Electricity as Applied to Torpedo and Other Naval Purposes

Lieutenant F. T. Hamilton R.N.

To cite this article: Lieutenant F. T. Hamilton R.N. (1892) Electricity as Applied to Torpedo and Other Naval Purposes, Royal United Services Institution. Journal, 36:172, 617-634, DOI: [10.1080/03071849209417655](https://doi.org/10.1080/03071849209417655)

To link to this article: <http://dx.doi.org/10.1080/03071849209417655>

Published online: 11 Sep 2009.

Submit your article to this journal [↗](#)

Article views: 9

View related articles [↗](#)

Wednesday, May 4, 1892.

ADMIRAL H.R.H. THE DUKE OF EDINBURGH, K.G., K.T., G.C.B.,
&c., &c., A.D.C., Commander-in-Chief, Devonport, in the Chair.

ELECTRICITY AS APPLIED TO TORPEDO AND OTHER NAVAL PURPOSES.

By Lieutenant F. T. HAMILTON, R.N.

IN May, 1885, a lecture on this subject was given at this Institution by Lieutenant, now Commander, Batten, when Sir Cooper Key took the chair. Since that time, although we have not learnt very much that is actually new about electricity, great advances have been made in perfecting the methods of application, and, as a necessary consequence of competition among manufacturers, the material used becomes better and cheaper every day; therefore its use for naval purposes has become more extended. At one time there was a great tendency to elaborate most intricate machines, which were expected to do everything short of talking, but the more practical experience we get the more we see that electricity, for naval purposes, must be applied in such a manner that the instruments and machines used must be simple, and made in such a way that they will stand the exposure and rough usage inseparable from ship work.

In dealing with this subject, there is not time in the limits of a short lecture to go into the whole question, or to go over again any of the ground trodden by Commander Batten, nor, indeed, is it necessary; therefore it is proposed now merely to make a sketch of the principal points on which we have made advances since 1885. And to facilitate comparison, I will take the different branches of the subject as near as possible in the same order as in the 1885 lecture.

Electric Lighting.

Taking, then, electric lighting first. The internal lighting of men-of-war has now become the rule instead of the exception; it is found that it is economical, clean, and convenient, and, except in the case of quite small vessels, where space does not admit of duplicating the dynamos, and the complement does not admit of telling off special men to tend the machinery, it is invariably fitted. A trial was made at one time of using the hull of the ship as a return, and the "Polyphemus," the P. and O. steamer "Massilia," and Brazilian

ironclad "Riachuelo," and other vessels, were so fitted. The advantage of such a manner of fitting is only economy; the disadvantage is an increased risk of an accidental breakdown, for this reason: If you have a complete wire system, a leak on one lead does no harm, and a second leak on the same lead does no harm; it is only when a leak occurs on both leads that harm is done, whereas with the earth return system a single leak at once disables a part of the circuit, thus doubling the chances of a breakdown. The complete wire system is, therefore, always used now, an alternative system of candle lighting being always fitted as well in English men-of-war, the reason being, not so much to provide against breakdowns, as with the amount of dynamo machinery now supplied that is an unlikely occurrence, but to provide against the contingency of not being able to light your fires, or of wanting to economize coal. This latter point, viz., economy of coal, is a very important one. In war-time a cruiser will probably require every pound of coal she can carry for steaming purposes, and she will probably use no electric light at all. To give an idea of what this means, practically, a vessel of the "Latona" class would use about 5 tons of coal for keeping her internal lighting going for a week, and the space occupied by this amount of coal would stow candles sufficient to last the ship for nearly six months. I do not mention this as a reason for not lighting ships internally, but rather to show the necessity, in war-time especially, of having the alternative system of candle lighting; or, in other words, as a general rule, electric lighting is a great economy and convenience, and, as such, we are right in employing it; but occasions may arise, especially in war, when the small amount of coal it uses cannot be spared, when no money could represent to us the value of a few extra tons of fuel.

With regard to the fittings for internal lighting, no great change has taken place, but all the smaller changes are working in the direction of making everything as watertight as possible, and the cables instead of being led about the ship in more or less clumsy wooden casings, are now made covered in lead, and are put up without any casing, the lead being considered to be ample protection.

With regard to the search light, its use has largely developed, many more being now carried; there is, however, still a great difference of opinion as to the best way of using it. Some prefer a large number of small lights (one war vessel having as many as 13), others prefer a smaller number of lights of high candle power; of course the more powerful light penetrates farthest, but it is open to the same objection as the market basket that contains all the eggs. On the other hand, a large number of lights must be confusing to those using them, and tend to make the ship very conspicuous. Another point connected with the search light that gives rise to great controversy is, whether it should be high or low; if high, the surface of water that is covered by the concentrated beam is very small, and consequently there is a difficulty in picking up an object; if low, some say that the rays striking the water are reflected upwards, and striking on the mist form a screen to objects beyond. There is one point on

which every one is apparently agreed, that the farther you go from the source of the search light, the better you see the objects it illuminates; for this reason, the smallest gunboats are given a powerful electrical apparatus, as they are always likely to be useful as electric light stations for the larger ships. Vessels are also sometimes supplied with portable search light plant, so that it can be landed at a suitable point commanding the anchorage, and well away from the ship herself. Another means by which the observer is enabled to get away from the search light is by using the automatic lamp and controllable projector. By means of an electric motor in the pedestal of the projector, it can be directed both in elevation and training, by merely pressing electric buttons at a distance. There are numerous automatic lamps, that is, lamps in which the consuming carbons are made to feed themselves by utilizing the magnetic force of the same current that causes the light, but unless we have a projector controlled in the manner I have just stated, the automatic lamp is not worth the extra complication it involves, as, if we are obliged to have a man at the projector to train it and elevate it, we may as well let him regulate the carbons by hand. The objection to the controllable projector is its weight and complication. But still the fact that it enables the same person that is observing the approaching torpedo-boat to direct the movements of the projector himself, instead of passing orders to another man (always an uncertain proceeding), perhaps outweighs the objections.

Secondary Batteries.

Having considered the advance made in electric lighting, let us now consider secondary batteries or accumulators, by which we are enabled to store up electricity, and use it again when we require it, the operation of storing only depriving us of about 10 per cent. of the current. These batteries are very convenient for burning electric light, driving electric boats, and for any other purpose for which a powerful and constant current is required. The objections to their use are their weight (as the plates composing them are made of lead), the time they take to charge, and the fact that they require most careful handling, and are easily injured if neglected, or charged or discharged too quickly. The aim of all the manufacturers has been, of course, to diminish these objections as much as possible, but, so far, not with very marked success. To illustrate one of their uses, I have got here a battery of forty of these secondary cells, kindly lent by the Electric Power and Storage Company, for giving us current to work these lights and instruments, and it will be a good example of the direction in which the makers are working if I show you how they have improved their cells. One of the great difficulties has been that if the cells are charged or discharged too rapidly, the positive plates bend and touch the negative plates, and so short-circuit the cell (as it is termed) and spoil it. The plates of the cells are made of lead, with a paste of oxide of lead adhering to the surface. In the earlier plates the lead is formed into a grid, and the oxide

placed in the holes; these lumps of oxide constantly drop out when the plates bend. In the latest form of plate there is more lead, so it is less liable to bend, and the oxide seems to stick in better. This gain in strength enables the cell to be charged and discharged at twice the rate of the earlier pattern, but as there is less oxide compared to the size of the plate, there is less capacity; that is, the cell will not store so much electricity, and also it is heavier in proportion to the work it does. The following table will give an idea of the advance made in the rate of charging and discharging, and the expence in weight and capacity at which it is gained:—

Type.	Size of plate	Maximum rate of discharge.	Time of discharge.	Capacity.	Weight of 31-plate cell complete.
		ampères	hours	ampère hours	lbs.
L (old)	9 sq. in.	4	9	36	286
K (new)	9 sq. in.	8	3½	28	357

It is not advisable that the rate of charging should be more than 75 per cent. of that of discharging.

The improvements have therefore given us a stronger and less delicate cell, and one that can be charged and discharged at double the former rate without injury, but we get this at a cost of about 22 per cent. less capacity, and 33 per cent. more weight. The deterioration is now calculated at about 7½ to 15 per cent. per annum. A light and efficient accumulator is a boon we must look forward to yet; with it, steam launches would soon become a thing of the past, and we should be within a measurable distance of the flying machine. Besides the cells I have been describing, a small form is also used for taking the place of primary cells in cases where power is necessary and space is an object, such as in the case of small hand lamps; in the small form, however, the secondary cell is an expensive luxury, as it is even more delicate than the large one, and therefore its life is generally not long.

Whilst on the subject of cells and batteries, I will point out a late development of the primary battery which bids fair to come largely into use, that is, the so-called dry cell. In this the liquid is absorbed by plaster of Paris, or gelatine, or some doughy substance, so that there is nothing to upset. Hellsen's cells, which are an example of this type, were used in the small electric boat on the lake at the Naval Exhibition, for working a small magnet in the boat; they remained in use the whole time the Exhibition was open, which proves that they have great lasting power. They are excellent for ringing bells and such like work, and promise well even for batteries, for firing detonators and charges, under some circumstances.

The subject, which next claims our attention is

Electric Communications.

Electricity lends itself to increasing the convenience and rapidity of communications to a very great extent, for signalling beyond the visual distance it is the only method, besides sound, and for short distances where the places between which it is desired to communicate are separated by walls or decks, or bulkheads, it is often the most handy method. In our modern ships of war, for instance, when it is desired to communicate between conning towers or bridges and the engine room, we find armoured bulkheads, watertight bulkheads, and all sorts of obstructions in the way, so if we wish to have one of the old fashioned telegraphs worked by rods we either have to lead the rods in exposed positions where they are liable to be shot away in action, or we have to make holes through watertight bulkheads, thus endangering their efficiency, or make so many angles and gearings that the telegraphs are almost useless on account of the friction and back lash in the working parts. For this purpose then electric telegraphs are peculiarly adapted; distance (within the possible limits of a ship) and angles make no difference, and if the wires connecting the instruments are severed by shot in action, they are easily repaired, whilst the rods of the mechanical telegraph could probably not be repaired without dockyard assistance. Different patterns of these electrical telegraphs have now been in use for some time; the difficulties to be overcome with regard to them are, first, the efficiency, under circumstances of sea service, of the batteries or other sources of electricity that work them, and, secondly, that they should indicate accurately at whatever speed the handle is moved, as however careful an Officer of the watch may be he will naturally push the engine room telegraph over with a jerk if he finds that his ship is just going to run into something. To get over the difficulty of the batteries, nearly every known source of electricity has been tried. The current required should be large, as the larger it is the less delicate the instruments need be; naturally, therefore, secondary batteries have been tried, but by reason of their delicacy and the care required in their use they are not altogether a success. Primary batteries, as being more easily repaired or replaced, have been more largely used, but it is difficult to get great power from them. It is also proposed to work telegraphs with the direct current from the dynamo machine; an instrument of this description has been invented by Mr. Richards, a Constructor in the Admiralty. It only takes half the amount of current necessary to light one lamp, and that only intermittently, whilst it is in actual motion; and as in our modern ships we have ample dynamo power, and always have steam to work it when under way, there seems to be no objection to using the dynamo as our source of electricity; this is, however, quite a new departure, and we have not yet got any practical experience of its working.

The machine that is at present most commonly in use is the Willis's, and the latest improvement of it, the Willis and Robinson's

telegraph. This instrument can be worked either by secondary or by primary batteries. The great point in its favour is that it cannot be thrown out of adjustment by being worked too rapidly, as the handle is not in direct connection with the electric mechanism. The fact of putting the handle over winds up, or extends or compresses a spring, which, in its turn, drives some clockwork; this makes the contacts; and no matter how angry or excited the Officer of the watch may be, the clockwork will only cause the contacts to be made at a certain slow and deliberate pace, quite fast enough for all practical purposes, but not so fast as to incur any danger of upsetting the adjustments. Another good point is that should this instrument show the wrong indication through the handle being worked when the battery is disconnected for any purpose, or through any other cause, it will readjust itself, simply by putting the handle hard over.

Instruments of this description are used for engine-room telegraphs, helm telegraphs and indicators, and for distance indicators to telegraph the distance of the enemy or target from the Officer taking the range to the guns. To prevent the possibility of mistakes, it is always advisable, in any instrument of this description, to have an answering dial, so that you can see that the man at the other end has received the correct signal.

A large ironclad now being built at the Forges et Chantiers de la Méditerranée is quite the most perfectly fitted ship, electrically speaking, that has ever been built; she has electricity for everything, and we shall have to refer to her more than once. Among other things she is to be fitted with a most elaborate system of telegraphs for all purposes (see Fig. 1). Messrs. Elliott are now preparing the instruments; they consist of engine-room telegraphs, helm telegraphs and indicators, distance indicators and telegraphs, and revolution indicators. These last are very ingenious instruments, invented by Spratt. The fact of pressing a button on the side of the instrument clears off any former record, and starts the clockwork, which goes for fifteen seconds; on the screw shaft is an electrical contact that is made four times in each revolution, at each contact the instrument indicates one; so that, at the completion of the fifteen seconds, the number shown is the number of revolutions the engines are making per minute.

Whilst on the subject of telegraphs, it will not be out of place to consider the question of electric logs. A difficulty has always been, to keep the revolving contact watertight; this has now been got over in Granville's log, by making the log itself one plate of the battery for working the instrument, the iron hull of the ship the other plate, and the sea itself the exciting liquid, so that insulation is not required. It only remains therefore to decide what combination of metal with iron will give us the best result. Zinc gives a high electromotive force, but is not constant, as the sea water acting on the zinc oxidises it and the strength fails, necessitating constant cleaning. Plumbago gives the best results altogether, as it makes a cell strong enough to work one dial, and does not oxidise at all. If it is desired to use

more than one indicator, the difficulty is easily got over by making the small current from the log work a small and delicate relay, through which a powerful battery on board could be made to work as many instruments as you like. A combination of this instrument with a revolution indicator such as I have just described would enable you to read the speed at any minute by only pressing a button and waiting a few seconds until the counter had finished counting.

The telegraph for distant signalling of messages is of course now universal, and it is therefore very likely that in war-time men-of-war may have to use it under circumstances that will make it impossible for the proper operators to attend. This makes it necessary that a small body of seamen should be trained in the use of the instruments. For this purpose there is a school of telegraphy at Portsmouth; and certain ships are supplied with instruments, so that the men may be kept efficient.

Another use of the telegraph that we are hearing a good deal about at present is for communication with outlying lighthouses and lightships. There are two difficulties in the way: first, that of getting the wire on board the lightships that must of necessity swing to the wind or tide, or through the surf that is sure to be continually beating on the rocks round an outlying lighthouse.

Numerous watertight swivel contacts have been tried for the lightships, they are more or less satisfactory for a time, but they constantly break down; and as for the lighthouses, no shore end of cable has yet been made with a sufficiently heavy armouring to stand the action of a heavy surf on rocks for very long. A plan has, however, been patented by the Telegraph Construction and Maintenance Company, by which communication can be made to both lighthouses and lightships without the cable actually going on board them at all. The plan is this. A twin cable is led out from the shore to within about a quarter of a mile of the lighthouse or ship, the cores are then forked out, and end in large earth plates about one-quarter of a mile apart, one on either side of the place we want to telegraph to. Two earth plates are put overboard, one from either end of the lightship, or on either side of the lighthouse (see Fig. II). If now Morse signals are sent along the twin cable from the shore, using an interrupted current produced by a clockwork sounder, they can be distinctly heard in a telephone on board the lightship. This plan is now under trial, and, I am told, is likely to get over the difficulty of communication.

But the second difficulty is not so easily disposed of. At present lighthouses and lightships are supposed to be exempt from attack in war-time; but if we have telegraphs to them, it will be a sore temptation to use them as outlying signal stations for reporting the enemy's movements, and even if our morality is proof against the temptation, what enemy is going to give us credit for such correct behaviour? The result is, we should, as soon as war is declared, have either to remove them or protect them. The impossibility of protecting them is shown when I point out that there are over fifty round the coasts of the British Isles that an enemy might suppose to

be connected by telegraph, and that he would therefore be quite justified in destroying.

The telephone is not of much use in a man-of-war, as even in ordinary circumstances the noise of the engines, and the noises inseparable from having several men living together in a confined space, make it difficult to hear through; and in action it would of course be absolutely useless. It has also been given up by divers, as they prefer a voice tube, but it is of great use for running temporary lines for signalling during shore operations, or for keeping up communication between different parts of a mine-field, whilst laying mines for the defence of an anchorage.

Another way in which electricity helps us in signalling is by using either coloured or flashing electric lights. There is one system in which three lanterns are used, from which you can at will show either a red or white light. Thus if three lights are used together we can get eight combinations, and if two lights are used as well four more combinations may be obtained. These twelve would be quite sufficient for the few important signals that are required to be carried out quickly at night, such as large alterations of course, stopping engines, or starting. The system has also been largely extended, so as to make a complete code, by increasing the number of lanterns and using, in addition, indicator lights to point out the chapters of the signal book to which the number shown refers. In connection with this system, an Officer of the Austrian Navy has introduced an ingenious but somewhat elaborate switch, whereby the operator only has to set the number of the sign on a keyboard, turn the switch, and the proper signal is automatically shown.

Great difficulty has been found to make the flashing system work properly. There are two ways in which the flashes can be produced, first, by veiling the light, and, secondly, by extinguishing it; if a light is extinguished by a switch in the ordinary manner, you will notice that it takes a very long time for the carbon to cool down to blackness, and, being cold, it also takes a long time to warm up again to incandescence; the higher the candle power of the lamp, and, therefore, the thicker the carbon thread, the longer this takes. The result is, either the flashes have to be so slow that it is difficult to take in the signal, or they are all blurred together and it is impossible. Another difficulty is, that when the current carried through a switch is large, as it is in the case of lamps of high candle power, each break of the current causes a spark that in a short time burns up the switch.

Therefore, to get over these difficulties, several attempts have been made to produce the flash by veiling a light that is continuously burning; they have not been satisfactory, as the fact that the mechanism must be always exposed to bad weather and to violent alternations of heat and cold, renders a delicate instrument impossible; whilst, of course, a large and heavy instrument cannot be placed aloft where, for distant signalling, the flashing light is principally required.

We therefore have to fall back again on the extinguishing system

and try to get over the difficulties; this has been done very fairly successfully in the following manner:—So as to allow the carbons to cool quickly, instead of having one thick fibre, we have a number of thin ones; the lamp so made is called a multiple-fibred lamp; and, as a still further development of the same principle, we put each of the small fibres into a small lamp of its own. This improvement gives us two advantages, first, there is better ventilation and, therefore, more rapid cooling of the fibres; and, secondly, we get rid of the risk of one loop catching over another owing to vibration of the lamp. The incandescence is more rapidly obtained by having a resistance inserted in shunt with the key, which allows a small current to be constantly running through the lamp, not powerful enough to give any light, but only sufficient to keep the fibres at a very dull-red heat; this resistance also helps to get rid of the spark at the switch when turning the light off; and this object is further helped by having a condenser placed so that each coating is in connection with one side of the key. A light of this description, placed on the truck of a ship, is very useful for distant signalling, but does not, of course, have quite the range that the search light has when thrown up into the sky, especially when there are heavy clouds about that can be illuminated by the beam; this method, although slow, still remains the best for very distant work.

The next point on our programme is range-finding. Lieutenant Fiske, of the American Navy, has invented a very ingenious plan, by which electricity can be made to assist us in finding the range of a target or enemy's ship at sea.

The principle of the invention is, that we have two telescopes separated by as great a distance as we can conveniently obtain on board ship (see Fig. III). This distance, forming the baseline for the calculation, should be as long as possible, so as to obtain accuracy. The telescopes are mounted on horizontal arcs, which are constructed with a thin wire imbedded in insulating material, running round the edge; attached to the telescope is a rubbing contact that touches this wire; the telescope pivots are joined together through a battery, and connections are made between the ends of the arcs so that the two portions of each on either side of the telescopes form the four arms of an electric balance, and between the arms of the balance is placed a galvanometer to indicate by its deflections when and to what extent the balance is disturbed.¹ Now, if these telescopes are moved along the horizontal arc, the resistance that the arc presents to the passage of the electric current is altered, but if the telescopes remain parallel, the resistance in both arcs is altered to the same extent, and the electric balance is undisturbed, and the galvanometer does not move from the zero point, but the telescopes are only parallel when the object to be observed is at an infinite distance. If, now, the object nears us, the telescopes begin to converge, and the nearer the object comes, the more the telescopes converge, and, therefore, the more the balance between the two resistances is disturbed, this causes a deflec-

¹ The lettering on the two diagrams in Fig. III will enable the reader to refer the connections to the graphic diagram of the balance and so make the principle clear.

tion of the galvanometer proportional to the disturbance of balance. If, now, we mark the galvanometer to correspond with the distances due to the different angles of convergence of the telescopes, we have at once a direct-reading range-finder. This description is not scientifically accurate, as it omits two errors which are so regulated as to eliminate one another, but it is sufficiently accurate to show the principle. This instrument is said to give great satisfaction on board the American cruiser "Baltimore," to which it has been fitted; it has also been fitted up on board the ironclad building in France, to which I referred above, in which ship there are three pairs of instruments, viz., one pair on each broadside in small sponsons about 300 feet apart, and one pair on the fore-bridge, with a base between them of between 50 and 60 feet, for taking ranges right ahead or right astern. These latter instruments are rather differently constructed to the others, as, owing to the short base, they have to be more delicately adjusted, and they do not admit of a training of more than 5 or 6 degrees on either bow. The galvanometers for showing the distances are placed in the electric room, a place in the centre of the ship set apart for the testing and management of all the electric circuits in the ship; in which room the ship's electrician and his staff would be stationed in action. They would read off the distances from the galvanometer and instantly telegraph them to the different guns by Willis's distance indicators.

We will now consider the application of electricity to motors. Their use for various purposes has increased very largely of late years, and they are a great convenience, owing to the ease with which the power is conveyed to them (wires being all that is required), and to the portability of the machine itself whilst working. An example of their portability is the electric drilling machine now largely used in the construction of iron ships.

Where power has to be distributed by the agency of steam or hydraulics, somewhat elaborate fittings in the way of pipes have to be placed, that are not only cumbersome in themselves, but, and this is a serious objection in a modern iron ship, they necessitate piercing the watertight bulkheads; whereas, if electricity is used, the wires can be led through the bulkheads in such a manner as to leave their watertightness still intact.

The objections to the use of electricity are, however, very serious. First, there is an enormous loss of power due to the change of form in which that power is applied, i.e., commencing with steam or heat, which is our primary motive power, we change it into electricity through the medium of a dynamo, then back into mechanical work through the medium of the motor. The second objection is that to develop the power of a motor great speed is necessary; therefore gearing is wanted to reduce this speed to whatever our requirements may be, and of course the use of gearing means a further great loss of power. Thus electricity is a very extravagant way of applying force.

For working guns in ships, where we require to apply our power at many different points, steam is, of course, disadvantageous, as the

trouble of leading steam about the ship and keeping the joints always tight, and the inconvenience attached to getting rid of the waste steam, renders its use almost prohibitive, and another method of transmitting power becomes necessary. The means usually adopted are hydraulics, and in point of economy there is no doubt that it is far the best, for one great reason, that it can be applied direct to the work it has to do without the intervention of gearing.

Nevertheless in one or two American ships and in this new ironclad we have already mentioned as building at the *Forges et Chantiers* electricity has been adopted, I presume on account of the quality I mentioned above, viz., that it lends itself to facilitating the transmission of power through watertight bulkheads without impairing their usefulness, and also to the fact that the wires are so much easier to repair if damaged in action than pipes.

This vessel is armed with four 24-cm. guns mounted *en barbette*, one forward, one aft, and one on each broadside, and also four pairs of 12-cm. Q.F. guns on twin mountings, the ammunition supply being between them. The larger guns are both trained and supplied with ammunition by electricity, whilst the smaller guns have only electrical ammunition supply. For training the 24-cm. guns, two motors are supplied to each, one being spare; the motor revolves a sprocket wheel by means of a worm and wheel; this sprocket wheel gears into an endless pitch chain which encircles the trunk of the mounting, itself an integral part of the revolving platform. This trunk also forms the ammunition lift, and the ammunition is hoisted through it by another endless pitch chain actuated by a smaller motor. The ammunition hoists at the smaller guns are worked in a similar manner. All the motors are therefore well down below, and are, in fact, under the armoured deck, and in most cases, if not all, they are near steam engines, so it is difficult to see what advantage is gained, as the steam itself might have been used, but I believe the electricity is a duplication of power. The electricity in this case is produced by two very large dynamos driven by engines that appear to be of about 40 horse power.

Motors are also used for driving launches and other small boats. Here again we have a most extravagant form of propulsion, more extravagant even than the motors we have just been considering for manipulating guns, as in this case we have to make one more change, i.e., here we change our steam into mechanical work for driving the dynamo, then into electricity, which is again changed into a chemical form when charging the secondary batteries, then again into electricity, and again back to mechanical work through the motor. Each of these changes means a waste of power amounting in the aggregate to nearly half the power originally developed by the steam engine.

Another disadvantage of this form of propulsion is the enormous weight of the secondary cells; so great is this weight, that high speed is an impossibility in an electric boat containing its own accumulators. In fact I think I shall be within the mark if I say that no boat of this description has ever exceeded 9 miles

an hour; the speed is reduced not only by the enormous weight the boat has to carry, but also by the fact that, the motor revolving at a high speed, the propeller has to be of short pitch; consequently the percentage slip is increased, as also is the skin friction of the propeller itself.

Against these disadvantages we have, when we are dealing with vessels for pleasure purposes, absolute luxury and comfort, as there is no heat, or smell, or dirt, and little or no noise, and for war purposes we are enabled to have a boat driven silently, and without a chance of sparks or smoke to betray her advance to the enemy, therefore probably most useful for torpedo work.

It will, perhaps, be of interest if I describe a boat of each of these types recently constructed by the Electric Power and Traction Company at their works on the Thames, near Hampton.

The pleasure vessel is a river yacht 55 feet long over all, and 8 feet 6 inches beam; she carries 3 tons of accumulators and machinery, consisting of 100 accumulators of the B 15 type, having an output of 150 ampère hours; these cells can be fully charged in 5 hours, and at the full speed at which the boat is driven they discharge in 7 hours; this gives a speed of 7 or 8 miles an hour, and develops about 5 horse power. A switch close to the steering wheel is so arranged that you can go full or half speed ahead or astern, the difference in speed being obtained by, in the case of full speed, arranging the cells 50 in series and 2 in parallel; and in the case of half speed, 25 in series and 4 in parallel; the half speed is about 5 knots. The propeller makes between 700 and 800 revolutions a minute, its pitch being 16 inches and diameter 20 inches. All the accumulators and the motor are either in lockers forming seats, or under the bottom boards, so that the whole of the boat is available for accommodation.

The boat that is presumed to be for war purposes is similar to one that was at the Naval Exhibition. She is a clinker built boat like a large gig 40 feet long; she contains $2\frac{1}{2}$ tons of accumulators and machinery, and weighs about 4 tons without warlike fittings; she is to be hoisted up on board a ship. She has 60 cells, which are used all in series at full speed giving an output of 40 ampères for 4 hours, and a speed of 8 miles. Two of these boats have been recently sold by this Company to the Russian Government. For the purpose of comparing these boats with steam launches, it is perhaps fairest to take the 32-foot Naval Service steam cutter. In this boat with a weight of boiler and machinery (with steam up) of $1\frac{1}{2}$ tons, we get a speed of about 10 miles. There are, however, two points of advantage in the electrical boat over the steamboat that we have not yet noticed: first, that in the former we do not require to carry any extra weight, such as coal and fresh water to keep the engines going; and, secondly, that we can stow the weights in the electric boat to better advantage than in the steamboat, as it does not matter where the batteries are placed, so long as they are in the boat; therefore, as they need not be high, we are enabled to build a boat of deeper keel and consequently finer lines. This advantage does not seem to have

been made full use of yet; when it is, perhaps we may get rather better comparative results between the two modes of propulsion.

We must now pass for a few moments to the question of firing guns by electricity. We have been in the habit of using what is termed a "detector," that is, a galvanometer, so that we can see at any time if the circuit is complete. An improvement on this has been recently introduced by which, instead of seeing, we can hear if the circuit is correct by substituting a sounder for the detector. This instrument has been brought out by Messrs. Armstrong.

Whilst on the subject of guns, I may as well also mention night sights, or a plan for illuminating the sights at night so that aiming is made much easier. As an example, I will take those patented by Captain Grenfell, which consist of two very small incandescent lamps, the current for which is obtained from small primary or secondary cells. The lights themselves are screened from the eye, but throw their light on inclined bars which form the sights. A switch is introduced between the battery and the light, with a resistance in it, so that the brilliancy of the light can be regulated to suit different conditions of atmosphere. These sights will probably very much increase the accuracy of night firing.

The last subject we have to deal with is torpedoes, not because it is least important in this connection, as it practically was brought into being by electricity and exists by it; there is, however, not much that is new to be said. I do not mean to say that as great an advance has not been made in this subject as in others; but this advancement is more in the nature of detail, that it would be impossible to go into in a short sketch like this, and there is very little involving new principles.

As regards submarine mines, the only point we need notice is mechanical mines, or those that carry their means of ignition within themselves, and therefore require no cables. They have been brought more into prominence of late, owing to the notion having been started of using them for what is termed "Torpedo Blockade," that is, for dropping in front of an enemy's harbour to blow his ships up should he attempt to come out. I have often heard it said that we never require to bottle up an enemy into his ports, we want him at sea. Although I hope that may be true, I don't think it can be denied that a very short search into history will show us many cases in which we should have been glad to have the power of worrying our enemy in this way; at any rate mines of this description would be very fair substitutes for cruisers watching a narrow channel when the cruisers themselves are not obtainable.

To be efficient they must be provided with an automatic mooring apparatus that will moor the mine at any required depth from the surface without the necessity of previously taking soundings.

With regard to torpedoes proper, that is, mobile charges as distinguished from stationary charges or mines, electricity is still used both as a means of steering torpedoes and also propelling them. For propelling them, as one might expect from what we have seen of the difficulties of electric boats, the source of electricity cannot be con-

tained in the torpedo itself, with any hope of attaining a high speed. We have, therefore, to fall back on the plan of having a cable between the torpedo and the source of power, for conveying the electric current to it. The most successful torpedo of this type is the Sims-Edison, which has been going now for some years; it was fully described in Commander Batten's lecture in 1885, and since then it cannot be said to have improved very much, but its speed and range have increased, and it is so far serviceable that it will undoubtedly be used in war by some nations.

Attempts have been made lately to use it from ships under way, and there is no doubt that, so far as the machinery that it is necessary to carry is concerned, it can perfectly be done. But its proper sphere of usefulness is undoubtedly as an auxiliary to harbour defence. The difficulty with it will, I am afraid, always be the cable, for this reason. Electrical power can be obtained in two ways: we can either have high electromotive force and small current, or low electromotive force and large current. Either combination will give the same result; just as in the use of water, a high pressure and small quantity can be made to do the same work as a low pressure and large quantity. Now, if the electrical current running through the cable to the motor in the torpedo is very large, the cable must be large and heavy; and the torpedo itself, which has to hold the cable that is to be paid out, must also be large, so as to be able to carry the weight. It is a great advantage, therefore, to reduce the current and increase the electromotive force, but we then come face to face with another difficulty, that if we have high electromotive force, we must have extra good insulation on the cable conveying the electricity, as a leak in the insulation will be immediately fatal to the working of the motor.

Therefore we want to hit off a mean that, whilst giving us a small current and therefore light conductor, will not unduly increase the electromotive force beyond what the insulation of a flexible and light cable is able to stand; in the end it will probably be found that the users of this torpedo will have to rest satisfied with a cable that will be efficient for one or two runs of the torpedo only, but will not stand more use than that. This, of course, means extra expense, a small matter in war-time.

Captain EARDLEY-WILMOT, R.N.: Your Royal Highness, ladies and gentlemen, I was quite sure that we should have a very excellent paper from Lieutenant Hamilton on a subject to which I have paid some attention, and what we have heard has quite come up to my expectations. He truly says "the more practical experience we get the more we see that electricity for naval purposes must be applied in such a manner that the instruments and machines used must be simple." One point also which it is desirable to bring out with regard to the internal electric lighting of ships is this, that however pleasant it may be, and no doubt it is, especially in hot climates, there must always be the danger in action of the wires being shot away, and the ship being thrown into darkness at a critical moment. Therefore, although we may, perhaps, rely upon electricity for lighting the ship below the water-line, all the parts above the water-line certainly should have a duplicate system of candles or oil lamps. I could have wished the reader of the paper had given us a few practical illustrations of the uses to which these electrical machines

had been put, and I may, perhaps, be allowed to mention one or two instances where we have used electricity with very useful effect. He alluded to the search lights and signalling. A few years ago, when we were employed in an operation which political circumstances compelled, viz., the blockade of the coast of Greece, in which your Royal Highness commanded, we had a large number of ships distributed over a large area, and they had to be more or less in communication. In the ship I commanded we had a powerful electric light, and I was enabled to keep up communication with my senior Officer at a distance of 20 miles by pointing the search light in the sky, observing it, and allowing it to flash forth again by means of a shutter, as now used, with an ordinary lantern for short distances. Practically we are better off for distant signalling by night than we are by day. There is one thing, of course, to be remembered, that the electric search light is practically useless in foggy or misty weather. The electric light can, however, be used for different purposes, and I will mention one instance where we found it exceedingly useful. When we were in the Red Sea in 1885 we had a powerful electric light on board. An expedition used to start off in the early morning, and had to be supplied with water. At that time every drop of water had to be distilled in steamers and collected in tanks. It was then put into skins and carried by camels. The expeditions used to start off early in the morning, and it was necessary that the skins should be filled during the night. So we arranged a series of lights on shore, composed of small incandescent lamps, which were worked from the ships' dynamos, through a cable laid to the shore. By that means the whole of the tanks were lit up, and the proceedings were carried on with great expedition and efficiency. The next thing was to place the skins on the camels' backs. The camels were brought to within a few hundred yards of where this was going on, and were made to lie down. There were a large number of them waiting to be loaded. The next thing was that there should be light in order to carry this into effect. I then utilized the search light, which was turned on the camels with a diverging lens, which enabled the rays to spread over a considerable distance, and reduced the brilliancy of the light. It was a curious thing to see the effect on the animals. At first we thought they would start up in fright and be off, but the only thing was that every camel turned its head to where the light came from. At 4 or 5 o'clock in the morning, being all loaded, they marched off. That is a practical illustration of what can be done with the electric light other than for the purposes to which the lecturer has referred. As regards the range-finder described by the lecturer, I think it hardly applicable to a ship of war at sea, under the varying conditions of action. In the first place two observers are required: they must be at different ends of the ship, and in communication with each other. Telephones will not answer when there are guns going off; I think we want something simpler than that, by which the distance can be ascertained by a single person and communicated to the guns. Certainly we have had a very instructive lecture on many interesting subjects.

Admiral COLOMB: I am quite incapable, your Royal Highness and gentlemen, of discussing the paper, but when we come here it is a sort of duty that devolves upon us to endeavour to start a discussion. That has been already well started, but there seems a little hesitancy in following it up: therefore, I rise to congratulate my old shipmate on the lecture, which I have most thoroughly enjoyed. I only wish that I knew something more about the subject, so that I could further enter into it. But I have a little sensation of feeling, after hearing the lecture, that I am rather glad, upon the whole, that I am out of it, because the thing is evidently getting serious, and what one feels about it is that, possibly, if warfare is going to fade off into electricity, it may be a good thing. The only part I am at all capable of appreciating is that part which referred to signalling, and I must say I am pleased to see that there is a possibility of at last getting moderately rapid flashes from a high point in the ship. That apparatus seems to answer very well, but not perfectly, because I am sure, if flashing signals are to be perfect, as they ought to be, something still more rapid than that has to be arranged. I have been much struck watching flashing signals in the Army. I believe that they are further advanced than we are in that part of the science—that their signalling is more correct and quicker than ours. They have the advantage in the Army of having

no other system competing, and some of our competing systems undoubtedly interfere with the flashing system by restricting practice. It is evident that we are going on in the right track, and that results will be ultimately obtained which will be satisfactory to everybody. I beg to congratulate the lecturer heartily on his paper.

Admiral LONG: Your Royal Highness, ladies and gentlemen. Though I am by no means competent to criticize the admirable lecture we have heard, I do not like to remain silent, seeing that Lieutenant Hamilton has taken so much pains, and has got so many beautiful instruments here to instruct us. One lesson we must all learn from the progress of electricity in the Navy, is the advantage of steady, persistent application to one object. It certainly is most wonderful to me to see the progress that has been made in the practical application of electricity to naval things since I first went through the torpedo course in the year 1869. Matters were then in a very different state to what they are now, and I think we cannot but admire the pertinacity, the ability and zeal, with which Officers have stuck to it since then, and have now brought about a state of affairs in which, I believe, we are second to no nation in Europe. There are only one or two points upon which I might make a remark as to communication with lightships. It may not be generally known, that so long ago as 1887, there was a lightship, the "Sunk," in communication with the land by a cable, which passed up through the mooring swivel centre, which was made hollow; it was found very satisfactory. During the manœuvres I was in the Downs: we used to receive telegrams from this lightship, telling us whether any enemy was in sight, and there was no failure at any time. With regard to the three-light signal system, I should like very much to ask Lieutenant Hamilton whether we have that system in use in any ship in the Navy. I think there is a system called the Conz, and also that of Kaselowski, but whether it has been tried in our Service I am not aware. Also with regard to the secondary cells: I should like to ask whether the motion of the boat at sea is found to injure their permanency, whether they are found to wear out more rapidly when used for that purpose than when used on shore. There is no doubt an electrically-propelled boat is a most admirable thing for the use of torpedoes. It may be remembered, perhaps, that on one occasion an electrically-propelled boat went across the Channel, and its progress was so silent that they actually caught a sea-gull floating on the water. That is certainly a point of great importance in torpedo warfare. In Portsmouth Harbour it was quite curious to see how silently the electrically-propelled boat rushed along. The want of speed, I think, is no defect for that purpose, because any boat or vessel going at high speed causes such a disturbance that it becomes at once conspicuous. There is one application that, perhaps, might be made of the motor—I do not know whether it ever has been done, but it struck me it might be a useful way of driving fans for ventilation in out of the way places. Our ships now are full of holes and corners which need ventilation very much sometimes, and I think it possible that the application of electricity might be found to be useful. I do not know that there is anything else which I can say with advantage on this paper. I think Lieutenant Hamilton, as we knew he would do, has treated the subject very fully and very ably, and I congratulate him very much.

Commander MERRYN, R.N.: Your Royal Highness and gentlemen, with reference to some remarks which fell from Admiral Colomb about the Navy being behind the Army as regards the rapidity of signalling, I should like to draw attention to the fact that the conditions of our signalling are entirely different from those of the military. We do not spell out long messages word by word, as is done by the sister Service. We have a code, and it is quite possible for us to do efficiently all our signalling work much slower than is necessary for the land Service. Our distance signals are generally signals referring to our codes, and can be made slowly, carefully, and taken in with certainty. We do not attempt to spell out long messages in which rapidity is of very great importance. Having had something to do with the preparation of the electric flashing-signal light apparatus which Lieutenant Hamilton has shown you, I may state that a great many other systems were eliminated before that was brought out. Our distant night signalling refers to distances of 15 or 20 miles. The Army night limelight signal apparatus, which I think Admiral Colomb was referring to as being so

rapid, is only used at a distance of 2 or 3 miles. Of course the military day-system of the heliograph is very rapid, and is capable of being used at long distances. For our daytime long-distance signals we have to depend upon inferior methods, because we cannot get the steadiness of platform necessary for the heliograph; but for night long-distance signalling the comparative slowness is really no great objection to our system, because we are generally using a code and not spelling out words.

H. R. H. the DUKE OF EDINBURGH : I think it is the duty of the Chairman to bring a discussion on a paper to an end. My task is made a very easy one by the admirable paper which we have had before us, and which has left very little open to criticism, as has been clearly shown by the very small number of competitors who have come in to offer suggestions of their own. I can only point out one little omission in the lecturer's paper, which is, that whilst he mentioned the work which is being done at Portsmouth with regard to these matters, he overlooked the fact that there is a port rather further west from which I hailed yesterday. The instruments which you have seen are most interesting, and they are of course immensely in advance of anything we had before. I cannot at the same time help feeling that if we are to trust entirely to electrical communication, and to everything being worked by electricity in a ship in time of action, we shall stand at a great deal of risk. Of course, there is the great difficulty of getting from one part of a ship to another, and communicating, as the lecturer has pointed out, through these bulkheads and armoured decks, and so on; but it is to be hoped means will be found that we shall not have to trust entirely to one single wire, which after all may go wrong. Admiral Long expressed the hope that there would be other applications of electricity, for instance, to the purposes of ventilation. I may mention to him that I saw most admirable little electric fans last year in the Emperor of Russia's new yacht then at Falmouth, which were fitted in all the lower parts of the ship, which had no scuttles. These fans when worked gave a most beautiful current of air; but they had the great drawback of being rather noisy, and I expect a good many people who wanted to sleep would feel inclined to turn off the fans and do without the fresh air. I do not think I am sufficiently an expert to discuss any of the details into which the lecturer has entered. I will therefore conclude this discussion by tendering him our warmest thanks for his most interesting and instructive lecture.

Lieutenant F. T. HAMILTON : The only point, your Royal Highness, in the discussion which I think requires a word from me is that raised by Captain Eardley-Wilmot. I do not think I made it quite clear as to the range-finder for right-ahead work. This ship to which I have been alluding has range-finders for that purpose. They have a 50-foot base line across the bridge, and the instrument, instead of having a wire running round the arc, has it wound on a coil, so that a very slight motion of the telescope will give a large motion of the rubbing contact on the wire. With the instrument so modified you can get the range with accuracy up to 4° or 5° of training on each bow. With regard to the explanation not being mathematically correct, I think I confessed that in the lecture. The mathematical errors in my explanation are two in number, which are made to eliminate one another by the adjustment of a resistance in the galvanometer itself.

Captain EARDLEY-WILMOT : I did not mean your explanation : I meant the instrument was not mathematically correct.

Lieutenant HAMILTON : I think you will find that it is made so with this correction. With regard to the three lights which Admiral Long spoke of, that system has been in use in the flagship in the Channel for some three or four years. They rigged it up themselves in the "Northumberland" originally, and it was afterwards used in the Mediterranean. They found it, I believe, most useful for alterations of course at night and that sort of thing. With regard to the motion of the boat injuring the secondary cells, there is no doubt it does. It must shorten their lives to a certain extent, but there is very little experience of them in any places where the boats knock about at all. The principal place where electric boats have been used up to now, is on the Thames as pleasure boats, and there I do not know that they find very much difficulty. With regard to the fans Admiral Long spoke of, in addition to those mentioned by your Royal Highness, they have one on board

the "Royal Sovereign," fitted up as an experiment by a firm of the name of Blackman and Co. I regret having omitted to mention the Telegraph School at Devonport.

Field-Marshal Sir F. LINTON A. SIMMONS, G.C.B., G.C.M.G. : We owe a debt of thanks to His Royal Highness for coming to preside at this meeting, where we have heard such an exceedingly interesting lecture delivered by Lieutenant Hamilton. The remarks of His Royal Highness are quite sufficient to show that he highly appreciates the value of electricity as applied in ships-of-war and to war purposes. Having served in the Mediterranean when His Royal Highness commanded the fleet on that station, it was a source of great gratification to me always to see that fleet maintained in the highest order and in the most perfect condition, and to know that every encouragement was given to Officers to develop any project that might be beneficial to the Service of which he is so great an ornament. I ask you to offer your sincere thanks to His Royal Highness for presiding on this occasion.

Admiral Sir E. FANSHAWE : I beg leave to second that.

(The resolution was carried by acclamation.)

H.R.H. the DUKE OF EDINBURGH : I beg to thank you and to assure you it has been a great pleasure to me to be present.