On Coaling Ships

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Wednesday, February 6, 1889.

REAR-ADMIRAL P. H. COLOMB, Member of Council, in the Chair.

ON COALING SHIPS.

By Lieutenant T. Y. GREET, R.N.

(Read in his absence by Mr. R. A. Baillie, C.E.)

ANYBODY who witnessed the Manœuvres of 1888 must have been struck by the deplorable condition of the coaling arrangements of the Fleet. This, the most important factor in the whole science of naval warfare, appears to have been lost sight of in the great, and certainly very important items, of speed, armour, and guns. Yet what will be the use of these, if the ship cannot move for want of the means of propulsion? Take one example—there are many—the Blockading Squadron off Lough Swilly. It must be remembered that the enemy was in his own port, he could constantly replenish his bunkers. But how different the case of the Blockading Squadron: they were always on the move—which meant using coal, especially as they had to be ready at short notice to go full speed—and the consumption of these big ships is considerable; in consequence, one or more of them was always out of action, filling up with coal, so that really a fleet of ten ships can only be considered one of eight. Now, while these two ships are coaling, the remainder are steadily but surely eating away at their coal; suddenly the blockade is broken, the Blockaded Fleet shoots out well filled up with coal. The Admiral of the Blockading Fleet follows, but how far? His ships have only half their bunkers full, or perhaps some are nearly full and others nearly empty, and to his disgust he has either to give up the chase, or risk capture through going on with an inferior force; or perhaps in the excitement he forgets that coal is running short in some of the ships, and they have to be left behind to their fate, or towed by others into a port. Can anybody imagine anything more heartbreaking or more calculated to lead to disaster? Yet I think this must have been apparent to every man in the Fleet. Surely the time has now come when this all-important question should be given the attention which it merits; let speed, guns, and armour rest awhile—not a bad idea, as people appear to be getting somewhat mixed on those subjects through over-attention—and they will then be able to go back to them with redoubled vigour, their minds strengthened by change and rest.

Now, let us see some statistics on this coaling. Luckily, during

the manœuvres the weather was for the most part fine; it might be otherwise. In the first place, ships had to go some distance to a harbour; this meant coal both to get there and also to return to the Fleet, as it had to be done at a somewhat quick rate of steaming, coaling at sea under the present arrangements being almost out of the question, yet it could be done in very fine weather. Private vessels are afraid to go alongside a man-of-war, even in very ordinary weather, for fear of getting stove in; of course this is natural, but it will not do on service. The Admiralty ought to have their own colliers. The following are some of the times taken in coaling:—

"Agincourt," at Plymouth, with a large lighter on each side, fitted with derricks and steam winches and every facility, owing to her numerous ports	500 tons.	12 hours.
"Iron Duke," at Plymouth, with one lighter, but having only one hatch, consequently only able to coal in one position	330 "	22 "
"Iron Duke," at Portsmouth, a jetty on one side, and a lighter on the other, bags being already filled	55 "	2½ "

At Spithead, it was really pitiful to see a lighter with two small derricks coaling a ship, one bag going up at a time. The above are the arrangements at the two principal Naval Arsenals in the Kingdom.

Now, from colliers at Lamlash, which may be taken as an example of what would go on in war-time, and which had two hatches and two steam winches—

The "Agincourt" took in.....	187 tons.	9 hours.
The "Shannon" "	146 "	12 "
The "Iron Duke" "	167 "	9½ "
The "Tartar" "	63 "	6 "
The "Neptune" "	250 "	10 "
The "Inflexible" "	227 "	12 "
The "Inconstant" "	197 "	13½ "

At Sheep Haven, in a heavy swell, and coaling all night in pouring rain from a collier—

The "Iron Duke" took in.....	116 tons.	9½ hours.
The "Iron Duke" took in, at Lockandaile	220 "	9 "

In the Downs from horse-boats carrying about 12 tons, which had to be hauled to and from the collier to the ship, and using cutters for towing, bags being filled by men from ship:—

The "Iron Duke" took in.....	97 tons.	12 hours.
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The following gives some idea of what is at present considered smart work in coaling:—One Commander signals to another, "375 tons in 19 hours, what do you think of it?" Yet considering that ships carry 1,000 tons as a rule, this would mean a ship being out of action for nearly three days; and one has to consider what would be the result to the men? They come away from a blockade harassed and worn out by the anxiety of night and day look-out and constant attack by torpedo-boats, to have three days of utter discomfort and

extreme hard work, which I venture to say would swell the sick list to an alarming extent, and so tend to cripple the fighting capabilities of the ship, as every man is a fighting factor.

Now, from the foregoing, it is evident that what is required is that a ship should be able to take in her coal on her station in the blockade, and at a very quick rate; also that she should constantly replenish, and so be ready for any contingency. There is a great advantage in filling up frequently before too much is used; if necessary a portion, according to deck space, can be left on deck more conveniently and stowed at leisure, as everybody knows it is the last part of coaling that takes so long on account of the stowage. This leads us to another matter which greatly needs alteration, that is the present shape and position of the bunkers and the means of filling them. It would appear as if when the ship is designed everything has its place allotted, after which the remaining space, mostly holes and corners, is designated "coals;" therein lies a great cause of delay. Why not make the bunkers of plain shape; wing bunkers round the engines and boilers, and plain boxes going right across the ship before and abaft the boilers? These would dispense with the numerous holes in the deck, and their shoots, also with having to move the coal about the deck to them from where it comes in. Then instead have a trunk or shaft of convenient size cut in the deck fitted with a sufficiently strong hatch of iron, and from this, shoots at an *angle* to carry the coal to all parts of the bunkers; if any trimming is required these shoots can be cut off by dropping a shutter in them.

Let us refer to the various methods now in use at the different yards.

It seems strange that the coaling arrangements at present are practically the same as they were when steam was first introduced into the Navy, although the subject has been several times discussed in this Institution. The only difference that I can see in the last twenty-one years is that we have borrowed from abroad the system of coaling with baskets, this only at the western port; and canvas buckets holding about 78 lbs. are now on trial. Of course the cheapness of native labour renders coaling abroad quicker on account of the number of men that can be employed, and these men do little or nothing else; but this description of labour makes them, being barefooted and having little clothing to hamper them in their movements, adepts at it.

At the western port, alongside the dockyard, the coaling is done by means of carts (carrying about a ton each load) which bring the coal from the shed and shoot it alongside the ship; it is then passed in through the ports by means of baskets holding about 100 lbs. each.

By these means 600 tons are taken in in 15½ hours. Here it depends upon the rapidity of the carting, the endurance and the smartness of the manual labour.

For coaling in the Sound, hulks are fitted with derricks and steam winches; some of these only have one hatchway, consequently, most of the older ironclads and vessels can only coal from one position at a time, which is a great source of delay; this is especially the case with vessels having a battery, and, consequently, few ports. The coal

in these hulks is in bulk, and is got on board in bags, which have to be filled by men from the ship coaling.

At Portland, the bags are first filled at the coal wharf by men from the ship coaling, they are got into lighters fitted with no appliances, and then hoisted on board. This is a very tedious process.

At Portsmouth, the coal bags are generally ready filled at the wharf, and the lighters also are loaded with them, whence they are hoisted in by the ship's appliances.

The system of loading by baskets is certainly by far the best at present; it is a question whether the smaller baskets used abroad are not better, especially if they were supplied for coaling from lighters, which is not the case at present. At Sydney, Cape Breton Island, vessels go alongside a wharf, down which trucks are run, and their contents, about $4\frac{1}{2}$ tons, are shot on to the deck of the ship.

The system advocated in this paper certainly has the following advantages over any other at present adopted, viz.: (a) Is quicker, (b) much cheaper, (c) more efficient.

(a) It is quicker, because a continuous stream of coal is always pouring into the bunkers, and there is no delay hooking on bags or filling them, nor cause for desire to "stand easy" among the men, few of whom would be required, which would be a great advantage in war-time.

(b) Cheaper, owing to saving in the cost of coal bags, which quickly wear out, and many of which are lost overboard. It would save transshipment (at present transshipment occurs twice) if colliers are used instead of the hulks as at present, and cost of hulks' crews will be saved. If there were two of these colliers of about 1,000 tons each at each port, one of which could always be loading while the other was at Spithead or in the Sound supplying the fleet, and a wharf with tipping-trucks for the harbour, coaling would not be the lengthy operation it is at present. This, I submit, would be a great saving to the Admiralty.

I am not quite certain about my figures, but am not far wrong. Welsh coal costs 7s. per ton at the pit's mouth, and north country coal 5s. Freight to Plymouth is about 4s. 3d., and to Portsmouth per ton 4s. 6d.; these are low prices. The transshipment from collier to yard or lighter, roughly, 1s. 2d. per ton; this makes the cost per ton to the shipper, taking the average, about 11s. 6d. The rate-book says the contract price is 15s. 2d.; perhaps the Admiralty put something on for maintenance of hulks, cost of bags, general wear and tear, &c.; but I think the Admiralty might save at least 5s. per ton by having their own colliers fitted in the method below described, and have far greater efficiency; in time of war it would be almost imperative that they should have their own vessels, of whatever description used, for the reason I have before mentioned, and because merchant captains at present are afraid to go alongside a man-of-war, and there are other reasons which will occur to all Naval Officers. These vessels could be classed in the same category as the yard craft, and the saving in the expense of coal would soon pay for the building of vessels. In the case of transshipment to the harbour dépôt, the new collier would

discharge the coal at a much lower figure into the trucks, and at a much quicker rate.

(c.) It is more efficient because practically automatic, and not dependent on manual labour.

With regard to coaling at sea, under the same conditions of wind and weather, it would certainly have the same advantages over the present system there as it would have in port.

I think it hardly necessary to discuss the way in which the coaling is done on board a man-of-war. But suffice it to say, it is done by whips from yards, stays or derricks rigged over the ports, manual labour and steam capstan being the power employed.

The following is a description of the vessel and her appliances:—

The collier can be of any size, and fitted out as a sea-going vessel, with engines of sufficient power to insure a good speed.

The coaling apparatus is worked by steam supplied from the main boilers; this is important, because no donkey or auxiliary boilers are required. The exhaust steam from the coaling machinery is carried back to main condensers in engine-room, thus keeping the water in main boilers in good condition, as no waste is required to be made up by sea-water feed.

The coal is delivered on board the ship through telescopic iron tubes or shoots, direct into portable funnels; or the spout on the end of shoot is placed directly into the bunker hole in the deck, and the delivery is regulated by the speed of coaling machinery, and may be from 20 to 200 tons per hour, as found most convenient.

The holds are ceiled at sides and bottom with light plating to secure a smooth surface and facilitate the flow of coal to lower ends of booms.

The collier is fitted with six bulkheads. The machinery for working the cargo is fixed between the two midship bulkheads, and consists of one pair of small engines to work the coal buckets, and another pair to lift and lower the hopper and coal shoots.

Heavy wood rubbing pieces are attached on the sides and gunwale.

The forward part below deck is conveniently fitted up for berthing the crew. The after part below deck with cabins, &c., for Officers. The lavatories are placed under the bridge deck forward.

When in special cases of build, ballast is required, the ceiling in bottom of holds is made thicker, the space between ceiling and bottom forming a very convenient water-ballast chamber.

The price is of course dependent on the requirement and capacity, the larger the collier the less cost per ton.

The coaling of steamships is by this method performed very quickly, at minimum of labour and dust.

On account of the sponson ports and overhanging gear on a man-of-war's sides, the collier should carry very large fenders of about six feet in diameter; there would then be little chance of damage being done to either collier or warship. These fenders could easily be made of a suitable material giving lightness and elasticity, for instance, coir rope.

An exact position with regard to lying alongside is not necessary, as

the end of the coal shoot is quickly guyed to any particular bunker-hole where the coal is required. This is a very important feature, as it gives the men time to carefully trim the bunkers, and not interfere with the steady delivery of coal.

The coal is delivered into the telescopic shoot from a hopper supplied by buckets, each of one hundredweight or other suitable capacity, attached to steel endless chains, working on barrels on the ends of a light steel-plated boom. The upper ends of booms are hinged on the barrel shaft working in bearings secured to the hopper. The hopper is guided vertically by the light plated steel columns, and lifted or lowered by screws attached to under side of hopper, worked by suitable machinery placed in the centre compartment under deck. The elevation of the hopper is decided by the position and level of coal in the holds. The two operations, viz., elevating coal to the hopper, and lifting or lowering the hopper with coal shoots attached, are quite independent of each other and simultaneous, and manipulated from the same locality; when the last part of the cargo is being delivered, the hopper is at its lowest position, with the lower ends of bucket-booms at the farthest ends of the holds. At the commencement of discharging cargo, the traveller-wheels on lower end of booms are resting on the surface of the coal. As the cargo is being discharged, the booms gradually radiate to the position tinted blue, the traveller wheels resting on the bottom ceiling plating, then by lowering the hopper the ends of the booms travel to the extreme limits of the holds. The operations of elevating the coal to the hopper, of lowering or lifting the hopper with coal shoots are entirely in the hands of the engineer, and made at intervals or continuous as may be convenient.

When making the voyage the apparatus is lowered to the position shown, the light steel-plated columns being telescopic, the coal shoots are turned fore and aft, the whole occupying the small central deck space shown on plan. The whole apparatus then offers very little surface to the wind.

When bunker-holes are inaccessible to ends of coal-shoots, the delivery is directed in portable tubes or trolleys, and tipped at a convenient bunker-hole. These trolleys form part of the collier's gear, are made light, and readily lifted on board. The portable funnels before mentioned are also part of her gear. Thus the collier is adapted and fitted for coaling any ship.

Men-of-war can also use their collision mats rolled to form a fender. By these means, and with slight way on, the hawser from the collier to the ship being made fast on the inner bow of the former, in order to allow a stream of water to pass between the two, coaling at sea from a collier as described above would not be a very formidable operation, and in harbour would apparently meet all requirements.

A single apparatus can be applied easily to an ordinary collier, where the machinery can either be placed below by building a bulk-head, or on deck like an ordinary donkey engine. Supposing the vessel has two holds, one can be placed at each of them, and each apparatus can be made to discharge 100 tons an hour.

Mr. JAMES RIGO, C.E. : I should have preferred that some one else had been called upon before myself to take part in this discussion, and I will endeavour to be as brief as possible. My business is that of an engineer, and, in connection with this question of loading coal, I have been at work now more than twenty years. In the year 1882 the difficulty of coaling steamers was brought before me very prominently by a firm of shipowners in Liverpool, and I was led to take out a patent for a method of doing almost exactly what this steam collier is intended to accomplish. With regard to the drawings which are before us, I cannot help thinking that they are open to criticism, and that they are here for that purpose; and, among other matters which it seems to me may be criticized and condemned more particularly is the bucket, which I consider would be impracticable. Buckets are not suitable for loading coal, and that preferred in the Navy cannot be put into buckets at all, because it is South Wales coal, and is in far larger blocks than that obtained in Lancashire and the North. The coal to be dealt with would require trays and not buckets such as these. In my specification I have made a difference between *buckets*, which were a success for loading grain, and the *trays*, which we intended to use under similar circumstances to those now under discussion. I understand the booms travel along the coal. If they are not protected in their travel *from* the coal I do not think it possible satisfactorily to work the machinery which we are informed is placed amidships for raising and lowering the columns to which these booms are attached. There are other matters of detail which, I think, are open to criticism, but the object intended to be attained is a very admirable one, and I think, subject to these criticisms, this could be made perfectly practicable as a collier for coaling a man-of-war at sea. There are, however, other occasions when these, as well as other vessels, have to be coaled, and I venture to think they are as important, if not more so, than coaling at sea. There are coaling stations of three kinds. In the first place, those in which coal is loaded from railway trucks at a considerable elevation. Secondly, there are stations such as that of the Tanjong Pagar Dock Company at Singapore, where they take coal out in cargoes, stow it in sheds, and that coal is subsequently put on board the steamers by means of a large staff of coolies, the whole of the coal being carried on these men's shoulders. Thirdly, the most important description of coaling station is such as that of the Grand Canary Coaling Company, where the coal must be loaded out in the open, just as grain is also loaded at Taganrog. These three cases have to be dealt with, and I think each of them is quite as important as the one which is the exact subject under consideration. As it is of interest I will just add, with regard to this patent of my own for a floating elevator, of which here are the drawings, that I found, on taking it out in 1882, that the cost of coaling, as compared with manual labour in Liverpool, would be as follows. The calculation from which I quote formed part of a descriptive article respecting my system which appeared in "Engineering" at that time:—

"Cost of Bunkering Coal with Patent Elevator.

	£	s.	d.	s.	d.
Engineer, per week.....	2	0	0		
Stoker	1	7	0		
Additional labour (two men).....	2	10	0		
	5	17	0		
Depreciation 10 per cent. on cost of elevator (2,500 <i>l.</i>) for one week.....	4	16	2		
Coal and stores per week (three working days)....	3	5	0		
Filling.—Eight men, each 7 tons per hour = 56 tons per hour or 560 tons in 10 hours (1 day) = 1,680 tons in 3 days at 1 <i>½</i> d. per ton.....	8	15	0		
Trimming 1,680 tons in bunkers at 2 <i>½</i> d.....	17	10	0		
Royalty on 1,680 tons at 0 <i>½</i> d.	3	10	0		
	43	13	2		per ton.
Present charge is 1,680 at 1 <i>s.</i> 6 <i>d.</i>	126	0	0		= 0 6 <i>½</i>
	82	6	10		= 0 11 <i>½</i> "

Now, the buckets must be filled by hand, and I venture to assert, without fear of contradiction, that it is utterly impossible to load coal in the manner shown by these buckets. It can never be taken up by such buckets, but must be put in by hand, and the price which is now being paid, or was then paid, was 14*d.* a ton for that labour. The best gangs of coal stvedores were found to be capable of lifting, each man, seven tons of coal in sixty minutes; therefore, eight men, being a gang capable of working at these elevators, each lifting seven tons per hour, would result as shown in 1,680 tons being loaded in three days at 14*d.*, or 8*l.* 15*s.* for this labour.

Captain FITZGERALD: How high will they lift it?

Mr. RIGG: Merely within a man's reach into the buckets. To this were added trimming and royalty, thus resulting in the cost shown of 64*d.* per ton. The charge then being made by stvedores was 1*s.* 6*d.*; therefore there was an economy of 114*d.* by adopting this mechanical method of loading as distinguished from the system of loading by manual labour, if it may be called a system at all; so that there is a loss of 1*s.* per ton on that account. I will not trouble you with more detail than this, because I feel my time ought properly to be limited, but I may mention that I have within the last six months completed, at the request of the President of La Société Française des Houillères du Nèver, the drawings and specifications for the machinery, and it is now being built in France, of an elevator which is to be erected at Venezuela for this precise purpose of coaling steamers, but steamers which can be brought alongside. There are about ten drawings here and twenty sheets of specifications in connection with it. The first drawing gives a side elevation of this portable elevator for loading into side bunkers on both sides of a steamer simultaneously.

The CHAIRMAN: I do not want to interrupt you, but I am a little struck by the fact that we must not get away from the discussion of this particular paper to another. Probably we shall be very glad to hear the details from you on a proper occasion, but your remarks are too far away, if I may say so.

Mr. RIGG: The question of side bunkers was raised as an incident in the paper. Here are side bunkers as shown in the sectional drawing provided by the French Transatlantic Mail Steamship Company. The whole of the work is done by one pair of winding engines and by one man, and the expense is found to be very much less than that of manual labour. I am perfectly satisfied that a mechanical method of loading coal will have to be adopted before long. I might add one word to what I said just now. A question has been raised as to whether the elevator described in the paper has been tried. I understand it has not; but with regard to this one of my own, I spent the summer of 1883 with it on the Black Sea. We loaded under test at the rate of about 160 tons per hour, and I employed with it only a pair of 7-inch steam-engines. I believe this is the largest quantity that has ever been turned over within that time. The elevator with its pontoons weighed about 70 tons.

Captain FITZGERALD: I do not propose to follow the last speaker through his explanation of his drawings: I would rather confine myself to the paper which has been read. I cannot believe, in the first place, that the continuous action which, if I understand it aright, is supposed to take place with these buckets, like an ordinary dredger, would work in the way supposed. I think something of the kind might be devised in which you could fill the buckets by hand. There would be very little manual labour in shovelling the coal down hill into the buckets and working the hoist intermittently, so to speak, elevating the coal, and getting it a good height, so that it will run down into the bunkers; but as to this continuous working with the closed shoots, when I hear that it has never been tried, I am very much inclined to look at it with considerable scepticism. I think the shoots would be almost certain to choke in a very short time, and those closed shoots choked would stop work altogether. I understand it is not intended to be used for coaling at sea. The last speaker alluded to that, but I should think any seaman who saw that arrangement coming alongside at sea would ask them to haul off, and would rather chance bags or any other method, because the whole thing is too gimcrack for use at sea. There is one point to be considered in this coaling question (of course the Officer who read this paper is considering a man-of-war, and not a merchant

ship, like the last speaker). We are considering the coaling of a man-of-war, but as a matter of fact the coal is put on the deck of a man-of-war faster than it is wanted in many cases. It is a question of stowage. Generally after the first hundred tons or two are on board there is no use shooting coal on the deck. In the modern ships there is no deck to shoot it on to as a rule. The writer says there is a great advantage in filling up frequently before too much coal is used. So there would be if you could get it in; but in the way our men-of-war are built now, in a great many cases you cannot get the coal in till about one-third of it is out. It does not run down your bunkers. You may burn 100 tons of coal, and you may say "coal ship," but you cannot *do* it. From the shape of the bunkers the coal won't go down; it does not run away from the top, therefore you cannot fill up constantly. Then there is another question. The writer suggests, "Why not make the bunkers of plain shape; wing bunkers round the engines and boilers, and plain boxes going right across the ship, before and abaft the boilers?" I should like to see what the naval architect hes to say to that. The writer evidently does not remember that our coal is our armour in modern ships. They have taken away our armour, and we are to trust to the coal for protection, and so far from plain bunkers running across the ship, one of the principal things we are to trust to for armour to keep the ship from being sunk, or the engines being smashed, is coal stowed in all sorts of in and out complicated places. You have to deal with the fact that the bunkers are not as you would like them to be. As we hear that this ingenious machine has not been tried, I think we are justified in saying try it before asking us to accept it, and I am very much afraid it will be found to be utterly unpractical.

MR. JOHN COLLETT: I should like to make a few remarks on one point. The lecturer tells us that with two colliers for each dockyard, carrying about 1,000 tons of coal each, there would be a saving by his system of 5s. a ton on the present method of supply. It is not quite clear to my mind how that is arrived at, but the greater part of it is apparently obtained by deducting the cost of the coal at Portsmouth, estimated at 11s. 6d. a ton, from the alleged rate-book price. So far from any saving being effected, I am prepared to contend that the cost would be considerably more than at present. Descending to details, the cost quoted of Welsh coal at the pit's mouth, the freight to Portsmouth, and of discharging, may be taken as fairly accurate, assuming, as appears to be the case, that the data are those of about twelve months ago; but there is an error of addition, which makes the total 12s. 6d., and not 11s. 6d. per ton. One element, however, that of transhipment from the collier to the yard, is usually included in the freight, and may be taken in diminution. On the other hand, the cost of transfer of coal from the pit's mouth to the docks at Cardiff, which is, roughly speaking, about 1s. 6d. a ton, is omitted. The data given, corrected in the way I have suggested, will make the estimate 13s., not 11s. 6d., a ton. Again, the contract price, alleged to be derived from the rate-book, is taken at 15s. 2d. per ton; as a matter of fact, the average of rate book price was 12s. 3d. last year, the price at Portsmouth being even under 12s. I think that these facts show that the greater part of the alleged saving disappears at once. Certainly there would be a small saving in the number of coal bags used, and in wear and tear of the hulks, &c., but it would not amount to much. It is stated further that two colliers would be required at each port, or for the four principal ports alone, eight in all. To compare this system financially with the present system, you must employ these colliers continually, so as to bring the freight down to what you pay to the merchant colliers at present, assuming that the Admiralty colliers are worked as cheaply. But two colliers of 1,000 tons each, running continuously, taking the average voyage at 10 days, viz., $1\frac{1}{2}$ day going, $1\frac{1}{2}$ day coming back, 2 days loading, and 2 discharging, and a margin of 3 days for the run, which is a moderate allowance, would considerably more than meet the requirements of the whole of the yards. You therefore have too many colliers for ordinary purposes, and, on the other hand, you have too few for quick supply. When wanted—for in time of war or any other emergency what would be the use of two, or even eight, colliers?—you would want a large fleet of them, not only for supplying the home yards, but all the squadrons round the coast. It would be impossible, I consider, for the Admiralty, with any regard for economy, to keep always in reserve a huge fleet of colliers equipped in this manner. Supposing the mechanical plan

advocated were practicable, the only feasible way to give effect to it would be to subsidize colliers to keep the apparatus on board; but this would also mean a large annual expense. In conclusion, I must confess that I do not see, even if the price of coal under both plans be taken as the same, and I have shown that the actual price is less than that estimated, how you can escape a very much larger cost under Lieutenant Greet's plan than the present system involves.

Captain CHASE PARR, R.N.: The last speaker has shown that the expense of maintaining these colliers constantly in use would be considerable, and keeping that gear fitted would also lead to considerable expense; but I do not see why colliers should not be provided with simple whips and derricks in the same way the colliers at Sydney are fitted, which bring the coal round from Newcastle and put it on board the men-of-war in the harbour of Sydney over the upper works of the highest man-of-war at a very much quicker rate than it can possibly be stowed in the bunkers. Of course for the first couple of hours perhaps the run of coal is not as fast as it can be stowed in the bunkers, but after that for the last two or three hours the delay in the stowing is so great that a very much slower supply of coal is all that is needed, and I think for war-time all that would be needed would be that a certain number of colliers should be provided with this very simple whip and derrick apparatus, and that that would meet all the requirements of the case. These vessels ought not to be too large.

The CHAIRMAN (Admiral Colomb): It is usual for the Chairman to say a word or two before calling upon the lecturer to answer the criticisms that have been offered. I think, small though we are in number, the discussion has been distinctly useful, and a great deal of light has been thrown upon the question from one or two points of view. I understood the paper myself to be founded almost actually upon the experience of the last year's manœuvres—I took that from what is said at the beginning of the paper—and that the intention was to remove those difficulties and not to go further into the question. I do not know what was in the lecturer's mind, but the question during the manœuvres, as far as it came under my notice, was that either large colliers required some much more rapid means of discharge than they possessed, or else that the colliers supplying a fleet in that way must be small and numerous. With these large colliers there was great delay after being placed alongside one ship before they could get to the next, and the whole fleet could not be coaled till this process had been gone through with each ship in succession. I rather supposed, I do not know whether I am right or not, that this arrangement was entirely with a view of removing that difficulty, and I presumed the idea was that colliers employed by the Government would be fitted in some method of this kind. I am not competent to criticize the machinery, and to say whether it would answer its purpose or not. We have this advantage, that the gentleman who is reading the paper for the lecturer is a competent man, and the firm to which he belongs is a competent firm. I think Mr. Rigg's remarks have been in that way very useful too, and that it is a great advantage for us that engineering firms are turning their attention to this question, which every naval Officer knows is a very important one and wants to see solved in some way. The question before us to-day, as I understand it, has not been the sea part of the business, but the coaling in harbour, and especially the coaling of fleets in harbour under pressure of war and away from regular naval bases, making attacks upon the enemy's coast and that sort of thing; or blockading where you have not your home appliances ready, and where those appliances must appear in the ships attached to the fleet for the purpose of coaling them. I will now call upon the gentleman who read the paper to answer the criticisms which have been made upon it.

Mr. BAILLIE: With reference to the cost of coal, I took the average cost of Welsh coal and north country coal at Portsmouth and Plymouth, and I think on running it out, it came more exactly at 11s. 6½d. I could not be certain about the contract price being 15s. 2d.; they are Lieutenant Greet's figures. Mr. Collett would know the exact present contract price. As to the bunkers, I think ships are at the present time being built with cross bunkers and wing bunkers along the engines and boilers.

Captain FITZGERALD: Where?

Mr. BAILLIE: In the "Camperdown," at Portsmouth. There are also the water-

ballast chambers, which, with the cabin and ward rooms along the engine and boiler space, would be use for coal in war-time.

Captain FITZGERALD: Every bunker is divided into about twenty different compartments. All I meant to imply was that the modern ships' bunkers were unfortunately more complicated than the old ones which we have hitherto had to deal with.

Mr. BAILLIE: Of course we know that the stowage and trimming of coal takes the longest time, but if there were more men available for stowing the coal, which would be the case if the coal were put on board by machinery, the trimming and stowage would be done much quicker. With reference to machinery, I may mention that the size of the engines required to elevate the coal in the present design would be two 8-inch cylinders, 16-inch stroke. The weights of the different parts of the machinery above deck would be: cross head, hopper, wheels with bearings and shafts, 3 tons 5 cwt.; the two booms with wheels at lower ends and rollers, 6 tons; shoots and nozzles, 3 tons; two sets of 40 buckets and chains, 4 tons 10 cwt. This makes a total weight of say, roughly, 17 tons. The four top columns weigh 4 tons. Working out the centre of gravity of the above, I found it was about 10 feet above deck when the whole apparatus is lowered ready for sea. The collier is designed to carry 800 tons of coal with a total displacement of 1,880 tons.

The CHAIRMAN: It only remains my pleasing duty to return your thanks to Lieutenant Greet, in his absence, for his paper, and also to Mr. Baillie for the able way in which he has read it.