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# Evening Meeting.

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NAMES OF MEMBERS who joined the Institution between the 30th May and 19th June, 1876.

## LIFE.

Spratt, A. G., Lieut. 1st West India Regiment.

## ANNUAL.

Lloyd, G. M., Lieut. R.A.

Graham, F. W., Captain 103rd Regt.

Harrison, Henry, Lieut. late 8th Hussars  
Boys, Charles Vincent, Lieut. late 7th.  
Surrey Rifle Volunteers.

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Monday, June 19th, 1876.

ADMIRAL SIR HENRY J. CODRINGTON, K.C.B., in the Chair.

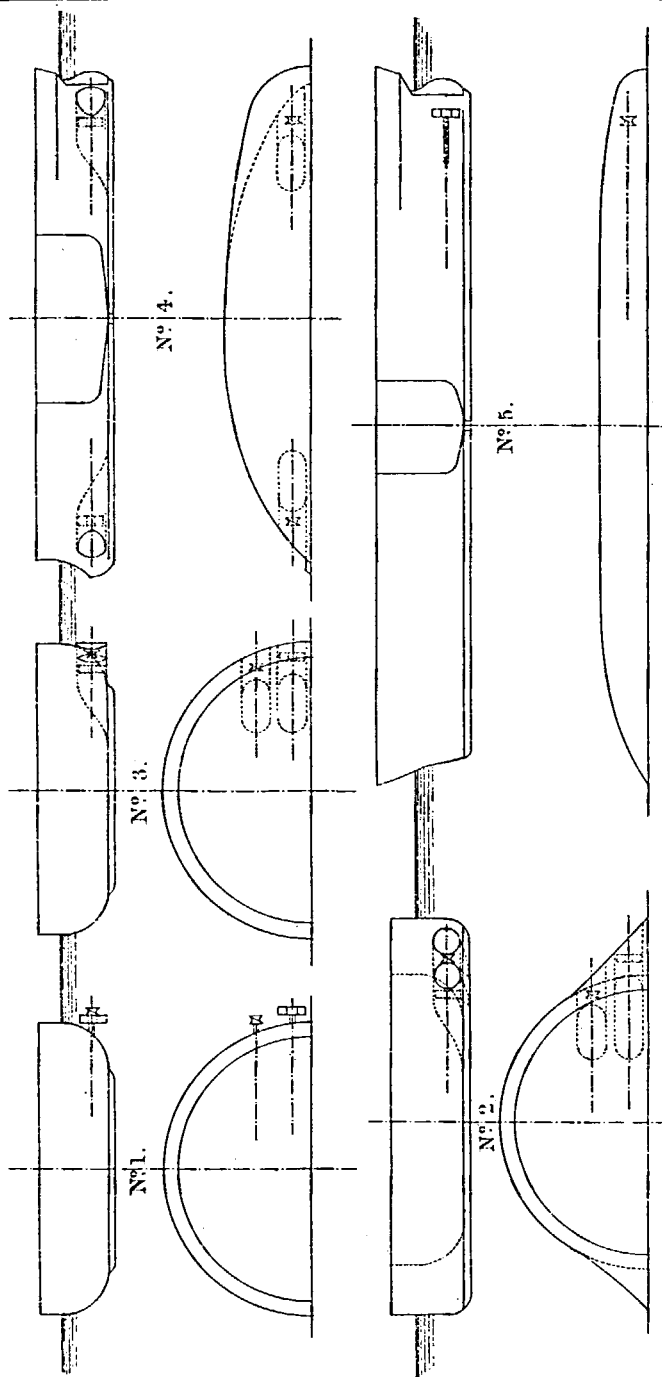
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## ON THE BEST METHOD OF PROPELLING STEAM SHIPS, SO AS TO GIVE THE GREATEST FACILITY FOR MAN- ŒUVRING IN ACTION, AND FOR AVOIDING COLLISIONS AT SEA.

By R. GRIFFITHS, Esq., C.E.

SINCE I proposed reading a paper on the above subject, I have been making several experiments with models, and it may not be out of place here to explain those results which are connected with the present subject.

Since the introduction of steam for propelling ships, there have been proposed numerous plans and suggestions for obtaining the greatest speed with the steam power employed, the principle movement being in the direction of lengthening the ships relative to their width; this plan has been carried so far, that screw ships are now constructed whose length is from eight to twelve times their beam; while armour-plated ships have been carried to the other extreme, and have been constructed with a length only equal to their width. With regard to the lines of a ship, there appears to be as great a diversity of opinions as with regard to its proportions; and there are advocates for full bows and sterns, fine bows and sterns, wave lines, and lately, I find, for stream lines; but it appears extraordinary that, after all the elaborate experiments that we constantly hear of being made, with such extraordinary results, there does not appear to be any improvement in the speed of ships-of-war, relative to the power exerted to propel them; over that which was obtained twenty or thirty years back. Nor has there been any improvement, as far as speed is concerned, in the screw-propeller; the only improvement has been made by the engineer, who has constructed engines which, with the same consumption of fuel, give out considerably more power than was formerly obtained.



Scale  $\frac{3}{4}$  Inch = 1 Foot.

The great question that now requires to be solved is, how to make war-ships capable of meeting all the exigencies of the present age? It will be admitted that, whatever may be the destructive weapons used in naval warfare, speed and facility of manœuvring will be essential elements in the ship's favour. Of the two, I consider speed and safety to the ship of the greatest importance, and, to obtain it, ships must be made from four to six times their beam in length. The movement at present appears to be in favour of *shortening* ships of war: this offers several advantages, such as reducing the armour relative to the displacement, and enabling the ship to manœuvre better; but I find that when the length is reduced to three and a-half to four times the beam, the resistance, relative to the displacement, begins to increase. The diagrams, Nos. 4 and 5, represent models of the same displacement, the weight of each, with the propelling apparatus, being 44 lbs. No. 5 is eight times its beam in length, viz., 5 feet long,  $7\frac{1}{2}$  inches beam, and is fitted with twin screws in the ordinary manner. No. 4 is two and three-quarter times its beam in length, viz., 3 feet  $2\frac{1}{2}$  inches long, 1 foot 2 inches beam, and is fitted with screws in tunnels. When the models were towed through the water at the same speed as when propelled by screws, the resistance of the short model was to that of the long as five to three; but when they were propelled by the same power and screws, both made the same speed, viz., 88 feet in a minute. This was caused by the screws in the tunnels of the short model drawing their supply of water from underneath the model at sufficient distance forward to prevent them retarding the model by drawing it from the stern; but when the screws were moved back  $3\frac{1}{2}$  inches out of the tunnels into the open water, and the tunnels plugged up, the speed was reduced to 62 feet in a minute, and the resistance to the power was increased. For, when the screws were in the tunnels, the revolutions were 645 in the minute, and 565 when the screws were moved into the open water, though the strength of the springs and the pitch of the screws were exactly the same in each case; and in all my experiments I find that, when the screw cannot, or does not, obtain a sufficient supply of water, it requires more power to obtain the same number of revolutions, and less speed is given to the model relative to their number.

The armoured ships of the present time are generally fitted with twin screws, with separate engines to each screw, both engines being together, and subject to be disabled together, in case of the ship being rammed, or a torpedo striking it. My opinion is, that ships of war should have their engine-power and screw-propellers separated into four distinct compartments, so that, should the ship be injured by ramming or by a torpedo, only one-fourth of her engine-power might be disabled; this method would also give increased facility for manœuvring. When twin-screws were first introduced, it was expected that, by reversing one screw, a ship might be turned round on its centre, and would also answer her helm quicker than if fitted with a single screw; but practice has shown that twin-screws possess no advantage over a single screw for steering or turning a ship. Now all the anticipated advantages of twin screws can be more than fully

realized by having two screws within tunnels at each end of the ship; for, by going ahead with the port engine and astern with the starboard engine at one end, and ahead with the starboard and astern with the port engine at the other, the vessel would turn on her centre in a very short time, and would answer her helm when going either ahead or astern much quicker than is now the case. Moreover, when the screws are employed in tunnels, they can be so arranged that they may draw their supply of water from *inside* the ship in the event of a large breach being made by a ram or a torpedo, and thus the whole power of the engines could be made available to pump out the water while the vessel would also be propelled.

With regard to the speed obtained by the models, when the difference of resistance is taken into account, it will be found that nearly 16 per cent. more speed is obtained by working the screws *in tunnels*; and there can be no doubt but that this amount is lost in all vessels which have their screws worked in open water.

In order to avoid collisions at sea, which have of late caused so frightful a loss of life and property, it becomes imperative on steam ship owners to adopt every practical plan that would have the effect of reducing the risk of their occurrence. The most necessary requirement is to have the ship constructed so that she will answer her helm quickly under all circumstances, and I feel convinced that commanders of steam ships are often unjustly blamed by the public when they have met with a collision, for when a steam ship gets so near to another as to render a collision probable, the first thing that is done is to stop and reverse the engines. The helm has then no control on the ship, while the momentum carries the ship forward for a considerable distance. In many cases she would be more likely to escape the collision if the engines had not been reversed, for then the helm might have been sufficient to turn the ship so as to escape it; but should this have been done, and a collision take place, what would a jury and the public say? All passenger steam ships ought to have their engine-power divided between the bow and stern, which would give considerably greater safety, as well as speed and other advantages. With such an arrangement, a commander would have perfect control over his ship, for by stopping the bow-engine and reversing it, and allowing the stern-engine to remain working, the ship would be brought to a standstill quickly, while her helm would continue to act until she was entirely stopped. I have no doubt that at some future time the Legislature will compel passenger ships to divide their engine power, and not allow so many lives to depend on one engine and on one propeller,

I will now briefly describe the models and give some of the results obtained by my experiments.

*Diagram No. 1* represents a model similar to the Russian circular ironclad "Novgorod," which when tried gave a speed of 52 feet in a minute with 640 revolutions of the screws.

*Diagram No. 2* represents the same model, but it is fitted with elongated ends, and the screws are placed in tunnels. When tried it went 68 feet in a minute with 645 revolutions.

*Diagram No. 3* represents the same model, but without the elongated

ends, the screws being still in tunnels. This went 66 feet with 645 revolutions.

*Diagram No. 4* represents the model  $2\frac{3}{4}$  times her beam in length, which is fitted with screws in tunnels. When tried it went 88 feet with 640 revolutions.

*Diagram No. 5* represents the model of an ordinary ship 8 times her beam in length, fitted with twin screws in the ordinary manner, which went 88 feet with 620 revolutions.

In these experiments, the power employed and the displacement of the models were the same in every case. The experiment in towing models Nos. 4 and 5 to show their relative resistances, before referred to, was accomplished as follows: the models were attached to each end of a rod 6 feet long, and a line was attached to the rod between them. The point of attachment of this line was then shifted till the rod would remain at right angles to it when the models were towed at the speed they would make by their screws, viz., 88 feet a minute, and then the distances from the ends of the rod to the point where the line was attached showed the relative resistances of the models. These distances were found to be 2 feet 3 inches from the short model and 3 feet 9 inches from the long, so that the resistance of the short model was to that of the long as 5 is to 3. In another experiment the short model was propelled by her screws moved back out of the tunnels into the open water, and the tunnels left open, and the speed was then found to be only 71 feet in a minute with 600 revolutions; and when the tunnels were plugged or stopped, the screws being left in the same position, the speed was reduced to 46 feet in a minute with 558 revolutions.

In conclusion, I would remark there is one feature in connection with having the screw-propellers worked in casings or tunnels to which I drew attention here some time back, and to which I would again refer, viz., as to the facility it offers for drawing the water out of the ship, should she be rammed or be struck by a torpedo. An armoured-plated ship, with 800 to 1,000 nominal horse-power, would require four screws of 12 to 15 feet diameter, and, when worked at full speed, would discharge a column of water through each of them at the same speed as the ship would make. It follows, therefore, if the engines gave out the power that would propel the ship at 10 knots, each screw would discharge the water inside her at the rate of about 3,000 tons of water per minute, provided suitable arrangements were made; and since the probability is that a ship in action is more likely to be disabled by a ram than by a shot, or by a torpedo, I think this point should be well considered by those who have the designing of our ships-of-war. I agree with Captain Scott, in the very able paper he read here last Friday, in which he gives the first place to the ram, and the next to the unsinkability of ships-of-war, and I consider that we shall very soon find that the guns will become of secondary consideration to the qualities of high speed and unsinkability in ships. From some recent experiments which I have made (which, for several reasons, I cannot at present disclose, though I may state this much), I foresee that greater speed, invulnerability, and unsinkability *may* be effected by very simple modi-

fications in the construction of our ironclads, and which results are quite within the power of the authorities to effect without that enormous outlay which the armour-clad ships of the ordinary types would require for effecting these objects.

The CHAIRMAN: I hope some gentlemen present will favour us with their remarks on the lecturer's paper. I would myself begin by asking a little more information on one or two points. I do not quite understand whether those tunnels are to be opened below, so as to allow the water to flow into them from below. (Mr. GRIFFITHS: Exactly so.) But supposing we leave them open below, so as to allow a free volume of water to rise up underneath and flow into them, how is the proposed connection made with the cavity of the ship, in order to extract the water which has leaked into it? How is that communication to be made so that that water which rises from below into the tunnel will not by preference go also into the cavity of the ship, as well as supply the screws? How is the engineer to shut off the external water rising up from the bottom, and to take the water from the cavity of the ship? Then we must remember that by putting four engines into a ship; two at each end, we come across other difficulties. First of all, there is the difficulty of the chance of collisions, which mostly affect the fore-body of the ship. There will also be a very large gap taken out of the strength of the ship in the fore-body, in addition to what is naturally taken out of the run of the ship. We must provide some means of strength for that fore-body, or something to make up for that. Then there is the difficulty of having four engines to deal with, instead of merely at most two: there is the supply of fuel and all the requirements of the engines, the additional space required, which would take out of the space for cargo or for anything else, and of course the additional hands required in the engineer's department, to attend to four engines instead of two. I presume in the trial of the towing, the screws were not fixed; in each case there were two screws, and in each case those two screws were allowed to be free.

Mr. BURN: Mr. Chairman and Gentlemen,—I should like to offer a remark or two. Mr. Griffiths has been good enough to give us a great deal of information on the screw, but there are one or two details he has entirely left out. He has not told us what time his vessel will back in, and whether there is any difference when he applies the tunnel in combination with the screw; that is to say, supposing he is going at a certain speed, and stops the engine and reverses, I should like if he would give us what time it takes before the vessel stops, then what time it takes before she goes astern, and also whether there is any visible difference when the tunnel is left out?

Captain Sir GEORGE BIDDLECOMBE, R.N., C.B.: I should like to make one remark with regard to enclosing the screw with a tunnel. We have already in the Navy fitted one vessel of that sort. Mr. Turner, assistant master shipwright at Keyham Yard, in 1858, fitted one (as stated in a lecture given by me here), and from various experiments he had previously made, he concluded that it would be very successful. The Government gave him the opportunity, but I am sorry to say the speed obtained by the screw being enclosed did not come up to what she originally worked at when it was open. I merely mention this as a fact. In regard to introducing a screw into the fore-body of a ship, especially of a man-of-war constructed as a ram, I do not know how that would act when you are going to ram a ship. For instance, in coming into collision with her, the chances are your screw would be in a very awkward position, and possibly get much injured by the collision, and you may not then be able to work the screw again. There is another point the lecturer mentioned in reference to collisions, that it was objectionable to stop and reverse the engines. My experience does not lead me to concur in that opinion; but I think if we saw a collision about to take place, common sense would dictate that we should stop the engines at once, because with the speed the ship had upon her, the helm would still be acting. I do not agree with the view that the ship is not acted upon by the rudder after the screw ceases operation.

Admiral SELWYN: I have one or two remarks to make on this subject, because I have taken a considerable degree of interest in Mr. Griffiths' experiments, as show-

ing the anxiety of a steady worker to prove by models all that could be so arrived at, and he has done a great deal in this direction. I also take a great interest in developing the screw off the face of the earth. I want to see its place taken by the turbine, and Mr. Griffiths has made a step towards making it a turbine by casing it. I doubt very much indeed that a division of the power, and therefore of the engineers and stokers, would be an advisable thing, either on board a man-of-war in action, or in a merchant ship, with a view to economy. You cannot work a number of stokers at two sets of furnaces in different parts of the ship with equal effect to that obtainable with the same number at a single set of furnaces. You must have different engineers, therefore you must engage inevitably in more expense. You must have two engineers in each watch, and a certain number of stokers to each set of fires. Each man cannot do his best work if he has not his full number of furnaces to attend to, and if he is obliged to go to another part of the ship. I should say you must have your staff nearly doubled. It is a question of economy. Whether it may be more advisable in the view of propulsion to put them there, is another thing; but at least in our mercantile marine, economy carries the day in every shape and form. Mr. Griffiths' experiments show very strongly the enormous value of a constant reference to a still larger series of experiments, of which very few people avail themselves to their full extent. I speak of Colonel Beaufoy's. Colonel Beaufoy has shown in a very large and long series of experiments, nearly all the facts that we now are trying to bring out. These would be more generally referred to if only they had been put in a condensed form; but it takes a man half a lifetime to get out the value of Colonel Beaufoy's experiments. He has shown one remarkable thing, and that is this: that whether you divide the water by a very narrow fine bow, clearing the fluid like an axe, or whether you put that narrow fine bow flat on the water, and drive it over the water, the resistance is for all practical purposes the same: having fine lines, there is no more resistance in the one case than in the other. I say this because Mr. Elder distinctly showed by an experiment precisely similar to that of Mr. Griffiths, that is to say, a species of steelyard arrangement at the stern of the ship, and towing large models from it, that whether he took the finest vessel of deep draught and ten beams to the length, or whether he took a vessel of similar tonnage, but made of the shape of the segment of a sphere, there was not the slightest difference between their resistance. But there was this remarkable difference in another way: that whereas the sharp deep-keeled vessel plunged under water constantly and made bad weather of it, the segment of the sphere always rode over the water with perfect ease. I must demur to Mr. Griffiths' ideas about the turning by twin screws. I went down with all Mr. Dudgeon's early twin screws, and was witness to their turning with the utmost facility in smooth water. I am not so sure that they would always turn well in a heavy sea, and I have heard that they do not do so. But it is a great thing to be able to turn in a ship's own length, even in smooth water. When we attack in harbours or in smooth water, we shall very often find it of very great value, and as we shall not generally fight fleet-actions in gales of wind, it may be extremely useful in that case at sea also. Twin-screw ships do turn on their own centres so quickly that the remark of Sir Edward Belcher, who was with me on that occasion, was that he could not train the gun on board the ship so quickly as he could turn the vessel; that it brought the gun up to its mark better in every respect for the gunners than if he had tried to twist the gun about with screws and levers. Still, all these experiments have their value; and although I quite agree that for a man-of-war a screw at the bow is a very questionable advantage, I should much rather have something inside the ship altogether, if I could do it. When we come to substitute the use of the ram for guns and shot, I quite agree with the lecturer that the ram is a shot of the number of thousand tons force which is due to the mass propelled and its velocity, and therefore it is an irresistible shot. Admiral Sartorius's views on that subject are too well known in this Institution for me to advert to them. He was one of the first advocates of it, and he has been proved to be perfectly right in all that he advanced. But if we are to have a ram it is impossible to have the screw in the bow. It would simply be throwing away half the whole engine-power to do so. We could not hope to have the bearings in their proper place after the shock of ramming, and we all know what a distorted bearing of a screw-shaft is. Therefore I do not think we shall make any great progress in that direction. In the

experiment Mr. Griffiths has also tried an enlargement (first proposed in this theatre by Mr. Reed) of the Russian circular ships, giving her the bow and stern which Mr. Reed advocated, that is to say, a species of compromise between the sharpness of the deep-keeled ship, keeping the wedge shape to cleave the water, and the extreme diameter of the Popoffka and her sisters, I see one of those compromises which seldom gives full value in any direction, and Mr. Griffiths has thoroughly well proved that it does not give value in the sense of superior speed to any very great extent. On the other hand, taking the circular ship for what she is worth as an unmasted steam-driven vessel of enormous capacity and tonnage, capable of carrying coals for any voyage at any speed, with any gun and any weight of armour, I do think that there is a great advance to be made, and I hope to see strong attention given to the subject, as I also hope to see new experiments made on the "Waterwitch," to give us some idea of the value of the turbine-propeller.

MR. GRIFFITHS in reply said: The first question is whether the screw takes the water from below. It certainly does, as shown in all these drawings; it comes from below right into the screw and passes out at the stern, and at the bow enters in front and passes out underneath the ship. With regard to the strength of the bow, I contend that the strength of that bow is as great with these screws as you can make it on the ordinary plan. Now, if I make a beam through the ship like a backbone, and make the tunnels and put the screws as far back as you like in the ship, the tunnels being built in the ship, how can anything give way? or that backbone can be made as far back as you like into the ship; so far as that goes, it is equally as strong as if there was no screw at all in the bow. The great advantage of taking the water from below is, as has been explained several times,—Mr. Froude experimented upon that,—that if you put the stern screw outside, it sucks away from the ship that water which would go to fill the space the ship has left, and, consequently, there is just double the resistance to the ship when the screw is pulling the water back. That he has proved and explained in two or three papers, and I find that to be the case in my experiment. It is not only what it takes from the ship, but this water that is forced back stops the current which runs after the ship to fill the space, so that it has a double effect in stopping the ship.

With regard to sucking the water out of the ship, one way which I have tried, and which I believe to be the simplest plan, is to have outside this tunnel (*pointing*), about half way around it, a space left all along connected with a pipe inside the ship. The forcing of the water through that tunnel will suck the water out of the ship. There was an experiment to this effect shown the other evening at the Royal Institution by Mr. Froude. The first who brought that out was Bernoulli, who showed that if water was flowing through a horizontal pipe at 9 feet per second, and a vertical pipe was connected with the horizontal one, water would be drawn up the vertical pipe a height of 2 feet in opposition to gravity. Mr. Napier, of Glasgow, has proved that by putting a pipe through the bottom of a ship, the suction of the water down, would show the speed of the ship. This takes place here exactly, when the screw is working, the water is forced back at half as fast again as the speed the ship is making, or faster according to the power exerted; first it takes the speed of the ship and afterwards the speed the screw forces the water back. If you are sucking the water from the inside at that speed, you may depend the water will go pretty quickly out of her.<sup>1</sup>

ADMIRAL SELWYN: Is the access of the water cut off at the time you use the inductive, or the educative, effort of the screw to pump the water out of the ship?

MR. GRIFFITHS: No, certainly not. The screw uses the water from the sea, but the force of the water that it sucks through the tunnel also sucks the water

<sup>1</sup> I find from some recent experiments which I have made, that this plan cannot be relied upon, for the least leakage of air into the conducting-tube will destroy the effect of it, and an arrangement to shut off the sea-water from the screw and open the communication from inside of the ship to the screw would be preferable, or a rotary or other pump could be easily worked from the screw-shaft when required and the discharged water could be used for manœuvring the ship if required.

out of the ship. Nothing is wanted but a valve to stop the pipe that is connected with the water within the ship.

**A VISITOR:** When the vessel is proceeding forwards, does the water go back, because if the water goes back then it is all slip, the ship would not move. Water never does run back when the ship is going forward.

**Mr. GRIFFITHS:** Of course when the screw is working the ship moves on; if the ship is kept standing still, the water will be forced back. Loose the ship and nearly double the water goes through the screw directly.

**The VISITOR:** Not driven back.

**Mr. GRIFFITHS:** The ship goes forward. You must take the speed the ship goes, as well as the quantity of water the screw draws. I think in one of the papers I read, I explained that the pressure is double when the ship is under way.

With regard to the boilers, all the boilers would be placed in the centre of the ship whether working the forward or aft engine, and, consequently, that removes the difficulty with regard to the stokers. There need not be two sets of stokers if you divide the power, any more than if the whole boilers were working on one engine. Then as to how soon she will go astern: I found that by reversing the forward engine she would stop in one-third the time that she would if I reversed the after engine, because she drives that water forward against her, which is not the case with the engine at the stern; as to the speed, it is no matter at all which way I go, forward or backward, it makes no difference in speed or anything else. With tunnels around the screw there is a loss of speed, but how nobody ever ascertained the cause of it, is strange. I was with Ericson trying that experiment forty years ago, and he found directly there was loss of speed. When a screw is working in open water it gets a great quantity of water all round the periphery to supply it, whereas if you put it in an ordinary casing you stop the supply and your screw is short of water, but if you continue your casing and put a bell-mouth equal to the quantity of water the screw requires, you make up for that loss,—it is the funnel-mouth that makes the difference. In these casings I have a funnel-mouth which gives me about 50 per cent. more water than the area of the tunnel gives me. I enlarge the mouth of the tunnels according to the power used on the screw, and the effect of the screw in propelling the ship is in proportion to the water it gets supplied with.

**The CHAIRMAN:** However we may criticise some details of this plan, I think we must all feel obliged to Mr. Griffiths for the information he has given us on this point. There is a great deal that I admire in it and a great deal in which I go cordially with him, though in one or two points I might criticise him. I think we must all thank him very much for his lecture.