is set for signalling only, as a vessel may pass over with perfect safety, the firing being left to the will of the operator. I should like to say a few words in regard to the submarine detector. It is based on the principle of the induction balance—Professor Hughes' more recent application of it, or rather discoveries in connection with it. The application is new for the purpose to which it is applied, and I have endeavoured to put it into the most practical shape for practical work. It occurs to me it ought to be very useful for many purposes on board ship, such as recovering lost anchors, discovering the position of submarine cables, and more particularly the locations of submarine mines. Or, it may be used to discover treasure or sunken vessels, and for the assistance of divers in muddy waters, and many other purposes.

The CHAIRMAN: I would ask whether it could possibly be of any use in communicating across a cable, because there would require to be some exposed metal.

Captain McEvoy: Any insulated metallic substance can be instantly discovered. The principle is this. There are two circuits, one the primary, the other the secondary, and in this sinker or sounder there are two coils of wire, and in the box there are two coils. When it touches any metallic substance the balance is destroyed, and instantly there is a rumbling noise in the telephone.