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Friday, April 13, 1883.

VICE-ADMIRAL W. G. LUARD, C.B., President, Royal Naval College,
Greenwich, in the Chair.

ON COALING SHIPS OR SQUADRONS ON THE OPEN SEA.

By Lieut. R. S. LOWRY, R.N.

Read by Lieut.-General LOWRY, C.B.

The CHAIRMAN: The author of this paper is serving on the Australian Station, in the "Espiegle," and his father, General Lowry, will read it to us.

General LOWRY: I must ask the kind indulgence of my comrades of the sister Service if, in putting before them the contents of my son's paper, I prove that I am myself somewhat "at sea" on the subject. That subject is important, and I trust its treatment and discussion to-day may be productive of some good to the public service.

SOME apology is due from one like myself, without much practical experience in it, for writing on the above subject. It is solely in the hope that far abler hands than mine may be induced to take it up that I venture to touch it. Nevertheless, its vast importance, and the need for its full consideration in every detail before the outbreak of a naval war, has been strongly impressed upon me both by the careful study of able articles from British and foreign pens, and from a recent personal experience of the difficulties to be met when coaling where proper appliances for doing so are not to be found.

Few will deny that the mobility of our ships and squadrons, their usefulness, and to use a slang, but very expressive term, their "staying powers," would be vastly increased if some effective plan were found for coaling at sea.

I think I am within the mark in stating that during the blockade of Charleston by the Federal fleet, nearly one quarter of that force were always absent from before the port, employed in filling their coal-bunkers.

During the same war Federal cruisers while searching for the "Alabama" were constantly obliged to quit that portion of the ocean allotted to them, in order to fill their bunkers after one or two useless chases of suspicious-looking vessels. But those who have read the various able papers on the different branches of Naval War published in the Journal of this Institution, cannot fail to have been struck with the necessity which must so often arise of replenishing coal-bunkers at times when it would be most detrimental to the service on which the ship may be employed, had she to proceed to the nearest friendly port for that purpose.

To quote a few writers in support of this opinion—

Captain J. C. R. Colomb, R.M.A., in his able paper on "Naval Intelligence and Protection of Commerce in War," states that—

"We have in maritime war to provide for three great naval operations:

"1st. Blockade of the enemy's coast.

"2nd. Securing the ocean routes of the world.

"3rd. Coast covering operations off neutral seaboard to provide safety for our commerce between such seaboard and the ocean routes."

Dealing with (1) on Blockades—

Captain S. Long, R.N., in his paper on "Naval Blockades as affected by Modern Weapons" (which unfortunately I have not by me at this moment, and so am unable to quote *verbatim*), lays it down as "absolutely essential to the maintenance of an efficient blockade that the blockading fleet should be within easy reach of their base, or at least seize some island near at hand from which coaling could be easily carried out."

Provisioning is, of course, equally essential, but all ships can carry provisions for three or four months, few could stow coal for as many weeks, especially if false alarms or chases cause full steam-power to be used occasionally. Could the fleet be kept supplied with coal by steam colliers and this transhipped while lying off the port, the numbers of ships in it might be reduced, the coal would last longer (that consumed on passage to and from the base of operations being saved), and the arrangement of reliefs would be greatly simplified.

Of course the advantage of such an arrangement would be more felt in the blockade of ports distant from our base, such as Toulon, Rochefort, Cronstadt, or New York, than in ones close to a coaling station of our own, such as Cherbourg, Jahde, or Portland (U.S.A.).

(2) and (3) may be dealt with together, for cruisers employed off neutral seaboard would be unable to obtain their coal from neutral ports, and would depend on British colliers for their supply, hence they would come under the same category as the cruisers employed on the great ocean routes.

Captain Colomb, in the before-mentioned paper, has told us how, by the proper working of a Naval Intelligence Department, the Captain of a cruiser (whether our own, or the enemy's) might know where to lie in wait for any number of British colliers carrying coal to neutral ports.

As yet we have had no practical solution of the difficulty of transshipping this coal in average Atlantic weather on the open sea.

Sir T. Brassey, K.C.B., in his work on "The British Navy," says: "The limited supply of coal is a most serious defect in English vessels of the older types." He gives the coal endurance of the "Inconstant" at 24 days, and of the "Shah" at 4 days full speed steaming. Of what use would either of these ships be after steaming easily into the centre of the North Atlantic, perhaps having had steam ready for full speed at daylight on 10 successive mornings, if called on to carry out a protracted chase?

Captain Scott, R.N., in the discussion on Sir T. Brassey's paper on "Unarmoured Ships," read at the Institution of Naval Architects, Session of 1876, states: "I think, moreover, that you require, if you have groups of squadrons, somewhat equal coal-carrying power, or *means of coaling at sea which we have not yet hit upon.*"

Had I the back numbers of the Journal by me, I believe many other and similar opinions might be quoted from its papers and discussions, all tending to show the importance of this subject, and the small amount of consideration which it has as yet, apparently, received.

Those who served in the Channel Squadron in August, 1870, will well remember the delay of that squadron for nearly a day between Lisbon and Vigo, the hard work, the damage done to boats, the great part of a day occupied, and the risks incurred whilst endeavouring to supply Her Majesty's Ship "Captain" with some 50 tons of coal from the bunkers of two other ships. I have neither logs nor journals by me now, but if memory serves me right, in fine weather, and the boats of a large fleet available, only 30 tons were transhipped in about six hours (enough for two days' moderate steaming), *and this coal was mostly wet*, through being carried in open boats unprotected from spray. To avoid risk of foundering the boats had to carry but light loads; the time occupied being of course lengthened by the fact that steam launches were at that time less common, and less easy to hoist out in a sea-way than now, so that most boats were worked under oars. When lying alongside, of course the greatest care had to be taken in sending boats off, and during the six hours many narrow escapes from serious injury or total loss were run by the boats. Of course it is much more difficult to tranship coal from the *bunkers* of one ship to those of another, than it would be to do so from the *hold* of a collier, but as labour power was practically unlimited in the ship's filling bags, this did not materially retard the rate of transshipment, which appeared to be affected solely by the difficulties of water-transport.

In the most perfectly calm weather most serious risk of injury to the lighter fittings on a ship's side would be run by attempting to allow the collier to lie alongside, and on 99 days out of 100 in the North Atlantic, this would be impossible. In most ships ample numbers of hands are available for the work of filling, emptying, transshipping, and hoisting coal, the great difficulty is how to get it over the intervening water space between collier and ship, with safety and rapidity, keeping the coal dry. It would also be a convenience if the coaling could be carried out without entirely stopping the ships, say, under easy steam of 4 or 5 knots.

At present the only available appliances seem to be the boats of the ship and of the collier, the coal itself being carried in bags.

Unless supplemented by an extra supply in the collier, the complement of coal-bags allowed to men-of-war, which is about 5 per 100 of indicated horse-power, would rarely be sufficient to allow coaling to be carried out in ordinary ships' boats without delay from this cause. Recently when coaling the sloop in which I am now serving

in one of the South Pacific Islands, only the cutter and steam cutter (without engine and boiler) were used in bringing the coal off from the shore; the establishment of coal-bags (71) was insufficient to load both boats, and the time occupied in coaling was nearly doubled from this reason, the working parties both afloat and on shore being frequently obliged to wait for each other. Ordinary ships' boats and bags utterly fail to keep the coal dry in any loup of the sea or rain.

This plan, too, is quite impracticable in a fresh breeze, and even in moderate weather entails much risk of foundering on the boats employed; the stoppage of the fleet or ship is also necessary.

Any satisfactory means of coaling at sea ought apparently to satisfy the following conditions:—

(1.) *Rapidity*.—Nothing short of 20 tons per hour for an ironclad if hoisting overall, or 40 tons if she has several ports that can be worked for coaling, or 15 tons in a small vessel, ought to be considered a satisfactory solution.

(2.) *Safety*.—The coaling must be capable of being carried out in any breeze in which ships' boats not heavily laden could carry working parties to and fro with facility. The boats or coal-carriers employed must be safe from sinking even if accidentally filled or injured in transit.

If any form of pneumatic or other tube is used as a coal-shoot between the ships, it must allow of the ships being at least 20 yards apart if steaming through the water, or 100 yards if both are stopped. It must also be very flexible to allow for the motion of the ships.

(3.) *The coal must be kept dry* to avoid danger from spontaneous combustion, and deterioration while in the bunkers.

(4.) *The coal-carriers or boats ought to be such that they can be towed alongside the ship from the collier while both are going at a speed of 5 knots*.—Owing to the particular service on which they are ordered, it may be most important not to stop the ship or fleet entirely. With a large squadron, the capacity of whose bunkers may vary greatly, one ship may require coaling much before another, and it may be inconvenient to stop the squadron, or risky to leave one ship behind, let us say in the supposed vicinity of an enemy's fleet.

(5.) If boats are used, they must be such as can be conveniently hoisted at the collier's davits; if some other form of coal-carrier, they must be such as can be conveniently stowed in the collier's hold or on her decks.

(6.) The minimum of labour should be required for filling, hoisting, or emptying them; they must therefore be of minimum size and weight for the amount of coal they carry.

(7.) Without being too expensive, they must be of strength and durability enough to stand considerable knocking about at sea and on foreign stations.

On studying the above conditions, it appears to me that they cannot be satisfactorily fulfilled by any ordinary boat carriage, but that they could be by means of some form of water-tight coal-carriers, and possibly by a pneumatic tube connecting the vessels. This latter proposal I do not feel myself competent to work out in detail.

In both, the practical working and the amount of coal carried, would be immensely facilitated and increased if, for ocean-coaling, some form of patent fuel were used.

Taking the conditions *seriatim*, let us see what qualifications the "coal-carrier" must have to fulfil them.

(1.) *Rapidity.*

(a.) The "carrier" must be of such a type that it can be filled, closed, opened, and emptied at least as fast as an ordinary coal-bag, *i.e.*, 10 men in a commodious hold ought to be able to fill 8 tons in an hour.

If the carrier is formed of some hard substance, as iron or wood, it will not require one man to keep the mouth open as in filling canvas bags, hence a gain of nearly 30 per cent. in labour when filling. The top should close easily and make a water-tight joint, the carrier either turning over or the bottom opening mechanically in one motion. The carrier must be of such a height and shape as to be readily filled by means of shovels, and not be more than 3 feet high. The coals should fall out on the deck by their own weight.

(b.) It must be of such a form as to be easily towed, therefore not too bluff at the ends, and the slings and towing spans so formed that a long series of carriers or a continuous stream could be kept going between the collier and the ship.

(c.) It must be of such weight as to be easily hoisted inboard by the yards, coaling ports, or derricks; for this purpose $1\frac{1}{2}$ tons might be taken as the limit of weight for each filled carrier if to be hoisted at the yard-arm, or a $\frac{1}{4}$ ton for very small ships or coaling ports.

(d.) The slings must be so made as to be readily hooked on in a tumbling sea with the ship moving 5 knots; for this purpose the upper ring of slings must be fitted to stand up rigidly, and be about 1 foot in diameter, so that a large hook could be readily guided into it. This hook must be such that it will not come accidentally unhooked if the carrier be suddenly lifted by the sea; some form of spring like that fitted to a watch-guard hook would answer this purpose.

(e.) The towing arrangements must be such as can be readily slipped without the necessity of a man going into the water, or on to the carrier for that purpose.

(f.) The carrier must be easily closed, hoisted out empty, and returned to the collier for refilling.

(2.) *Safety.*

(a.) The carrier must be water-tight and carry a sufficient quantity of air in a compartment separate from the coal to ensure its flotation, even if the coal gets flooded.

(b.) Strength sufficient to protect from injury in case of striking bolts, &c., in the ship's sides.

(c.) Slings, both towing and hoisting, of ample strength.

(3.) *Coal to be kept dry.*—This entails water-tight joints for all openings in the "carrier."

Nos. 4, 5, 6, and 7 must be dealt with when considering the forms of coal-carriers suggested, but convenience of stowage renders it necessary that the rigid ring for hoisting should fit into some form of countersunk hole for stowing away, and that the angles of the carriers are such as to fit into each other when several are stowed together, in such a manner as to avoid having empty spaces left between the carriers.

It would greatly expedite the coaling of small ships, and to a less extent of larger vessels also, if the first 100 tons at least could be stowed in the carriers before the collier leaves port. I am aware that by doing so some space will be lost and considerable expense incurred, but during *war time* it is often of invaluable importance, and by wasting it an opportunity may be lost which perhaps will never recur. A vessel in the act of coaling, her decks lumbered, and with perhaps many of her men in the collier, must be looked on as almost useless for the time: if an enemy be then sighted, some delay must occur before chase could be given. Again, all coal must be stowed, and the ship ready to clear for action before nightfall, or a heavy squall or fog may come rapidly on, in which it would be most dangerous to be towing hawsers, carriers, or boats: hence, even a few hours' or minutes' delay in coaling at sea is a thing to be avoided; it ought to be made an evolution, well thought out and systematically arranged for beforehand.

If it were possible I would stow coal with as much care as provisions, every hundred-weight in its own case. That this is not an impracticable suggestion may be inferred from the fact that all the coal sent out from England to a mercantile firm in Brass River on the West Coast of Africa a few years ago (and for all I know still is) came in 5 cwt. wooden casks perfectly water-tight. Her Majesty's ship "*Pioneer*" when coaling used to tow these alongside, and hoist them aboard. In this case the casks of coal were not intended for use aboard ship, or in any very large quantities, and some delay was occasioned by the want of properly fitted towing and hoisting slings, and by the time taken in starting the hoops and wooden head.

All this would be obviated in carriers specially made for the purpose.

The best form of these carriers and the details of their construction would probably be more effectively dealt with by a mechanical engineer than by a naval Officer. As in the question of ship construction, I imagine that it is far better for us to state definitely what we require, and leave those who have made such subjects their life-long study to meet our requirements as nearly as they can. Nevertheless, I think it is well to give a rough sketch of a coal-carrier which will meet *some* of the requirements, leaving it to cleverer heads to work out, develop, and mature the idea.

While considering the coal-carrier, I have suggested but a very inferior one, and hoping that it may lead to the proposal of a far better one, let us see how it will meet the requirements laid down.

(1.) *Rapidity.*

(a.) The carrier can be filled quickly, as it stands only 3 feet high, the door is large enough for three men to work together at, and the coal falls by its own weight into any part of the box.

It can be closed quickly by half a dozen turns of three screws, which make the joint water-tight.

To empty it, the catch slips which hold these screws can be knocked off with a hammer, the side opening outwards from the hinge below the air-box, and nearly all the coal falling out by its own weight, the remaining small quantity being easily tilted out.

(b.) Facility of towage.

CARRIER. PLAN.

Largest size to carry one ton.

Weight of case $1\frac{1}{2}$ tons when filled and ready for hoisting out.

Semicircular or half rings at *a*, and lying flat in countersunk holes for stowage.

F. Air chamber. E. Door.

Method of stowage in hold of collier.

Side view.

- a.* Half rings standing up and keyed there.
- b.* Hinges to door.
- c.* Fastenings to door.
- D. Coals.
- E. Door.
- F. Air chamber, 15 cubic feet.
- G. Cork pudding, 2 inches in thickness.

Method of hoisting through coaling ports.

The pyramidal ends ought to oppose but a small resistance to the water. If specially prepared strops and toggles (with laniards) are used on the towing hawser, any number of carriers could be fast to the same hawser at very small intervals apart.

(c.) The sketch and dimensions given are for the largest sized carrier proposed with a weight of $1\frac{3}{8}$ tons when full. Probably one of half the above dimensions, carrying half a ton of coal and weighing $\frac{3}{4}$ of a ton when full, would prove most convenient for ordinary service.

(d.) Ease in hooking on the hoisting tackle to the slings seems ensured by the semicircular ring one foot in diameter, and, when keyed, standing rigidly up.

(e.) Special strops on the towing hawser, with well greased toggles and loops attached, ought to be easily slipped with a boat hook, or by hand when the carrier is lifted out of the water.

(f.) The empty carrier can be hoisted out at least as quickly as the full one.

(2.) *Safety.*

(a.) The air-box proposed is sufficient to support the weight of carrier and coal if made of the size proposed, even if the coal gets flooded.

(b.) Strength. If made of $\frac{1}{8}$ in. steel, or $\frac{3}{16}$ in. iron, and protected by a cork "fender" or "puddings" round the centre and angles, it ought to stand all ordinary rough usage.

(c.) The rings for slings can be made of any desired thickness.

(3.) The coal ought to be easily kept dry, for there is only one opening to the case, and that is flat and oblong, long but narrow, so that it could be easily rendered perfectly water-tight when screwed well home to an india-rubber seating.

(4.) As the carriers are water-tight and sharp ended, they can be towed alongside the ship at any moderate speed.

(5.) The ends of the carriers forming a right angle, they can be stowed close against each other as shown in "plan of stowage."

(6.) This depends mainly on material used and workmanship in construction.

(7.) The carrier proposed does not seem to be very expensive, as it can be kept in store or in use for years, and is available for any class of ship.

In conclusion, I must warmly disclaim any idea of having solved this question, but I do hope that, having brought its claims and its importance forward, those who have time and talent will not rest until it can no longer be said that "we have not yet hit upon a means of coaling at sea." It may be long ere some apparently perfect plan is proposed, but in the meantime any fairly good one is better than none.

Let us follow the old "Excellent's" motto, "Si vis pacem para bellum," and in coaling as in the greater and more attractive subject of gunnery, let our motto be, "Ready, aye Ready."

General LOWRY: I sent a copy of this paper to Captain J. C. R. Colomb, R.M.A., for any remarks he might desire to make on this occasion. That gallant Officer is so well known to members of the United Service Institution as one of large views and well thought out and matured opinions on most subjects coming under his consideration, that I venture to ask the Chairman's and your permission to supplement the paper you have heard, and open its discussion by reading Captain Colomb's remarks on it:—

"Having through the kindness of General Lowry had the advantage and pleasure of reading the valuable paper by his son, Lieutenant Lowry, R.N., 'On Coaling Ships or Squadrons on the Open Sea,' I wish to express my very great regret at being prevented from attending the lecture in person, and taking part in a discussion which I hope may be worthy of the very important question with which the lecture deals. I should wish to take this opportunity of congratulating the Naval Service on the fact that this paper gives evidence that young naval Officers, as represented on this occasion by Lieutenant Lowry's paper, appear to grasp boldly problems which maritime war will certainly present for England's solution, and it is therefore gratifying to note them treading worthily the path of their distinguished seniors in the Service. It is, I think, hardly correct for the writer of the excellent paper to state 'that cruisers employed off neutral seaboard would be *unable* to obtain their coal from neutral ports' in war; I think both international law and custom, established by precedent, will entitle the war-ships of a belligerent to obtain from a neutral, without any infringement of neutrality, sufficient coal to enable the war-ship to proceed to the nearest port belonging to her flag. There are limitations as to time, &c., which I need not now allude to. But this fact really enforces the importance of the question raised in this paper. Because, as I have elsewhere often pointed out, this international law or custom must in the nature of the case operate to the disadvantage of England when engaged in maritime war, because England has ports on every sea and in every quarter of the world. For example, suppose a war with Russia. Say in the Pacific a Russian war-ship, followed by a British war-vessel, comes from the southward—both with exhausted coal bunkers—to San Francisco. The quantity of coal allowed to the Russian war-ship would be calculated by the quantity of coal she would require to cross the ocean to her nearest port, Vladivostok, while the British supply would be measured only by the quantity necessary to take her, as it were, round the corner, to Esquimalt. Now, with bunkers full, the Russian war-ship may go south to prey on our commerce; the British war-ship *must* go north if she is once more to become efficient by having her bunkers filled. I take this example as not merely a possible, but, I think, a very certain description of what will very likely happen during maritime war, and I select the Pacific because it is the ocean on which the author of the paper is serving. Next to the defence of our fixed coaling stations, comes, I think, the question (excellently and most modestly) raised by Lieutenant Lowry, and there-

fore, in the interests of the protection in war of our huge mercantile marine, I trust the paper will attract the serious attention it deserves. In the example I have given, our risks and dangers could only be obviated by coaling the British ships at sea beyond the neutrality limits of San Francisco. I can see grave mechanical difficulties must be overcome, but I entirely agree with the writer, 'that it is far better for naval Officers to state definitely what they require,' and 'I feel sure that if it be possible for mechanical contrivance to overcome the difficulties presented by the requirements of the Naval Service, those difficulties can and will be overcome by that pre-eminent engineering skill which England possesses.'

The CHAIRMAN: It is now my duty to call upon any of those gentlemen who wish to take part in this discussion.

Admiral SELWYN: I recognize with great pleasure the very clever and well thought out attempt at the solution of a great problem which has been put before us. Unfortunately, there is no doubt whatever that the necessities of the case have confined us down to a most unsatisfactory quantity of fuel on board steamers at sea. It is all very well to say that you can go at low speed for a long time; but that depends on what your adversary thinks about the matter, and it will never be satisfactory to my mind until what I think I see in the near future takes place, when thirty days' fuel can be carried at sea for full steam power; but that we have not got yet. I think it will not be a year before you do get it. But the problem of how to coal at sea is one to which I, too, have paid some attention. I am not going to bring forward my own ideas against Lieutenant Lowry's, but simply to examine what are the difficulties which must stand in his way. He has, in my opinion, thought out the matter as closely as any man could possibly do, nor do I recognize anything about the whole plan which might not be accepted or fathered with pride by any engineer in the kingdom. He has considered the space, the expense, the mode of action, in a way that very many engineers could not have considered it, not having the experience at sea which is necessary to do so. But there is still the difficulty that, to do this, you must stop your fleet, or bring them down to a very low speed, which is undesirable. I think it can be done without interfering with the speed of the ship at all. Then he has got a great number of rather expensive coal cases to be carried in colliers, which, as he says, add considerably to the expense and to the space requisite where he introduces air-chambers, as he necessarily and very wisely does, and this comes out simply as a matter of money. It costs so much more money per ton of coal put on board the ship. Now, to some persons that would be a very serious objection; but to my mind, there is no price of fuel whatever that can be thought of for one instant in comparison with the efficiency of our fleet. If that be fully secured, then neither the nation nor the Government ought to find fault with the expense at which it is done. But as our preparations in the Navy must be continuous and permanent, it seems that you would have invariably to carry these cases when they were not required. Now that I regard as rather a more serious difficulty. They must be on the spot. You may get coals, for instance, from several of our Colonies. Can you expect these chambers to be always supplied to the colliers at the coal mines? I think there is something to be thought out there, as to how it would work, which must lead people to consider afresh the whole subject, and to weigh that difficulty in comparison with other difficulties belonging to any other system. But after all, gentlemen, good as this plan is, excellent as I believe it would be in practice, as Lieutenant Lowry proposes, prevention is very much better than cure. Let us turn all our attention, as it has not been turned, I am sorry to say, to those means which may enable us, first, to economize our fuel. For the last fifteen years there has been steadily put forward a thing which is now succeeding admirably well in private hands, in which only 1 lb. of coal per indicated horsepower is required instead of 2½ lbs. That is the first thing to be considered, before you consider what you will do with the coal after you have got it in your collier. The reason why I ceased to turn my attention so strongly in this direction as I had done previously, was that I am absolutely confident you are going to see the end of coal for steam fuel at sea altogether. It will not pay to take coal on board ship at this moment. We have not done much in the matter since I first attacked the subject some years ago, but the Russians, I am happy to say, are finding out the

value of liquid fuel, and when you get liquid fuel, I need not tell you, all these difficulties of passing it from one ship to another will very materially disappear. I have said everything I can in praise of Lieutenant Lowry's plan; I think it very good indeed for our present necessities, but I trust to see those necessities largely abolished in the future. I am quite sure that if half the attention were given to this subject which has been given to the guns, which are utterly useless without the power to carry them about, we should long ago have seen a solution, and a satisfactory one. I believe that it is the practice to refer these matters to Committees. Now on that subject, I heard a very clever dictum, coming from a curious kind of authority, which I may repeat. Mr. Moody, of Moody and Sankey, appears to have been plagued, I do not know whether in his musical or religious work, by Committees, and he at last brought out a piece of concrete wisdom, which I commend to the serious attention of every Englishman: "If Noah had had a Committee, the Ark would never have been built."

Captain BEDFORD PIM, R.N.: The gallant General commenced by saying that he was somewhat at sea in reading this paper. I am sure you will agree with me that, had the son been present, he could not have done more justice to the paper than his father has done. It is seldom one hears a paper more admirably read. I think I should be disposed to attack this subject from a different standpoint altogether from that which Lieutenant Lowry takes. I do not quite understand how he could transport this coal from one ship to another, especially in these days of long ships, when the collier would be rolling, gunwale under, on the slightest possible provocation. But I think I should attack it in this way. Sir E. J. Reed told us, many years ago, that an ironclad could be built to sail as well as steam, equal at all events to the fine old wooden frigates, &c., of the past. Now, we know that no ironclad is worth much at sea under sail. Why do we not build ships that will keep the sea under sail, the same as the ships of our forefathers did, as long as the provisions lasted? There is no difficulty about it. It seems to me the coal question would then be solved. If you had ships, from gunboats up to ironclads, that could keep the sea under sail as long as their provisions lasted, you might save your coal, and only use it to draw off a lee-shore or engage an enemy. Then you would have no necessity to coal a ship on the ocean, which I, as an old-fashioned seaman, am afraid is altogether impracticable with even a light sea on. I do not see how you are going to coal a ship in mid-ocean. You may transfer a small quantity on an emergency, but nothing more. With regard to international law, all the coal you are allowed from a neutral port in time of war—for coal is a contraband of war—is just enough to take you to your next home port. Well, as Captain Colomb has pointed out so well in the letter which he has written to General Lowry, on the Pacific coast it would be a very serious matter indeed. We could only take coal on board sufficient to take us, say, from San Francisco to Esquimalt, 600 miles, while the Russians would be entitled to sufficient to take them to Vladivostok, several thousands of miles from San Francisco. I do not mean to say that the Russian men-of-war would avoid going to Vladivostok; but, supposing they did, and turned back and fell on some of our so-called cruisers, it would not be pleasant, but rather a serious matter. But I think this difficulty with regard to the Pacific might be solved in this way. There are some islands, which I was employed in surveying some years ago, the Galapagos. They would make a splendid coal-depôt. Why do not the Government, for a few thousand pounds, buy the Galapagos, where you might have anchorage in the smoothest of water and render the coal depôt impregnable, and take your ships in any time you please? No more central place could be found on the Pacific station, and nothing would be easier than to turn them into a large coal centre. I am afraid that if you rely upon Esquimalt in the event of war, you will rely upon that which will fail you. I hope that some of the younger Officers will take up the thread of the argument and give us the opinions they entertain of coaling an ironclad on the open sea.

Captain NOEL, R.N.: I have only a few remarks to make on the paper. I think Lieutenant Lowry deserves very great credit for bringing this subject before the Institution. I am very much impressed with the manner in which his plans have been worked out, and I think them deserving of a great deal of credit as a bit of engineering. There is no doubt that this subject is one of the very

greatest importance; our ships of war must be limited in their coal capacity, and therefore we shall suffer if we cannot get coals under certain circumstances. Economy of coal is the question of the day, or it will be, when we go to war; and if we can economize coal by any other means, such as by use of sail power, so much the better. I am going to read a paper here shortly on the sail power of ships of war. I consider it essential for all cruising vessels that they should have some other means of propulsion besides steam; still such other means of propulsion is only to assist in economizing fuel. Here we have a means of facilitating the supply of fuel. Of course we must be continually coaling, and I quite think we ought to find out a way of coaling at sea for several reasons. In the first place, in a severe war we may find that the coaling stations that we reckoned so much upon have been seized by the enemy, perhaps are held, or the coal destroyed: so we must have colliers with us. In order to keep our ships free to work under steam they must have colliers with them. In calm weather coaling at sea is not attended with any very great difficulty; but then we cannot always wait for calm weather, and then it comes to the question of how we are to coal, and I must say Lieutenant Lowry has done very great service in moving this question. I do not quite like his plan. I do not think the coaling can be done with any great speed in closed carriers, but there might be times when you could not coal in any other way. Therefore I think that if a steamer is sent out with coal to attend on the squadron or vessel, whichever it is, it would be very well if she had a hundred or so of these carriers, or carriers of a similar nature. I should not trust entirely to them: they would only be requisite under very exceptional circumstances. In my opinion a steam collier should carry actual coaling barges, say of 50 tons: let every collier that goes out with the fleet carry four large iron barges properly fitted with fenders, then there would be no more difficulty in coaling at sea in moderate weather than there is in coaling in an open roadstead which we have all experienced, and, as far as passing through the water is concerned, in the Mersey it is seldom you have a tide of less than 5 knots, which is exactly the same thing as passing through the water at that speed when under weigh. I think it would be a good thing if the colliers which are sent out to the fleet were provided with various appliances—among them some means of carrying coal, such as that proposed by Lieutenant Lowry. Of course it is necessary to coal at great speed, where you can, and the system of coaling at speed, no doubt, rests in a great measure on having the coal in bags. There might be some question about the stowage of coal in bags on board ship, whether the material would be liable to cause spontaneous combustion or something of that sort; but if the tar in the present bags is a source of danger, we must find bags which are not so dangerous. Coal, I consider, should be carried in bags; the colliers should be supplied with coal-lighters and perhaps, in addition, some of these carriers. I think the Institution has every reason to thank Lieutenant Lowry for bringing this subject before them.

The CHAIRMAN: Failing anyone else making a few remarks, perhaps you will allow me to do so. I have been unexpectedly asked to take the chair here to-day, having intended to be present at an interesting lecture now going on at Woolwich on a question in which we all are interested—the bombardment of the forts of Alexandria—but there was a failure of a Chairman, and I am only too glad to supply his place. I am not prepared to enter into any particular remarks on the question beyond those which suggested themselves as the paper was being read. I think we cannot express ourselves too strongly upon the matter of an Officer like Lieutenant Lowry bringing such a paper to the notice of the Institution. It is extremely valuable that we should have the ideas of the younger Officers in the Service, because they are the people who have to encounter and overcome such practical difficulties as exist in coaling ships at all times, and especially at sea. Now the question of coaling ships at sea is no doubt an extremely important one, and yet one which I believe has hitherto received little or no attention. I regret that we have not some one from the Admiralty here to-day that we might hear what their opinions on the subject are. Lieutenant Lowry commences by expressing his idea of the great importance of the subject, that it should be fully considered before the outbreak of a naval war, and there is no doubt the only people who can really take that subject into satisfactory consideration are the Admiralty themselves. Probably

they may be induced by what passes here to-day to give at all events some passing consideration to it. The point which Lieutenant Lowry dwells on next, and which I think seems to be of the greatest importance, is that it is not the difficulty of filling the coals on board the collier or of hoisting them in on board a man-of-war, but the difficulty of how to get over the intervening water space between the collier and the ship. I am sorry to say that I cannot for one moment believe in the practicability of this plan which has been put before us to-day. Its great merit is, I think, in directing attention to the necessity for some means of getting over that intervening space between the collier and the ship wanting the coals. There is no doubt that there must be colliers accompanying our squadrons in the future, and the question is, how to get over the intervening space of water between them and the ships. Take the type of vessel which we all know now, the "Hecla" type, which has been so successfully fitted as a torpedo-ship, and imagine her used as a collier. I believe that will be something of the type of ship that will be employed as a collier in the future. We have now the means of hoisting up very heavy torpedo-boats. That is a necessity which was forced upon us, and as soon as it was forced upon us it was successfully overcome. There are some davits now made which, with perfect safety, will hoist up all but the first-class torpedo-boats. I think Captain Noel has hit exactly upon the right means of overcoming the difficulty of getting over the intervening space. Coaling must always be done, I believe, by bags, and not by vessels constructed of hard, rigid, uneven surfaces, and there would be no difficulty in making bags incombustible, not liable to spontaneous combustion, and with these davits I have mentioned, there would be no difficulty in hoisting up suitable boats (I will not call them barges) for conveying the coal from the collier to the man-of-war. Those boats I imagine would be devised to carry from 20 to 25 tons, and with a turtle-back deck over them, leaving only a space in the centre, also protected by a high combing, through which the coals would be hoisted out. Then you would be able to get your coals in or out equally as well when the ship was going 5, 6, or 7 knots as when she was at anchor, because it would be only a question of the seaworthiness of the boat. Admiral Selwyn has adverted to several points which certainly are extremely important, although perhaps not under discussion at the present moment. One was economy of fuel. I remember twelve or fourteen years ago, when some contracts passed through my hands, putting the point, which was very much criticized at the time, that no contract should be entered into by the Admiralty for engines until 1 h.-p. was obtained for every 1 lb. of coal consumed.

Admiral SELWYN: It has been done in my presence under the test of the dynamometer.

The CHAIRMAN: Captain Bedford Pim's ideas as to sailing ships must be looked upon as very retrograde. The "ironclads" he talks of did very good service at Alexandria, and had they been limited to their sails they would have made a very poor show indeed.

Captain BEDFORD PIM: They were but weak forts. I did not say confine the vessels to sail.

The CHAIRMAN: I have had the pleasure of commanding several of those ironclads, and I have not had more pleasure in a wooden ship than I have had in an ironclad. One of the great objections to this proposal, I think, is the vast space which would be wasted, I mean so far as stowage is concerned, by the air space required for each carrier. I have seen a good deal of hoisting things in tideways and so on, and I do not believe those carriers could be hooked on and hoisted in with a ship going 5 knots. Allowing for the ingenuity and thought which has been bestowed upon it, I can only say, as an old practical seaman, that it is not in my opinion practicable. As the greater part of this paper is devoted to the details of the construction and management of the carriers, I really do not know that I could occupy your time to any advantage by saying anything more about them, but what I do hope is that the discussion of this matter here, and possibly elsewhere, may lead to the appointment of one of those bodies of men which appear to be deprecated so much by Admiral Selwyn, namely, a Committee to consider the question. I believe myself in the usefulness of Committees. Probably I may be influenced in that opinion by having served on them myself;

but I do think that this is especially a subject upon which the appointment of a Committee to inquire into the whole matter, and to make suggestions and recommendations, would be extremely useful.

General LOWRY: You will not, I am sure, look for any comment at my hands upon the discussion which has taken place. I am glad to have had the privilege of reading my son's paper on this occasion, and I thank you for the great attention you gave it. I shall be yet more glad if—as Admiral Luard said—it tend in any way to call public attention to a matter of grave and pressing importance. Whatever may enable us more efficiently and promptly to coal our Navy will be a step in the right direction, and one on the accomplishment of which vast issues may hinge. It must needs not only affect the defence of that commerce of ours, which a nation that is not well prepared to defend will not long possess, but of those great Colonies of England which form her magnificent heritage in all parts of the world. I thank you much.

On the motion of the Chairman, seconded by Captain Pim, a vote of thanks for the paper was voted to Lieutenant Lowry, and to his father for reading it, and on the motion of Captain Jackson, R.N., a vote of thanks was passed to Admiral Luard for presiding.

The resolution was agreed to.