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Ebening Meeting.

Monday, February 20th, 1871.

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in the Chair.

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20th of February, 1871.

ANNUAL.

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Macneil, J. G. R. D., Lieut. 41st Mad.
Nat. Infantry

ON THE TRUE ECONOMIES OF ENGLAND'S NAVAL POWER.

By Captain J. H. SELWYN, R.N.

IN the year that has just passed away, there has been suffered by the Navy of England a great and extraordinary loss. A lesson of unprecedented severity has been taught to all who are connected with England's Naval power. That loss and that lesson should now produce their legitimate and only useful effects, and this will not be the case, should vain regrets over the past, or still more vain recriminations in the present, be allowed to take the place of due precautions for the future, or of calm scientific enquiry into the occult causes of disaster. My purpose, therefore, in this paper will be to consider the *false economies* that have led, or that may still lead, to such evil results, and the *true economies* that may almost certainly prevent them. In doing this, I shall not confine myself to the consideration alone of such failures as that of the "Captain," but I shall attempt to notice some of the most obvious changes that may be and ought to be made, in order still further to develop and secure that important basis of the greatness of this country, which is found in her Naval power.

I shall commence by observing, that of all unwise economies, that has ever been held to be the most foolish, which to secure a slightly or

even considerably lessened cost in the first instance, sacrifices the real efficiency of the thing constructed. Such a case arises when we construct any new type of vessel on the large scale, without exhaustive previous experiment on the small scale. Such a case arises when for the sake of a lessened cost of ship, we reduce the number of day's fuel *at full steaming power* carried by a man-of-war. Such a case arises again when, to reduce estimates for coal, we prevent the acquirement of that knowledge by the officers who have to use those men-of-war which can alone obtain a successful result, when their right use has become a vital necessity. Such a case always arises when, to satisfy a popular clamour, we cut down votes for the purposes of experiment; we discourage and attempt to rob inventors; whenever, in short, we persist in doing things the wrong way instead of bending all our energies to the discovery of the right mode of action, simply because it is less troublesome to follow beaten paths even at the cost of going astray from our real object, than to understand those who press on our attention a new road to success. If, instead of issuing an order to abstain on all but special occasions from the use of steam, an offer were made of a reward for, or even interest were shown in, the proper utilization of fuel, science would not have to regret the fact, that in our Navy only half the true evaporative power—only half the mechanical duty of which even our present fuel is capable, is ever ordinarily obtained in practice—and our Officers would attain a knowledge of steam tactics with no greater expense than at present. I draw attention particularly to the latter fact, for a fact it is. Numerous British merchant steamers have been running for years, and one corvette in the British Navy has been running for months, developing just twice the mechanical power, with the same consumption of fuel. H.M.S. "Briton" has been able, by the adoption, in a moderate degree, of the improvement of which I speak, and which has been known and practised by the mercantile marine for some time, to burn less than 2 lbs. of coal per indicated horse-power instead of 4 and $4\frac{1}{2}$, which is the consumption of other, even recently built, vessels of our Navy. In other words, if we take the case of a vessel of 800 nominal horse-power, which would ordinarily burn 75 tons a-day at full steaming, the same power is now obtained by one, and ought long ago to have been obtained by every ship in the Navy by the expenditure of 35 tons only. The improvement I refer to, is, that known as the compound engine, but which really depends solely on the use of a higher pressure in the boiler, for its satisfactory results. When steam pressure in the boiler is as high as 80 lbs. instead of 25 lb. or 30 lb., as we are now using, there is this great difference: at the pressure of 80 lb., the temperature is 324° F., instead of with 25 lbs. or 30 lbs. respectively, 267° F. or 274° F. This difference in the latent heat enables us to use the steam twice over, first in a high-pressure cylinder where there is no attempt at condensation or the production of a vacuum; and, secondly, in the ordinary condensing cylinder in which such means of producing a greater effect have always been used. But there is an invention in progress to which my notice has recently been drawn, and which I believe likely to succeed admirably well, which will relieve us from the

necessity of having any boiler at all, though we must still have a furnace and fuel. As matters are at present, I should in vain solicit any due attention to this fact, *and this ought not so to be*. I have said that according to actual facts patent to everyone, our ships that now are being built, or that have been built for the past two years, ought to be running on just half the fuel they at present use or contemplate the use of. I now propose to show you that I have myself proved more than a year ago that they might be run with one half of that again, so that the expenditure above referred to of 75 tons per day for 800 nominal horse-power would be reduced by the first improvement in one of the "true economies" to 35 tons per day, and by the second to 17.5 tons per day. In other words, if at present such a power could be exerted for three days, the first improvement would make it six days, and the second 12 days. On the table of experiments with liquid fuel which I show (see Appendix) you will see that each pound of fuel was made to evaporate 17 lbs. of water instead of eight, which could be done with other fuel (solid) in the same boiler, and that considerably more water was evaporated in the same time and with the same heating surface, and this with an ordinary boiler, perfectly capable of burning coal, as usual, if required, and having added to it no expensive or cumbrous apparatus. Therefore, wise and cautious experiment, steadily continued, might long ago have given us this, which I put forward as one great and true economy of our naval power.

The next part of my subject will be the consideration of wind-power, which there is a strong tendency to ignore, or to undervalue by those who, being only engineers, prefer to rely entirely on fuel for their motive power.

And here I will remark that it is absolutely certain that wind-power can be efficiently utilised even where sufficiently powerful considerations exist to prevent the use of ordinary masts and sails. I have seen models propelled in the wind's eye by wind power, strange as the assertion may seem to those who do not consider that the propeller may be acting under different laws, and be in a different condition from that which they suppose two miles per hour dead to windward is more than most vessels with full sail power can accomplish by beating, and this could easily be done by the application of a fraction of the wind power to a propeller acting on the water, or to a self-contained power like the turbine or hydraulic propeller. I say self-contained, for the hydraulic propeller differs in this from all other modes of propulsion, that it has no other limit than the horse-power of the engine that drives it, to the speed attainable by its use. The paddle, or the screw, after attaining a certain velocity, will churn the water, but will fail to drive the ship; the hydraulic propeller will give useful effect in increased speed for every lb. of fuel you can burn, for every additional horse-power that you can generate.

So far as I know this fact has never even been noticed hitherto by the inventors or advocates of the "Waterwitch," and it ought to be strictly investigated.

But to return to wind-power, however applied, there is first the great

economy during peace to be considered that results from its use, there is, secondly, the fact that engines may break down, that boilers may burst, that your coaling port or fuel depôt may be blockaded just when you have used the last few tons in reaching it, and, lastly, that it has not yet been shown, either at Lissa, or anywhere else, that the masts of vessels were really a cause of serious impediment either under steam or in action, while it is indubitable that in many cases the irregular movements of a vessel are beneficially modified by the presence of masts and sails, and most injuriously affected by their absence. At the same time I have no doubt that all idea of beating to windward would be wisely given up, that a great simplification of masts and rigging would be possible when this view is entertained, and that true economy in this instance will be found to consist in using wind-power to go to leeward, and steam-power for action or to go to windward.

Having thus treated briefly of the forces which are to drive our ships, I will next take the forms of ship which ought to be driven; and here I must observe that though no rule can possibly be laid down which will enable one type of ship to satisfy all our requirements for defence and offence, it is most possible to avoid such a stigma as that not unjustly applied by a high naval authority in the House of Lords lately to our modern ships, "that they are neither fit to defend our shores, nor to cruise at sea." It is not only possible to avoid it, but there is no excuse for even the semblance of such a state of things. Let us see how far the charge may be a just one. It can hardly be said that a ship is fit to cruise at sea which may be upset by such accidents as a white squall, a summer gale, or even a real hurricane, coinciding with a disturbed ocean level, all or any of which may come with no sufficient warning to allow their avoidance. Neither is that vessel fit to cruise at sea which carries only three to four days full steaming power, and yet is unable to rely on her sails alone for either tacking or wearing with any reasonable certainty, or on any reasonable distance; neither, again, is that a sea-going cruiser which can turn bottom up if a wave of 20° inclination coincides with a heel due to sail pressure of 10° or 15° .

It has actually been attempted, by those who never saw a ship except in harbour, to allege that our seamen are likely to handle such ships as are now given them, *improperly*, which being translated means, that they will not be able to keep an engineer's box from taking its position of equilibrium bottom up. It is unfortunately an undeniable fact that if the "curve of stability" be calculated for any of our modern ironclads, it would point to the certainty of their turning right over directly a given angle of inclination, far short of that which is known to seamen as "on the beam-ends," is reached. In some classes of our modern ironclads, nothing but putting extra weight in their bottoms, which has no value except for this purpose, will keep them from turning over in the most ordinary circumstances.

This is not scientific ship building. What England requires from those who call themselves scientific naval architects is not "curves of stability" shewing when and where her seamen will be drowned, but ships of stability, which, as long as the water is kept out of them, will

never do any such thing. This used to be the case once, and ought to be the case now.

Lord Hardwicke was right in saying that "these ships are not fit to cruise at sea." Are they better fitted to defend our shores? This is easily settled. First, their draught of water is such as to make them specially unfit for North Sea work, where the principal defence would have to be accumulated; and, secondly, their small number, relatively to cost, and, therefore, small number of guns carried, notwithstanding the size of these guns, make it certain that they are ill adapted for this work also. It is only further necessary to say, that science has long ago shown how in small light draught vessels, carrying the very heaviest guns, it is possible to defend our shores efficiently; how with floating forts to dispense with endless fortification, not of strong places, but of weak points; and how for sea cruising, the only real requisites are safety, speed, and power of sustaining it. If we choose to have mailed giants carrying monster guns in order to be prepared for fleet actions, well and good; but they must never be substituted for, or confounded with, either the protectors of our commerce and honour during peace, or the small active defenders of our coast during war, though they may be floating forts and fit for fleet action under steam. If the power given by Captain Moncrieff's inventions be properly utilized, but little armour will be required in sea-going ships, and that little will protect both the vitality of the ship and the offensive weapons she may carry, and yet it will not affect her stability. Turrets, except for smooth-water work and on raft-like vessels, were always a delusion, since they never have given, and never can give all-round fire, their chief claim to excellence, and now, that on the gun has been conferred the power of lowering itself behind the side armour to be recharged, there is still less reason for their use. No naval architect ought ever to have called that a sea-going cruiser in which it was proposed to carry 800 tons of dead weight on and about the upper deck, unless a form of vessel were taken giving enormous beam, like those proposed here by the late Mr. Elder, and

which, for fleet work or floating forts such as I have spoken of, would be far more formidable than any ships now afloat. On this head I think the true economy will be to have distinct classes of vessels for the distinct purposes to be subserved, and to engage in experiment forthwith with this view. The "Staunth" and her consorts may be accepted as an instalment of what should be done—but far more efficiently done, for our coast defence; but the hybrid heavy draught breastwork "Monitor" will have no proper place. Secret telegraphic

communication, available to the coast guard by night as well as by day, which our present telegraphs are not, would place a mosquito fleet, in the shortest possible time, on any part of the coast they were called on to defend, formidable to the very largest ships of the enemy by reason of their number and small size, almost indestructible by his fire, and by their light draught of water, safe from his near approach. Thus, too, the fullest use could be made of the seamen at the various mercantile ports in case of necessity. They could be easily trained during peace, and would be always at hand during war. Such gun-vessels may be fast, and will certainly be handy. As many as twenty could certainly be built for the price of one breastwork monitor, and they would each carry one gun, as big as any on board of her. I had rather attack two such monitors than half of such a fleet, for the ram or the torpedo may dispose of the monitors at a blow; but how can any one deal with the stings of such wasps as he would have in the gun-vessels, for gun-vessels and not cruisers these ought to be, each carrying, if possible, a 25-ton gun, or if not that, as large a one as could be fought and carried? These vessels should never be taken away from their district, but should occasionally be assembled for combined manœuvring. They should be in charge of local naval Officers, and be manned by local seamen. A threatened descent might thus be seriously impeded, if not driven off in the time that would otherwise be consumed in calling larger vessels from a distance, for such a descent will never be attempted near a large fortified arsenal, but at undefended portions of the coast. I know it is said that to land troops in the Crimea and elsewhere, has taken much time, and has proved difficult. I do not believe that this will be the case when an intelligent selection of a deep-water shore for disembarkation allows intelligent and energetic seamen to run the nose of each steamer on to the portion of beach allotted to the troops they carry. I do believe that any nation possessing emigrant steam lines, can land from each of such vessels from 1,000 to 2,000 infantry with ease, or an equal proportion of artillery, cavalry, and stores. I do believe that a few hours of a foggy night would be sufficient time in which to effect the operation, and I fear that at present no adequate means exists for preventing such a descent. This, again, ought not so to be, and it is *false economy* not to be prepared against it. Thus then, there would be three distinct classes of vessel in our Navy not interfering with one another, but all available for defence, or if need be, offence, viz., the light gun-vessel never leaving our coast, costing little or nothing for maintenance, for she can be manned by true Naval Coast Volunteers; the floating fort capable of high speed continued for a long time on an emergency, yet needing no masts nor sails, and therefore no sailors, unless as chiefs or navigators—nothing but artillerymen and engineers (I speak of the vessels proposed by the late Mr. Elder); and lastly the ocean-navy proper, fast, commodious, lightly armoured, yet heavily armed, cheap during peace and formidable to the enemies' cruisers or commerce during war, frigates of the future, with full and properly disposed sail-power and condensed fuel for use on occasion, so consumed that not a pound of useless weight is carried, with armour sufficient to protect the men at their quarters, but not devoted to pro-

tecting the whole ship above water. If the hydraulic propeller be used no injury under water likely to occur from shot, would be fatal. But all this will require experiment, and *experiment* is the only means of reaching *true economy*. A few strokes of the pen may reduce expenditure, but there must be much labour of the brain, and hand too, before true, lasting, economies can be realised.

I will now advert to those economies, real and false, which affect the *personnel* of our naval power. First, as to the seamen, for to paraphrase Goldsmith—

“Chiefs and their staffs may perish or may fade;
A breath may make them, as a breath has made;
But the bold mariners, their country's pride,
When once destroyed can never be supplied.”

That is, in time to be useful. There is little use in ignoring the fact that the modern requirements of our men-of-war seamen, involving constant drill and discipline, even more than a sailor's knowledge of the handling of wind power, have gone far to separate the naval service from the commercial marine of England, and it is here the false economy not to keep up a large force of really trained men-of-war's men, providing at the same time by the admirable proposals brought forward here a few days since for substantial reward in continued employment on shore for those who had well served their country at sea, and also providing, as might easily be done, that during peace sufficient profitable employment should be found for those who might be waiting to take their turn at sea. Economically conducted Government manufactories of such articles for naval service as only government requires, might amply fulfil this condition of preparedness for all those eventualities which come *so suddenly* upon us in these times, and a great deal of the modern man-of-war's-man's drill could be done on shore far better than at sea.

Continue therefore and multiply those training ships for boys which are already doing better work than many educational boards, for these supply a real demand, not an ideal one; these make honest handworkers, not dissatisfied brain idlers. Teach them that they are prized by the State they serve, and shall be liberally, not grudgingly rewarded. Teach them that good conduct will raise them in real and permanent position, according to their real capabilities, not in false imitations of tinsel rank. Responsibility is often a real terror to those who know themselves well fitted to obey, but also know that the accidents of birth have never fitted them to command. It is not true that any education, still less such education as can be given after the child passes into the world of schoolboys, will ever enable all men to be equal in capacity for taking the place of governors rather than of governed among the human race.

Instances of self-raised men are not indeed rare, but they prove the force of genius and character, not the power of education, and here I take occasion to say that, whether for Officers or men, a seaman's best education, as that indeed of all other professional men, consists in teaching him to do as well as he possibly can that which his future life probably will require him to continue doing, not any attempt at a smattering

of all knowledge, in many branches of which he can never succeed in being anything more than a bungler.

I now turn to the *personnel* of Officers, in which England has in former times been so rich. As engineers—for the first who embarked the Thames in modern days was a naval Officer—and many there are now in our Navy who have shown a skill under circumstances of exceptional difficulty, of which civil engineers might well be proud, for fertility in expedients is a well known quality of naval Officers; as diplomatists of firmness who never meddled or muddled; yes, even as directors of great commercial enterprises in times of peace, I am proud to assert that no profession has ever shown more readiness of hand, brain, and heart, than the Navy of Great Britain. But if by an unwise economy the position of such a professional man should be rendered to the last degree uncertain, if, in addition to ignoring merit, it should be attempted to over-ride professional claims, then it seems certain that no such results can in the future be obtained as have so largely contributed to the state of England's naval power in the past.

We may acknowledge the difficulties of ever-increasing-half-pay lists and obsolete professional knowledge, but these may be more reasonably attacked by a true union between the junior Officers of the Navy and mercantile marine than by ill-treating old servants; this indeed would be a true economy, and nothing could more contribute than such a course to root in the hearts of the nation, the most wholesome of feelings an Englishman can have—a true love and veneration for England's naval power.

The CHAIRMAN: The present paper has touched upon these subjects:—

- Fuel.
- Sail power properly applied.
- Motive power.
- Forms of ships, and the utilization of separate forms of ships to separate purposes.
- Economy of *personnel*.

If any gentleman is inclined to speak on the subject, and will confine himself to these heads which I have just read, it will be treating the subject clearly, and will take up less time. The first subject is fuel. If any gentleman is inclined to speak upon that point, we shall be glad to hear him.

Mr. BELL GALLOWAY: It is a lamentable fact that the ships in Her Majesty's service at the present time are using an estimated quantity equal to $4\frac{1}{2}$ lbs. per indicated horse power. It has also been stated that in a vessel called the "Briton," it has been practically proved, that 2 lbs. per indicated horse-power is all that is requisite to accomplish the object of power. The question then comes, why should it be that $4\frac{1}{2}$ lbs. should be paid for by the Government of this country, when 2 lbs. is quite ample for the purpose? The next question is this, is our form of propeller best adapted to utilise the fuel required for the production of power? Captain Selwyn has pointed out that with the hydraulic propeller in proportion to the power applied, you can have a better result than from the screw or from the paddle. If that be so, why then is not that used as the correct form of propeller? My last remark will be this, that I hold equally with Captain Selwyn, and I believe it will be admitted upon equitable principles by every one present, that if encouragement were given to those who devote their time, give up their energies, and use their means for the development of science, the country would save a large amount, science would be promoted, practical results would be obtained, and so much fault-finding,

so much grumbling, and so many anomalies would not exist, and we should be all the more benefited by it.

Captain COLOMB, R.N.: I should like Captain Selwyn in his answer to state what he calls "properly-applied sail power." As to motive power; I only wish to say—in a measure to back up what Captain Selwyn has said about the hydraulic propeller—that I do not think that the service is quite aware that the "water propeller" has never been properly tried; it has always been tried under conditions where other elements have interfered with its value, *per se*. We don't know at this present moment—nobody in England can say for certain—whether the "water propeller" is an economical or an uneconomical power for propelling a man-of-war.

Mr. ANDREW MURRAY, C.B.: Having had much to do with the experiments with the hydraulic propeller to the extent to which they were carried out by the Admiralty, I am glad of an opportunity of backing up what Captain Selwyn said with respect to it in combination with sail power. I look upon the results that may yet be obtained from it in that respect as probably superior to any that have been obtained from any other steam propeller in combination with wind. With the hydraulic propeller the water is taken into the ship as she proceeds, and immediately acquires the velocity of the ship, and is carried with it, and it is then acted on by the centrifugal pump in the interior, and driven out at a velocity in accordance with the speed of the engine. The velocity with which the water is driven out, and from which the power of propulsion is obtained, is always in accordance with the speed of the engine, and it appears to me that nothing is lost in the action of this propeller by the speed with which the vessel may be going under canvas at the time when it is set to work to act in combination with the sails. That is not the case either with the screw propeller or with the paddle wheel.

Captain SELWYN: May I draw the speaker's attention to the fact that I introduce a perfectly new consideration on the point. It is that the hydraulic propeller is a self-contained power, like that of the rocket, and that the more power you put into the ship the more will be the effect on the ship, whereas that never can be the case with any propeller which depends on its area of push for its power over the vessel.

Mr. MURRAY: I was speaking about the propeller, simply, when called upon to act in combination with wind sail power; that, if a vessel is already going ten knots under canvas, if you put on steam power with either screw or paddle-wheel the advantage gained is slight. I hold that with the hydraulic propeller, supposing that the ship is already going ten knots, she will get the whole advantage of that power, the same as if starting and proceeding with that alone. I have advocated that view for a long time. I am sorry that the circumstances have been such connected with the "Waterwitch," as to have prevented the Admiralty considering it right to continue the experiments. More experiments are particularly wanted. We know nothing of the subject, we neither know whether to send out the water through a small orifice with a high velocity, or through a large orifice with a slower velocity. We know nothing of the form of the pump. I disagree entirely with the form of pump in the "Waterwitch," but that is in the hands of the patentee—not in the hands of the Admiralty. Intending to speak upon this, I thought I ought to speak upon all the points in the paper at the same time. It is new to me to divide the points in this way, otherwise I would have made a few remarks upon the economy of the fuel. But, perhaps, it will be more in order that I should do that afterwards. (Go on.) I should only say that Captain Selwyn spoke of the compound engine in the "Briton." I would call to his memory that that is not the first compound engine that has been used in the Navy.

Captain SELWYN: I said it has long been known in the mercantile marine.

Mr. MURRAY: But that is not the first engine tried in the Navy. There were three vessels, many years ago, tried competitively. Two other vessels, the "Scrapis" and the "Crocodile," were fitted with compound engines by the late Mr. Humphreys. There were some points in which some difficulties accrued in their working, and to my great regret an order was given by the Admiralty, and a backward step was taken, to restore the engines to single acting cylinders. As a passing remark, Captain Selwyn will forgive me, he said that the constant temperature of 100° meant nothing.

Captain SELWYN: It means nothing as regards the evaporation of water.

Mr. MURRAY: Let me explain what we understand by it. I think the audience will easily understand that if we take a quantity of water at 33°, the coldest water you like, or take it at 60°, and put it to boil on the fire at that temperature, it will require a little more fuel than if you put it on at 100°. That is the reason why we take 100°, because the water put into the steam-engine boiler sometimes comes from the condensers, and it is slightly warm, sometimes 80°, sometimes 90°, sometimes 100°, and we allow for those few degrees.

Captain SELWYN: It does not give the unit of heat.

Mr. MURRAY: It simply gives what I state, that you will evaporate more water if you put it on the fire at 100° than if you put it on at 60°, because it does not require the fuel to raise it from 60° to 100°.

Captain SELWYN: If you take from a temperature of 212°, it does not give you a more accurate measurement of the unit of heat and its work done, as if you had so taken it, as Professor Rankine does, from 212°.

Mr. MURRAY: You can always bring it up to 212°. We take the water as put into the boiler, whatever that may be, 40° or 80°, and bring it up to the 100° as a standard.

Captain SCOTT, R.N.: Will you allow me to make one remark about the hydraulic propeller (I have not spoken upon the subject before), that it has always appeared to me to be a most important means of propulsion. At present we cannot turn our long vessels, but Admiral Inglefield, who is now engaged in working out the application of the hydraulic to turn the propeller, is also paying considerable attention to the subject of applying the hydraulic to turning the vessel herself. When the hydraulic propeller, as a means of propulsion, is combined with the means of turning the ship, you will, I think, have every advantage that can possibly result from its use. I cannot but concur in what has been said as to the inconclusive character of the experiments that have hitherto taken place. As a first experiment on a large scale, the results obtained in the "Waterwitch" are very remarkable. Many of our vessels with their exposed rudders are very liable to damage. Their engines also are much exposed. If we can by means of the hydraulic propeller get not only a means of propulsion, but also an auxiliary means of turning those ships, even if your main engines break down, you will be still enabled to bring your broadside guns to bear by turning the vessel. I look upon the hydraulic as one of the most important means of propulsion that has been devised, but think it is still valuable as a turning power.

Captain SELWYN: I hope engineers will not be deterred from speaking after considering the extraordinary result (see Appendix to paper), shown on that table, because I may say that there has been no continuous evaporation of water ever obtained in any country from that common type of boiler, anything equal to what is shown there. That is the first time that it has been done. It has been done as experiments on a small scale. I accurately checked them, and various other conditions. For nine months that boiler was going on making steam.

Captain HANSON, 1st Surrey Rifle Volunteers: I am a Volunteer, but I have taken great interest in naval matters also. I should, therefore, like to put one single question. Can such a vessel as is shown in the diagram which Captain Selwyn has drawn, and which seems to me very much to resemble a form of vessel which was lectured upon here some time ago—a saucer-shaped vessel—sail? The diagram only gives the midship section of that vessel.

Captain SELWYN: That vessel can proceed under sail with the utmost facility. The longitudinal section may be prolonged into any form of the ovoid you choose to adopt, or it may be the complete segment of the sphere.

Mr. HANSON: I answer you directly, in order that no argument may proceed on a false basis. This is by Mr. Elder not put forward as the only shape in which you may put a ship, but as being the segment of a sphere, or a body approaching to a sphere, the greatest containing body with the smallest perimeter, with the least draft and the greatest speed.

Mr. HIDE: Perhaps you will permit me to remark that the paper which the gentleman just now enquired about, was read by me some two years since in the

theatre of this Institution. It was a paper on ships with deflecting sides. Subsequently, the late Mr. Elder read a paper on circular ships. The diagram which Captain Selwyn has drawn represents simply a cut or section through the middle of that circular ship. The vessel that I proposed, and which I have advocated for some 18 years, has the same section, but is not circular, but an ellipse, an elongated oval, still having deflecting sides. The object of having deflecting sides in preference to vertical is simply this, that all artillerymen, all constructors of guns, naval Officers, and those who know anything about modern artillery, agree that vertically-sided ships cannot keep out the projectiles of these modern days. We have just constructed a gun known as the 35-ton gun, which is said to be able to throw a shot through a 12-inch plate at a distance of 2,000 yards. If that be so, and we have no doubt it is, what class of ship can you build which will be capable of keeping out these direful projectiles of modern days? Perhaps Sir George Sartorius will remember that I had the honour of some conversation with him upon this subject two years ago. The drawings, diagrams, and models were left in this Institution for some days after the evening of the paper, so that any gentleman might see how simple and how convenient a ship could be built having sides at an angle of some $22\frac{1}{2}^{\circ}$ or 30° to the line of fire. It is well known that experiments at Shoeburyness and other places show, and even in actual warfare we know, that if a shot hits unfairly a surface, that shot passes off and ricochets. Now, why cannot that principle be employed in the construction of our ships? It can. There is not the slightest difficulty about it. If the ship's sides are presented to the line of fire at a sufficiently low angle, there is no projectile that can be thrown from a gun that will pass through them. This is now what most naval powers are seeking to obtain. I can tell you that the Prussians at this moment, in their arsenal at Kiel, are making experiments, and are, in fact, constructing vessels of this class. That is a fact which ought to be known to the authorities of this country. It is perfectly plain that in all personal encounters you attempt to parry a blow instead of receiving it. The art of fighting in defence is to parry a blow. Why not then investigate a system which presents to us at least a common-sense plan of keeping these direful shots out of our ships? If you will allow me a moment, I will make a midship section to show exactly the form of vessel that I allude to. (Drawing the same on black board). The plan of the ship would be an elongated ellipse or oval, with sides at an angle of 22° to 30° , and the turrets, if such a vessel had turrets, would be placed one at each end. Now, the armour with which these ships would be protected need not be so thick and so heavy as the armour used in our present ships. I know the argument has been used, that the long surfaces in the deflecting sides added together would make a heavier armour than if placed vertically; but the reply to that is this, if you place it vertically, shot will go through it; if you keep it at a low angle, the shot will pass off by ricochet. All sailors, all artillery Officers, who have seen the models—and I shall always be pleased to show them—tell me that this is the form of ship which is most likely to keep out the shot of our modern guns. It is obvious, if the Prussians are giving attention to it, and if naval Officers generally and artillerymen are giving attention to it, that it has some advantages. I have no doubt that these immense guns which are now being manufactured, will of necessity compel such a system as this to be introduced in the construction of some of our future ships.

The CHAIRMAN: We now come to the utilization of separate forms of ships to separate purposes.

Captain SELWYN: What is meant by separate forms for separate purposes is that to which I alluded to, namely, the three classes of vessels, one constructed solely for shore defence, in which will be the best utilisation of our coast volunteers; the second also for harbour defence during an inchoate phase of war when the requirements are not fully defined for fleets, and then they are useful as floating forts afterwards; these would come in for even fleet actions near home; and the third, ocean cruisers. The "Staunch" and her consorts are existing examples of the first class.

Captain MONCRIEFF: In reference to this part of the subject, the smallest gunboats which have been used in the Navy, namely, the "Staunch" class, have the advan-

tage of economy, when looking at the price per gun in these vessels in comparison with the price in larger vessels. I have before me a statement relating to several classes of vessels. The "Staunch" gunboat, mounting a 12-ton gun, is put down at £6,000 per gun; the "Inconstant," unarmoured frigate, at £13,000 per gun; the "Caledonia," with 4½ inch light plating, mounting eight 6-ton guns, six 10-pounders, and twelve 68-pounders, £11,500 per gun; and the "Royal Sovereign," turret ship, with 5½ inch plating, mounting five 12-ton guns, £10,000 per gun. In the heavier armoured ships the expense per gun increases very much. The "Sultan," with plating from 9 inches to 6 inches, and 12-ton guns, costs £31,000 per gun; the "Devastation," a turret ship, with plating from 12 inches to 10 inches, with four 12-ton guns, £69,000 per gun; the "Glatton," turret ship, from 12 inches to 10 inches, and with two 12-ton guns, costs £81,000 per gun. It is therefore evident that if these small vessels are well suited for a special service, it will be more economical to employ them for that purpose than the more expensive kind of ships.

Captain SCOTT: I think Captain Moncrieff has made a slight mistake as to the guns. The "Devastation" guns are 35-ton guns, and one of the 35-ton guns is at least equal to a dozen of the smaller guns he has named. The "Glatton's" are 25-ton guns, and the "Inconstant's" are 12-ton guns.

Captain MONCRIEFF: I beg your pardon; I have made a mistake.

Captain SCOTT: Of course it was merely a mistake. You must remember that efficiency depends upon what service you want the vessel for. The "Inconstant" is a vessel that you can send all round the world. She is a fast cruiser under sail, and can carry heavy guns and a great number of men wherever wanted. Nobody can say that the "Staunch" can do such duty as that; she is merely a coaster. As regards the value of the "Staunch" class, there I perfectly agree with Captain Moncrieff. There is no doubt that these vessels are of very high value for protecting our harbours and coasts, but I do not think you can compare them with vessels that are not only good for home service but good for foreign service, and good for any other service.

Captain SELWYN: May I recall Captain Scott to the subject of the paper, which is, special vessels for special services.

Captain SCOTT: Allow me to say that I am perfectly in order. I am speaking of special vessels for special services, and will now say that I think the "Staunch" is rather too small for her intended service. We want a vessel of similar type, but capable of carrying the heaviest gun, viz., a 25-ton or 35-ton gun; she must therefore be somewhat larger than that vessel is. Not only should she be able to protect our own shores, but she should be also able, if it were requisite, to carry her guns across to the neighbouring shores. I think the power of England depends upon offensive power much more than upon defensive. To come to the next class of vessel. You want fast unarmoured cruisers with the highest speed, and the other qualities that Captain Selwyn has stated. As to line-of-battle ships, you want very powerful vessels that will stand a great deal of hammering. We have now got such vessels. Whether powerful vessels will be required hereafter more than lighter vessels is well worthy of consideration. Still, our heavy ironclads are exceedingly powerful vessels, and they will enable us to hold the empire of the sea, whilst with fast unarmoured cruisers of similar type to some we have built and are still building, we could chase any other vessels off the sea. Our "Staunches" and proper coast defences would then make our island perfectly secure (so that we might sit down at rest and feel contented with the assurance that we had not gone far out of the way in the line we had taken). I do not think we have yet got so far as this, for we want a great many more fast unarmoured cruisers, and we want more vessels of the "Monitor" type, and a great many more "Staunches." Instead of a few of such vessels having been ordered to be built, we ought to have already built a hundred. Then, with regard to what has been said of experiments, we are entirely deficient of definite experiments. The cost of most of the gunnery experiments that have been made, I look upon as money thrown away. We really do not yet know what the actual power of our guns is, although we have gone on piling up armour on the sides of our vessels (in my opinion we put on a great deal too much) without knowing what armour we

really require. We have been firing at Shoeburyness upon plates fastened in a particular way, and supported in a manner that they are never supported when placed on a ship, and we are now going into further experiments of similar character which will therefore be equally futile, for they cannot yield any practical results. Without making too long a story, I wish to say that our false economy in making cheap and incomplete experiments is one of the most dangerous things at the present time. This is an age of progress, and unless we carry out complete experiments on a comparatively small scale, we shall be hereafter trying in war experiments on a large scale, which may prove almost fatal to our supremacy.

The CHAIRMAN: The next subject is the economy of the *personnel*.

Captain SELWYN: By that I mean the Officers and the manning of our ships.

Commander BRENT, R.N.: I cordially agree with Captain Selwyn, that our men should be well trained. It is a subject of great importance to all naval men, to the Navy, and to the country in general. That part of Captain Selwyn's paper might almost form a paper on "internal organization of the Navy." Of late years, during a ship's commission, we have been trying to teach our men almost too much. Captain Selwyn said they should come on board perfectly trained. I quite agree with him, and if we run over what we have to teach the men during a commission, at the end it is found they are not perfectly taught, except, of course, the few men who come from our gunnery establishments. As he said, we shall have vessels with guns, and if we run over what we have to teach the men during a commission, at the end it is found they are not perfectly taught, except, of course, the few men who come from our gunnery establishments. As he said, we shall have vessels with guns, and also work field guns. They must be fair swordsmen, and to acquire a thorough knowledge in each one of these points, takes almost a lifetime. The men should come on board ship perfectly instructed in these points, and then we should have to teach them seamanship. I think a part of the year should be set aside in which every ship in the service should turn herself into a gunnery ship for a time, and run through the gunnery and the military duties that seamen have to learn now-a-days. It is of great importance that we should not have perpetual instruction going on while the ships are in commission. Seamen gunners come on board, and we have no trouble with them, but no Gunnery Lieutenant is satisfied with his work at the end of the commission; he has quite broken down, and if you ask him, he will tell you he has taught the men in a certain way, but he is not satisfied with the result. A man-of-war's man has much to learn, and he should come on board ship knowing his gunnery work. I think we ought to have larger gunnery establishments, in order to teach the men, so that you should start on your commission with every man on board, except the boys, perfectly instructed, then you would merely have to keep up that knowledge and teach them to be sailors.

Commander PUSEY, R.N.: I should like to ask the last speaker a question with regard to what has been said about gunnery establishments; is it not a fact that after seamen have been well trained, and have been a long time on board in a sea-going man-of-war, and have passed out of their drills, they are still kept on, day after day, in musketry drill, cutlass drill, and gun drill, and whether it is not that which disgusts seamen so much with the idea of gunnery?

Commander BRENT: I do not think the seamen are disgusted with the gunnery, because you find all the best men go to the gunnery establishment, but what is done is that they are never perfectly taught in sea-going ships, they only get a smattering. I know that no gunnery Officer is satisfied with his work at the end of the commission. The drills get so broken into by the ordinary work of a man-of-war that nothing is perfectly done, and as Captain Selwyn has said, we want the men to be well trained and well taught before they go to sea.

Captain COLOMB, R.N.: I understand Captain Selwyn to say that he thought the times were such, that the Navy less and less approximates to the merchant service, and I understand him that we must depend more and more upon the Royal Navy, and less and less upon any help we might get from the merchant service. I think that is only true to a certain extent. If we, as Naval Officers, were at the head of the government of the country, I have no doubt whatever that we should be able to depend entirely upon our own men, but the government of the country is such that

political exigencies will perpetually necessitate the pricking of the Navy as you prick an india-rubber ball, and permitting it to collapse for given periods of time. I think the only way to puff this ball up again in time of danger is to keep, as we are now keeping, a totally separate Reserve in the merchant service, that we can call upon when we want them. It is a body of men not likely to be touched. It escapes in the estimates, it does not cost much, and when politicians take a pull at the Navy, they are unlikely to take a pull at the Naval Reserve from the merchant service. Consequently, we always have that body of men to fall back upon in times of panic, which inevitably follow a time of great economy.

Mr. AUSTEN, C.E.: I wish to speak upon the subject of fuel. I have only to state that I have devoted eighteen years of sharp practical investigation into the use of peat as a fuel. That coal is derived from peat is positively certain, but it is the work of 6,000, 7,000, or 8,000 years before it is sufficiently condensed to form coal; but by mechanical application you can drive the air and water out of peat. It is a fact that our British peats have at least 75 per cent. of water in them, which wants driving out, and how to drive it out has been the problem. I have had the good fortune to succeed in doing it. What was wanted was not compression, but condensation,—how to drive out the air and water, and then present the peat in a mass that would be applicable for the furnace. I have seen experiments tried in Ireland. They make the peat into the form of a disc by driving it through a cylinder and cutting it off about three-quarters of an inch in thickness. These were thrown into the furnace, and it was found that they had to be pulled out again to be broken up with what is called the clink hammer. It struck me the best thing was to form a ball. Parties have said to me, "Why don't you cut it into squares or cubes?" My reply is, that if you cut it into squares—every man who has been on board ship knows that if you have to stow a large bulk of artificial fuel in the shape of squares or cubes, you must send in a man to crawl on his hands and knees to stow it in its place, and send him in again to pull it out; whereas in the shape of a ball the peat will roll itself out when it is wanted. Then I found it was impossible with any machinery we have, to produce a square or a cube so condensed as the ball in my hand. I then produced this article in the shape of condensed peat fuel. It is 50 per cent. heavier than coal, and I give you my word, for it is not a mere asseveration, that one ton of this will do nearly three times as much as the best hand-picked coal that was ever dug from the mine. This has been proved by experiment, and it only wants to be proved on a large scale by access to powerful machinery sufficient to make 50 tons a day. I do not make these assertions as mere asseverations, because they have cost me years of reflection. Had I been a man of wealth, and could have put my hand on a few thousand pounds for machinery, I should not have to ask assistance, or to ask the co-operation of any man living. I would have gone on and spent my last farthing to prove it. But I have been prevented bringing it forward for want of means. I have now orders from the Peninsula and Oriental Company, from the West India Mail Packet Company, from the Admiralty, from the dock-yards, from the Underground Railway, from Hong Kong merchants, and last, but not least, from Russia. The Russians have offered to take all the material I can make for St. Petersburg and Moscow. Unfortunately I have not the means of making it. I am proud of my country in every other respect, but it is an unhappy country for a man who is born with a genius or brains; he is treated like a mad dog instead of being treated as a first-class man, as he would be in America. I appeal to any American present, whether, if I had produced such an article as this in Boston, I should have passed a fortnight without having a number of friends around to take it up, but in this country I must starve, or go into the workhouse. The object I have now is the introduction of peat as fuel, so that the Secretary of the Navy should be able to send a ship of war out to sea with three times the quantity of fuel that she can carry at present. If that is not an advantage to Her Majesty's Navy I do not know what is.

Mr. C. F. T. YOUNG, C.E.: The paper read by Captain Selwyn touches on the economy of fleets, both in form and maintenance, construction, and so forth. I should like to make a few remarks. First, I am glad to hear that these experiments with liquid fuel have been carried on for so long a period as nine months. I have

seen a great deal of the fuel myself, and it is perfectly safe and perfectly efficient. It has this great advantage, that it does not deposit a non-conducting material on the heating surface like coal, therefore you get a greater effect from the heating surface. In regard to the economy of our ships, the other day I was going over the figures of our earlier ships, such as the "Achilles" and the "Warrior," and contrasting them with the results of our later ships, the "Hercules," for example. The engineer's question is this. Here is a weight of a given amount, moved in a given time at a given velocity, at an expenditure of a given amount of power; and the generation of that power necessitates the expenditure of a certain amount of fuel. I find, taking the "Hercules," and comparing her with the "Achilles," she gives 40 per cent. retrograde economy, that is to say, costs 40 per cent. more in the way of fuel to move that ship (I am speaking of the "Hercules with all the modern improvements) at the same velocity as the "Achilles" some eight or ten years ago with the old engines. I have Mr. Reed's book, and he states that the new engines with all the latest improvements go to 3 lb. or 3½ lb. per indicated horse-power, and the old ones go to 4 lb. and 4½ lb. I take the extreme in both cases, that is to say, taking a given amount of work over four years for both ships, that the "Hercules" would use 11,000 tons more fuel to do the same amount of work, moving at the same rate than what the "Achilles" would do. I do not find that we have got an economy by these very short stumpy ships. I do not say that we must have ships so long as the longer ones; still I am satisfied that these very short ships are neither economical in the first cost, nor are they economical in the results obtained by burning a given amount of fuel.

Captain SELWYN: Captain Colomb has asked what I meant by "sail-power properly applied." I think if he has time to look over the paper he will see that I laid down an axiom, which as far as I am aware, has not hitherto been noticed. It is that sail-power should never be employed where steam is present, to go to windward. That is a wrong application of sail-power; and inasmuch as with the very best beating, you can only go to windward two miles in one hour, you had better do it with steam direct. There is another point which Captain Colomb did not, perhaps, quite understand. I said that sail-power could be applied without masts and sails. It seems very curious that wind-power could be applied without masts and sails. It is absolutely and perfectly true, however, that although the horizontal windmill only gives out about 33 per cent. of the theoretical power, yet that that power applied to the propeller will do more work than if you applied the full power of the ordinary sails in propelling a vessel to windward by beating. I am speaking now of a case in which, for other reasons, you wished to do away with the existing masts and sails altogether: you can have such wind-power still, as will propel your ship if the engines break down. That is what I call the scientific and true application of sail-power; not relying upon what we have done in other times, under other circumstances, but considering what can be done and what ought to be done for due economy in the present time and under present circumstances. Mr. Hanson asked what will be the length of the vessel I mentioned. That question I pretty nearly answered. The vessel I referred to was proposed by the late Mr. Elder, and I quite recognise the value of his proposal—not at all with regard to any shot-deflecting properties it might possess, which are outside the question; but with regard to the peculiar fact that this is the only shape of vessel that will give you the highest containing power, because it is a segment of the sphere which is the greatest containing body. It is the only vessel which will give you, with great capacity, fine lines to be rapidly driven. It is the only vessel which, with a minimum of armour, can be made to give the maximum of security. It is the only shape of vessel which will bear the weights placed upon it high up, which no deep draught breast-work monitor will do with safety. It is, therefore, worth considering, when we have to talk of a fleet which will manœuvre readily and handily at sea, in columns or lines, as it may be desired, under steam alone, with very liberal limits as to the duration of that steam, if these improvements be adopted,—capable at all times of ramming an enemy, but not of being rammed except by a similar vessel, and then very inefficiently; capable also of being propelled by hydraulic power which will set at nought that newly invented demon, the torpedo. The great value of the hydraulic power is

this: if it were proved that it never could surpass the screw or the paddle, there would still remain the fact that it pumps the vessel out with the full power of the engine exerted, while it is also propelling her; consequently, no shot, no torpedo, even, in a well-constructed vessel, could sink the ship. I quite agree with Captain Colomb that such a water-propeller was very inefficiently and very ignorantly tried; and those who tried her were satisfied to relegate her to the things that were, after having proved that the very first of such propellers was equal to the best screw they had built on the same lines, and with the same dimensions. With regard to Mr. Murray's observation on the compound engines, I beg leave to point out that I did not say at all that compound engines would do everything for a man-of-war at once. But what I did say was this, that it is a scandal to the Navy to see a dozen such as the "National" steamships from Liverpool running to-day, developing 800 horse-power, on less than 2 lb. of coal per indicated horse-power per hour, while only one vessel of the Navy has arrived at that conclusion, which yet has not availed to change the practice of wasting fuel in other ships now building. If people will ignore inventors and will never be contented to take up an improvement until, by passing through all the phases of mismanagement, they at last arrive at the true practice of the invention, instead of asking the inventor to do it for them, then I say it is not wonderful that that which is done by the mercantile steam ships in one year, cannot be done by the Navy under ten years. I recognize the difficulties under which all officials labour. I recognize the tendency in this country to cut down votes for experiments, and to throw difficulties in the way of invention. But I say in my paper, and I repeat here, this ought not so to be. With regard to the calculation of evaporative effect from a certain temperature, I have shown the calculation from 100° F. as well as from 212° F. It is obvious to anybody that as it is not from the changing heat at which water may be pumped into the boiler, but at the constant degree at which water will make steam, the calculation ought to start, and that has been considered by all philosophers, and ought to be considered by our Naval authorities, if they wish to get true comparative results from fuel, I think it is obvious the sooner they change and work from the constant of 212° instead of 100°, at which no steam can be generated at all, the better. With regard to Captain Scott's observations on the hydraulic propeller, I have already stated that it has the advantage of unsinkability. That is a great advantage. It has also the power of doing away with the training of guns, because the ship can be trained with the hydraulic propeller in less time, given a certain shape of ship, than you can train the gun, and will give all round fire as far as it is useful at sea. When you add to that the fact that after all a vessel of 3,000 tons, propelled at the rate of even eight knots an hour, has a superior effect to the biggest shot that was ever fired, you will understand how valuable it is; you have a vessel so propelled that at any moment and in any direction she can be sent with full velocity against an enemy. Those who have passed through a collision in a railway train know how something like 300 tons, which is the fair average weight of a train, going we will say at fifteen miles an hour, will compare with 3,000 tons going eight miles an hour. Is there any doubt that the attacking vessel in ramming must always be the superior. You need not consider whether you have any guns on board, provided you have got a sufficient steam propeller to use in this way. I do observe on this with the more pleasure that I know I am in the presence of an authority who has never failed to advocate that form of offence. Mr. Hyde spoke of the deflecting sides. I must say that there is a certain law connected with deflecting sides. It is this. Given a weight of armour, it does not matter whether you dispose it on an incline or upright; *i.e.*, in the one case less height or surface admits of more thickness, in the other extended surface necessitates less, but deflective power makes up the difference. There is this difficulty, that the moment you get alongside a vessel only slightly elevated above yourself in height, and able to fire down upon you with properly constructed gun carriages, all your fancied security disappears at a blow; and if you get under a high fort like the Wasp battery in the Crimea, you will get stung right through from top to bottom. Deflecting sides do not then come into play. There is another objection to deflecting sides. Deflecting sides are very true, in an engineer's point of view, when you can secure a smooth sea and no heel or roll. But I have not yet found out the time when a ship

is on an even keel at sea. Our Chairman has seen many years' service at sea, and I have no doubt he has equally failed. With regard to the cost of the breastwork monitor compared with the small "Staunch," Captain Scott did not quite recollect that a 4½-inch plating will not keep out anything. Therefore we had better compare it with a ship unarmoured altogether than with one which has got 4½-inches of plating on her side, for not only will she not keep out any shot, but she will contribute to the deadly effect of that shot by the pieces of plating which will be driven in among her crew. The breastwork monitor may carry, I will say, a 35-ton gun. Now, I do not know any reason, I have never yet heard any reason, why a vessel 100 feet long should not carry a 35-ton gun too. If you build her of iron, and build her properly, and do not insist upon having a carriage which transmits a great deal of shock horizontally, which Captain Moncreiff's carriages will never do, you take away that strain which has hitherto prevented us from carrying the weight in a vessel of small size, and you prevent all that dangerous shock which might shake even an iron vessel to pieces. I say that a vessel of 100 feet long and 12 feet beam will easily and properly carry on Captain Moncreiff's carriage even a 35-ton gun for coast defence,—not to go any further than the coast,—to be properly manned with a small crew, such as can be given to a gun-carriage properly made and working itself, properly supplied with shot, not supplied with provisions and sails, which are only necessary for ocean cruising, but so efficient that she will give us back that percentage of loss which we now have to pay for panics.

A VISITOR: Will you say what depth of hold will be required for Captain Moncreiff's gun-carriage?

Captain SELWYN: I think if you say five feet draught you could easily manage to do that on certain lines.

Captain MONCRIEFF: It would require a little more displacement.

Captain SELWYN: You may give more width. I am not asking for very high speed. The displacement you say must be more.

Captain MONCRIEFF: 16 feet beam.

Captain SELWYN: We will take it at that.

The VISITOR: The gun is to be lowered below the water line.

Captain SELWYN: Not necessarily so. It may be so lowered. It will not do if it is a 35-ton gun, seeing that it is 9 feet in the breech. That is how they are made now. It is to be hoped that they will be made less cumbersome some day. But the cost of the breastwork monitor is compared not with one gun,—I think I understate it,—but with twenty guns in twenty small vessels. I know some gentlemen who will undertake to construct such vessels for very much less than the "Hotspur," that shall carry quite a formidable gun enough to prevent a landing on our shores.

The gunnery question and the necessity for training our seamen comes next. Here I must remark that I did not suppose it was possible to put on board men-of-war, men thoroughly trained to everything they could learn on board a man-of-war. Nor do I think it would be desirable to teach them without that life at sea which is, after all, true training. But they can learn certain things better on shore than at sea. Among those things are the drill of swordsmanship, military drill, shooting with the rifle, and probably a certain amount of the shooting which will be required by the artillery, not that which refers to shooting at moving objects with large artillery. But I propose that this should be done, that the whole of the necessary forces should be kept up for manning our Navy in time of war; that that portion which is not employed during the time of peace should be so trained and so managed as alternately to take its place at sea, and learn that training, too; that while on shore it should not only be drilled and trained, which could be done in these matters that I have spoken of, which would occupy a small portion of their time, but that the remainder of their time should be occupied usefully and economically as producers. Constant drill has been spoken of as disgusting the men. I have no doubt whatever that every man thinks himself perfect as soon as he has got a certain amount of proficiency. But I never saw the man who could, without detriment, premit in either arts and arms, the constant practice of those professions, and though the drill may in some cases be carried too far, yet I think it ought to be left to the instructors on the spot, and, then, I have no doubt

whatever that it would be done properly. As long as everything is centralised, and no judgment is permitted to those who are alone capable of judging by reason of their presence on the spot, so long will you have such anomalies as that; with increased expenditure you only get worse results. Captain Colomb compared our Navy to a puffed ball, and I think not unwisely. But you must recollect that if you get men who never having been in the Navy, are utterly untrained to the work of the Navy, and who, by being exercised at a 32 lb. gun on our old carriage, would never learn to work one of Captain Scott's or Captain Moncrieff's guns, I am rather inclined to think that that trust in them would be a puffed ball. I do not like the idea of a Naval Reserve which is to be relied upon in war by those very naval Officers who do not see it during peace. Mr. Austen spoke very largely of peat and its mechanical application. I say distinctly, and I hope Mr. Austen will take it to his heart, because it will save him a great deal of time and a great deal of money, that mechanical appliances for condensing fuel can never compete with nature where she supplies the article already condensed, or where that condensed fuel is to be had as the refuse of a paying chemical process for other purposes. More than that, peat can only be made up of carbon, with a very small and inefficient proportion of hydrogen and some oxygen. The purest carbon known is the diamond, and that diamond, if carried into its most perfect combustion, can only evaporate 15 lb. of water per pound of diamond. Mr. Austen can never hope to get his peat into the condition of the diamond. If he does, I would advise him to sell it as diamond; if he does not even do more, it is not possible to get out of it more than 15 lb. of water per pound of diamond. This is not three times the work of coal. If he can prove his point, then there is a new practice in opposition to the theories of all the chemists of this and of preceding ages, which will enable him to give us a mechanically condensed solid fuel superior to coal. I will draw his attention to another subject. We use fuel as a gas, we do not use it as a solid. To convert a solid even into a liquid, expends a certain amount of heat which is so used, and which is not available for making steam. To convert the liquid into gas takes up another proportion of heat; and all that heat is taken away from the effectual work done. Consequently, you never can hope, by using a solid at first, to get the same result that you would get, were you to use first a liquid, or better and secondly, a gas. The best form in which to obtain combustion is that of gas, which requires little or no expenditure of heat to separate particles before entering on combustion. With regard to liquid fuel, Mr. Young has truly said that it is not dangerous, that it is not difficult to burn, that it requires no stoking. This is the result of nine months' experiment at Woolwich; I do not say that we were at it day and night, but were at it nine months consecutively. It has since been dropped because the experimental vote of the House of Commons did not enable us to go on with it. There is the state in which rests one of the most important discoveries with regard to the due economy of fuel. And, recollect, I am not the inventor, nor have I anything to do with it; I am merely the scientific advocate of the question. There rests one of the most important discoveries, which would at once enable a vessel which now goes, we will assume, with a given quantity of fuel, ten days at full steam, as the old steam line of battle ships did, to go twenty days, and if she had compound engines, to go forty days with the same. Now, that is an enormous economy; it does more to solve the whole question of Steam *versus* Sails than anything I can think of. It introduces a new field of improvement. My whole paper is devoted to the object of proving that applied science can produce more economy, if we attend strictly and closely to it, than can ever be accomplished by the most economical Chancellors of the Exchequer, or by the most economical Ministries, and this with a vast increase of real efficiency.

The CHAIRMAN: We have had a very interesting paper indeed. I am happy to say that every time I have the pleasure of hearing Captain Selwyn, he always gratifies me with the able manner in which these subjects are treated by him. With regard to the question of fuel, I must make one little excuse for Government. Government have a very large number of vessels: the machinery is already made. Of course improvements are daily taking place, and Government could not afford to alter all the engines at once. But the merchant, who is fitting out perhaps only one vessel,

can take advantage of every improvement, without any other inconvenience than simply paying for the new alterations in the machinery. Government cannot do that, at least until the improvements have been well verified. At the same time I quite agree with Captain Selwyn that Government are much too slow in adopting improvements. With regard to sail-power, I also agree with Captain Selwyn. In steamers, particularly, the sail-power ought to be entirely secondary and subordinate to steam, except in special cases. But there ought always to be sufficient sail-power in case of any accident happening to the machinery or to the screw, to enable the vessel to draw off from a lee-shore, or to reach a port suited for repairing its damages. I also agree with Captain Selwyn that the sail-power ought never to be such that we should hope to depend upon it when a vessel is being close-hauled or beating to windward; that ought to be better done by steam, except in cases where steam is only the auxiliary power with a disabled machinery. Sail should only be made use of in a fair wind and off a lee-shore. With regard to the forms of ships, there are three particular kinds of warfare that a nation's war ships ought to be fitted to carry on, viz., coast warfare on an enemy's coast, ocean warfare, and defensive coast warfare. Each of these kinds of warfare demand special qualities adapted for that particular service, independent of the general and important qualities which should be common to all vessels of war to enable them to act together. For defensive warfare I think with Captain Selwyn that small vessels with one or two very heavy guns and the smallest possible tonnage, with some little sail-power, are likely to be very useful for defensive means which, with the torpedo and ram, and the great improvements that have taken place in artillery, throw all the advantages entirely on the side of defence *against a sea attack*, and render it perfectly impossible for our shores to be successfully invaded. I think it is quite evident that the advantages just alluded to, if we choose to make use of them, such as these small vessels, and those vessels which should be expressly constructed for the means of defence of our coasts and harbours, as rams, torpedoes, railroads along the coast, which would render us perfectly safe from any kind of attack that could be made against us *from the sea* by the combination of any number of nations. Time would fail me to enter into details as to the forms of vessels best suited for the purpose. I am of opinion with Captain Selwyn in the general principles he has laid down. The same remark will apply to the next head, the utilisation of separate forms of vessels for separate purposes; these are according to my views the three forms that I have been alluding to, and the three purposes for which the demands of naval warfare requires these forms, should be best adapted. I also agree with Captain Selwyn as to the economy of the *personnel*. It is unnecessary to go over the subject again; therefore, I shall conclude by thanking Captain Selwyn for the very useful and interesting paper that he has read.