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ignition from the point of one cartridge striking the cap of another in tubular magazines.

Major ANDERSON : I am not quite certain about that ; it is the United States cartridge.

Mr. BURTON : I would like to call your attention to this cartridge I hold in my hand, which I wish you to examine ; it is so constructed *that all danger from premature explosion is entirely overcome*, it can only be ignited in the gun, or unless struck by a blow by a pointed instrument, through the hole in its base. It may be re-loaded like others, the cost is the same. All my efforts to induce the Government to adopt it failed ; they would not even consider it, as it did not emanate from Enfield.

PAULSON'S ELECTRICAL AUTOMATIC LOCOMOTIVE TORPEDO.

By Mr. R. PAULSON.

BEFORE I enter into the subject of my paper I must ask the members to indulge me for a few moments. I feel that I address this meeting rather at a disadvantage. In the first place I am a stranger, and, therefore, should I unwittingly transgress any of your rules, I hope due allowance will be made. Secondly, the subject I am about to deal with requires rather careful handling, and I feel rather at a loss how to proceed when I stand before you to describe a weapon in only a broad, imperfect, and crude manner ; for although I am fully prepared under proper conditions to prove that the assertions made in my paper can be carried out in detail, still for obvious reasons it would not be good policy on my part to disclose those details, a torpedo being a weapon that can be and is made secretly.

In commencing my paper I must tell you that I make three distinct torpedoes. One of these, very small, simple in construction, and cheap, 12 feet long by about 12 inches in diameter, used for the destruction of an enemy's mines or in case you want to enter a harbour. This torpedo can be steered automatically, aided by clock-work, so as to run for a certain distance in a straight direction, then to go serpentine or in circles until it comes within the attraction of a mine, when it will be steered towards it, and will explode on contact ; I do not propose to put any engines in that torpedo.

The second point of my invention refers to improvements in constructing and working the Service torpedoes. The apparatus weighs about 7 or 8 lbs., and will automatically steer a torpedo in any direction. It may be fitted to the present Service or Whitehead torpedo, and also to submarine or torpedo-boats, and I claim that aided by this and *other* improvements, the speed will be increased about 25 per cent., the explosive power used, although the same weight for weight, is quite as safe, but fifty per cent. stronger. This I have proved in a very simple manner. I have also two systems of overcoming the protection provided by nets, that can also be fitted to the Whitehead or other torpedo.

The third torpedo is the one which I make about 25 feet long, and is used solely for coast defence. This weapon travels at a greater

speed than has yet been attained by any torpedo, it carries more motive power, and also a very destructive explosive, very powerful but not too powerful, that is to say, not so destructive that it might injure friendly torpedo-boats that happened to be too near, because if too large a charge were used it might crush in the sides of a submarine-boat, but it would still be sufficient to destroy the largest iron-clad. This torpedo may either be steered automatically or controlled from the shore part of its course.

The cost of the small torpedo to which I first referred is about 100*l.*, and the cost of fitting my complete arrangement to the Service torpedo would not exceed 15*l.* I will now proceed to more particularly describe the improvements. The working pressure can be increased to 1,500 lbs. per inch, which is also maintained during the entire run; when the torpedo is checked or nearly exhausted it comes to the surface. This improvement can also be applied to the Whitehead and other torpedoes.

Another of the principal features of the torpedo is the arrangement by which it steers itself automatically in any given direction, in a direct line, independently of its being launched straight, and of adverse currents, or of any deflection accidentally caused. In carrying out this arrangement electric contact is made through and by means of a suitable compass. Now I am well aware that to merely make such contact so as to ring an electric bell has been done before, but on trying that system I found it did not answer at all; it had to be greatly improved, and what I claim in my patent is the automatic steering of torpedoes, which has never been done before. Other torpedoes have mostly been steered or controlled by wires from the shore, but automatically never. This torpedo also carries a battery, the negative pole of which is placed in connection with the coils of two sets of electro-magnets from which leads are conducted to two metal pins fixed on a disc of insulating material. The other pole of the battery is placed in communication with a balanced magnetic needle of special construction. The metal pins are placed one on either side of the needle, and the course of the torpedo having been determined and set, it is started. Any deviation of the torpedo from its assigned course causes a relative movement of the needle which touches one or other of the pins, thus establishing the circuit through the coils of one or other of the two magnets. An armature connected with the rudder is attracted, and by this means the torpedo is again placed in its right course when the contact is broken. Any deviation from the right course in the case of the controlled torpedo is immediately indicated to the persons so controlling it, and also its course from time to time.

[Mr. Paulson now explained, by the aid of the model before the meeting of a small bronze torpedo about 30 inches in length, mounted on a swivelling stand, with electric wires and a bell, that any deviation from the course the torpedo is set to run was indicated by the ringing of the bell. Each blow on the bell would represent the deflection of the rudder, and the continuous ringing of the bell indicated that the rudder was set hard aport or starboard as the case might be.]

PAULSON'S IMPROVED OR AUTOMATIC TORPEDO.

Horizontal Section.

AA. Screw propeller. B. Propeller shaft. CC. Horizontal rudders. DD. Fins. EE. Electric magnets. FF. Eugene. G. Secret chamber. III. Batteries. J. Steering compass. KK. Studs connected with electric batteries III and electro-magnets EE. MM. Motive power chamber, 1,500 to 2,000 lbs. pressure. NN. Explosive charge. OO. Smaller charge for breaking nets. PP. Triggers.

One very important point is the compass. Its power of attraction must be much greater than the ordinary compass; that was a very difficult point to deal with. The magnet in the first instance was made very heavy; then I found the friction on the point, when suspended, was so great that the earth's magnetic force was not sufficient to properly work it. There were many similar difficulties that had to be overcome before a compass was obtained that would perfectly answer the purposes required. The outer case of the torpedo may be partly made of compressed strong waterproof paper or fibre, and is thus not affected by climatic changes or long storage. The construction of the various other parts is extremely simple. The battery can be stored any length of time; it weighs under 2 lbs. and will last about two hours without recharging, giving off 8 volts, or it will keep a small electric lamp glowing for that time. This automatic steering arrangement can be also applied to unmanned torpedo-boats or submarine vessels generally.

With regard to the protection afforded by torpedo nets, in my patent I show a small charge, about 10 lbs., carried in front of my torpedo; that is also a speciality that I claim. I am told that a torpedo fully charged has been fired to test the best nets in use in the Royal Navy, and the result was that a hole 40 feet in diameter was made in the net. I am also told that if you *merely suspend* 33 lbs. of gun-cotton on the present Service torpedo nets, it will not destroy, but only bulge them out; that is because it was merely loosely suspended. But if you have 10 lbs. of gun-cotton in front of a torpedo travelling 25 knots an hour, the result would be to cut the nets, even though they were almost as thick as a cable, as they would not then be loose, but made taut from the force of the blow given by the torpedo itself and at the moment of the explosion. The range of the torpedo, as I improve it, is from 1,000 to 2,500 yards, and its speed 25 to 30 knots. It travels almost noiselessly through the water, and the depth can be accurately and uniformly regulated. The counter may be so adjusted, if required, that should the torpedo fail to strike the object, it can be made to return to the starting point without risk of exploding. Besides steering automatically, it may also, if desired, be controlled by means of a wire, somewhat on the Lay plan, from a torpedo-boat or from the shore, for part of its course, and liberated when within easy striking distance of the object, the operators being quite out of the range of discovery by the enemy's electric search light.

[Mr. Paulson also explained that his torpedo defies capture by any of known methods. It may be fired from any open boat or from the shore (without a torpedo-boat), rendering it therefore valuable for coast and harbour defence; also for the protection of our Colonies and coaling stations, as it does not, moreover, require specially trained torpedo Officers for the work.

It was also stated that a torpedo upon this principle has already been made and fired on the Norfolk coast, when most of the results now enumerated were ascertained, and several distinguished and experienced naval Officers, who have had the invention explained to them, have expressed themselves highly pleased and satisfied with its merits.]

Captain CURTIS: I wish that some of our younger Officers were here who are acquainted with torpedoes. I have not been afloat with them, but I understand Mr. Paulson to say that they may be either automatic, or controllable from the shore. Do I understand, in the first place, if you want to go north, you put that indicator north, and the torpedo is supposed to go on that course irrespective of any wire?

Mr. PAULSON: That is so.

Captain CURTIS: After it has once started, you have no further control over it.

Mr. PAULSON: No further control.

Captain CURTIS: I think that is a very doubtful advantage. You tell us that if the torpedo does not hit the ship, it comes back again by some kind of attraction. I understood that if it missed the ship, it took a devious course, and came back to the vessel again. I also understand that if it does not strike the ship, it remains afloat. I think it would be very awkward for you to cruise amongst your own torpedoes, because you might come against one of them, and it might explode. I understand that there is some magnetic attraction between that torpedo and soft iron. If so, that attraction must be very great to overcome what we call the deflective wave. I recollect when I was a youngster I tried to get ashore at Mont Junk at Barcelona; the water was very deep, and really you could not get the dingy alongside the shore; the deflective wave drove the boat off, and you had to be pretty smart when the boat took the rise in order to jump ashore, because the boat was repelled back. I have heard of a case where a ship was saved from a rock off Cape Doro, in Greece, by the rebound of the wave; it is very often the case that the rebound sends the ship back. We often hear of people being drowned, although they can swim, because they cannot reach the shore, on account of the reflux wave, note particularly at Dungeness. I was going up the Channel on one occasion, when a man with delirium tremens jumped overboard; the paddle-wheel came down, and instead of sucking him under, according to popular idea, the water which was deflected drove the man away. I was so interested in this, that next day I got several empty bottles, and I could not by any means get the paddle to go over any one of them, they were all driven away by the deflecting wave. I believe Officers say that if a ship is going 14 knots, and a torpedo-boat is going 19 knots, the proper mode is to attack her bow, because in that case the torpedo-boat will be less likely to be under continuous fire. But there is another way of looking at it; if you fire on the quarter of a ship, the following water will suck the torpedo under, but a boat coming up on the quarter or stern will be under continuous fire. With respect to this deflective wave, the French say that at their torpedo experiments all the torpedoes struck, but we were also told that the weather was very calm, and that the state of the sea was not to be compared to Bantry Bay during the experiments there. I did hope that we should hear some lecture from our Chairman with regard to Bantry Bay, but whether it is intended to keep the information there acquired a secret or not, is best known to those concerned. It was stated (I believe it is no secret) that the "Polyphemus" had her nets out when she attacked the boom.

The CHAIRMAN: That is so.

Captain CURTIS: There is no doubt that the net is the cheapest protection you can possibly have, but although a net can break up a sea, it cannot stop a sea. It is just the same with your cable; you can break the cable because of the resistance that it gives, but a torpedo-net gives less resistance, and yields. It is a well-known mechanical principle that a thing may yield, and you cannot blow it up, whereas if it offered more resistance you would break it up. There is no doubt that this is an extremely ingenious invention, but I do not see after you have set the indicator north and south, as the case may be, that you have any control over it. There may be something in the attraction of a ship, but you may depend upon it that the deflection of the water, and the force of the water, is something terrific. I believe that the transmission of force through water is almost simultaneous with the force itself, because it travels 600 yards in a second of time, as quickly as sound. At the earthquake in the Straits of Sunda, it was found that the earthquake wave travelled at the rate of 1,250 miles an hour, and that is one of those things that naval Officers

should take into consideration. When I was afloat, we knew very little of the theory of turning ships, and so forth, but Captain Colomb has made a study of this, and has reduced it all to writing. When I was afloat, we were not allowed to have the courage of our own opinions; our superiors always knew better than we.

Mr. PARLSON: I may say in reply to Captain Curtis that he is quite correct in saying that if you set this torpedo on a given course, after it has left your hands you have no more control over it. The torpedo is automatic in all its details, unless it is controlled by a wire. But if I set her north, and she travels north, I can set the counter that regulates the distance and cut-off valve, so that it will turn the compass-card south; electric contact will then be made until you get the torpedo's head south, and this causes it to return to its starting point. Now, gentlemen may understand what I mean by "returning on her course." Or this can easily be done by clockwork; I can set a clock inside, and so arrange it that the torpedo shall travel say 1,000 yards in so many minutes and seconds, and then be made to return as before. If she has passed the vessel aimed at, the counter might be made so as to put a safety-bolt between the projecting trigger and the charge, so that if she struck in returning one of her own vessels, an explosion would be prevented. It simply shoots a safety-bolt, just in the same manner as pushing a safety-bolt on the lock of a gun. There has been a good deal said about attraction. I do not know whether H.M.S. "Polyphemus" did deflect the torpedoes at Bantry Bay. I have not proved whether the attraction of an ironclad would be sufficient to deflect my steering compass, and thus the torpedo; some naval Officers have expressed one opinion, and some another.

Captain CURTIS: The suggestion was ignored in this Institution by a torpedo Officer, who would not take it into consideration at all.

Mr. PAULSON: Then about the nets; I maintain that so long as a net is perfectly loose, it would be very difficult to get through it; but when you have a torpedo weighing 500 lbs., the force of that torpedo would stretch the net, and make it as taut almost as if it was a cable. Then it could be cut even by the explosion of a very small charge of guncotton, as a thick wet blanket which if loosely suspended will stop a bullet. Something was said about the vessel's speed deflecting torpedoes. I should say a great deal depends on the shape as well as the speed of the vessel. I know the "Polyphemus" went about 18 knots, but I should be surprised to hear she could do anything like that speed when she had her nets out. I am well aware that water will transmit power, and if you explode guncotton under water, you may feel the shock a mile or a mile and a half off. A gentleman told me the other day that he had got some guncotton, and as the acid made it rather dangerous, he took it down to the Thames in order to get rid of it. He said there was a vessel nearly a mile off, and after the explosion she signalled to him that some of her plates had started, which made her leak. The gentleman said he did not believe it, but anyhow they seem to have felt the shock. My own belief is that if Mr. Nordenfelt exploded his torpedo and 300 lbs. of guncotton under water, his own submarine boat would, if anywhere near, be completely crushed up. I need only now, in conclusion, thank you very much for the kind attention you have given to the subject, and hope that you will pardon me for having detained you so long.

The CHAIRMAN: The lecturer has just alluded to the area of explosion. I should be glad if he can tell me whence he gets his dimensions of the area of explosion.

Mr. PAULSON: From Professor Abel's own reports. You will find them all published; they are approximated over a given distance.

The CHAIRMAN: I was with Professor Abel at the time these experiments were carried out, and half-a-mile is far beyond anything that he attained at the Spit-head trials. The area of explosion of torpedoes is in the form of a very oblate cone. It sometimes extends horizontally for 300 yards at the bottom of the sea, but it comes to a very fine point on the surface, so much so that a boat 20 feet off is quite safe. The torpedo explodes, and the column of water is thrown up through a very small opening in the surface of the water. The explosion seems to have a double effect, at first when the torpedo explodes a narrow column of water is thrown up 60 or 70 feet. Then if you watch you will see a second but much broader column of water come to the surface having a diameter of from 40 to 50 feet.

This is the rebound of the wave against the bottom, and the rapidity with which it follows the first column depends on the depth of water. It is with this second wave that all the dead fish and the mud comes up, the first one being perfectly pure. The wave from the ship's bows which affects the torpedo is not an imaginary thing. If you fire a Whitehead torpedo out of the bows of a vessel at an angle of 7° on the bow, if it is a certain height above the water the bow of the torpedo enters the water first. You see the wave take the bow, throw it off from the keel line, and then as the stern takes the water afterwards, the stern is thrown round, and thus generally directs the torpedo nearly right ahead. In the same way if you fire right ahead with the Whitehead broad from the bow it drops into the divided waves, this wave first carries the bow round, and then carries the stern round. It will come round about 5° in the opposite bow; that shows the wave does affect it, but if the stem and stern enter the waves simultaneously the deflection will not take place. The power of compressing fibre is a very well-known fact. Compressed fibre is now used in the United States for the tires of railway carriages. It is compressed at something like 9,000 lbs. to the square inch, and stands a great deal of wear. I do not think it has been made sufficiently thin to construct a torpedo of, but I do not say that such is an impossibility. As regards holding a wet blanket up before you, I never met any one who ever held a wet blanket up before him, and allowed any one to fire at him through the blanket, and I rather think that if any one tried it I should not meet him again. The attractive power of ironclads enters into a great number of people's heads. The formula for attraction is as the cube of the distance, and therefore you may imagine that a very little way off from an ironclad there would be no effect whatever on a compass. Although the ironclad is a very powerful magnet, yet you may safely say at 120 yards it would not affect any compass whatever, or even the most delicate electrical instrument. I will not take up any more of your time, but I think you will all join with me in thanking Mr. Paulson for his interesting paper.

ELECTRIC GUNS AND AMMUNITION (RUSSELL'S PATENTS).

By (the late) W. SETTON.¹

THE application of electricity as a means of igniting gunpowder in the cartridges of small arms is not a new idea. Several patents have been taken out for this purpose during the last twenty years, not one of which has been hitherto found to be of any practical use in the field.

Prior to the dates of the patents of Dr. Russell, the inventions embodying the use of electricity in military and sporting guns have been of two classes.

In one the cartridge contains a platinum wire, one terminal of which connects through the barrel and breech with one electrode of the battery, while the other electrode is connected to a sharp needle or firing pin, which when pushed forward by the pull on the trigger, or pressure on a button, penetrates the cartridge and its charge of powder until it touches the other terminal of the platinum wire, thus completing the circuit and firing the gun.

¹ Mr. Setton was killed the following week, being shot through the heart by an unintentional ignition of an electric cartridge.