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COALING OF SHIPS OF WAR AT SEA AND IN HARBOUR.

*By Mr. G. C. MACKROW, M.I.N.A., Naval Architect to the Thames
Ironworks Shipbuilding Company.*

Wednesday, 22nd June, 1904.

Admiral Sir N. BOWDEN-SMITH, K.C.B., in the Chair.

THE members of this important Institution have already had before them two papers on a similar subject to that which I now venture to submit to them, one by Lieutenant R. S. Lowry, R.N., in 1883, and one by Lieutenant C. E. Bell, R.N., in 1887, and copies of these papers have very kindly been placed at my disposal by your esteemed Editor.

I have also had the privilege of reading a very valuable paper by Mr. Spencer Miller, an Associate of the Society of Naval Architects and Marine Engineers of the United States, so that I know pretty well all the systems that have been devised—at least, as far as they have been published—and, further, that the British Admiralty have also given the Spencer-Miller system a trial, but with results that we believe still leave further room for improvement.

Captain (now Vice-Admiral) FitzGerald said, when discussing Lieutenant Bell's plan, that he did not think any apology was necessary on the part of any naval officer or other person who may bring this important subject before the members of this Institution, and therefore I feel emboldened to submit a proposal, that we have been working at at the Thames Ironworks for the past four years, to a body of naval officers such as compose this Institution, and who can best appreciate its value.

I need not take up the time of the meeting by referring to the various steps by which we arrived at what we now submit as a practical solution of the problem. The vital points, viz., the hoisting and transferring of the bags of coal from the hoist on to a continuously running conveying line, travelling at any speed up to 1,000 feet per minute, and again upon reaching the battle-ship transferring the bags of coal from the said running line to the deck without in any way reducing its speed, is a feat, we believe, which has never before been accomplished. These points we have tested as far as possible on shore, and we can deliver from 50 to 200 tons with ease, and we should now be pleased if our Admiralty, before whom it has been for the past four years, would decide to give it a trial at sea.

That some slight modification of the details may be found in practice to be necessary is probable, but I have every confidence that these can be readily made.

I presume that the three requirements, as stated by Lieutenant Bell as necessary to any satisfactory solution, are accepted by all present, viz.:—

1. Rapidity.
2. Safety.
3. Ability for the ships engaged in the operation to proceed with the minimum diminution of speed.

With regard to the first point—viz., rapidity—we undertake to deliver from 50 to 100 tons per hour, in a seaway in which the collier does not roll more than 15 degrees, as Admiral Wilson gave it as his opinion that should the collier roll beyond this, coaling operations on board could not possibly be continued.

With regard to the second point—safety—I may here say that it has been the main point of consideration by us, as the risk of danger by the accidental falling of our suspension weight, unless arrested or otherwise provided against, might prove very serious, but we believe we have fully provided against such an accident, as we shall hope to show later on in the course of this lecture.

With regard to the third point, we submit that the vessels can perform this operation equally well at high speed, at low speed, or at anchor.

I will now describe the gear, as represented in the model and plans before you:—

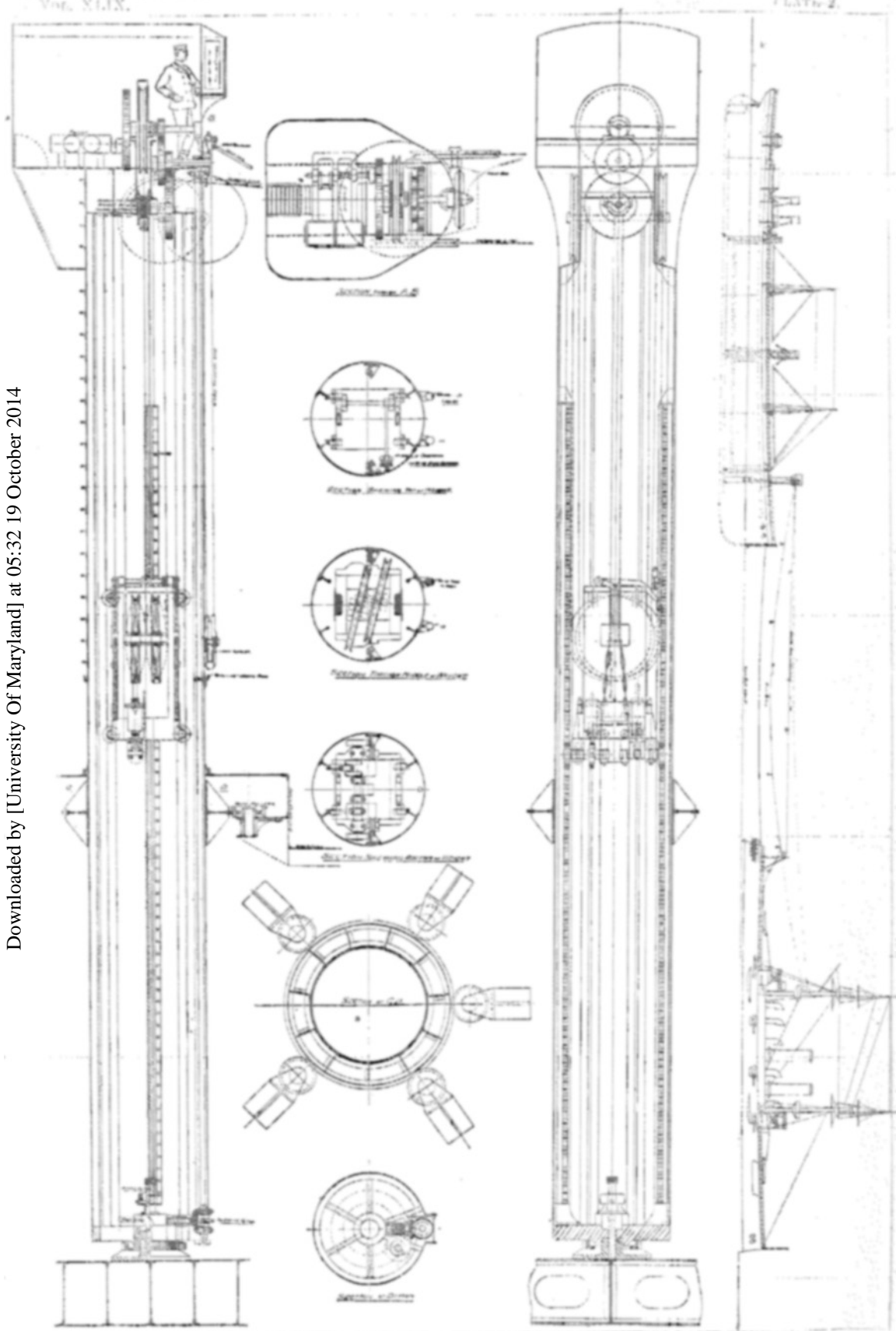
Firstly, we have a vertical cylinder (which we call a slewing jib or transporter), which contains a tension weight and a set of sheaves in the same, suspended by means of the conveyer line from another set of sheaves attached to the crown of the cylinder or transporter.

Secondly, we have an endless steel wire travelling rope passing round the two sets of sheaves in the transporter, the bight being carried to sheer legs on the after part of the deck of the war-ship or to the military top, as preferred, where it will pass round a free wheel or pulley, and by means of the above-mentioned tension weight we have a practically uniform tension on the said rope maintained, notwithstanding the distance between the ships varying to the extent of ten to twelve fathoms.

Thirdly, we have a novel form of hoist secured to the front of the vertical cylinder with a series of projecting hooks that catch other duplex hooks attached to the coal bags, and carried on a circular continuously-travelling feeding ring which is fitted around the transporter at a height of about five feet above the deck, and provided with scores in its upper edge about two feet apart, into which these hooks drop, and are carried into position ready to be automatically picked up by the above-mentioned projecting hooks.

Fourthly, at the head of the above-mentioned hoist we secure what we call a shunt bar that receives the duplex hook of the coal bag when it is cast off the hoist, whence it travels by gravity down the shunt bar, and so passes on to the transporting line.

Fifthly, a small engine is fixed at the head of the slewing jib, and this will give movement to the following gear—viz., the transport-



ing line, the hoisting gear, the feeding ring, the tension relieving gear, and also the slewing gear, so that the sheaves at the head of the transporter may always teach direct to the sheaves on the war-ship, in order that the coaling operation may proceed independently of the relative positions of the ships. By this means the collier may be towed direct astern or on the quarter at pleasure, or even on the broadside should occasion require it.

It will be seen from this that a continuous train of coal bags may be hoisted from the deck of the collier, transferred to the transporting line, and when arriving at the war-ship be again transferred by means of another shunt bar from the transporting line on to a carrier rail, and so arranged to travel to any point on the deck that may be desired near the coal shoots.

It will be observed from the above remarks that there is no reciprocating movement, but that it is a continuous one, and so no time is lost while the empty bags are being returned, as they are sent back on the inward running line, while the coals are being sent out to the war-ship by the outward running line.

So far we have dealt only with the question of delivery of the coal from a collier to a battle-ship or cruiser, and have assumed that the coal can be brought to the head of the transporter at the same rate as it can be despatched to the war-ship.

This at once raises the question as to the desirability, or not, of having specially built fast colliers, and it is the opinion of many naval officers, notably Lord Charles Beresford, that such vessels should be built to carry some 5,000 tons of coal and capable of steaming fifteen knots per hour, and some five years since Lord Charles Beresford telegraphed my company—the Thames Ironworks—to give him an approximate price for such a vessel, as he was going to broach the subject in the House of Commons.

We did so, and this led us to get out a special design for a collier on the above lines:—Length, 450 feet; beam, 50 feet; draught of water, 26 feet; twin-screw engines of 5,600-I.H.P., and a displacement of 11,000 tons.

We proposed to place the propelling machinery aft and to divide the fore part into six holds, and in each hold to have at the lower part a filling-room entered by means of a trunk from the upper deck. In three sides of this room we had proposed to fit a door as in an ordinary coal bunker, the coals paying down by gravity to these doors; but we now propose to erect a sloped or arched floor, to be kept about seven feet from the bottom of the hold, so as to allow the coal to pay down on to a table in the filling-room, and from thence be raked into bags suspended with their open mouths close to the table, and when filled to be hoisted up the trunk to a traveller fitted overhead along the upper deck, which, being made to travel continuously, would convey the coals from the holds to the heel of the transporter, as above mentioned. The bags, as they arrived at the revolving ring at the heel of the transporter, would each in its turn be caught by the hook of the elevator, and so be hoisted to the head and transferred to the conveyer line as above described. We estimate that with twenty to thirty men in either of the compartments we could easily fill from 600 to 1,000 bags per hour, equal to from 60 to 100 tons, making a total of from 360 to 600 tons per hour.

The objection that may be raised to this proposal would be the cost of raising and maintaining such a fleet of colliers, as the special case we are proposing to meet is that of an emergency in war time. In times of peace our coaling ports would, of course, be always available, and the proposal for coaling at sea is only in view of such a contingency as meeting the requirements of a "fleet in being" stationed, it is assumed, at a given rendezvous, from which point it would be desirable that the fleet should issue fully provided with coal to make a descent upon the enemy in the open, or to blockade a port. What we have thought would be a wise arrangement would be to subsidise a few fast steamers, such as the 17-knot Cunard cargo-boats, and fit them for the reception of one or two of our transporters, say, one in the bow and one in the stern, the one in the bow to clear the fore hold, and the one in the stern to clear the after hold. This would necessitate the collier being towed by the war-ship and depositing the coal in the after deck of the same, and the collier to take a second war-ship in tow, and deliver the coal from her after hold to the fore part of the war-ship, and by these means the tow rope would always be kept taut, the leading battle-ship steaming slowly, say, four or five knots, or even less, if the second war-ship turned her engines astern. It has been objected that the tension on the transporting line, say, of three tons, would tend to draw the collier toward the battle-ship, and result in allowing the tension weight to descend to the bottom of the transporter and thus destroy the tension. This objection we have thought could easily be met by the helmsman putting the helm over a few degrees, thus increasing the resistance; the transporter being made to slew, the transporting line could always be kept teaching direct to the free wheel on the battle-ship, which wheel, being also made to slew, the transporting line would always run true.

If the above arrangement was adopted the coals would have to be bagged in the open holds as at present, and we should propose to fix a rail such as we have often fitted in the coal bunkers of H.M. ships, to convey the coal from one end of the bunker to the bunker doors. This rail would be supported on portable standards on upper deck of collier secured to the combings of the hatchways and carried all round the decks, forming an endless rail, the loaded bags going forward on, say, the starboard side and the empty bags returning on the port side, the usual steam derricks and winches on the masts being used for hoisting the coal after being bagged in the open holds and depositing them on to the above-mentioned bar, and suspended by the duplex hook attached to each bag as before described. This method would, of course, require more hands and involve more labour than in the case of the specially designed collier with the filling-rooms, but not more than is required at present when unloading by means of the transporters generally in use in the Navy.

The entire question is one on which naval officers will join issue, some contending for the handling of coal more mechanically and systematically, others contending that the "handy man's" own nautical devices may be safely trusted, each commander being left to train his crew in his own method.

In peace time, as before stated, we have not to consider so seriously the question of the coaling of H.M. ships, as, in most of the ports or harbours of our distant colonies labour is cheap and plentiful, as we

have heard of nearly 2,000 hands being employed in one port and the vessel coaled in a prodigiously short space of time.

Still, it may be considered to be advisable to have a simple method of coaling even in port or harbour, and our Admiralty has been induced to give a trial to a proposal we have submitted to them.

Our proposal for loading in harbour is as follows:—

To build a 1,000-ton lighter and fit in the lower part of the hold a filling room, on the sloping crown of which coals are deposited as in an ordinary open lighter. The sloping crown or floor does not run home to the side of the lighter, but stops some three or four feet short of the side, thus allowing the coal to pay down through this opening on to a receiving table placed underneath the opening, on the edge of which table the bags are held open and the coal is raked off the table into the bags, and as the table is cleared more coals pay down by gravity, and so entirely obviates the necessity and consequent labour of digging and shovelling, as in an ordinary open hold. The bag filling being carried on under cover, the men are protected from the scorching rays of a blazing sun, the chilling blasts of an easterly wind, and can work in wet weather as well as in dry, and with much more comfort and with less labour.

The lighter is divided into two parts, one hold forward and one aft, and in each lower hold or filling-room there is ample room for twenty men to work filling, each man handling three tons per hour, equal to 60 tons, or, by increasing the number of men to thirty in each hold, we can deal with 90 to 100 tons of coal per hour, making a total output of 200 tons per hour.

At the end of each hold we fit one of our Express Transporters, which will lift the coal after being bagged to any required height, either of a gun-boat alongside or of a battle-ship, the bag of coal upon reaching any required height, being detached and allowed to slide down the shunt bar on to the deck of the gun-boat or battle-ship as the case may be. By this means, from the time the bag is filled in the hold of the lighter and hooked on to the overhead travelling rail until it reaches the deck of the battle-ship, it has not to be handled by anyone.

The dust arising from this operation is surprisingly small, as the coal pays down quietly, and what dust there is floating in the air is removed by a Sturtevant or other approved fan working in the end of each hold and depositing the fine dust in a receptacle provided at the end of the hold, so that a constant supply of fresh air is maintained.

Electric lights are to be fitted both in the filling rooms and aloft, and the whole of the mechanism for hoisting the bags from the receiving table to the traveller, again to the hoist, is in charge of one man to each hold, stationed on deck amidships, who can see what is passing, and can stop and start the gear at pleasure.

These lighters, being for harbour use, are not self-propelling, but are supposed to be towed from the coal dépôt to her berth alongside the battle-ship. To load the lighters from collier or barges it is proposed to fit a couple of steam cranes to work a Hené's Grab, an appliance that has come largely into use of late years in most of the gas-works in this country, where large quantities of coal are continually dealt with, 80 tons per hour being easily moved on shore by one grab.

GENERAL PARTICULARS OF TRANSPORTER.

Extreme Length of Transporting Trunk	..	56 feet.
Diameter of " "	..	5 feet 3 inches.
Total Weight of Transporter complete	..	28 to 30 tons.
Height of Transporting Line above Sea at Collier	..	about 35 feet.
Height of Transporting Line above Sea at Battle-ship	..	about 30 feet.
Dip of Line when Loaded	..	from 13 feet to 19 feet.
Weight of Tensioning Apparatus complete	..	8 tons.
Normal Tension on Transporting Line	..	2 tons.
Transporting Line of Special Flexible Steel Wire Rope	..	2-inch cires.
Diameter of Sheaves on Tread	..	3 feet 6 inches.
Working Speed of Transporting Line	..	600 feet per minute.
Spacing of Coal Bags on "	..	60 feet apart.
Weight of Coal in each Bag	..	2 cwt.
Speed of Hoisting Gear for Bags	..	60 feet per minute.
Working Distance between Transporter on Collier and Sheer Legs on Battle-ship	..	350 feet.
Amount of Veer and Haul	..	66 feet.

Mr. ARNOLD F. HILLS (Managing Director of the Thames Ironworks Shipbuilding Company):—While the gentlemen present are turning over in their minds the questions that they would like to put to Mr. Mackrow, I should like, with your permission, to bring out a few of the points in the paper so far as they affect, it seems to me, our naval policy. Mr. Mackrow has dealt very fairly, I think, with the mechanical arrangements by which it is proposed to deliver coal from a collier to a battle-ship. When I first of all asked Mr. Mackrow, some four or five years ago, to investigate this question, I had in my mind principally the necessities of war-time; but it is probable that in times of peace there will be considerable requirements for mechanical coaling arrangements at the ports, without considering the necessity of coaling at sea at all; in fact, I think Mr. Mackrow mentioned that we are just about to build a coaling dépôt for the Admiralty for the purpose of handling coal mechanically, and for transferring it from the dépôt to cruisers or battle-ships that may come alongside. There is no particular difficulty about that problem at all, but there is a particular difficulty about the problem of coaling at sea. The reasons why I believe it is essential—certainly for an Imperial Power like our own, with fleets going all over the world—to have such facilities are something as follows:—One of the conditioning questions of naval operations is the supply of coal. The engines determine the speed of the ship; the engines in their turn are determined by the supply of coal; and in the original design of the ship herself you have to consider this question of coal supply as a primary condition. The principal reason why our English battle-ships have grown to such an immense size has been the necessity for a sufficient supply of coal to take them at high speed over from 1,000 to 2,000 miles radius at sea. That means that the ship has to grow, the armour has to grow, the engine power has to grow; everything on board ship grows proportionately, and the result is that our recent battle-ships of from fifteen to sixteen thousand tons have begun to be of a size which makes some of us begin to feel a little afraid. The accidents of war have been brought home terribly close to our minds during the last few months by the fact that a first-class battle-ship can go down, under the influence of a mine explosion, in less than two minutes, and it gives

us cause to think. That was one of the matters that I had in my mind when I first asked Mr. Mackrow to consider this matter, because if we can provide battle-ships with a full supply of coal, and let these coal depôts, or fleet-colliers, or whatever you may choose to term them, keep within a close distance of a fleet in action, it is not necessary that those ships should be so large. That is one advantage, and it largely affects the question of the design of a battle-ship. Then you come to the question of naval operations themselves. No one would deny, especially with the experience of the last three months, that any fleet that can carry, say, fifteen or twenty thousand tons of coal, or any vessel that can keep up with an ordinary fleet, would be an immense advantage. At present a Navy in undertaking operations has to take its battle-ships five or six hundred miles with the coal they have on board, and then, having exhausted the coal, they have to return to some place settled beforehand so as to re-coal and get ready for fresh operations. Any fleet that could keep the sea for three or four weeks at a time, having abundance of coal delivered to them, would have an immense advantage in any operations undertaken. That is the second advantage which this scheme provides. Then we come to the difficulties that have to be overcome. I am bound to say in that respect that the Americans have been a little ahead of our own Admiralty. The experiments made with Mr. Miller's device in the United States have not been wholly successful, but at all events they were a part of the idea, and nobody knows what the difficulties are until they have tried the apparatus at sea. So far, our experience has been on shore, and we are exceedingly anxious that the Admiralty should give us the opportunity of experimenting with this apparatus at sea. We have overcome the difficulties on land, but we are not quite sure that we know all the difficulties that may arise at sea. When the collier and the battle-ship are moving at different speeds, when there are variations in the waves and water, new difficulties may arise in the transportation problem with which we are not familiar; and therefore until we have had that practical experience I do not profess that we have overcome all the difficulties at sea. But we have tried the apparatus on shore, and we have delivered up to 200 tons of coal an hour on a full-scale model from one point to another. We have no doubt whatever as to the general practicability of the scheme, but we would like to have a little further experience at sea in order to find out what those practical difficulties may be. Anyone considering the matter at all will realise that the great difficulty is, compensating the continually varying movements of the battle-ship and the collier, and the difficulty we have had with the Admiralty has been that they take exception to our rising and falling weight. They say: "Supposing one of your lines were to break, and that weight were to fall, it would go through the bottom of the ship, and that would be a serious state of affairs." We have not yet been able to persuade them, first of all, that a ship can very easily be designed so that if the weight did fall through the bottom it would involve no serious danger to the ship at all; and, secondly, that we have put counter-checks and catches, similar to what are running on lifts in every hotel that you go into, so that in case of any breakdown, before the weight could fall far it would be taken charge of. We, as ordinary engineers, have satisfied ourselves; we have made very proper provision against the risk of this danger; we are prepared to take the responsibility—not only to take the responsibility, but to take the cost, because I intimated to the Admiralty some time since that we are prepared to rig up a collier, to put this gear on board, and to make the necessary experiments, probably costing several thousand

pounds, provided that they will make the experiments with a battle-ship or cruiser, and if the thing is satisfactory will take it over for use with their fleets. I am very glad indeed we have had this opportunity of discussing the matter before the United Services, because I think it is a matter of public importance that a problem which has been worked out by a responsible firm, with the expenditure of considerable time and money, should be tried in the interests of the nation itself. Finally, I should like to point out that if this system does work successfully at sea, if you can deliver from 100 to 150 tons of coal by a single rope from one collier to any battle-ship, that you have got over one of the great difficulties so far as naval operations are concerned. You have only to build a fleet-collier, carrying from 15,000 to 20,000 tons of coal, to go out with the fleet, and you will have sufficient coal reserves for large operations. The same thing applies probably to ammunition and guns. It is one of the great problems of the day as to how a fleet in active operations can keep its guns in condition when the rifling has worn out, and supply themselves with fresh and large supplies of ammunition, more than they can actually carry on board a ship. It is becoming, I think, painfully apparent that you cannot build a ship of a size which can conveniently carry all it requires in the way of reserve, either of coal or ammunition, and it therefore seems to me probable that if these experiments were successfully made the Government might adopt the principle of fleet-colliers, with every fleet carrying a reserve of 20,000 tons of coal and a reserve of ammunition, which would travel at the same speed, so that a fleet would go out not only equipped with its ammunition and coal that it carries on board, but with a large reserve of ammunition and coal, which could be carried by the store-ships travelling with the fleet. I must apologise, Sir, for speaking so long, but I wanted to bring before the notice of the meeting what we are trying to do upon the scheme which has been suggested.

Vice-Admiral W. L. MANN:—The only remark I wish to make in regard to the very excellent mechanical arrangement which has been shown us is with regard to the distance away at which the collier is towed. 350 feet is a very small distance when you are towing a heavy ship at sea. I should like to know whether that has ever been actually tried.

Mr. MACKROW, in reply, said:—The experiment that the Admiralty made with one gear was with a vessel towing 400 feet astern, and they told me plainly that they would not care for more than 300 or 400 feet at the outside. We could go, in our original proposal, to 500 feet. Perhaps you did not notice that I said that we had arranged originally to tow with 300 feet between the collier and battle-ship, and give 200 feet veer and haul either way, so that the two vessels could have gone 500 feet apart. My first idea was to tow by means of our transporter line, and not to have a special tow-line at all. What effect a three-ton tension at the head of our transporter in the bow of a collier would have I cannot say. I am very pleased indeed to be able to submit this problem to naval officers, because, really, it is a naval officer's problem, viz., whether you could tow from the head of the transporter by means of the transporter lines, or whether of necessity you must have, in addition, a tow-line. The Admiralty have said: "By all means, we should always work with a tow-line." Very well, in that case the tow-line is the limit of distance the vessels can go apart; but if they wish for 400 feet they have only

to regulate the towing-line for 400 or 500 feet, as they please, only our endless line must be made to match, and the tension weight increased accordingly. We must come to some decision on that point. I think you understand about the endless line. We have to splice that wire line in about 60 feet of length, in order to make a good sound splice. I have been waiting for some gentleman to raise the most serious objection, which is a sort of nightmare to the Admiralty, namely, this question of the falling weight. Certainly, if that weight did fall, without any provision for arresting it, I have no doubt it would make a way for itself.

The CHAIRMAN:—Will you state the size of the weight?

Mr. MACKROW:—It is determined entirely by the length of line you wish to have; I mean the length of reserve. I think I can make the naval officers present understand by this illustration. It is really the principle of two single blocks suspended side by side. The two standing parts are joined, forming a bight at one end, and then the two hauling parts are assumed to be carried out and joined, thus forming the bight at the other end, on the battle-ship, so that you can have two series of single blocks or double blocks or treble blocks. You understand that if you have to haul two treble blocks apart you require much more power, so you want an increasing tension-weight. Our original idea, with this 400 feet of line, was to have a 30-ton weight, but as the Admiralty now say that 60 feet—say 10 fathoms—is plenty for the veer and haul, we have reduced our weight to 7 or 8 tons. But the great fear which has already been expressed has been that if the line should break and the weight fall, and that if no provision was made to arrest it, it would necessarily go through the bottom of the vessel, and, of course, tend to loss of life. One Admiralty officer suggested that we should make a well-hole in the bottom of the ship, so that if the line did break, the weight could go through and overboard. I said: "No, in the twentieth century surely we can catch a falling weight of 8 tons"; I could not entertain such a crude idea. In all the thousands of lifts that are running all over the country it is very seldom you hear of a mishap. But I want to show you now, as you have not called attention to it, what would happen if the line did break or was thrown off, by means of this model which we have here—how we can catch the weight. It is a very simple matter. We have four wire ropes, one of which is sufficient to sustain the weight. We arrest the fall of the weight in about one foot by means of the gear shown in the section and in the model. We have let the weights fall scores of times, and it has never failed, so that I do not think there is anything to fear from that point. In view of the Admiralty's fear, we had, however, also introduced a second break gear: Two small oil cylinders, with an opening in the cylinders to allow of the oil flowing through to give a certain speed of travel, so that should the line break, the weight, instead of falling suddenly to the bottom of the trunk, is allowed to fall gradually down the rack-work that we have fitted on the two sides.

[Mr. Mackrow then showed, by means of the working models, the manner in which the weight was caught if the line broke, and also exhibited and explained a model representing a section of a 12,000-ton floating coal dépôt.]

The CHAIRMAN (Admiral Sir N. Bowden-Smith, K.C.B.):—Through the courtesy of the Thames Iron Works Shipbuilding Company, I was permitted to go down and see this apparatus at work on a large scale on their

premises. The experiment was carried out in a long shed, and I saw real coal bags lifted up on to the wire rope, carried along, and deposited on the deck of a supposed battle-ship; and everything worked admirably and without a hitch. But, of course, as Mr. Arnold Hills and the inventor admit, this arrangement must be tried at sea before it can be pronounced a success. It must be evident to the audience that the endless wire rope is always kept in tension by means of the clever suspension weight which is exhibited. We sailors know that when we are towing a ship the tow-rope tightens or slackens by the action of the sea on the vessels; but the suspension weight tends to keep the endless wire rope always taut. Mr. Mackrow has told us that he has provided against the danger of the weight falling, which is one of the objections raised against the invention. When watching coal bags travelling along the wire rope it occurred to me that in carrying out this operation at sea some of the bags might be jerked off the line into the water; but if it did result in a bag or two of coals falling overboard, or some bags touching the water, I do not think that would be sufficient to condemn the invention. I am somewhat surprised that this apparently clever invention has not yet been tried at sea. I am sure that under officers like Admiral Sir A. K. Wilson, in the Home Fleet, or Lord Charles Beresford, in the Channel Fleet, any invention for coaling at sea would receive, not only a fair trial, but a most intelligent one. I agree with what has fallen from Mr. Arnold Hills, namely, that if we could adopt a satisfactory means of coaling at sea it might lead to a reduction in the size of our ships, that is to say, we might have five battle-ships with the displacement of four of the present vessels, for these cruising colliers would carry other stores besides coal, and thus considerably reduce weights. There can be no doubt, of course, that the Admiralty are fully alive to the importance of coaling at sea. Doubtless many plans and proposals have been submitted to them; but I can sympathise with the inventor and the proprietors of the Thames Iron Works in being kept in a state of suspense as to whether their invention is likely to have a trial or not, particularly as Mr. Hills has stated that his firm is ready to contribute a large sum towards the expenses of the trial. I will not detain you longer, but am quite sure you will join with me in according a hearty vote of thanks to Mr. Mackrow for his clever invention, and thank him for showing us the working model at this Institution.