INSTITUTE OF MARINE ENGINEERS

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SESSION 1904-1905.

President—THE HON. C. A. PARSONS.

Local President (*B.C.C.*)—LORD TREDEGAR.

Volume XVI.

ONE HUNDRED AND SIXTEENTH PAPER (OF TRANSACTIONS).

THE APPLICATION OF ELECTRIC POWER ON CARGO STEAMERS.

BY

MR. D. K. ROBERTS (MEMBER).

READ AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, FEBRUARY 24th, 1904.

READ AT

58 ROMFORD ROAD, STRATFORD, E.

ON

MONDAY, MARCH 28th, 1904.

PREFACE.

3 Park Place,

Cardiff,

February 24th, 1904.

A general meeting of the Bristol Channel Centre of the Institute of Marine Engineers was held here this evening, Mr. J. Darling presiding over a crowded attendance. The following nominations were made for office-bearers and members of committee: As Chairman of the Centre, Lord Tredegar; and Messrs. M. W. Aisbitt, John Geo. Walliker, A. E. Smithson, J. Fleming, T. A. Reed, J. Chellew, D. K. Roberts, W. S. P. Collings, John Scott, Charles Jones, E. Mott, W. Graham, J. T. Shelton, S. W. Allen, W. Evans and Frank Shearman. Mr. Aisbitt is the retiring vice-president, Mr. Walliker the hon. secretary, Mr. Smithson the hon. treasurer, Mr. Fleming the representative to Council, and Messrs. Reed, Chellew and W. Simpson the retiring committee-men. The last-named gentleman withdrew.

J. G. Walliker,
Hon. local Secretary.

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In these days of keen competition and low freights, the margin of profit in the ordinary cargo steamer is reduced to vanishing point, and while it is the constant aim of shipping managers to cut down expenses to the lowest limit, it is difficult to see how under present conditions the margin of profit can be increased without taking full advantage of the improvements which science and our increased knowledge of the adaptability and economy of electric power offer us.

During the last decade the use of electric power for various industrial purposes has advanced by rapid strides, and for economy in production and facility of distribution has proved far in advance of any system of steam power, more especially when the power has to be utilized over a large area, involving numerous lines of shafting and belting, or subdivided into comparatively small units, each taking its supply of steam from a central group of Boilers through a system of distributing pipes.

A familiar example is that of a large shipbuilding yard or engineering works, where the machinery is scattered or divided into groups, which may not require to be at work simultaneously, but which must each be ready to do its work when required. With steam as the motive power, this machinery, driven by belts and shafting from a central station, is subject to a considerable loss through the necessity of driving the line shafting constantly, while in the case of scattered groups of steam driven plant the principal loss is due to condensation of steam in long lines of pipes, with risk of damage and leakage.

By the adoption of electric power, distributed from a central station, all these losses are avoided. The power is completely under control, and the plant may be divided up into groups, each driven by its own electric motor, the lines of shafting and belts reduced to a minimum, and a decided saving in power and cost effected.

The saving is largely due to the arrangement of generating machinery. Instead of a number of engines at various distances from the boilers, using enormous quantities of steam per I.H.P., with all the incidental losses by leakage of joints, condensation in pipes, etc., we have one well arranged and closely governed steam engine situated in close proximity to the boilers, with a comparatively short length of steam pipe, well protected and accessible at all times.

The dynamo being arranged to maintain a constant speed under any variation of load, the engine governor is so devised as to cut off steam or open out as required to maintain this constant speed, and so we have a saving at the very source of the power, from the fact that at the moment one or more of the motors are switched out of circuit, the engine instantly responds by reducing automatically the quantity of steam supplied.

So well are these generating sets controlled that the variation in speed on suddenly switching from light to full load, or *vice versa*, does not exceed 5 per cent.

At the present day, the construction of electrical machinery and the application of electric power are, in my opinion, much further advanced than steam power was at the period when the latter was first adopted for marine propulsion on a commercial scale, and while it may yet be years before we arrive at that stage of progress where we can propel our ships by electricity alone, this being generated in shore stations and stored on board in accumulators or storage batteries, yet the writer believes that the time has come when serious consideration should be given to this economical method of distributing power on board ship, if not for the main propelling engines, at least for the auxiliary machinery.

It is with this view that the writer offers the suggestion of the adoption of electric power on cargo ships, the power to be generated in a central station by a steam engine of economical type, and thence distributed to the pumps, fans, and other machinery auxiliary to the main engines, and also to be utilised in port for the rapid and economical handling of cargo.

It is generally agreed among marine engineers that the auxiliary machinery, such as feed pumps, air, circulating and bilge pumps, should not be driven from the main engines, but should be as far as possible independent, as they are then better under control and less liable to risk of accident when main engines are racing, and can also be worked under more economical conditions. The principal objection to the independent system is the additional amount of steam required by a number of separate engines, the difficulty in working this steam expansively and so utilising the greatest amount of heat, and also the serious loss due to condensation in the pipes.

Various plans have been suggested to overcome these difficulties, but it appears to the writer that the most economical of all is to drive this auxiliary machinery by electric power. The work required of the pumps is variable in amount, and while a direct acting steam engine can be so controlled as to respond to these variations, there is still a considerable amount of loss.

The electric motor is an ideal method of driving machinery, as it automatically adapts itself to the variations required, and only absorbs from the source of power the exact quantity required for the work in hand.

Dealing first with the question of generating plant, it is well to note here that the demand for machinery for ship lighting purposes has grown rapidly within the last few years, with the result that there are now on the market combined engines and dynamos specially adapted to the peculiar conditions on shipboard, where space occupied, weight of plant, and reliability in running must all be carefully considered.

There is, therefore, no difficulty so far; it is merely a question of increase of power, and as the power of the plant must be equal to the maximum demand, it is easily arrived at.

For the purpose of illustration, the writer proposes to take a cargo steamer recently built. The length of this ship is 460 ft., dead weight capacity 11,000 tons, fitted with forced-draught boilers, with part of auxiliary machinery driven by independent engines, and with a direct driven dynamo for electric lighting purposes, having an output of 18 kilowatts.

This ship has five large cargo hatches, with two steam winches at each hatch. The auxiliary boiler which supplies steam for the winches, etc., is 14 ft. 6 in. diameter by 11 ft. 6 in. long, and can be utilised at sea as a main boiler under natural draught. The main engines develop about 2,000 I.H.P. at sea.

While at sea on the voyage, the normal full load will be the power required for the main engine pumps, forced-draught fans and lighting circuit, and may be taken as follows:

Air pump	10	effective H.P.
Feed pumps	20	,,
Bilge pumps	2½	,,
Circulating (centrifugal)	8½	,,
Forced draught fan ...	6	,,
Lighting circuit ...	24	,,
	72 or, say, 75 H.P. effective.	

In port while discharging cargo the full load will be:

Ten winches at 10 H.P. each ...	100 H.P.
Lighting circuit ,, ...	24 ,,

a maximum load of, say, 125 H.P. effective, but as part of this is intermittent work we may consider 100 H.P. as likely to be the normal full load in port.

To provide against delay by accident or breakdown, it is advisable to supply two sets of generating apparatus, each of which would be capable of taking the normal full load. The two sets can be run in parallel when an unusually heavy load is on, and there would always be a spare set capable of dealing with the normal load in the case of a breakdown.

The writer would, therefore, propose two sets each as follows:

Engine of the vertical compound high speed type.

Diameter of H.P. cylinder ...	9 in.
,, L.P. ,, ...	$15\frac{1}{2}$,,
Length of stroke	7 ,,
Revolutions per minute	500 ,,
Steam pressure	150 lb.
Effective H.P.	100

This engine would be directly coupled to a dynamo of the multipolar type, revolutions 500 per minute, voltage 110 or 220, with an output of 75 kilowatts.

The overall dimensions of this set mounted on bedplate are 12 ft. long, 5 ft. 4 in. wide, and 6 ft. 9 in. extreme height, so that it will be seen the space occupied is not excessive.

The switchboard would be adapted for the double set, and would have two panels, provided with the necessary instruments for measuring pressure and current, and the switches and fuses required for the various circuits.

Regarding the pumps it must be remembered that the demands of the navies of Great Britain and other Powers for electrical machinery have enabled manufacturers to place on the markets standard types of condensers, pumps and motors, which may be relied on, and the pumps here proposed are of this class: Air pump of the well known Edwards' type, with three chambers, each 10 in. diameter, with stroke of 8 in. This pump would be driven, through gearing, by a motor of the protected type running at 1,100 revolutions per minute. Circulating pump of the centrifugal type, 8 in. diameter, directly coupled to a similar motor running at 600 revolutions per minute. The feed pumps to be in duplicate, each consisting of a set of three-throw vertical pumps, diameter of plungers 4 in., length of stroke 6 in., running at sixty revolutions per minute against a pressure of 150 lb. per square inch. The motor would be similar to that of the air-pump but running at 970 revolutions and developing up to 20 horse-power. The forced-draught fan is particularly adapted for electrical driving, and, being directly coupled to the motor, would probably absorb from 3 to 6 horse-power. The bilge pump is similar to the feed pumps in type, but requiring a much smaller motor, and the pump could easily be arranged to work intermittently, and so save power. The lighting circuit would remain the same as at present, and allowing the full amount of 18 kilowatts for which the present lighting dynamo is arranged, it will be seen that the proposed set is able to run at sea well within its rated output, even with all lights on and all pumps in action, so that the best economical results are obtained from the steam.

But although there are undoubted advantages in the use of electric power for driving the auxiliary machinery at sea, this advantage would disappear were there nothing further to be gained by the use of the power in port, as it is in the rapid handling of cargoes that the shipowner expects to effect the greatest saving.

In every new ship that is built this point receives close attention, and the number of derricks and winches is being increased until we have such extreme examples as those of five and seven pairs of twin masts with derricks and winches to correspond, and capable of discharging eight to ten thousand tons of cargo in thirty-six hours.

These are, of course, special ships for special trades; but taking the average ship for general trading, it is clearly recognised that speed in handling cargo is an important factor in the earning power of ships.

This is easily understood, since every day in port means increased outlay in harbour dues; and supposing, for example, that a ship carries under ordinary conditions six cargoes in a year, and by the use of improved appliances for handling is able to get rid of these six cargoes and load a seventh inside the same period, it is clear that the gain will be considerable.

With steam winches it is found that the greatest delays are not due to the incapacity of the winch, as a machine, to handle the weight, but to the difficulty in supplying steam in sufficient quantities to obtain the full power. More especially is this the case in cold weather, or during periods of frost, to say nothing of the cost of running steam winches night and day to prevent freezing up. There is always the risk of serious damage by the water of condensation finding its way into the cylinders, or bursting the pipes by shock.

Again, at sea during bad weather the winch steam-pipes in their exposed position are always liable to damage, and are, as a matter of fact, the cause of continual expense from this damage.

Of course, the obvious remedy for shortness of steam is to increase the size of the donkey boiler; but this, for various reasons, is not always an advantage, while it does not reduce the loss by condensation and risk of damage.

This loss by condensation, when carefully gone into, can be shown to be serious, and the enormous quantity of steam used by winches per useful horse-power is well known to engineers.

In a paper on "The Utilisation of Exhaust Steam," read before the North of England Institute of Mechanical and Mining Engineers, Professor Rateau, dealing with steam consumption of non-condensing free exhaust engines, and the result of his observations and experiments, says: "The steam consumption of this type may be taken at 100 lb. per useful horse-power per hour. This figure is a very high one, and is due to the intermittent character of the work, and to the loss of heat at each stop, which of course reduces the efficiency. It may be assumed that at least 20 per cent. of this steam consumption is lost by condensation in the steam pipes and in the engines."

As these remarks are the result of extensive experiments during actual working, it may be taken that the donkey boiler has to be at least 20 per cent. larger than necessary for the useful work, and in steam winches it would appear that there is room for great economy in fuel and cost of upkeep.

With the use of electric power there are no such disadvantages in distribution. The steam is used in the most economical manner to produce the power, and the power is transmitted with the minimum of loss. Take the question of steam consumption: the great saving on this point alone is clearly evident when we compare the relative piston areas and steam pipe sizes. In the case of the steam winches, we have six winches, each with two 7-in. cylinders; four winches, each with two 6-in. cylinders, giving a combined piston area of 687·9 square inches. In the compound engine driving the generating set we have one cylinder, 9 in. diameter, area 63·62 square inches; and one cylinder, 15½ in. diameter, area 176·71 square inches, giving a combined area of 240·33 square inches, or about one-third of that of the winch cylinders.

Comparing the steam pipe areas, we have in the former case a main supply pipe 5 in. in diameter, the area being 19·68 square inches, and in the latter a main pipe of 3 in. diameter, area being 7·06 square inches, which is again only about one-third of that required for the winches. As regards economy of distribution, the efficiency of the electric motor is very high, and one of the great advantages of electric power over steam, hydraulic or compressed air systems is the transmission of power without transference of matter, so that there is neither gravity nor material friction to be considered. The standard of reliability of electric motors is a very high one, and it may be safely asserted that there is no form of motor which is so reliable and needs so little attention as a modern electric motor. The exceedingly severe conditions under which tramway motors work and the great numbers which are in use, have concentrated an immense amount of experience into a few years, and although the tramway motor is a special machine made for a special purpose, the conditions of which are exactly known, yet most of the points which make the tramway motor so reliable can be, and are, embodied in the best make of motors for general purposes. For crane or winch work which is intermittent in character and deals with greatly varied loads, the series wound motor has great advantages, as it automatically adapts the speed to the load, lifting a heavy load at slow speed and light load at quick speed, or, in other words, the motor has in itself the power to change the ratio of its gearing in accordance with the demand on it. It is this automatic change of speed which makes electric winches so successful, and explains also the enormous success of electric traction.

The proposal made here is to substitute for the ten steam winches an equal number of electric winches of 8 to 10 H.P. effective, the current to be conveyed to these winches by means of portable flexible cables led from junction boxes situated in convenient positions at each end of the deck houses. These cables can be connected or disconnected in a few minutes and coiled up and placed in a store-room, thus leaving the decks entirely free from obstructions at sea. The permanent wiring would be carried up from the distributing panel to these junction boxes, and in most cases this could be arranged without passing through any cargo space, but the details would require to be arranged to suit each particular ship.

The question which naturally occurs to one at this stage is, "How does the cost of all this apparatus compare with that of the present system of steam driven pumps, winches, etc.?"

At first glance it may appear to add greatly to the capital cost of the vessel, but closer investigation shows that the difference in cost is not so great as might be supposed.

We must, in order to arrive at a fair comparison, deduct from our original specification the cost of the various steam driven pumps, fans, winches, etc., which it is proposed to supersede by electrical power.

For the pumps as fitted in the ship we have under consideration, we may allow on a moderate estimate £650, as this includes the cost of pump levers and castings, also cost of independent steam feed and circulating pump, and engine of steam fan.

Allowance must also be made for the cost of the present dynamo and engine used for electric lighting purposes, and this amounts to £400.

For the steam winches on deck we can allow £700, and the actual cost of the steam and exhaust pipes, including pipe chairs, plate covers, distributing valves, etc., is £950.

This figure is the actual cost of piping, etc., from the donkey boiler to winches, and does not include the cost of steam pipe for steering gear, these being led separately, as shown on the lantern slide.

It is interesting to note the great difference in cost between deck steam pipes, which require to be well supported and protected, and the flexible armoured cables which can be led in any direction and occupy little space. The cost of the best double-armoured cable, of a size suitable for the work and sufficient in quantity to wire the winch leads twice over, amounts to about £50, so that on this item alone we save enough to pay the cost of one set of generating plant.

There should also be allowance made for the reduction in size and cost of donkey boiler which is possible under the system, but we can waive that in the meantime and allow the donkey boiler to remain as before.

Our deductions on the original specification, therefore, amount to :

Auxiliary machinery on main engines	£650
Lighting dynamo	400
Steam winches	700
Deck steam pipes	950
	£2,700

Against this we have the following costs for electrical apparatus, the figures being actual quotations from makers :

Generating plant (2 sets)	...	£1,650
Pumps and motors ...	...	800
Switchboard complete ...	...	150
Winches	...	1,000
Deck Wiring, etc. ...	...	100
		£3,700

The difference amounts to £1,000, which, on the capital cost of £66,000, is about $1\frac{1}{2}$ per cent. There is no doubt, however, that the cost of the electric apparatus would be reduced as the demand increased; but taking the above figures, it is evident that the increase in first cost is comparatively slight, while the advantages to be gained are considerable. These advantages may be summarised as follows: Auxiliary machinery independent of main engines, and under complete control; economical generation and distribution of power for same; duplicate sets of the most important items; increase of speed in handling cargo and consequent saving of time; greatly increased economy in the distribution of power to deck machinery; freedom from obstruction on deck by steam-pipes and casings, and reduced risk of damage at sea, with consequent saving of expense; economy of coal both at sea and in port, and reduced tear and wear of donkey boilers.

The writer has purposely refrained from dealing with the technical details of the electrical machinery referred to, as several recent papers read before the Institute have dealt with these matters, but if this paper should lead to a discussion in which any further information is required, the writer will be prepared to supply it.

The following lantern slides will be shown: profile and deck plan of steamer referred to in paper; details of winch steam pipes and distributing valves ; enclosed compound engine and two pole dynamo for ship lighting (Scott and Mountain type); enclosed single engine and similar dynamo ; arrangement of two two-pole dynamos with engine placed between same ; eight vertical spindle motors for centrifugal pumps fitted to Smith's Dock Co.'s pontoon, N. Shields; open front single cylinder engine and two-pole dynamo with portable electric pumps, electric radiator for heating saloons, etc., electric-driven fan and motor (three views). Samples of flexible cables will also be shown.

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, FEBRUARY 24th, 1904.

CHAIRMAN: MR. J. DARLING.

OPENING the discussion, Mr. GEORGE SLOGGETT said he thought that, while the transmission of power by electricity had much to commend it, there might be drawbacks to its use for deck machinery, subject as the motor and cables would be to sea damage and the buffeting of heavy weather voyages. Then there was the question of the extent of electrical training possessed generally by the marine engineer of tramp steamers in modern electrical installations for power. His ability to put right any kind of breakdown to electrically driven winches, etc., which might occur during a voyage, was by no means so certain as it was in breakdowns to steam winches and steam auxiliary machinery. These latter the marine engineer sometimes did wonders with in the way of keeping them running under difficulties, although they caused him many worries. But he believed the fitting on board of a large quantity of the present electrical appliances would greatly add to the engineer's anxieties, unless an electrician were also carried on the vessel.

Mr. YOUNGER said few would be inclined to cast doubt upon Mr. Roberts's statement that great economies had been effected by the adoption of a central power station for driving various machines in a large engineering or shipbuilding establishment. Nevertheless, he knew of an instance in which an electrical installation in an establishment on the Clyde had been superseded by gas engines, and instead of driving the different sections of the engineering shop from one central electrical power station, a number of gas engines, about 100 H.P. each, were placed in the several departments, and a considerable economy was effected over the electrical plant. As to the figures of estimated cost given by Mr. Roberts, he was inclined to doubt that ten serviceable electrical winches could be obtained for £1,000. The paper said nothing about moving the motors and apparatus of the electrical winches from contact with the bedplate when the ship was en voyage. If left on the deck they would be exposed to heavy seas. He very much doubted whether they would be able to stand the tremendous smashing about the deck of waves washing aboard.

Mr. T. A. REED recalled with pleasure that this institute was early in the field in advocating the adoption of electric power on board ships. Some years ago Mr. Sydney Walker advocated the same, and quite lately Mr. E. Nicholl had written a very able paper wherein, like the present writer (Mr. Roberts), he advocated electric-driven winches and other auxiliary machinery. For his part, he believed that electric transmission of power on board sea-going vessels had come to stay, but whether in the present stage of development it was sufficiently far advanced to be thoroughly relied upon was a point upon which shipowners required convincing. Had makers yet produced a thoroughly water-tight motor for permanent use on deck, or was it practicable to take a portable motor out of a dry store-room when the ship came into port and attach it to the winch? In theory it was all very beautiful, and he had not the slightest doubt but that in the near future electrical engineers would have devoted themselves to marine requirements to such good purpose that what were difficulties at the present time would be non-existent, and all auxiliary plant, at least on board ship, would be driven by electricity.

Mr. W. A. Scott (Visitor) said motors under 30 or 40 H.P., suitable for winches, could be built absolutely enclosed and water-tight. As to speed variation, in corporation work electrical engineers were tied down to a maximum of 3 per cent. for momentary speed variation and of 1½ per cent after the load was thrown off. Marine engineers could not wish for much better than that. In many electrical supply stations the whole of the auxiliary machines were run by electrical motors. At Glasgow all the auxiliary pumps—condensing, feed, and circulating pumps—were thus driven, and they had run for two or three years absolutely without a breakdown. They were found to be exceedingly economical. A 10 H.P. motor would easily give 80 per cent. useful effect. As to the cost of electrical winches, a satisfactory motor and winch of 10 H.P. could be obtained for from £110 to £120. All they had to do was to say what they wanted and the electrical engineer would supply it at a price. If he saw there was the demand he would take care to meet it. With regard to motors standing the heavy seas coming on board ship, he cited the case of twelve motors which, at the beginning of the Boer War were abandoned in a mine, and after being in 500 ft. of water for two years they were taken out and simply dried in a stove.

Out of twelve only two were not found equal to being put to work again.

Mr. J. T. SHELTON said he had not had time to carefully read the paper, the discussion of which, he hoped, would be adjourned. The paper was full of suggestion and useful knowledge. At the outset of consideration of electrically-driven winches they must, however, be convinced that there should be no chance left open of the motors being rendered leaky and ineffective by exposure to weather or otherwise.

Mr. HERBERT LEWIS (Visitor) said his experience showed him that the marine engineer had an excellent working knowledge of electricity, and he cited a recent case in which the chief engineer himself took readings with delicate electrical instruments and located a leakage on board. Shipowners and marine superintendents had not taken up this subject of electrical transmission of power on board to the extent that the development of the agent had merited, but he saw unmistakable signs of an awakening.

Mr. W. A. SCOTT said he had omitted in his previous observations to refer to the statement that a firm on the Clyde had seen fit to substitute gas engines for an electrical plant. Of course, each case must be decided on its own conditions, and he was not aware of the circumstances of the case in question. For example, at a colliery in South Wales was at one time an old beam engine—100 in. steam cylinder and 10 ft. stroke—which took four Lancashire boilers of 60 lb. pressure to work it at about two strokes per minute. By the introduction of electricity, one compound engine with $16\frac{3}{4}$ in. h.p. cylinder, 28 l.p., 3 ft. stroke, and one Lancashire boiler at 100 lb. pressure, was driving a three-throw pump in the pit with a motor, and the combined efficiency of the plant was about 68 per cent., from the high H.P. of the engine to the water discharge at the top of the pit. That spoke well for electricity.

Mr. YOUNGER said the firm on the Clyde to which he had alluded effected the change from electricity not because electricity was not economical, but because gas engines were more economical. If they had to generate electricity by first generating steam and compressing it through an engine, they were bound to have less economy than in the case of a gas engine.

The CHAIRMAN agreed with Mr. Reed that electricity had come on board to stay, especially in view of the admitted fact that electrical appliances were now supplied of guaranteed efficiency. For his part, he had no doubt that the marine engineer of to-day was looking ahead and was equipping himself with that electrical knowledge which was bound to be of the greatest use to him. He had already shown himself equal to the management of refrigerating machinery and the electric light on board ship.

On the motion of Mr. MILLS, seconded by Mr. REED, it was resolved to adjourn the discussion.

Adverting to the remarks which had been made, Mr. D. K. ROBERTS said the enclosed motor was practically water-tight. The average sailor played the hose on everything in sight and within reach, and in this way could the outside case of the motor be cleaned. On any wet night in Cardiff they could see tram-car motors submerged; and he believed that whatever breakdowns had occurred such were not due to the motor but to other causes. With regard to the comparative cost of steam and electrically driven winches, the fact that the steam-winch had been standardised reduced the cost to a minimum, and it was safe to buy almost anywhere, the difference in cost between the makers being very trifling. Electrical winches could not be purchased in the same way; there were persons who would supply anything, and a few failures at the beginning might prove disastrous to the adoption of the electrical winch. As to the cost of up-keep, experience showed —there were scores of electrical winches running on the American coast and in the American lakes: whilst the Cunard Company had ordered a considerable number on the Clyde—experience showed that the only cause of depreciation lay in the armatures, which required re-winding from time to time, and was not a costly business. While the electrical winch motor was enclosed, the piston rods and all the gear of the steam winch were always exposed to the action of salt water. With regard to the case on the Clyde mentioned by Mr. Younger, where electricity was substituted by gas, he believed the true explanation was the difference in the cost of gas as supplied at the works and the cost of coal. It was a well-known fact that house gas was much cheaper in Glasgow than in almost any other place in the country, being about 2s. 1d. per 1,000 cubic feet. It was an easy calculation to ascertain the amount of gas per I.H.P. required by this type of gas engine and compare it with the cost of coal required for the same effective power as developed in the steam boiler. Mr. Younger had touched the crux of the thing when he stated that the intervention of the steam boiler was the serious item in electrical power. With regard to damage at sea, the reason he suggested portable cables on deck was that, being used in electric lighting on board ship, they would be familiar to the engineer. There was no difference between the lighting dynamo and the power dynamo: the engineer who could attend to a 25 H.P. lighting circuit could, without any great trouble, attend to a 100 or 200 H.P. power circuit. As to the portable *versus* permanent motor, there was a design where the motor could be unshipped from the bedplate and removed to the storeroom. But there was no necessity for this removal, because when the sea came aboard it simply washed the outer case and no water penetrated to the interior of the motor.

The discussion was adjourned for a fortnight, the proceedings terminating with a vote of thanks to the Chairman.

DISCUSSION

HELD AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, MARCH 9th, 1904.

CHAIRMAN:

MR. M. W. AISBITT.

MR. A. E. MILLS: Before going into the details of this well worked out paper, I should like, with your permission, to explain a few details of the construction of dynamos and motors as used on cargo steamers, in order that a better idea may be gained as to what is likely to get out of order, and how to locate any fault that may occur. The principle of the dynamo is founded on the discovery that if a coil of wire be moved in a magnetic field in such a manner as to cut a varying number of lines of force, an induced current will be set up in the wire in a certain direction; so that if we obtain two powerful electromagnets, that is, with many turns of wire, and place them in such a position that the space between is full of these magnetic lines of force, and revolve our armature, which contains several separate coils, we have only to collect these induced currents in the coils at the commutator in a proper manner to complete our continuous current dynamo.

The direction of the lines of force in the magnetic field may be very nicely shown and kept as a record by placing, say, a glass slab covered with shellac varnish in the field, and sifting iron filings over the surface.

Of course, the electrical expert is able to calculate the number of turns and the size of the wire necessary in the field magnets and armature, and also the amount of iron required in each for a certain output; but all the marine engineer need trouble about is the arrangement of the wires in the series, shunt and compound type of dynamos, and the advantage of each.

TYPES.—In the *Series* dynamos the current generated in the armature passes from the positive brush around the magnets, through the external circuit, and finally reaches the negative brush.

This machine is suitable for a constant current, or where a number of incandescent lamps are arranged in series. The shunt dynamo is similar to the series, excepting that only part of the current generated in the armature passes from the positive brush around the field magnets. This machine is more suitable for charging accumulators where a variable and adjustable E.M.F. (pressure or volts) is required.

In the last type—the compound dynamo—which is now very largely used, we have a combination of the two types, and it will be seen that a constant pressure is maintained in the outer circuit, for if more work is put on the outer circuit there is a greater resistance to the current, consequently a greater portion of the current circulates around the field magnets, thereby strengthening them and increasing the electromotive force or pressure in the armature, and consequently in the outer circuit. If, on the contrary, some of the work should be taken off, a greater proportion of the current passes through the outer circuit, and a lesser portion around the field magnets, thereby decreasing their strength, and also the electromotive force or pressure in the outer circuit.

TESTING.—Now, from what has been said it will be seen what faults are likely to occur in running a dynamo or motor. In the field magnets or armature the wires may break, or the insulating material may be faulty, either between the consecutive coils or between the coils and the core. In the commutator —which consists of insulated copper strips—to which the armature wires are connected there may be a possibility of the insulating material being imperfect between any two strips, and, of course, in the outer circuit, breakages may occur either in the mains or in the branches. So that if an engineer with a couple of dry cells has a galvanometer and a resistance box, the former for measuring the strength of a current passing along a wire, and the latter, which contains a Wheatstone bridge, for measuring the resistance to the passage of a current, I don't think he would have much trouble in thinking out how to connect up the different instruments in order to find a fault if he had seen the instruments once used, or had even read about them. Of course, in a number of cases the fault can be located by examination without the aid of testing instruments, and therefore I am of opinion that a marine engineer can be quite enough of an electrician to be able to manage the running of an electrical plant.

Now, coming to the paper, I notice Mr. Roberts doesn't take into account the windlass, which, no doubt, he would drive electrically, or else he would have to run a steam pipe along the deck. This may or may not increase the effective horse power required at sea, but it would certainly increase the difference of cost between the electrical and steam driven plants. Then, again, with all the motors on deck I think it would be advisable to have a spare armature, and as the motor on the windlass would be somewhat larger than the ones for the winches, it would probably be as well to have a spare armature for that.

I would suggest that if an electrical plant be fitted to a steamer that the steering gear should also be worked by a motor, yet this, of course, wouldn't alter Mr. Roberts's figures, but I remember reading of a yacht having been so fitted, and of the gear working admirably.

The only drawback that I can see to having motors on deck is that the stuffing boxes, which, I suppose, would be fitted where the motor shaft left the casing, would in time wear, and consequently allow the sea-water to enter; and then, again, when it was necessary to repair the motors at sea, would it not at times be necessary to shift the motors bodily to some place under cover in order to prevent their wiring getting wet? Of course, I can see that when motor driven winches do come into general use that the junior engineers will have a more comfortable time. I would like to ask Mr. Roberts to give us his idea as to the wiring. Would he recommend fitting separate supply and return wires, or would he suggest the concentric system? And, again, would he run separate wires from the end of the deck houses, and connect up each motor in parallel from junction boxes in them? Now, as regards the motors in the engine-room for driving the air pump and feed pumps, I have doubts as to the advisability of doing this, although I know these pumps are so driven in some power stations, but I believe there are by far a greater number steam driven. The difficulty appears to me to be in the gearing, which has to be of a high ratio. Mr. Roberts gives us in the case of feed pumps: revolutions of pinion, 970; revolutions of spur wheel, 60; a ratio of about 16, which, I take it, means too much wear and tear of the pinion for marine use, and consequently risk of breakdown. Then, again, the loss by friction, I should think, would equal the saving supposed to be gained by the use of electric motors over a steam driven pump; but as far as the circulating pump and bilge pumps (if of the centrifugal type) are concerned, I consider them very suitable for electrical driving.

Going into the question of economy, there is no doubt that the electric driving of the winches would result in great economy, for what the cost of the horse power of the winches is would be a rather hard matter to tell, as there is not only the condensation in the pipes, but the power required to drive the winch itself; while we do know what the cost would be when electric motors are used.

I believe the cost of production of a Board of Trade unit, which is about $1\frac{1}{3}$ H.P., has been in one instance a fraction of a penny, and taking this into account and also the less horse power to drive the winch itself, there must be a very large saving indeed.

Mr. Roberts suggests driving the generating plant by a compound engine, but I understand that steam turbines are now being used very extensively, and that only recently no less than twenty sets of turbines and dynamos from 78 to 100 H.P. have been ordered from one firm for the German Navy.

Mr. Mills concluded by reading the following communication he had received from Mr. W. O. Hesketh, whom he described as not only a marine engineer but an electrician:

Mr. HESKETH writes: Mr. Roberts in his paper goes fully into the matter, and as he has shown the "advantages" to be derived from the application of electric power on cargo steamers, it would perhaps be as well to briefly skim over the "objections" to its application. It is true that these are not numerous, for it has been fully shown that when it is possible to maintain the "efficiency of the installation" its advantages are many. But that is just where the great difficulty comes in, for it may be pointed out that from the nature of ship wiring, and the unfavourable conditions under which the insulation of the different leads has to be maintained, the latter is continually deteriorating. Instances are common in which the extensive wiring of large vessels has so far broken down that a complete re-wiring of the ship has become imperative. This may not be due to inferior material or imperfect workmanship. Its cause may rather be attributed to the atmosphere aboard ship, changes of temperature, to the sweating of the bulkheads and ship's skin, and to the effect of salt water and sea mists above deck or in exposed positions. Heated leads, short circuits, with an ever increasing difficulty to maintain a perfect insulation is a resultant. These occurrences are more marked when the wiring has been done in a cheap, second rate manner. And if shipowners only knew this point they would not be so keen on accepting the lowest estimate, for in no branch of engineering can the adage of "Penny wise and pound foolish" be so appropriately applied as in the one under discussion.

Many installations of the electric light and power aboard ship are allowed to commence work without any figure relating to the insulation resistance having been determined upon. This is a great mistake, for I myself have seen a ship sent away to sea fresh from the contractors hands with an earth or leakage of current sufficient to light a 16 c.p. lamp equal to ·6 of an ampere, and this on a small lighting installation. So that not only should the resistance be determined beforehand, but a responsible person should see the different tests taken. Mr. Roberts in his paper speaks of accumulators in connection with the economical running of auxiliary and even propelling machinery. I am of the opinion that the use of accumulators for this purpose would not only prove a great expense—for the efficiency of the most modern battery, under ordinary working conditions, discharged at the normal rate to their proper minimum, E.M.F. (voltage), ranges between 65 and 75 per cent.—but I am extremely doubtful if they would work under such a variable load. In fact, you might state that an accumulator would not answer its purpose, for they are only to be relied on when the load is steady, or fairly so.

Time will not allow me to write on the subject as much as I should like, so it would perhaps be as well if I just gave an idea of the method of taking the necessary tests.

These are three in number, namely:

I. Test of insulation resistance.

II. Test of continuity.

III. Test for crosses or short circuits.

Insulation resistance tests should be taken after the dynamo has been working on the different circuits for several hours. This preliminary working frequently brings out weaknesses, and a test showing high resistance at the outset may read very differently after the lamps have been incandesced for some time. The usual instrument used for this test is the galvanometer, used either in connection with a primary battery or a small accumulator (secondary battery). One pole of the battery is connected to the ship and the other to the galvanometer, and a wire leading from the other terminal of the galvanometer is connected to the main to be tested. If any deflection occurs in the galvanometer, it indicates a leak or short circuit.

THE TEST OF CONTINUITY is a very similar process. The leads to be tested are joined at one end, either by short circuiting from one to the other with a wire or, if it is a lighting circuit, by putting the lamp in the holder and placing the switch in position, and by putting the one battery terminal on the one lead and the galvanometer terminal on the other; there should be a very decided deflection if the circuit is complete.

TEST FOR SHORT CIRCUITS.—This test is of great importance, and should be conducted with persistence until the person testing is certain there is no leakage between any one lead and another lead of the installation. A feeble electromotive force does not readily detect small faults. The pressure should be as near the working pressure as possible.

Insulate the whole of the motor and lighting leads by switching off all machines and lamps. Connect the negative terminal of your testing set to the ship and go round all your leads one at a time with the positive terminal until you touch a lead which shows a deflection on your galvanomter. This shows there is a leak or short circuit on that respective lead, and you must trace that connection until you find the fault. The testing set used in this test is a small "Evershed's" portable testing set, which comprises a small hand-turned dynamo and is capable of generating a current at a pressure of 100 volts, connected to a galvanometer or an "Ohmmeter."

There are numerous small defects and difficulties in an electrical installation, but the greatest difficulty is to keep your insulation effective and so prevent *shorts*, or leakage of current.

Mr. G. F. MASON: I should like to add my thanks to those already expressed for the admirable paper Mr. Roberts has read. I am only sorry it does not give us an idea of the great amount of time he must have expended in its preparation.

Mr. Roberts has been very fortunate in the choice of his subject, for in electricity he has brought before us the most interesting and fascinating power in the service of mankind; and, considering the enormous advances made in this science in other directions, it is remarkable that it has been applied so little to useful purposes in the mercantile navy.

In the lifetime of many of us in this room we have seen the one wire one message telegraph advance until now eight messages can be sent on one wire at the same time, and the latter mechanically type-written out on receipt, or we can converse with our friends in Paris from here, if necessary; and, I believe, very shortly we may be able to see the faces of our friends while conversing with them at a distance by its aid. As regards motive power, we see Nature's forces, in the shape of waterfalls, etc., harnessed for the purpose of generating electricity and transferring it to a distance of over 500 miles for use in factories, street lighting and tram services, and, what is important, with little loss.

No one has yet arisen to tell us what this mysterious power is, but we have a fair idea of how it can be controlled and used, though, in my opinion, we are only now working on the fringe of its possibilities. Even now torpedoes are navigated and propelled without any material connection with the shore or power station. When such results are obtained, surely it is time the advantages of electricity for ships' purposes was made use of.

I was much surprised in the discussion a fortnight since to hear how little most of the speakers knew of what had been done on the lines of the paper. I would point out that the suggestions of Mr. Roberts cannot be looked upon in the light of an experiment. Nearly three years ago I had experience of two vessels carrying over 11,000 tons which had complete electric outfits similar to that in the paper before us, excepting the pumps. They had been running then eighteen months and two years respectively, and although trading between the Pacific and Atlantic Oceans, had given every satisfaction and no trouble. Messrs. Sloggett, Reed and Younger all expressed doubts as to the effect of heavy seas on the motors, but I cannot see any difficulty at all in securing a motor just as well as a steam winch. Experience has shown that there is no trouble as regards this, or with the insulation. The only real difficulty met with in previous ships has been from the heating of the armatures through want of ventilation, and this was overcome.

I don't agree with Mr. Reed when he says the makers have only to bring a cheap, practical motor on the market to have it taken up by shipowners at once. Such motors have been in existence for years. My experience is that with very few exceptions shipowners are very conservative and averse to innovations; for instance, the first successful vessel fitted with triple expansion engines had been running nearly sixteen years before this class of engine generally came into favour.

I totally disagree with Mr. Sloggett's remarks as to the incapacity and inability of the present day sea-going engineer to take charge of such electric plant as that proposed. Such a statement is a libel on the members of this institution. I would remind him that the authors of most of the papers we have the pleasure of discussing, including the present, are sea-going engineers of the past, and I hope and expect that many of the papers of the future will be written by the sea-going engineers of the present day. I know of three instances where engineers have been taken almost direct from their ships and put in chargė of electric power stations ; one station giving out nearly 10,000 horse-power. I have never found my engineers at a loss with the small electric plants under their charge, and there is really very little difference in looking after small dynamos and motors than large ones, it being only a matter of degree. There is as much difference between marine engineers, with and without sea-going experience, as an egg and a chicken—the chicken has all the egg's experience and its own as well. Of course, I am not comparing the members of the institute to chickens. Most people consider a good many of them to be very downy old cocks indeed.

In reference to the paper itself I have little to say, beyond praising the suggestions it contains, though I am in rather an anomalous position, as I would not go quite so far as the writer suggests generally, but in some instances go farther than he does. For instance, Mr. Roberts says nothing about the windlass ; I should certainly fit a motor to this, as is done in the boats I quoted, otherwise the saving in the cost of piping will not be much reduced, seeing a length of steam, and, I take it, exhaust pipe would have to be led from the main and donkey boilers with the necessary cocks or valves to the windlass, and, personally, I should prefer to work the pumps off the main engines, as I find that with the usual piston speed obtaining in cargo boats of the present day, the extra expense of separate pumps is not worth the candle, and the consumption is increased ; besides, there are many occasions when a donkey pump is required, when it would be folly to have to run a large engine and dynamo for the purpose. I don't know how Mr. Roberts has taken out or allowed quantities for the piping supposed to be saved in the engine room, but there would be very little difference in the cost of this item with his dynamo against the ordinary feed and ballast donkeys in the arrangement I prefer. Another objection to having all the pumps driven by motors occurs to me, as I remember an instance of an electrical installation, used for ventilating and light purposes, being rendered useless through the bursting of a small steam pipe causing a short circuit.

As regards the power he gives for working the pumps, I think this is distinctly understated; it, however, would make little difference in his estimate, as it cuts both ways.

I can bear witness to the correctness of Mr. Roberts' figures as regards the costs of the winches and motors; if anything, he has understated the advantage of the latter in this respect, and I am entirely with him in his proposals to do away with the steam winches and to substitute electric motors instead. Anything more wasteful than the present arrangement it is difficult to imagine. It is a good day's work to put out 700/800 tons with six or seven winches, and an expenditure of three tons, for this is nothing exceptional; and no matter how large the donkey boiler may be, the stevedore invariably complains of want of steam.

There is no doubt the motor winch has come to stay—its adaptability is great, risk of damage and upkeep almost nil; and when we can educate shipowners and engine builders to go in for smaller engines running at nearly double the piston speed of the present day, I have no doubt the similar arrangements to those suggested by the author will become almost universal.

Mr. E. NICHOLL expressed himself in favour of the adoption of electrical power for auxiliary machinery on board ship, subject to conviction with regard to details. He had the honour of reading a paper on the subject before the Centre some years ago, and he was sorry that the electrical agent had not been more extensively adopted.

Mr. D. B. HOW (Visitor) said that as an electrical engineer he was gratified that this subject of the application of electricity for the transmission of power on board ship was at last receiving attention from those concerned. There was no substantial ground for Mr. Mills' fears as to the gearing, which had to be of a high ratio for three-throw pumps. No trouble was experienced in actual practice in running a motor as high as 1,000 revolutions per minute and gearing down to a pump running at 60. There was not the slightest doubt about the greater efficiency and economy of electricity over steam; but do not let them put in direct current. With three-phase electricity they could do all that could be done with the direct. The great trouble with the direct current, particularly in motors, was with the commutator, with its unavoidable liability to sparking. There was no commutator necessary to the three-phase, therefore no sparking. It was a smaller machine, it could be wholly enclosed, and it was a good deal the simpler machine. For a three-phase current they could run a generating plant a good deal higher than the 500 revolutions mentioned by Mr. Roberts by coupling to a turbine, and a turbine of 200 horse-power was quite as efficient as a high-speed engine, providing it was condensing. In adopting the three-phase principle they got a cheaper installation, and —what was of importance on board ship—a much lighter machine.

Mr. J. T. SHELTON said that if they were assured that electrical winches could be made perfectly free from injury by sea or other water; that they could be worked by unskilled persons, easily reversed and the speed regulated, this would go a long way to their adoption. Hydraulic machinery for winches and derricks was a great improvement on steam, but he believed that this was surpassed by electricity. He should like to know, by the way, whether the electrical motors, etc., on deck would be likely to be affected by the heat of tropical latitudes.

Mr. MAJOR (Visitor) was decidedly of opinion that the marine engineer of the near future would have to be equipped with a knowledge of electricity in its application to power. The Board of Trade had already introduced the subject in its examination papers. In a book recently published by one of the tutors of engineering candidates he observed that 60 of the 270 pages of which the work consisted were devoted to electricity and electrical appliances, so that he had no doubt the marine engineer would in a short time be able to manage any electrical installation, whether for power or lighting, on board ship.

Mr. FREDERICK JONES: I have listened to and also read Mr. Roberts' interesting paper, which is overflowing with argument. One great point in the paper is economy. We are told in this paper that ten electrical winches will cost £1,000. I am told, however, that to buy ten of these winches would cost nearer £1,500, in addition to which you must buy dynamos to get the power to drive the winches. I have known that the upkeep of electric light in steamers every voyage would pay for the oil they would otherwise have used in lamps, therefore it follows that the upkeep of these electric winches every voyage would pay for the coal used by the donkey boiler. Imagine, gentlemen, discharging pig iron and pitwood with these winches with sailors who change ships every month! I am very much afraid that the day is far off when we shall abandon the steam winch, and until there are some means of transmitting the power direct there is no economy in it. One question I should like to ask Mr. Roberts is this: With regard to the motors for pumping Smith's pontoon, have they a small steam pump handy in case the current was interrupted? In conclusion, gentlemen, I beg to thank Mr. Roberts for the time and trouble he has taken on his interesting and advanced paper.

Mr. A. J. HARLOW: From Mr. Roberts' interesting paper and the discussion which has arisen therefrom, I was agreeably surprised to know that electricity as a motive power on cargo steamers had made such rapid progress, and that it was already in the hands of the Institute of Marine Engineers for approval and adoption.

It would be quite possible now to speculate to an unlimited degree as to the future of this science, but experience teaches us that the knowledge of to-day is as nothing compared with that of to-morrow. A few new facts often upset pet theories. It is in this direction that I claim your attention this evening.

Looking at this question from a shipowner's point of view, and substituting the ten steam winches by ten electric motors of the same power, would this change (as suggested by the author of this paper) enable a vessel to load an extra cargo in a year? Vessels are often detained in port from other causes, over which the much-abused donkey-boiler has no control.

Mr. Roberts gives us the combined piston area of the winch cylinders as 687·9 sq. in., and the area of cylinders for the generating plant for electric motors of the same power as 240·33 sq. in., or about one-third of the winch cylinders. This might lead one to suppose that the power and consumption of steam at the generators will be less than the ten steam winches. No doubt there would be some saving of steam, due to the efficient governing of the plant and the low consumption of steam in some of these high-speed engines, and also a saving from the loss of steam due to condensation in the deck steam pipes. However, the power developed must really be more, although in this case the piston area is considerably decreased, this being due to the increased speed of piston, viz., 500 revolutions per minute.

Mass, by the speed in feet per minute, is the factor which determines the power to be placed at the hatch. Increase the mass or the speed in feet per minute, and there must be an equivalent increase of power, let it be electric motive power or steam.

Then there is the efficiency of the plant. What would be the combined efficiency of this plant? Modern dynamo machines return as electrical a very high per cent. of the mechanical energy applied to them. Yet, however, there must be a loss of power in converting mechanical energy into electrical energy, conveying it a certain distance and then again converting the electrical energy back into mechanical energy. Without dealing with the power for the independent pump motors, let us take the 10 motor winches of 10 H.P. each, that is, a total of 100 H.P., and taking the efficiency of the motors at 85 per cent. $\frac{100}{\cdot 85} = 117\cdot 6$ is the H.P. required to be delivered at the ends of the mains supplying the motors, and assuming that there is no loss in conveying the power through the conductors to the various motors 117·6 is the H.P. required at the terminals of the dynamo machine, assuming the efficiency of the dynamo to be ·93 percent. $\frac{117\cdot 6}{\cdot 93} =$ 126·4 is the H.P. required at dynamo shaft, and say the efficiency of the engine is 85 per cent., which is fairly high, $\frac{126}{\cdot 85} = 148\cdot 2$ H.P. required in engine cylinders. Therefore the total efficiency of the plant $= \frac{\text{useful work}}{\text{total work}} = \frac{100}{148\cdot 2} = 67\frac{1}{2}$ per cent. This added to the extra cost of plant and maintenance of same will, I am afraid, at present prevent its adoption by shipowners. We must not lose sight of the fact that instead of 10 steam winches to keep in repair, we have 10 electric motor winches (with less working parts, it is true) ; also a very intricate high-speed engine, dynamo, switches, cut-outs, controllers and cables.

Yet, however, there are many good points in favour of the adoption of electric motors on cargo steamers, as enumerated by the author.

Last summer I was on the commissioning trials of H.M.S. *Kent* and H.M.S. *King Alfred*, two of our latest cruisers; they had several motor winches on board, made by Clark, Chapman & Co. On the *Kent*, amongst other motors there were two 73 H.P. boat hoists, running at 520 revs. full load, and two 32 H.P. coal hoists, 565 revs. full load. On the *King Alfred*, the capstans were worked by electric motors. The ease with which these several motors worked and the space which they occupied on deck made one wonder why they had not been adopted years ago.

On the table I have placed one or two pamphlets relating to an electric winch made by the Sunderland Forge; you will observe by the photos what a beautiful little machine can be substituted for the old 6 in. steam winch.

It remains with you, gentlemen, to prove to the enterprising and up-to-date steamship owner that this is the most economical method of distribution of power on cargo steamers, and its adoption will be only a matter of time. In conclusion, I thank Mr. Roberts for the pleasure I have received from listening to his interesting paper. And you, gentlemen, for the reception I have received as a visitor amongst you.

Mr. DU PASQUIER said the chief losses in steam driving were owing to the small steam units of the heavy steam consumptions, and, above all, to the condensation in the pipe leads. As to the polyphase motor, advocated by Mr. How, there were doubtless many great advantages attending it, but with regard to ship work, it occurred to him that the wiring was rather more complicated. But doubtless this was a matter of attention to detail which could easily be overcome. This being so, all the advantage lay with the polyphase motor, on account of lower maintenance cost and increased simplicity. He did not think Mr. Roberts had made as good a case for maintenance as he might have done in comparing electricity with steam.

The Hon. local Secretary (Mr. J. George Walliker) read the following contribution to the discussion from Mr. H. Brandon, West Hartlepool (Member):

I have read Mr. D. K. Roberts' paper on

"The Application of Electric Power on Cargo Steamers" with great pleasure, and must congratulate him for the able manner in which he has treated the subject. From an engineering point of view it would certainly be a happy change if owners would only substitute for the clumsy and wasteful steam winch the electric system.

Mr. Roberts points out the great loss there is by condensation, and he has certainly given the winch the benefit of any doubt. It is only necessary for one to watch the exhaust pipe of a ship's winch when working to see the enormous waste of water, more especially if the winch happens to be the one the furthest from the boiler. It is the stopping of the winch during the time the load is being attached or detached which is the principal cause of the loss, as during this time the cylinders lose so much heat, and there is also the loss through the steam having to travel, say, a hundred feet of piping, which is nearly always unprotected. There is no such loss by the use of the motor or electric winch, as it only makes the demand on the supply in proportion to the work it is called upon to perform; and again, the generating engine is always running, and is protected from the weather.

With the present system each gale the vessel encounters leaves some record of broken or damaged pipes or fittings. These little damages certainly assist in keeping a permanent smile on the repairer's face, but as much as the owner appreciates the repairer, that is only a poor consolation.

When steam winches become a few years old they are a source of trouble and expense to keep in repair, and the deterioration which takes place during the idle period is as great as, if not greater than, when working. This class of machinery, as a rule, receives very little attention; of course, the usual coats of paint have to be applied, if only for the sake of stopping up all the oil holes and plastering up the glands and making them unmoveable. It is also absolutely necessary that the salt water hose should be played on them at least once a day.

Owners may think that they would incur extra expense by using electricity, as electricians would have to be employed. This is not the case, and the average engineer would soon adapt himself to all changes. Men speedily acquire new routines—particularly when their existence depends on same.

The price of £950 for steam winch pipes, fittings and casings appears high, but perhaps the exhaust was taken back to donkey boiler.

I do not agree with Mr. Roberts as to driving the air, feed, and bilge pumps by motor power. The vessel quoted is rather large for the ordinary tramp; suppose we take a vessel of, say, 6,000 tons dead-weight capacity, would there be the proportional saving? I think not. In the first place it is a difficult matter to get builders to depart from their original design unless a heavy charge is made for such departure.

The principal point an owner desires to know is, will there be a saving by adopting this new system at the termination of, say, four years, and what guarantee has he that the upkeep of motors and generating plant are not going to cost as much as the old system? Another point will also be raised by the owner, viz., "Why should I have to provide two sets of generating plant?" "To prevent delay in case of breakdown," replies his adviser. "Well, but why do I not have to carry a spare funnel on my vessels?" It is questions of this character that make up life's little worries.

The principal objection to lighting small vessels by electricity is the expense in port after the working hours; the donkey boiler has to be kept on to supply the power. Of course there is the storage system to fall back upon, but this is expensive owing to its imperfection. There have been almost as many patents taken out for storing electricity as for hair restorers, and we have still the baldheaded with us.

It is clear from Mr. Roberts' paper that the initial cost of an electric installation would be greater than that of the present steam-driven pumps and winches. Very well, is there sufficient experience to warrant anyone to suppose that the cost of working would be an apparent saving in repairs in two or three years.

It is quite possible that the wear and tear on the motor may be a little less than on the steam winch, but there is sure to be a certain quantity of repairs that cannot be so readily executed. For instance, a vessel fitted as per the description given by Mr. Roberts would have to carry a good lathe, which would be an extra fitting.

There is not the inducement to go in for this extra plant for rapid discharging of cargoes as one would think, because the enhanced speed in handling cargo is not of much account to the owner of the ordinary steamer with stipulated lay days for discharging, or to discharge according to the custom of the port, which is usually about 300 tons per day.

There are not many ports in either Europe or the United States where the rapid despatch of a steamer would result in a saving of harbour dues, as the dues are, with few exceptions, based upon a price per register ton for thirty days. The Plate is the only exception the writer knows of.

A vessel discharging a cargo in Cardiff will pay the same dues if the discharging takes one or thirty days.

If the vessel is in a regular trade, and always on berth terms to take and deliver as fast as possible, the above does not apply, harbour dues excepted.

The shipowners do not merely want labour-saving machinery, but they want to save wages. It must be remembered that shipowners have had some experience of what new ideas are going to save them. The corrugated furnace saved 10 per cent., the triple expansion 25 per cent., the evaporator 10 per cent. Patent piston rings, piston-rod packing and non-conducting cements, patent fire bars, can be credited with 30 per cent. Then patent boiler fluids and a few other things make up a saving altogether of 95 per cent. Now the question is, will electric power wipe off the other 5 per cent., and thus save the 100 per cent.

A few weeks ago a vessel discharged 4,000 tons in six days, at a cost of 18 tons of coal. This gives 10 lb. of coal per ton of cargo. Assuming coals cost 12s. per ton, this gives a little over ½d. per ton for discharging. Is this expensive?

I hope, sir, the members will give Mr. Roberts the hearty vote of thanks the paper deserves.

Mr. HERBERT LEWIS (Visitor) referred to the rapid development in the application of electricity for the transmission of power in collieries which the past few years had seen.

Replying on the discussion, Mr. ROBERTS expressed gratification at the reception which had been extended to his paper, especially by the electrical engineers present. He had written the paper purposely with restraint and moderation rather than make the most of the economies and other advantages of electricity. He quoted figures to show that if instead of the free exhausting winch they substituted an electrical plant capable of the same output a saving was effected of nearly fifty per cent. on the donkey boiler alone. Something had been said as to skilled and unskilled labour. It was not an unheard of thing for damage to be done to a steam winch by men who knew little about it, while the controlling gear of an electric winch was much simpler, because if the load dropped off the electrically-driven machine was cut out of circuit. He had not included the windlass in his paper because he did not want to overload the paper; he desired rather to emphasise and illustrate the broad principle. He omitted reference to the turbine for the same reason. As to the cost of pipes to the engine room, this was included in his figures, which were the actual figures of the builder, and not mere estimates, and included everything that could be practically foreseen and provided for. The electrical plant was capable of an enormous increase of efficiency, and they need not necessarily have the full power set for intermittent work. As to a point in Mr. Brandon's contribution, harbour dues were not everything; electrical winches saved time in unloading and loading that far outweighed this consideration in the case of coasting ships running from port to port.

A hearty vote of thanks was passed to Mr. Roberts for his paper, on the proposition of Mr. Chellew, seconded by Mr. Nicholls.

A similar compliment to the Chairman, who gave it as his opinion that in a very few years electrically driven winches on board ship would be the rule and not the exception, concluded the proceedings.

PREFACE.

58 Romford Road.

Stratford.

March 28th, 1904.

A meeting of the Institute of Marine Engineers was held here this evening, when a paper on "The Application of Electric Power to Cargo Steamers" was read by Mr. D. K. Roberts (Member), who kindly came from Cardiff to attend the meeting, and several illustrations of electric winches were exhibited by means of lantern views. The chair was occupied by Mr. W. Lawrie. The discussion was adjourned to April 18th. The paper was read at 3 Park Place, Cardiff, on Wednesday, February 24th.

Jas. Adamson,

Hon. Secretary.

DISCUSSION

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, MARCH 28th, 1904.

CHAIRMAN:

Mr. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN: When we consider the number of papers that have been read on marine engines and their auxiliaries, it is not a little surprising that we still have laid before us such a very interesting paper as that which has been so ably read and so clearly illustrated by Mr. Roberts. A little over a year ago Mr. Roberts read us a paper on "Independent Pumping Arrangements on Cargo Steamers," and that paper evolved a very interesting discussion. I think the paper we have just listened to will be somewhat of the same nature, and as the time is rather far advanced I hope we shall proceed to the discussion as soon as possible.

Mr. KEITH C. BALES (Member) opened the discussion. He said: The paper we have just listened to is, without doubt, both an interesting and instructive one, and its value is considerably enhanced by the very clear slides exhibited by the lantern. In my opinion, the rapid growth of electric power of recent years is principally due to the fact that electricians have seen the necessity of becoming engineers as well as electricians, and also that engineers have added electricity to their ever-increasing knowledge. There can be no doubt as to the convenience of electricity; but while I do not propose to cavil at the author taking the shipyard as his example to prove his point, it might be as well to note that a shipyard is peculiarly suitable for electric motive power, owing to its machinery being scattered and the fact that it is usual for it to possess its own generating station, thereby obtaining the units at a minimum cost. These favourable conditions do not usually exist in the ordinary workshop, and there, unless the machines are motor-contained, the same amount of belting and shafting, etc., is required whether the motive power is electric, gas, or steam. Where the units are purchased from a municipal generating station, which is the usual practice, it is open to question whether electric driving is even cheaper than steam, and it certainly is not as cheap as gas-engine driving. For the purpose of illustration the author takes a steamer and draws up a specification of electrically-driven auxiliaries. In this connection it should be noted that there evidently is a necessity for a duplicate generating plant, or, in other words, the plant is not to be relied upon, which necessity does not occur in steam-driven auxiliaries. It appears to me to be open to doubt whether the loss of steam due to condensation, etc., is compensated for, as regards actual cost of running, by motor-driven auxiliaries, when it is remembered that it is first necessary to have the auxiliary boiler whether steam or motor-driven auxiliaries are used. Secondly, instead of using the steam firsthand, in the case of the motor-driven it is first of all necessary to drive the generating plant, which on shipboard has not the advantage of being in proximity to the boilers, as in a land generating station. Thirdly, a loss of about 900 cubic feet of cargo or bunker space occurs, due to the necessity for the duplicated generating set, which is permanent earning power lost, to say nothing of the saving in working expenses of one method over the other, necessary in liquidating the initial extra outlay of about £1,000. Those are the points that occur to the owner, and, as a rule, not much else. In the paper it is stated: "With steam winches it is found that the greatest delays are not due to the incapacity of the winch, as a machine, to handle the weight, but to the difficulty in supplying steam in sufficient quantities to obtain the full power" (p. 10). I do not think a great deal of value is to be attached to the shortage of steam argument, it surely being somewhat novel. The author himself appears to think it is somewhat weak, as a little further on he states: "Of course, the obvious remedy for shortness of steam is to increase the size of the donkey boiler." At the foot of page 12 the author deals with electrically-driven winches, and it occurs to me that the exposed position of the winch motor does not decrease their liability to get damaged by moisture; and while tramway motors are certainly called upon to contend with a lot of rough usage and fresh water, they do not have seas washing over them, which is a very different matter; so that the comparison is in favour of the tram motor rather than the winch motor. In enumerating the advantages of electric application to cargo steamers no comparison is made of the hydraulic motive power as regards the rapid handling of cargo. I trust the author will not think I am over-critical, but it appears to me he has taken considerable trouble in the preparation of this paper, which, as I said, is not only interesting, but instructive, and it is, I think, a pity to agree with him everywhere, as nothing develops a man's resources so much as opposition, nor draws further instructive information out.

Mr. SHEARER (Member): May I suggest that Mr. Flood should give us his views on the subject?

Mr. W. H. FLOOD (Member) said he thought the author had so well covered the ground that there was little left for them to say on the subject. From his remarks during a discussion on a similar paper last year he thought the majority of the members would know that he must coincide with nearly everything Mr. Roberts had said. Still, there were a few little points with which he did not quite agree. In the first place the author had compared the electric power of a shipyard with that likely to be used on board a ship. He did not quite agree with him there, and he did not think they would find that the plant put down in a shipyard would be at all suitable for use on board ship. Electric power on board ship was different in many ways, and required careful study and design. He was sure that the average shipbuilder's plant would not be suitable, as electric motors and other electric machinery intended for ships' use must be designed specially for marine work, the same as all other apparatus used afloat. He had looked through the paper to see if he could not drop across two or three soft places where he could find a little fault, but it was very difficult. However, on page 7 of his paper, about half way down, the author had given some particulars of the effective horse-power required by various auxiliaries—i.e., the air-, feed-, bilge-pumps, etc. Would he give them the duty of those pumps? It was very well to say the air-pump required 10 h.p., but that told them nothing as to what the pump was doing. Some information on that point would be very interesting. A little lower down on the same page the author referred to ten winches of 10 h.p. each, but he had omitted to tell them the particular duty of those ten winches. If he would give the maximum load that it was usual to put on those winches, and the maximum speed at which that load was lifted, it would help them a little in getting the proper rating of that motor which was called 10-h.p. A little further on he thought Mr. Roberts had made a remark which would convey to the members the impression that all dynamos would stand 30 per cent. overload without destruction. With that remark he must disagree. He had found by experience that there were some good makers of dynamos who supplied machines which would stand that excessive amount of overload, but, on the other hand, there were a great number of machines running on ships which would scarcely stand up to their proper rated load without getting excessively hot; and he thought he could say that if they subjected some of those machines to much above their ordinary or working load they would soon be reaching the sparking limit—that is, if the machine did not burn out before. There were some machines now constructed that would run absolutely sparkless from zero up to their full load, and 25 per cent. over that load; but 30 per cent. was, he thought, a little too much.

He would next like to call attention to a point in reference to the switchboards. The author had spoken of running the duplicate sets in parallel, but he had touched very little on the subject of the switchboard. In his (Mr. Flood's) opinion the switchboard was one of the most important points. When coupling two machines together electrically they would find, unless they had an efficient switchboard equipment, the whole machinery would fail. Further on he thought Mr. Roberts conveyed the idea that the whole of the motors should be of the enclosed type—i.e., of the water- or air-tight type; but on page 8 he said the motors for pumps could be of the protected type. He thought the protected type was the correct type, but he did not see why they should have a protected motor for the pumps and an enclosed type for another machine not exposed to damp. In the same paragraph the author mentioned the forced-draught fan as taking from 3 to 6 h.p. He would like to know the the duty of that fan, the number of cubic feet of air it was delivering, and the water-gauge pressure against which that air was delivered. It seemed to him that 3 to 6 h.p. was a pretty wide margin. On the following page reference was made to the donkey boiler. He had asked the question several times, but why could they not dispense with the donkey boiler and use one of the main boilers? On the bottom of the same page Mr. Roberts had seemed to have great confidence in the tramway motor. He thought that motor had had a fair trial, but to-day the design of the tramway motor was not being accepted for shipboard; they had really got a marine type of their own, and no doubt they would all be very pleased to hear that. (Hear, hear.) In the same paragraph the author suggested that they should use flexible cables between the junction boxes and the motors. He did not agree with that last suggestion. The best arrangement was to run the cables under the decks direct into the motors themselves. In his opinion there was no need to introduce junction boxes; by so doing they were introducing a weakness, more especially as Mr. Roberts suggested that 220 volts might be used. If they had flexible cables running about the decks they were going to have trouble. He had had but little experience with flexible cables, but he knew that even at 60 volts they gave trouble. One of the safest means of conveying power was to have the cables taken under the deck properly protected. He dared say they would have a difficulty in convincing shipowners that that plan was a perfectly safe one, but it could be, and was done. He must congratulate Mr. Roberts on the information he had afforded them with regard to cost of plant. On looking into those figures he thought he could say that they appeared to be perfectly satisfactory, and he would be pleased to take them as a little guide for future use.

Mr. J. THOM (Member) said the shipowner would look at the matter from the point of view that an extra £1,000 would be required for the installation of the electrically-driven auxiliaries, but if they took the donkey boiler into consideration that amount would probably be slightly decreased. Still, if the shipowner were not going to get the work done quicker he did not see where he would benefit. From the amount of power that the author had mentioned the winches would take, he was of opinion that those winches would not do the work as fast as the average steam winches as fitted now. He might be wrong, but in his opinion a 10-h.p. motor would not lift average cargo so fast from underneath beams and the back of stanchions as a steam winch equal to exerting 40 h.p.; and instead of taking 10 h.p. from a motor to do the work, it would be near 20 or over when you started to make the lift. Except they took all those points into consideration in actual practice he did not see there was much good in the particulars they had just had from the paper. Perhaps the author could give them those points further on. Speaking of the feed-pumps, which were to be driven electrically, the feed-pump did not always want to be driven at the same speed. When they began to variably drive a feed-pump they were going to take a variable amount of power, and he would say that the efficiency of that motor would go down rapidly, and probably, instead of taking less power, under those conditions it would probably take more. At the same time, if the estimate were true, the shipowner would be consuming less coal when working cargo; that was a great point. He thought, however, that the generators would require to be bigger than the author had mentioned. As regards connecting up with flexible cables, to be rolled up and taken away, it was all very well to start rolling them up, but while one man might be rolling them up a heavy piece of machinery might come on top of it. He did not think those cables were at all feasible unless they were protected under the decks in tubes. Permanent cables should be used, enclosed in pipes and sealed up, dry and air-tight. If any salt water got into the cable it had a very short life. Nothing affected insulation more than salt water. To test the class of a cable it had to retain its efficiency after being so many hours under salt water. That was a very severe test. Probably the enclosed type of motor would be used in the engine-room, and the entirely enclosed type on the decks, where they would be exposed to rain. He knew from experience that there was often as much wet in the atmosphere of an engine-room as there was on deck. That resulted not from rain, but from steam, and other such causes, although he had seen at times a good deal of water flying around in some engine-rooms. In his opinion the motors in the engine-room should be as entirely enclosed as the motors on deck, which meant making them larger to get the same results. The boiler could be very much less for doing this kind of work through electrical arrangements than for supplying steam in cold weather, but he thought it would be advisable to put 50 per cent. more power into the generators. The motor mentioned by the author might many times do the work quite well, when everything was in perfect order; at other times possibly not. These were the times when it was necessary to have some current arrangement or meter to tell you all was not well and that you would not get the lift up until some alteration was made. He thought it was quite possible to have something to let you know in the engine-room everything that was going on all over the ship with the motors.

Mr. W. E. FARENDEN (Associate Member) said their thanks were due to Mr. Roberts for bringing this interesting and important subject before them. The author had not included in his paper the windlass or the steering gear; could not these also be electrically driven? The effective horse-power required for the generating engine or power given to the dynamo when running at full speed would have to be supplemented by the power due to the energy expended in moving the working parts of the engine itself—say about 12 per cent., thus making a total actual horse-power of the generating-engine steam cylinders of about 112 i.h.p. 500 revolutions per minute was a rather high speed to work at, as it was found that slower running engines, working at about 250 revolutions per minute, gave very satisfactory results. The length of stroke was given as 7″, which was short for the size of the cylinders, and might account for the extra high speed.

He would ask Mr. Roberts if he had found trouble in continuous-current motors owing to the commutator sparking, and whether he would prefer fitting the three-phase system in preference to the continuous current. Some advocated that system, which was claimed to be simpler, and they got a cheaper and lighter machine. The forced-draught fan engine required was given as from 3 to 6 h.p. He would like to know what size fan was allowed for. Dealing with the question of cost, it worked out at about £1,000 more for the electric plant, and, when taken on the total cost of the ship, represents an increase of only 1½ per cent., but if they took it on the total cost of the auxiliary machinery alone it meant an increase of about 37 per cent. For a cargo steamer, where the shipowner was looking at every penny, that additional £1,000 would rather put him against adopting electric plant for all kinds of winches and independent pumps, particularly as it is apparently necessary to provide duplicate generating machines, for which additional space would be required; at the same time such requirements tended to show a want of confidence in the system.

Some of the advantages put forward by the author were very good, but he took it that the motors for driving the winches on deck would have to be specially protected against risk of damage by sea-water, etc., and at the same time ample provision must be made for ventilation. He would like to know how much more economical were motor-driven winches than those driven by steam, and if they were as reliable. Of course there would be the great saving in the length of steam and exhaust pipes, and the casings for protecting same on deck.

Mr. W. McLaren (Member) congratulated Mr. Roberts on his paper. The installation of electric power in factories and shipyards was a question that had to be decided by the different owners of such works to suit circumstances. In some the adoption of electric power effected considerable saving, in others the system of belt-driving suited better. He hoped the author did not lend himself to the idea of propelling vessels by means of storing electricity on board, as he thought the weight of such storage would quite preclude any such idea. Mr. Roberts allowed 20 h.p. for the feed-pumps; that seemed an excessive allowance for the amount of water required for the i.h.p. Two sets of pumps taken together he had worked out at about 2,932 gallons of water per hour, which was not an excessive amount for 150 lb. steam pressure. Yet it did not seem necessary to allow so much power for the 2,000 i.h.p. of the main engines, even if they allowed for waste and leakage from the glands—in all about 20 lb. of water per i.h.p. He thought that 20 lb. per i.h.p. was a fair amount to allow for a cargo steamer. In some cases they might do with a little less, but for a safe estimate he would allow 20 lb. It would have been as well if the author had given them some more information as to the quantity of water allowed for, relatively to the i.h.p. of the feed-pumps. The author had been liberal in his estimate of the auxiliary appliances, and he had been fortunate in being able to give them particulars of cost; he had not, however, mentioned the starters for manipulating the current to the motors on and off. He was quite at one with the author in regard to the speeds that he had mentioned, but he did not quite see his way clear in regard to discharging cargo. When so engaged, how were they to regulate the speed unless they had some of those variable speed motors? No doubt the steam winch was an expensive appliance on board ship, for they could not drive a winch to the same fine degree that they could a permanent or constant driven engine. It was being constantly driven backwards and forwards, and was thus not an economical machine; yet it had proved itself a very handy machine. But he would like to see some of the motors that the author had referred to. He might say that he was in favour of them, and he would like to see how far they could be used for pulling ships off banks or for warping vessels about in docks. He rather anticipated some difficulty in that respect, and expected that there would be a "bust up." He would much like if the author would give them some further information regarding the donkey boiler; he did not quite follow him in his paper, and was not quite satisfied with his figures. Then with regard to the two generating sets. If the shipowner were disposed to instal a substantial outfit on board he thought it was advisable to have the two sets, but he agreed with Mr. Flood in that he would not propose running them in parallel. He would rather see one-half of the ship run with one set and the other half with the other set. By so doing there would not be so much risk. If they were lifting loads on the parallel plan it would not give them a fair chance. If they had trouble with a hot bearing the whole system would be upset. He would like to know whether the author proposed to keep the lighting dynamo separate, or did he suggest the utilisation of the power generated for lighting as well? He had said nothing about the steering gear. Would he make reference to it, and also give them some further information regarding the windlass and capstan that he had shown on the screen? With regard to the possibility of damage through water, he believed that in the tramway yards they used a hose to clean the motors down. He had heard that they could build motors at the present day that could be cleaned down with a hose without any damage resulting.

Mr. Roberts then replied to the questions that had been raised. He wished, he said, to thank them for the reception they had given the paper. He was pleased to find they did not all agree with the views expressed. His paper was written to promote discussion. He had some samples of watertight cables, and he would say in reply to those gentlemen who had expressed the opinion that such cables were dangerous that they could "drive a horse and cart" over them without any risk. Those cables were well protected and very flexible. The principal objection to permanent wiring did not arise from engineers and shipowners, but from *Lloyd's Register* and the Board of Trade. The Board of Trade would not permit any voltage over 500 on board ship. They also objected to wiring unless it was carried out under very severe conditions; and he had considered his suggestion to be a compromise in so far as the actual cost of the flexible cables was so slight, and, assuming they only lasted a few months, they could be replaced at the bare cost of the cable. The question of leakage in junction boxes did not, he thought, affect the subject very much, for at the present time they had junction boxes for the purpose of deck lights, cargo clusters, etc., which gave no serious trouble. He did not think flexible lighting cables wore out very rapidly, although they all knew how roughly they were handled when cargo was being dealt with. One or two of the speakers had spoken of the fact that he had taken the shipyard as illustrative. There were several steamers with an outfit of electric winches. They were not used much in this country, but on the American lakes they had proved very snccessful. They achieved the rapid handling of the cargo, and the speed of the winch could be regulated in putting the cargo out. Suppose they wished to put out coal, which was a very common cargo: they could set the winch to run at a constant speed, and so put the cargo out rapidly. Any winch would run considerably faster when the load was off. The difference was that if the steam winch ran away it might do damage to itself, whereas the motor winch might run at a higher speed than usual, and could be checked without any damage being caused. It was a case of rotary *versus* reciprocating motion. In dealing with the shipyard as an illustration he had in his mind the exposure to damp and rain to which those machines were subjected, and, judging by results, dampness and moisture did not affect those winches so much as one would suppose. It was a common practice to connect up all the shunt-wound motors and let the current flow through them. That current flowing through kept the damp off. He did not see clearly how that could be done on board ship, but it might possibly be adopted. Mr. McLaren was perfectly right in his remarks regarding waterproof motors. The ordinary tramway motor, as a matter of fact, was washed down with the hose. They had had an inspection in Cardiff of the Corporation electric light and tramway station, and during the progress of the investigation they made they had an opportunity of seeing the cleaning pits. They had a good pressure of water there, and they took a small-bore fresh-water hose and played through the gearing. The motors took no harm; they were absolutely watertight, and it did not matter whether the water were fresh or salt. If it did not reach the motor it would not do much harm. He had taken the tramway motor as a type, and he had had in his mind the rough usage they had to go through. Any gentleman acquainted with Cardiff would know that there were places where the road dipped to below the water-level, and during the heavy rains those places were flooded to the depth of from twelve to fifteen inches, so much so that the ordinary foot and cart traffic was stopped. The Corporation trams, however, went through it, although the water was at times over the step. He did not know of any one case where the tramway system broke down through getting the motors wet. A question had been raised regarding the duplicate sets and the space occupied. In his opinion the duplicate set was not absolutely necessary, provided, as Mr. Flood had said, they applied to first-class makers for them. The great difficulty was that they did not always get the best on an ordinary specification, because the shipowner took the lowest tender. That was a great difficulty that they had to contend with, not only in electric, but also in ordinary repairs. The result was that they got scamped work. If they employed first-class makers who guaranteed their work, or any of the big firms who had a reputation to keep up, and gave such firms an order for reliable plant, he felt sure there would be no more necessity for duplicating generating sets than there was for duplicate lighting sets. When electric light was first introduced on board ship they had trouble through using cheap dynamos, and they found they did not pay. He thought the same remarks applied to the generating sets. In his paper he had given the space occupied by each set and also the h.p. for each set. The power was 100 effective h.p., with an output of 75 kilowatts. The power could be supplied to the winches with very slight loss, and they could get out of each winch 10 effective h.p. He did not suppose any of them had ever seen steam winches working up to that rate of h.p. on steamships. A question had been raised about the fan. He had with him a note of a small fan with which he had tried some experiments. That fan was of the Admiralty type, and it delivered 1,500 cubic feet of air per minute with 1,300 revolutions per minute. The motor h.p. was 3 (effective), but it was a very small fan, and was intended for a single boiler. It was also a very cheap fan, for the whole rig-out could be bought for £50. He did not think they would be able to get the steam fan for much less. Winch motors could be had at 15 h.p. effective, and those motors would work up to 25 to 30 per cent. overload for short periods. When he had mentioned a 30 per cent. overload in his paper it was a first-class machine that he had in his mind, and the maker thereof would guarantee that amount of overload for a short period. There was also a winch made for a 50-h.p. motor. The difference in price between a 15- and a 50-h.p. motor was £50, so it would be seen that, comparatively speaking, the difference in price was not very great. Reference had been made to the duty of the winches. A 6″ by 10″ steam winch was nominally equal to lifting a three-ton load at 40 ft. per minute, or two tons 60 ft. per minute, or with half-ton it would run 100 ft. per minute. For whipping out light cargo at half-ton loads they could do the work just as effectively with a 10-h.p. electric motor winch as with a steam winch 6″ by 10″. A 7″ by 10″ steam winch was equal to lifting four tons 50 ft. per minute on the barrel, or three tons 60 ft. per minute on the warp end. To do that on an electric winch they wanted a speed on motor of 550 revolutions. The weight of an electric motor equal to a 6″ by 10″ steam winch was roughly 60 cwts., the difference between that and a steam winch being very small. So far as space occupied was concerned, he would like to say that it could easily be taken from the machinery space. It did not encroach on the cargo space; and under the tonnage rules they must have 13 per cent. space for machinery, otherwise they did not get the 32 per cent. allowance from the Board of Trade. He was of opinion that on big cargo steamers there was ample room to place the generating set sufficient for the work he had mentioned. If they only wished to take 50 per cent. of the power of the total output of the machine they need only use 50 per cent. of the steam. The polyphase system—presuming they meant a 3-wire system—was only economical when they wanted a high voltage. With the 3-wire system they could double the voltage for convenience, and take their power on the parallel system. The only objection he saw to that was that the Board of Trade would not permit high voltage on steamers; that department was not educated up to the advantage of electric power. Personally, he did not see any great economy in the polyphase system, and it was on the question of economy that he objected to it. For moderate distances the most efficient voltage was 220. Regarding the motors, he was afraid he had been somewhat careless in describing the types. He had intended to say that for deck purposes he advocated the totally enclosed type. The motors in the engine-room were not so apt to be swamped, and there they could use the semi-enclosed type. As a matter of fact he had that day seen a set of electrically-driven pumps with semi-enclosed motor, and that motor was within 3 ft. of the pump, and it had been working very efficiently and without any trouble whatever. It was protected towards the pump, so that spray was kept off the motor. Speaking of the comparison of cost of electric winches with steam winches, he might say that the latter type had been standardised and the cost reduced to a minimum. Most shipowners took the cheapest, because they knew the difference between the various makers was very slight. If electric winches were run on the same principle they would be getting trouble, for some people would take the specification and supply what they stated to be the best. A few failures of electric winches under those conditions would cause the shipowner to think badly of the system. The only question with electric winches was the question of depreciation, and as to whether the increase in upkeep and first cost would be repaid by the increased speed in handling cargo and economy in pumps. By driving the auxiliaries by electric power they got a much more economical system of distribution. With regard to the expense of upkeep, he was of opinion that if they thought it over they would find that the difference between the wear on the gear of a steam winch as compared with the electric winch would not amount to a great deal; if anything, it would be in favour of the electric winch. A good deal of the loss and wear-and-tear with the steam winch was due to shock. With the rotary motion of the motor the gear would certainly last longer, and at the worst it only meant the rewinding of the armature. Let them compare that with the wear-and-tear of steam winches in coasting steamers, where the winches were used almost every day. As an example there were the colliers which came into port, tore the coal out, and returned at once to Cardiff. The winches of those vessels were always in trouble. As regards pulling the ship off a bank or heaving up the anchor, if they put the strain on one winch they would pull it to pieces. He had been asked to give the comparative boiler power. The cost of boiler sufficient to supply ten steam winches—viz., six of 7″ by 12″ and four of 6″ by 10″—would be, for free exhausting winches, one boiler (or two, to suit space), evaporation equal to 750 gallons per hour; cost, £530.

For electric winches of equal power (plant non-condensing), one boiler, evaporation equal to 400 gallons per hour; cost, £306.

Electric winches with condensing plant, one boiler, evaporation equal to 300 gallons per hour; cost, £241.

These figures show the great economy of steam in a well-designed generating plant as compared with steam winches, so that it is evident that the saving in coal alone would pay a fair interest on the slightly increased capital cost.

With regard to Mr. Flood's estimate about the effective horse-power of the dynamos, he might say that his figures were based upon certain definite experiments that had been carried out, and indicator diagrams that had been taken from independent air-, feed-, and bilge-pumps. During the discussion of the paper to which the Chairman had so kindly referred one of the members thought that the horse-power required for independent pumps was 6·25.

The CHAIRMAN: I think Mr. Latta said that for a steamer of 2,000 i.h.p. the power required for the independent pumps would be 6·47 i.h.p.

Mr. ROBERTS, continuing, said he had been referring to the effective h.p. to do the work required. They had so many gallons of water to deal with, and had to have steam to raise and deliver that to the pumps, and to do that they required 6½ h.p. With the steam-driven pump they required, in addition, a certain percentage of h.p. to overcome the internal friction of the pump itself and the friction of the steam cylinders and gear. If they doubled the h.p. it gave them 13 h.p., required for all purposes, to deliver the feed water against the pump pressure. In his paper he had allowed 20 h.p. for the feed-pumps, as he had not wished to cut the thing too fine. If they had a 20-h.p. motor to do 12-h.p. work they would have something in hand; and most engineers would agree it was advisable to have some power in reserve. Speaking of the switchboard, he would say that it required to be well arranged, and if they had two sets an equaliser would meet the requirements that Mr. Flood had mentioned. There was no doubt that to get good results they must have good tools; therefore he would say they could not expect to deal with cheap switchboards. The question had arisen as to the taking of steam from the donkey boiler or from the main boilers. Most engineers knew that the great difficulty with the main boilers was to keep them clean. In spite of evaporators, they were always troubled with scale, and that was one of the most detrimental things they could have in high-pressure boilers. The donkey boiler was an auxiliary boiler, and he did not think there was much to be gained by using one of the main boilers, unless they had three boilers, and used them in turn, so as to have a good opportunity for cleaning the other two in regular turn. He believed in auxiliary boilers, because they could use them at sea to connect with the main boilers. With regard to the use of tramway motors on board ship, Mr. Flood had referred to that type of motor. Would he tell them for what purpose he thought that type of motor was suitable?

Mr. Flood: For training guns, and other intermittent duty. The ordinary tramway motor is not one that is good for constant full-load duty, nor for fitting in an engine-room where it would be subjected to over 100 degrees.

Mr. Roberts, continuing, said it was a question of temperature. Mr. Flood was perfectly correct, because an enclosed motor was very efficient for intermittent work, but as the temperature rose it certainly made trouble. The effect was accumulative, and the higher the temperature the more risk they had of damage to their armatures. The question of heating in entirely enclosed motors could be overcome by increasing the size of the casing, and also by adding fans to it on the principle of the air-cooler. Those were points that could be dealt with in designing ship plant. With regard to the feed-pumps, it was said that the work was variable, and possibly the pump was required to increase speed when taking power into the generator. The figures he had given were about the maximum required for pump work, and as it depended entirely on the main engines it was a matter of calculation. The shunt-wound or the compound-wound motor would answer that purpose. The shunt-wound acted as a governor, and only permitted a variation of speed for a certain pre-arranged amount. They could arrange it as they liked, and the shunt-wound motor would answer that point. With regard to the question of waterproof cables, that, he thought, was a comparatively small matter. The cables were absolutely waterproof. To make a waterproof cable was a small matter. He would remind them of the submarine cables. It was only a question of degree. Mr. McLaren had referred to a previous paper on the subject of electricity that had been read at the Institute. He (Mr. Roberts) had read Mr. Barnes's paper on "Ship Electric Lighting," but his paper was written before he had read that paper. He wished to make it clear that he did not want to trespass on anyone else's preserves. With regard to the electric propulsion of ships, he certainly thought it was a long way off. He was not going in for marine propulsion. With regard to the comparison of weights, he thought the difference in weight was very slight between the steam and electric winch. If they took the different makes of the same size of winch they would find the electric winch was practically the same weight as the steam winch. He would also say that the electric winches could be so arranged that if they permitted the load to drop off, it automatically threw itself out of circuit, so that there was no fear of the winch running away and smashing up. It was so arranged that when released it cut itself out of circuit.

Mr. D. HULME (Member of Council) proposed a vote of thanks to Mr. Roberts for his very able, clear, and concise paper.

Mr. JOHN MCLAREN seconded the proposition.

The CHAIRMAN : A vote of thanks has been proposed to Mr. Roberts, and I think he well deserves it. He has come all the way from Cardiff so that you can have a fair shot at him. I think to-night's discussion has been very interesting, and no doubt when we proceed to discuss it again later on it will be found more so. In regard to steam winches, I have in my mind some of the bends and twists we had in the steam pipes after a gale of wind, which had to be straightened out before reaching port. If Mr. Roberts can see a way to relieve engineers of duties of that sort by advancing what he has advocated to-night he will be doing a good service to all who go to sea. I think we shall all give him a very hearty vote of thanks for his paper.

The proposition was most cordially agreed to.

Mr. ROBERTS : I thank you. Will you permit me to propose a vote of thanks to Mr. Lawrie, the Chairman.

Mr. J. THOM seconded, and the proposition was carried.

It was then announced that onMonday, April 11th, the discussion on Mr. Sumner's paper on "Marine Petrol Engines and Motor Launches" would be continued.

Mr. K. C. BALES moved, and Mr. W. MCLAREN seconded, that the further discussion on Mr. Roberts' paper should take place on April 18th. The motion was agreed to.

DISCUSSION CONTINUED

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, APRIL 18th, 1904.

CHAIRMAN:

MR. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN: Those who had the pleasure of hearing Mr. Roberts read his paper and reply to the criticisms must have been impressed with the grasp that he had of the subject; and, whether we agree with his ideas or not, I think he fully understands his subject, and if his claim for greater economy and rapid handling of cargo can be maintained he has made out a very good case. Of course, opinions vary on that point, and a great deal has been already said on the subject. It has been productive of a very full and ample discussion at Cardiff, where we have had some discussion almost on the lines of the text-books, and various other methods have been adopted to enlighten us on the subject.

Mr. A. E. SHARP (Member) said he was sorry he had not come prepared to speak on the subject, and would prefer to send in his views on the matter in writing after full consideration of the paper. At the same time he could not agree that the author had put a very fair case in regard to the electric cargo gear, and was inclined to differ from him on many points. First, as to the pipes. With a 3-in. pipe they might have a stop valve quarter-turn opening. The amount of opening of the valve was no measure in regard to the area of the pipe. Again, taking the collective areas of the winches and the collective areas of the compound engines, they could not expect to draw a fair comparison between high- and low-pressure cylinders of the engines for dynamos and the winch cylinders where they were using only one pressure of steam. Of course it was a very attractive thing to use a wire for the transmission of power; a wire was very easily put down as compared with a steam pipe. But the wire had its loss, just as the steam pipe had. They all knew the loss that was shown if they put a steam gauge on the end of a winch service-pipe; they would find that there was a great loss in pressure compared to that on the boiler. The same kind of loss occurred with the wire. They could not get the same voltage at the end of the wire that there was near the dynamo. The dynamo engine would have a maximum of efficiency when working perhaps at full load, but if they put one or two winches on the efficiency of the machine fell away very considerably. In the first place they had the steam engine that was generating the electricity; that might be working at 80 per cent. Then they had the efficiency of the dynamo; that might perhaps show another 80 per cent. Thus only about 60 to 65 per cent. of the power that they had in the first instance might be available actually. The motor, again, perhaps, might only yield 80 per cent., less or more according to the temperature, for the motor would fall away very considerably with the rise of temperature; and perhaps by the time they got to the work on the winch they would only have about 50 per cent. of the original power. The question of the different speeds at which they could run those motors was one he did not see that the author of the paper had mentioned, or explained how they were to get the necessarily different speeds, as a winch of only one speed was not of much use for working cargo. He was aware that there was a method of getting different speeds by the introduction of resistances, but by the employment of that method they would be throwing away more of their electricity. That was just a sort of whittling away of their electric power. Looking at the whole thing, he could not take the same view that the author had in regard to the application of electricity. The question of electricity for forced-draught fans might involve a motor on top of a boiler, where it would have a very different atmosphere to that in the shore generating stations—where, also, want of ventilation and presence of soot and grit would be very detrimental to a motor.

Mr. G. W. NEWALL (Member) said that from the title of the paper it was certainly one that should be welcomed by the Institute. The question of cargo steamers electrically dealt with was one that ought to be discussed. It was a good subject, and one that should be faced. He could give them some experiences that he had recently had at the works he was connected with, where, during the last five and a half years, they had thrown out as many as forty to forty-five steam engines. In fact, they would soon not know the steam engine, except the one used to generate the current. He thought he would be within bounds when he said that the number of motors inside the factory was nearly 350, whereas ten or twelve years ago they only had about a dozen. So far as electrically-driven plant went, they believed in it fully. They knew for a fact that between the generator and the motor they only lost about 3 per cent. of their power, which was very small compared to the loss from long lines of steam pipes, as were usual in large factories. Personally, he had very great faith in the motor for electrical power on board ship. The paper was certainly a very good one, and one that he must look into more fully. The motor, he thought, had not been taken up as it might have been from their side of the question. It was only because it was more or less thrown on them that they had to accept it. But it was worth accepting; that was his experience of it. It had certain features in regard to which the steam engine had to take a back seat. He could only talk of what he had seen, helped to design, and place at Silvertown. At that factory they had a cable in to give a very small loss on long distances ; that means that the cable is large to keep the loss down.

Mr. NEWALL : We have about 3,000 h.p. running all day long. It is constant.

Mr. SHARP : Where it is constant you will get a greater amount of efficiency than if you had to vary from 1,000 to 2,000 or 3,000 h.p.

Mr. NEWALL : We have some machines which one moment are absorbing 50 h.p., and within three seconds are absorbing 250 h.p., and these machines are driven by the same motor.

Mr. SHARP : If you had the same thing on board ship you may sometimes at night-time have very little on the machine when all but the absolutely "all night" lights are switched off. Suppose you had all the bath pumps motor-driven, you would have very little on the machine at night-time, and I contend that the efficiency of the machine would be very small during the night, if you had to put in a machine large enough for day purposes. Again, if you are going to fit a machine large enough for day purposes the first cost will be heavy, because you are putting in a big machine to do maximum work, and which you are only using for a very short period.

Mr. W. McLAREN (Vice-President), before referring to the paper under discussion, said he would recommend the members to procure a copy of a paper read before the Institution of Electrical Engineers by Mr. Wilkinson, who, he understood was connected with the firm of Vickers, Sons & Maxim. That paper dealt with the application of electric machines to any purpose they could get them into, and he thought it would afford them ample food for thought. In his paper Mr. Wilkinson described the variable speed motors, and it was surprising what could be done with those machines in the way of reversing. Some of them were used in connection with universal planing machines, and it was marvellous how the motors could adapt themselves to the return of the table before commencing the following cut. Mr. Farenden, who was at the meeting when the paper was read, would bear him out in what he said. The return speed of the motor was, he thought, treble or quadruple that of the cutting speed. It was good to hear of such machines being on the market, and he believed they were made by Vickers, Sons & Maxim themselves.

Mr. SHARP said it appeared to him that a machine of that description would be doing all its work whilst it was cutting. He understood that when it was on the return stroke it was doing absolutely no work at all but to return the table, and they could understand that the motor would "come away" with more revolutions when practically no work was being done. That was a case where a motor appeared at a decided advantage. In planing machines they had to have a different gearing to get a quick return. They could quite understand that when they had a machine that ran away fast when it was not doing any work, or when the table was returning, it was working under advantageous conditions. He did not know whether that might be the explanation, but that was how the matter occurred to him when he heard it mentioned.

Mr. W. McLAREN said he was not sufficiently well informed to define the system that was applied to those machines, but he thought he was safe in saying that some of the resistances were taken out of the field to give those extra number of revolutions with the lighter power, which caused the quick return of the table. It was so constructed, and the motor was not ungovernable, but was governable to that extent. He was not prepared to go any deeper into the electrical mysteries of that particular question. So far as his experience of factory work went, he would say that the motor did not exceed such a tremendous speed from its minimum to full load. He thought Mr. Newall was about right when he spoke of a loss of 3 per cent. between the generator and the motor, but anyone putting in electric power generally arranged that his generator was a few volts higher than his maximum so as to compensate for that loss, and thus he got his motors to run at the particular voltage for which they were constructed. It was a puzzling question how far they could go in for motor driving on board ship. He should say it was quite safe, and more economical than the use of steam winches. The motor, he thought, had arrived at such a state of efficiency and handiness that it was quite applicable to such work as loading and discharging cargo, but the question of gearing might be a difficulty. That would either be done with a worm gear or a cut gear—that was, a pinion and spur gear—so as to get smooth running. They could have a raw hide pinion, and he did not think they could get a sweeter drive than that. The difficulty they, as marine engineers, would experience would be the reduction or increasing of the speeds. The higher speed motor was the cheaper and lighter motor, but it was a question whether they should have motors of 900 or 600 revolutions or less. If they went in for lower revolutions it added to the weight and initial cost. Personally he was in favour of about 300 revolutions as a serviceable speed. That would be a substantial motor. He saw that some of the members at Cardiff had referred to the application of electric power to the windlass. He was of opinion that the motor was as applicable to the windlass as to the winch; but he was not inclined to favour the application of electric power to the steering gear. It struck him that the steering gear should be manipulated from the after-end instead of by means of the wheel and chain, or by the wheel and Brown Brothers' system, the telemotor, which was actuated by hydraulic pressure. If those wires were led from the bridge or from the wheel-house to the after-end of the ship, instead of having a steam engine or hydraulic power, the motors should be one on each chain. The difficulty which appealed to him was as to how they would brake those motors, unless they applied something of the Marconi system to hold on the paying-out motor whilst they were using the pulling-in motor. Returning to the question of winches, perhaps in cargo steamers the furthest they could at present go in regard to the application of electric power with safety and economy was with the winches. If they applied electric power to the pumps and other auxiliaries required in the engine-room it would be a source of annoyance to start the generator and transfer that power back again into a pump, say, to supply the donkey-boiler, when they could apply the steam to the pump direct and have the boiler up to their satisfaction. In passenger steamers, where there were so many uses for auxiliaries of that description, such as pumps, ventilating fans, cooking utensils, there was any amount of heating plant that could be done with the electric machine, and therefore that machine was the one for the passenger ship. He did not agree altogether with some of the details in the paper, but, taken as a whole, he was of opinion that electricity was the coming power in regard to its facility and adaptability for the transmission of power; and that was a point they must not forget. With regard to the use of flexible cables, could they not apply a submarine cable on the deck to counteract the exposure by the washing of the seas? The use of such a cable had never occurred to him before, although he had been some years in a cable ship. Mr. Sharp had referred to the heating of the motor if it were placed on top of the boiler casing. That could be easily prevented by altering the position, or leading the wires up through the stokehold. He was three years in one vessel where they had an electric lead running across the boilers not protected by any special casing. That lead was only put into wooden loops to hold it up at the angle bars, etc., and it seemed to stand well—at any rate for the period he had mentioned.

Mr. JAS. ADAMSON (Hon. Secretary) : The steering engine by Brown Bros. referred to by Mr. W. McLaren is fixed on the tiller head and moves with it. There is a pinion on the engine shaft which works into a quadrant secured to the deck. The teeth on the quadrant and pinion are shaped to give the least amount of vibration and noise, and no doubt an electric motor would serve the purpose as well as a steam engine. The telemotor is simply for actuating the admission valve in place of shafting and gear from the bridge, with the many bevel pinions and frequent difficulty experienced in awkward leads in way of deck houses. How far is electricity adaptable to the various auxiliary machines we have to provide for on board ship ? One great difficulty I apprehend—not having seen Mr. Wilkinson's paper—is the constant speed the motor is required to run at to maintain efficient economy. More efficiency is got out of the motor when running at quick speeds, while a slower speed for pumps is required than for winches. The question of voltage requires some consideration, and an arrangement with the Board of Trade, as Mr. Roberts has remarked. A motor of 200 volts would be as economically efficient as one four times that voltage.

Mr. NEWALL : It would be less dangerous.

Mr. W. McLAREN observed that the higher the voltage the greater the danger. That was just the point. The mechanical working had to be so perfect and so well paid for that the initial cost would be too great for ships' use.

Mr. ADAMSON, continuing, said he thought Mr. Sharp had not observed that Mr. Roberts had proposed to have two machines—one for the light load, and two working when the full load was on. There was no doubt, he thought, that in various works throughout the country the adoption of electric motors had been found much more economical than the steam engine. They had heard of cases where the gas engine had been found more economical than the electric motor; at least he had heard of such cases being cited. He had noticed a short paragraph as to some works which had recently been modernised and rearranged with a view to economy in cost of production, and it seemed to him that the best form of protection which could be adopted by our manufacturers was the introduction of the most efficient machinery and appliances, kept up to the mark in order to compete advantageously with their foreign rivals. On the subject of prices, he thought that Mr. Roberts had actual quotations for the figures he had included in his paper. He seemed to stand by the quotations he had given, and the electric winches he had shown on the screen were exhibited with a view to showing the style of winch for which he had received the quotation. Mr. W. McLaren had referred to the mode of driving the winches electrically, and it would be of interest to know the most approved plan; and if friction could be satisfactorily applied as such he thought it would be preferable to the spur gearing. He quite agreed that the subject of the paper was one that had not been brought before them too soon, and with the paper Mr. Roberts had given them and the research they could make during the recess they would be better prepared to discuss the subject when they met again in the autumn, having gained a little more experience in the interim of what was being done. Mr. John McLaren had referred to the work done in America with the electrical appliances in connection with the loading and discharging of cargo, and Mr. Roberts had referred to the work done on the American lakes with those electric motors, so that the initial stage had been already accomplished.

The CHAIRMAN said he agreed with the general remarks made by the members to the effect that they were very much indebted to Mr. Roberts for bringing the subject before them, as it was time they discussed the matter as fully as possible.

There was no doubt they would find that it might be a success for one appliance, but not quite a success for another. He thought it would be generally admitted that the steam winch was a wasteful piece of machinery; the manner in which it was worked, its position, and other causes all tended to make it so. Mr. Farenden had said he considered £70 rather a low price to pay for a steam winch. Ten years ago he had purchased a first-class steam winch for that price, and had even had them at a little less. An engine builder in Liverpool was in the habit of putting his spare hands on to making steam winches when they were not busy with other work. The result was that he could dispose of a first-class steam winch for even less than £70. There was another point upon which Mr. Farenden had touched, which he thought that Mr. Roberts ought to clear up. In his paper he had said: "The feed-pumps to be in duplicate, each consisting of a set of 3-throw vertical pumps, diameter of plungers 4 in., length of stroke 6 in., running at 60 revolutions per minute." Not very long ago Mr. Roberts had read a paper on "Independent Pumping Arrangements on Cargo Steamers," and in referring to feed-pumps in that paper he made the following remark: "For many reasons the boiler feed-pumps should be run slowly and steadily; quick running feed-pumps are wasteful and expensive." There seemed a slight discrepancy between Mr. Roberts' ideas when he wrote the former paper and his ideas as expressed in the paper under consideration. While he certainly approved very much of the paper, he would not say that all the author's suggestions were capable of being carried out, but thought that they ought to increase their knowledge on the subject, and also increase the use of electrical appliances on board ship. He did not know whether it was possible at the present day to make an electric winch that would stand the rough and severe work, or whether if they put in an electric winch they would be able to get more competent men to drive them. That, however, would be settled by experience. The first electric plant he had to do with on board ship was a great failure, because the machine was too fine. They were glad to get rid of it, but their experience told them what was required. The next machine suited very well, and the former machine which had not suited on board ship was running yet on shore. No doubt those little difficulties that still cropped up in connection with electric auxiliary engines would be overcome in time, but it was very probable that those who first experimented would be a little out of pocket. There were many further remarks that could be made on the subject of the paper, and he was sure they were all very much indebted to Mr. Roberts for bringing the matter up as he had done.

Mr. NEWALL said he would like to remark that, in reference to the subject under discussion, he had that day to design and fit up some hydraulic pumps which were only working at 15 revs. per minute, driven by electric motors. The hydraulic pump was a very fearful agent as regards varying speeds. They knew, of course, that on the up-stroke of the plunger there was no resistance, then all at once the water was locked in, and, being a pump for heavy pressure, there was a tremendous strain thrown on the motor. This pump was to work at 15 revs. per minute, another worked at 60 revs. per minute, whilst a third, with a pressure of a ton per square inch, worked at 70 revs. per minute. All those pumps were motor-driven. They could reduce down from 350 revs. to 5 revs. with two tons per square inch of water pressure, and yet work very efficiently. There were several ways in which this could be done, but the general way was to have a worm gearing. It was quite a simple method, and they could reduce the revolutions of the motor from 300 or 400 down to 30 if they wished, and the engine would behave well. It was astonishing how little room those machines took up, and there was only one moving part against the 30 or 40 in the steam engine. One almost began to wonder what a steam engine was like. That was the impression one got after working in a factory where they had displaced all the steam engines by motors. The motor was simply ousting the steam engine all over the country.

In reply to the discussion on 18th April, I am glad to see that the members accept the general principles of the paper, and that the objections are principally to matters of detail.

Obviously it is impossible in a paper like this to put forward details which will be adapted for all classes of ships and all circumstances, but I think Mr. Newall's remarks, based on his own experience, show that the electric motor can be adapted to suit all requirements, and that the system is elastic and able to adapt itself to circumstances in a manner quite impossible with direct-driven steam plant; and it is here where the economy comes in.

Take the case of a steam winch on a ship's deck furthest from the boiler. During all the time it may possibly be required to work the steam pressure has to be maintained in the pipes right up to the stop valve, and this leads to condensation and consequent loss, besides the risks of damage by water in the cylinders. With the electric winch under similar circumstances there is no "condensation" loss in the wire, and no risk of the motor being damaged by starting suddenly. Then the steam used in the generator is governed, so that only what is required for the work in hand is taken from the boiler.

We have been so accustomed to regard the steam engine as a simple and handy machine for marine work that we are apt to overlook the extravagance of cost at any distance from the boiler, and therefore it is exceedingly difficult to make it clear to the members in one paper how great the advantages of the electric system are when properly understood and applied. Therefore I hope some of the other members will take up the matter on similar lines, and I feel convinced that the more they go into it the better they will like it. If such a paper should be introduced during the coming session I shall be glad to take part in the discussion.

Dealing with the minor objections raised during this discussion, Mr. Sharp deals with the pipe sizes I have given. I do not quite see the point of his argument, but the 3-in. steam pipe is the full size required for the machine I proposed, and the supply is not regulated by the opening of stop-valve, but by the action of the governor on the cut-off. Regarding his remarks as to loss of efficiency, I think Mr. Newall has very clearly answered that point, and I would ask Mr. Sharp to trace the net efficiency of the steam winch in the same way as he has done with the motor, and I shall be surprised if he finds the work on the winch anywhere near 50 per cent. of the original power. It is more likely to prove only about 20 per cent.

Several of the members have referred to speed regulation of the motors. This, to the electrical engineer, is a very simple matter, as the motor can be designed to run at any required constant speed, and can be arranged for a variation of definite amount. To put it shortly, it is a question of more or less copper on the armature or magnets and the manner of winding same. I am certain that marine engineers will have no difficulty in obtaining exactly the motor they require for any particular purpose, if they clearly specify their wants and give the electrician liberty to design a machine to suit them. But to take any motor and attempt to use it for other purposes than those for which it is adapted is to court disaster.

Regarding the risk of injury to the motor of forced-draught fan on top of a boiler, I had an opportunity recently of seeing one at work on a fast passenger steamer. This fan was on top of boilers close to the funnel. The engineers report showed that the motor required very little attention, and was not affected by the temperature or dust, while the control was much simpler than that of a steam engine.

Referring to the Chairman's remark on feed-pumps, at first glance it would appear as if I had altered my opinion as to the speed of these pumps, but in reality this is not the case. My remarks in the previous paper referred to the quick-running pumps driven off the main engines, in comparison with the slow-driven independent pump, while in this paper the "three-throw short stroke" pumps are intended to run at a *maximum* of 60 revs. As a matter of practice they would be run at much less. Altogether these matters of detail must be arranged to suit the circumstances of each case, and there need not be much difficulty in meeting them.

I am very pleased to note the interest taken in the paper, and trust that the subject will not be allowed to rest here, but will be carried on until some tangible result is secured.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1904-1905.

President—THE HON. C. A. PARSONS.

Local President (*B.C. Centre*)—LORD TREDEGAR.

VOLUME XVI.

ONE HUNDRED AND SEVENTEENTH PAPER

(OF TRANSACTIONS).

PROTECTION OF METALLIC SURFACES.

BY

MR. H. BRANDON (MEMBER).

READ AT

58 ROMFORD ROAD, STRATFORD, E.

ON

MONDAY, APRIL 18th, 1904.

CHAIRMAN:

MR. W. LAWRIE.

PREFACE.

58 Romford Road,

Stratford.

April 18th, 1904.

A meeting of the Institute of Marine Engineers was held here this evening, presided over by Mr. W. Lawrie, when a paper by Mr. H. Brandon (Member) on "The Protection of Metallic Surfaces" was read, in the absence of the author, by the Hon. Secretary.

The discussion on the subject was adjourned till the re-opening of the Session in the autumn. Members are invited to contribute to the discussion in writing meantime.

Jas. Adamson,

Hon. Secretary.

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CHAIRMAN:
MR. W. LAWRIE.

THE object of this paper is to induce you to express your views for our mutual benefit. That some kind of protection is necessary for metals is obvious, as the loss through wasting, or converting one substance into another, is past all calculation. No doubt the earliest forms of protection for metallic surfaces were arrived at by coverings for decorative purposes, and the first would be greases with colouring matter, or some class of earth or clay worked into a paste or paint. It would soon be noticed that iron would not rust so rapidly under such treatment; by degrees coverings would be used as they are now for the two purposes, decorative and protective.

What is this wasting or rusting of the metals? All metals do rust, some slightly and others very rapidly; it goes on without any apparent assistance. The "Noble" metals only tarnish, which can be effaced by rubbing with a dry cloth; this tarnishing of silver is very pronounced if sulphur fumes are in the air. The base metals rust unless the greatest care is taken. If a sheet of iron be scoured bright and dried, and then some spots of water are dropped on to it, in a few hours the surface under the water will have taken a light red or orange yellow colour, and when all the water has evaporated, where each spot of water had been there will be a red mark. If the sheet is cleaned by rubbing it lightly with an oiled cloth, the marks that were red now appear of a dull colour, less bright than the places that were not wetted; examine these small discs with a powerful glass; the etching on the iron is plainly to be seen, showing that so much iron has been eaten away. Even if only air be allowed to play freely over the surface of such a sheet, in a few days' time this redness will appear, light at first, and after a time it darkens to deep red, and afterwards to deep brown. What is the cause of this?

If we put a sheet of lead to the same test, bright at first, in a few hours it becomes quite dull, but unlike the iron, this dullness on the lead sheet does not deepen; once covered it stops and this skin gets no deeper, but forms the lead's protecting coat. If two pieces of lead be scraped bright and put together with a little pressure and a sharp twist, they lock themselves together; try the experiment again, scrape the faces bright, but do not put them together until the following day, it will then be found impossible to make them lock together. What is this that attaches itself to the surface and so effectually keeps them apart? When lead is being melted a dross collects on the surface; if this be skimmed off the molten lead shows a mirror-like surface, which soon becomes dull again, and this removing of the dross could go on until there was no lead left. If a portion of this lead dross be mixed with about twice its bulk of powdered charcoal and placed in a crucible, the lid put on and sealed with clay, then heated to a red heat and allowed to cool, and the contents of the crucible shaken out, some dust will be found and a little button of lead. What the lead dross had taken up has evidently been given up again to the charcoal, helping to consume it, and this something is the oxygen of the air, which unites with the lead to form the dross or oxide of lead, and has again left the lead oxide to unite with the charcoal, forming carbonic acid gas and lead.

If a sample of iron rust be treated in the following manner, we are able to find what it contains: some rust in fine powder is weighed into a crucible and heated for two hours at a temperature of 200° F., allowed to cool and weighed; the loss of weight equals moisture. The crucible is again heated and kept at a red heat for about two hours, is again allowed to cool, weighed, and the loss equals the weight of the combined water. The residuum is now placed in a hard glass tube having an arrangement for passing dry hydrogen gas through it; the iron rust is heated to a red heat, and the hydrogen when passing over the heated rust combines with something in the rust to form water; this something proves to be oxygen which has left the heated rust. The residuum in the glass tube is found to be iron and highly magnetic. If the experiment be carried out with weighed quantities and the necessary calculations made, it is found that 100 parts of iron rust contain about 52 per cent. of iron, 22·5 per cent. of oxygen, and 25 per cent. of water; proving that oxygen and moisture are the causes of rust. As so much water is found in the rust, we naturally come to the conclusion that if no moisture were allowed to come in contact with the metal rust could not be formed; also if the surface be allowed to get wet and dry alternately more wasting takes place. The atmosphere always contains moisture, more at some times than others; this moisture contains carbonic acid gas, which assists the oxygen in its work of destruction.

That iron, when rusting, takes up some other body can be seen by its increase of volume, and, when forming, the power it exerts is irresistible. Take notice in old steel or iron ships of the rust formed between frames and reverse frames, and how they bulge between the pitch of rivets. This rust when beaten out leaves an open space; if a piece of this scale be examined when broken across the section, it shows forms of strata, indicating that it has been formed at different times. This is easily accounted for. Each damp or sweaty cargo supplies the necessary heat, dampness and gases. The following cargo may be one that does not sweat, then there will be a period of rest from rusting, and thus the strata is formed. Temperature also plays an important part in rusting, more especially if it differ on each side of the surface; this produces sweating on the side of lowest temperature; the sweat is condensed atmospheric vapour, and of course contains carbonic acid gas.

Rapid change of temperature also causes cracking of scale from the surface, leaving new surface ready for attack. This is very pronounced in many cases; ships' tanks, for instance, although always in a wet or damp state, do not waste so rapidly as one would expect, because the range of temperature is small, but when we come to the tank, which is subject to larger ranges of temperature (under boilers), there the wasting is very rapid.

The internal work in pontoon tanks lasts for years owing to the small range of temperature; the tank tops deteriorate worse, as they have a wider range of temperature through being exposed to the action of the sun. Wasting goes on less rapidly below water than in positions of alternate wettings, or, as sailors say, "between wind and water." This can be seen in boilers. The auxiliary boilers, that are only in use a short portion of their lives compared with the main boilers, waste much more quickly, and this can only be accounted for by the sweating arising from vapour leaking through faulty valves during the idle period. Surfaces that cannot have a protecting coat should be kept either wet or dry. Water holds a portion of oxygen, fifty volumes in every 1,000, at a temperature of 60° F., and as the temperature rises its capacity for oxygen or any gas decreases; at 120° F. only thirty-eight volumes per 1,000 are held, so if the water in the boiler be heated enough to expel the gas and then closed up, but little harm can be done.

We now come to the question, What bodies offer the greatest resistance to this all-destroying oxygen, moisture, and carbonic acid gas? They take the following order: platinum, gold, silver, copper, tin, zinc varnishes, oxides of lead, zinc, iron, lacquers, bitumen, and cement washes. In the arts the coverings are mostly for decorative purposes. Gold leaf is a most effective protection; a leaf of gold only one five-thousandth part of an inch in thickness is a perfect protection for years, and will resist acid fumes. Silver is used as a covering for cheaper metals, and is applied by a galvanic process known as electro-plating. The process of lacquering is both decorative and protective; lacquer is a varnish made by dissolving shellac in alcohol, and may be coloured with different pigments, gamboge, saffron, etc. Tinning is the process of covering specially prepared sheet iron, which is chemically cleaned, dipped in tin, and rolled. Enamelling is a process of covering iron with a glass glaze.

As our work is nearly all connected with shipping, the question of metallic coverings may be neglected, the process of galvanising excepted.

This process is much the same as tinning; the sheets are cleaned, dipped in a weak solution of acid, washed, and in some cases dipped in lime water to counteract the acid. The article is then dipped in the pot and receives its coat of zinc. It is a most effective covering and extensively used. Its only drawback is the injurious effect of the pickle on the iron. As engineers, the metals that claim our attention are those we have most to do with—iron and steel. To find an efficient protection for these metals, as used in bridge and ship building, has taxed the ablest of engineers and chemists, and the inventor has found, and does yet find, ample scope for his inventive faculty, and the result is that nostrum after nostrum is launched on the market, each better than the last, each with its long list of testimonials that it will not only prevent rusting but will destroy any existing rust; in fact, like a quack medicine, it is warranted to cure all ills. The protecting coat must be selected from metallic oxides, bitumens, varnishes, or cement washes. The principal pigments are white and red leads, zinc white, and iron oxides. There is also a number of pigments made from the ochres, barium, china clay, etc. White lead, as its name implies, is a white powder, and is manufactured in several ways. That most used is known as the Dutch process. Sheets of lead are subjected to heat given off by spent tan, which emits carbonic acid at the same time; also the fumes of acetic acid have free play over the surface. By this action the lead decomposes into a greyish-white powder; this powder is washed, ground, and again ground, with about 7 per cent. of linseed oil, and packed for sale. This pigment has found great favour as a paint for iron work. It has a fairly good colour, covers well, and resists the weather fairly well; it is, however, soon destroyed by acid fumes or weak acid water; it blackens if brought in contact with sulphuretted hydrogen; for this reason it should not be used in engine-rooms, if the paint is expected to retain its colour. Its principal adulterants are barium, china clay, and whiting.

Red lead is oxide of lead heated in a furnace until it has taken up so much oxygen. From litharge, PbO, it is transformed into Pb_3O_4. It is considered to be one of the best protectives for iron when mixed with oil. Oxides of iron are composed mostly of ferric oxide, Fe_3O_4. It is got from hematite mines; the ore is roasted, then ground with edge rollers, and washed with running water; the finer particles separate themselves from the coarse. The fine oxide is again ground with flat stones, the powder dried, and ground with oil. This pigment makes a first-class covering; it has good covering power, will stand the atmosphere quite as well as lead, it is no more affected by acid fumes, and has cheapness on its side.

Bariums and china clay form good pigments, and will retain their colour. Barium is known as permanent white; both it and china clay are absolutely unaffected by acids. Barium, owing to its cheapness, is used for adulterating white leads. I think the word adulteration is rather misplaced in these cases. If white lead is bought at 21s. per cwt., and on testing is found to contain barium, then this is adulteration; but if a mixture is sold for white lead and only charged 12s. to 13s. per cwt., this cannot be called adulteration, as a price to insure a genuine article has not been paid.

Bitumastic coverings are most effective, will stand a lot of rough wear, are not affected by acid fumes, and are cheap. This class of protection must always be applied at a high temperature. It is a good non-conductor of heat, therefore will not cause condensation on its surface, at least not to the same extent as paints; it is also able to resist the corrosive action of bilge water. The principal danger of using tars which have not been specially prepared for coverings is the liability they have to contain tar acids or ammonia. Cement washes are no doubt of some value; in fact, a good coating of Portland cement is a perfect covering so long as it remains in contact with the iron. In ships' tanks and the like it is extensively used, but for vertical surfaces it cannot be applied of sufficient thickness. When used as a cement wash, the cement should not be mixed in a solution with water, as this separates the ingredients ; the better plan is to first wet the surface with a brush, the cement then dusted on and again brushed over ; by doing this the full benefit is obtained.

Whatever covering is used, it should fulfil the following conditions as far as possible. It must not require any special instruments for its application, nor give off any poisonous fumes ; it must be easily applied and dry fairly quickly. Before the oxide pigments can be applied they have to be mixed with some vehicle, which is usually boiled linseed oil, and it is to this article that we must look for the real protection when coating with oxides. Oil and the pigments forming the paint are not a chemical, but a mechanical mixture. The oil and pigment can be compared to an emulsion where each granule of pigment is surrounded with a coating of oil, and they assist each other to form a covering.

Although the mixture of boiled oil and a pigment is a mechanical mixture, when the covering is applied and air has free access, then a chemical change takes place by the oil absorbing oxygen, and it is owing to this property that the oil dries. Boiled oil is linseed oil heated by blowing hot air through it. When it is undergoing this process driers are added in the form of leads or manganese ; these are added as they are good carriers of oxygen, which they give up to the oil, causing it to harden. Boiled oil, if allowed to dry in contact with the air, increases about 18 per cent. in weight. It is then a solid mass. If the oil dries too fast, then the surface will crack and allow air to pass through. Good oil should retain an elastic body that will allow it to expand or contract with the surface to which it is applied. For a paint to be perfect its coefficient of expansion should equal that of the surface it is supposed to protect. Of course, all coatings will deteriorate in time owing to physical as well as chemical action, but to insure lasting paint the oil must be good.

It is sometimes necessary to use quick-drying paint for holds, but they are not so lasting as oil paints. The drying is effected by spirits—naphtha—which evaporate quickly. The surface dries lustreless, and soon takes a powdery appearance and falls off, or is pushed off by rust which is formed underneath.

Whatever form of covering is used, two things are absolutely necessary : first, the surface must be properly cleaned of all dirt, rust, and mill-scale before the coating is applied; and secondly, the surface must be properly and effectually covered—no blowholes to allow air or water to get through the coating ; for whatever wasting takes place must originate at the outer surface—that is, if the coating is effective, there is every prospect of the metal retaining its efficiency. Two thin coats are better than one thick coat, and the first coat must be properly dried before the other is applied. It is also important that the surfaces should be clear of all moisture, as it is impossible for paint to adhere to wet surfaces. If moisture is trapped between the surfaces and the coating, it is sure to show itself by blisters, blowholes, or crinkling. Treatment of vessels whilst under construction is of great importance, and one that seldom receives proper attention ; the surfaces are not cleaned, and the coatings are not applied soon enough on each other. A coat is applied (perhaps of a doubtful quality), and before the next coating is added rust has started under the first.

Painting iron surfaces is quite a different thing to painting wood surfaces ; in the latter the paint has a chance of embedding itself in the pores of the wood, or the wood has the power of absorbing so much of the paint. With metallic surfaces it is quite different, the paint is only able to remain on the surface by adhesion, which makes it all the more necessary that the paint should have strong adhesive qualities, because nearly all the surfaces on board ships are vertical, there are only the decks, stringers, tops of beams, and tank tops that are horizontal. If the first coat firmly retains its position, then any number of coats may be applied, but if the bottom or priming coat is not properly fixed, or is on an unclean surface, then as soon as it leaves the surface it will, of course, carry all other coats with it. As the paint can only depend on its adhesive powers to remain on the surface, we may say that the rougher the surface is the better the paint will hold on; this is the case to a certain extent only. Consider what takes place when painting a very rough surface, say, a badly pitted plate. There is the risk that the little pit holes will not be filled up, or there will be a cushion of air at the bottom which will only require a slight rise in the temperature to expand the air and form a blister; and, again, the little hills or pinnacles on such a surface will be barely covered by the first coat, and perhaps by the time the second coat (if one is applied) is on the rust has started. The rougher the surface the greater chance it has of holding moisture and the smaller chance of this moisture being noticed. When rough surfaces are covered stiff short-haired brushes should be used to work the paint well on to the surface. The benefit of applying pigments to dry and clean surfaces can be seen on plates of great age, that have had forgemen's and platers' marks put on when the plates were new, and this, no doubt, is more due to the clean and perhaps warm surface than to the class of covering. These marks can be distinctly seen, and if the metal be examined will be found quite good, although the rest of the plate be badly pitted.

We now come to the question of protecting ships' bottoms both from corrosives and fouling. There are several important items in this branch. The surface must be smooth so as to reduce the skin friction of the water on the vessel's sides and flats as low as possible, and the harder the surface and more glass-like for this purpose the better. But there are other demands on the paints that prevent the surface being of a hard nature. The coats of paint must be quick drying to enable two coats to be applied in one day. It is quite possible to make a perfect paint as regards destroying life, but such a paint would be most injurious to the vessel's plating if the anti-corrosive is worn off, such as caused by friction against quay walls or cables chafing the bows; and if the poisons are too strong they would destroy the bottom coat and thus work havoc with the plating. Marine vegetation, unlike the land vegetation, exists by feeding through its leaves only; there is no nutrition derived from the roots, they are merely anchors. If a piece of seaweed be once detached from the rock on which the spores have grown it has no power of taking root again.

If a small piece of marine grass is viewed under a microscope it will be seen to be full of miniature rivers with the water in rapid circulation; it is by this circulation the weed lives, and if it has to be destroyed by poisons, then the poison must come from the anti-fouling coat and impregnate the water, or the paint must peel off taking the grass with it, or the ground must be too soft for the roots to hold against the friction the grass has on the water. The shell life that accumulates on vessels is the principal cause of the falling off in speed, and the principal use of anti-fouling paints is to destroy this life. The shell itself offers great resistance to the vessel's passage through the water, but this resistance is materially increased by the net which the molluscs put out when fishing for food, or for material for constructing its house, and by poisoning the water this life is destroyed. The poisons will not wash out so freely when the vessel is in harbour, or at anchor in some roadstead, as it does when the vessel is under way, and it is during this idle time that the serious fouling takes place. And if the idle time occurs after a long passage the paint is at the disadvantage of having parted perhaps with all its poisons. This is the severest test for a good paint.

It will have been noticed by many of you that a vessel will make a round voyage at a certain time of the year and return home clean; when the following voyage going over the same ground she will return home foul. The life in the oceans has its seasons like life on land, and this life is more abundant in some waters than others. There is a large number of anti-fouling coverings on the market, and some of them enjoy a good reputation. Some of them appear to be expensive at first cost, and many cheap ones prove expensive in the long run, hence it is advisable to be guarded against firms who will offer to supply good paint at a price and then accept any figure offered. One of the cheapest coverings for this purpose is tar and blacklead, and no doubt answers very well for vessels trading in fresh and salt waters alternately. The principal thing to guard against is to make sure the tar is free from all corrosives. A coating that at one time was in great favour, and is still used for sailing vessels, is a mixture of zinc white and tallow. It is a good anti-corrosive and prevents the formation of life to any great extent owing to its exfoliating qualities, but it loses this property as soon as the coating becomes hard. The principal objection to this coating is the time it takes to apply and dry, also the small amount of friction required to remove it from the surface and thus leave large places bare and open to serious attack.

Each maker of anti-foulings claims for his product some special virtue, and no doubt there are cases in which manufacturers incur great expense to bring their paint to perfection. The ingredients are supposed to be secrets of each firm; but even paintmakers have to give way to the analyst. The bodies of anti-foulings are pigments of zinc, lead and iron oxides mixed with oils, spirits and resins. The poisons most in use, mercury, arsenic, copper and lead; the chlorides of these metals are fatal to all life. One maker of high repute uses a large portion of shellac to form the body, with a poison composed of mercury and copper, with results beyond question.

Copper sheathing is one of the best anti-foulings, but as this cannot be used on iron or steel ships the idea is to copy the action by using covering of pigments. Too little regard is paid to the state of vessel when the paint is applied, and in many cases it is simply waste of money to apply paint; it is impossible to get good results on wet surfaces. The prevailing idea is to take the cheapest paint offered and to accept prices for docking and painting which will not allow a good job to be made of the work; all is rush and hurry, endeavouring to save a few pounds on first cost, which may entail the loss of hundreds. True economy is to purchase good articles and pay a fair price.

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The Institute as a body is not responsible for the statements made or for the opinions expressed in the following pages.

J. A.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1904-1905.

President—HON. C. A. PARSONS, M.A.

Volume XVI.

ONE HUNDRED & SEVENTEENTH PAPER (OF TRANSACTIONS).

DISCUSSION ON

PROTECTION OF METALLIC SURFACES

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, OCTOBER 10th, 1904.

CHAIRMAN:

MR. W. LAWRIE (MEMBER OF COUNCIL).

THE CHAIRMAN said it had just occurred to him that that being the opening night of the session it would be a very appropriate time for their honorary secretary to give them a few words. It was a great pity more of their members did not come there to give them the benefit of their experience and knowledge, because they knew that many of them had that experience which would be useful to them all, and it would be a good thing for the interests of the Institute if those members attended and so afforded them the benefit of their experience. Especially was that true in times like the present, when every nation was striving energetically and with all the power they possessed to capture a part of their great shipping trade. They had a commercial navy the like of which had never been seen before, the trade of which was estimated at something like ninety million pounds sterling annually. He thought that engineers—particularly as they had such a great interest at stake in the shipping business—ought to exert themselves in order to keep in the front rank which they already occupied, and so see if they could not prevent their friends from dispossessing them. He was sure they would not for one moment imagine that everything in connection with shipping depended on the engineeer. There were other departments in the shipping community which were necessary for carrying on the trade to a successful issue. Still he thought they bore a good portion of the work, and he was of opinion that it was only by meeting in the way they did, and exchanging views and helping each other, that they were likely to keep in the forefront, where they certainly ought to be. He would not trouble them further, because Mr. Adamson would now say what he had to say on the work that lay before them. Possibly he would not give them a forecast, but still he could afford them some idea of what he expected them to do.

Mr. James Adamson (Hon. Secretary) said he was somewhat relieved that the Chairman had dealt with the opening part of their meeting, as he had not come that evening prepared to say anything; in fact, he had that day been somewhat overwhelmed with the idea that he had to respond to the toast on behalf of the Institute at the annual dinner, and he was holding in reserve any ideas he might have for that auspicious event. Still, the subject of the

Institute was one that ought always to be fresh to every member. When they looked back and remembered the beginning of the Institute, the high ideals that were then formed regarding it, the work they had hoped to accomplish, and the improvements they intended to make in engineering practice, those who were with them at the start could see that some progress had been made, and that some portion of the ideal had been reached, but, judging from the paucity of their meeting that night, he thought they required to bestir themselves and try to rise to some of the original enthusiasm which possessed them in the early days. The evidences which they saw around them, as remarked upon by the Chairman, should only rouse them to greater efforts. The Institute was founded for the purpose of advancing the science of engineering to its highest ideal, and they were yet far from that standard. Their President had made a very great advance in regard to the steam engine, but the greatest improvement required was in the economy of the boiler. The boiler was a most important detail, and if the boilers were well looked after the expense of upkeep would be reduced to a minimum; and they knew the great expense incurred in repairs to neglected boilers. They might be on the eve of a great improvement in the construction of the boiler, to get more value out of the fuel, as they knew that there were many minds working in that direction at the present time, and he hoped the result would be as great an improvement in the boiler as there had been in the marine engine during the past thirty years. The present-day boiler was much the same as that in vogue many years ago, only with the difference in pressure. With regard to attaining the ideal that the founders of the Institute had at its inception, he would say that it rested with every individual member to do his best. Even if a dozen members set themselves to do their utmost to re-awaken an enthusiasm, those members, he had no doubt, would be able to work a very great improvement, and he hoped that would come during the session they that evening re-entered upon. The old proverb "As iron sharpeneth iron, so doth the face of a man his friend" was applicable every day of their lives in many ways, and no less so to the discussion of scientific questions. If they met together to confer from time to time on engineering progress, and gave forth their ideas thereon, there was no doubt they would improve themselves and also the general practice of the times in which they lived. Coming to the consideration of the paper before them that evening, the reading of which he said he had enjoyed very much, the subject was simply stated and pleasantly written. There was just enough of retrospective in it to provide that interest which they ought to feel in such an important subject. He had divided the subject into several heads, which might possibly guide them in their discussion.

1. The question of ships with iron decks unsheathed, exposed to wind and weather, was well worth considering, and whether it was the truest economy that ships should be so finished for sea, and whether the iron decks did not perish quickly when not sheathed with wood, and what paint or composition is best under these circumstances.

2. The painting of ballast tanks, both inside and outside, had been a vexed question for a good many years. One water-ballast tank he had examined lately had been recently strengthened, and a new top put on. Portions had been coated inside with oxide, cement, white zinc, and white lead, but the part which looked the freshest was that which had been coated with white lead. The conditions, although presumably the same, under which the tank had been coated might have differed slightly, but the white lead certainly looked the freshest after being on for about a year. The tank ran the whole length of the stokehold. The outside was coated with bitumastic composition, and looked fresh and good.

3. In connection with the framework in ships' holds, he had seen a ship eighteen years old where the

paint was still quite fresh, the explanation being that the ship had been well looked after when the paint was originally applied. That afforded a telling illustration that it paid best to make a good job.

4. There was a question which they had often discussed in connection with corrosion in steam spaces of evaporators, donkey boilers, and sometimes of the main boilers, where a certain amount of corrosion was found, due largely to alternate dryness and moisture, accompanied by super-heating from uptakes or other cause. The usual practice was to paint those portions with white zinc and kerosene. Bitumastic enamel composition had also been tried. One firm of paint manufacturers was experimenting with a view to making a composition to withstand the action of steam and minimise corrosion of steel or iron plates in the steam spaces.

5. The treatment of the framework under the boilers was a subject often discussed, and he thought what they had advocated in the early days of the Institute was now being carried out, viz., that the boilers should be kept as far as possible from the bottom of the ship, to allow space to walk underneath, providing a clear current of air, and thereby minimise the severe action to which the bilges and stokeholds were subjected.

6. What was the best thing to apply on boiler casings and uptakes? Many engineers simply applied whitewash or chunam. Whiting, with a little glue amongst it, mixed with salt and water, was also used. And the question as to which was the best composition to use in order to minimise corrosion at those places where there was great heat, and subject to water raining down from above, became one for study and worthy of discussion.

7. Another important matter was also becoming very pressing, and that was in regard to the pipes which carried the brine through the holds of ships that were refrigerated. There had been one or two accidents due to those pipes, one being at the brine tank, attributed by some to hydrogen being evolved in

the pipes, and an admixture of air forming an explosive mixture. One of the questions that arose was whether those pipes should be galvanised inside and outside or galvanised on the outside only—a more expensive process.

8. When they had iron and wood in contact severe corrosion came into play, especially in presence of moisture and acid from the wood. What is the best protection against this?

Those were one or two points that had occurred to him in connection with the subject, and he simply named them hoping to suggest discussion.

He regretted that Mr. Brandon, the author of the paper, could not attend, but, as desired through the Chairman, he himself would be pleased to read the paper again to the meeting.

Mr. W. McLaren (Vice-President), after the paper was read, said he was of opinion that a paint that dried quickly was not the paint to put on a ship's bottom if they wanted it to last, as such a paint might seem fairly effective for a month or two, but by that time the active poisons originally contained would have evaporated. He knew of an instance where one of the second-class cruisers had been plying up and down the Brazilian coast for nine months without docking, and on her last trial runs only lost 3 per cent. of her speed, which spoke well for the system of sheathing in use in the Navy. He did not think that the fresh water in the River Plate had a great deal to do with it. The cruiser was there for, perhaps, a fortnight, but on the other part of that coast it was a very bad place for fouling ships' bottoms, as he knew from experience, especially if they were lying anchored for two or three months at a stretch. On one occasion it was hard to get half speed out of a ship he was in, trying as hard as they could, due to the fouling of the ship's bottom. The bottom was coated with Rahtjen's composition—doubtless a very good paint; but they had been out for a long time and had got the bottom very foul. Mr. Adamson had spoken about walking under the boiler. Presumably he really meant plenty of room to crawl under. He thought the difficulty regarding corrosion could be obviated if the boiler were well lagged underneath. He believed in cement wash for the inside of ships' bottoms. There seemed to be an objection to a thorough inspection in shipyards unless there was a superintendent to see how the work was carried on. He was of opinion that painting was often "rushed" in shipyards, with the result that the frames did not get justice with the first coat of paint. It would be a great saving in after years if the first coat of paint were put on in a thorough manner.

Mr. W. H. FLOOD (Member) said he feared his experience of corrosion of steel was of such a minor order that there was very little he could add to what had already been said. He thought they had much to learn in regard to the corrosion of steel when in contact with salt water, and he was convinced that in 90 per cent. of the cases the corrosion which took place was due to an electrolytic action brought about by contact with moist air or sea water. He had had no experience thereon or opportunity of carrying out tests, but in order to satisfy himself that his views were somewhat in the right direction he had taken the trouble to look up some statistics from the *Transactions* of the Institution of Civil Engineers. He then read lengthy extracts from papers read on February 28th, 1882, by Mr. Mathieson; on June 5th, 1885, by Mr. Andrews, and on May 3rd, 1894, also by Mr. Andrews. Referring to the causes of rust, he said, in conclusion, that he was of opinion that in many cases the anti-corrosive paint that was put on simply formed an electrolyte, and so produced rusts rather than acted as a preventitive.

Mr. K. C. BALES (Member) said that although the author had seemingly selected a very simple title for his paper, when they came to discuss it they found how comprehensive a subject it was. It afforded another instance of how ignorant one could feel on such a subject. He thought that a lot of the corrosion of metallic surfaces, such as the frames and floors of ships, was really a case of shutting the stable after the horse was gone, having regard to the way ships were sometimes built. With the exception, perhaps, of Admiralty vessels, ships were built very hurriedly, and when the anti-corrosive composition was applied it was over a coat of oxide, and it lost a great deal of its value. It seemed that the protection they applied to metals must differ to suit different conditions. For instance, the protection might be for the outer skin of the ship, and that protection would not be suitable for the bilges or under the boilers. Again, they would require a different protection against the corrosion that took place between the liners of a propeller shaft or in the aperture of the propeller blades. There was a lot of truth in Mr. Flood's remark that corrosive action was not only caused by rust, but also by electrolytic action being set up. He knew of an instance in one of the Empress boats. The electrician of that vessel was a very able man, and he gave the subject a good deal of attention. The trouble was in the boilers, where it could only be got rid of by means of electric current, instead of by means of paint or zincs in the boiler. The protection of metallic surfaces for milk in a dairy was by tinning, not by galvanising. On the other hand, his firm were supplying a lot of steel pipes galvanised inside and out. A few days ago he saw a metal surface which was protected by paint, and that paint certainly seemed eminently suitable for the skin of ships where they required a paint that gave a good protection and at the same time a low skin resistance. That paint was on a sheet of tin, and the surface was like glass. He remarked to the representative, "That is a beautiful surface, but how long will it last? If you bend it up it will all go into crinkles and chip off." The sample of tin was then taken and bent to right angles, and straightened out again without sign of the paint chipping or cracking. They required to get the particular protection for the particular condition under which it was to be used; that, of course, was looking at the matter from the point of view of the shipowner. The shipowner wanted the surface protected in the most efficient manner. Mr. Adamson, before he had read the paper, had thrown out a few talking points, and it seemed to him they could considerably enlarge on those. The conditions under which the protected surface worked would have a bearing on the question. A paint might be very good for baths when cold water was used, but how would such a paint stand the action of salt water or hot water? All those varying conditions had to be taken into account in dealing with the protection of metallic surfaces.

Mr. C. NOBLE (Member of the Council) said Mr. Bales was evidently referring to a paint that had recently been brought out, which, he thought, was known as electro-galvanic solution. He had seen it applied to iron, to which it was a great protection. It also acted admirably when applied as a protection to baths. He had also seen it tried on cylinder covers. In one instance, when so used, it lasted for a voyage out to Japan and back again. It was an expensive paint, but it went a very long way.

Mr. JAMES ADAMSON said the paint that was suitable for one purpose might not be suitable at all for a different purpose. In dividing the subject into separate heads his object had been to group their discussion under these. At a recent Council meeting it was suggested that a list of all the papers they had had in the Institute should be published, to allow members the option of buying back numbers. The references made by Mr. Flood reminded him of that, as they had about thirteen years ago a paper on "The Corrosion of Iron and

Steel" from his old friend Mr. David Phillips, and he had the very plates in the Institute which were used as illustrations in the paper from which Mr. Flood had read extracts.

The CHAIRMAN said that one was not very long on board a steel ship before noticing the effects of corrosion. It needed no technical knowledge to perceive those effects, and, speaking in a general way, he thought rust was one of the greatest evils they had to contend with on board ship. Rust was not a very elaborate thing; it was simply a union of iron and oxygen. If they could keep the iron or steel absolutely dry there would be no rust. Or even if they could keep the air away from it, although the metal was wet, they would not get rust, and then they would have nothing to fight on board ship. That seemed all they need know about it. If engineers would give them their experience of what they had to do in the different parts of the ship, he had no doubt they would get a large amount of valuable information. He had seen a case where they scraped the side of the vessel, and the only difficulty in the side of the ship was that there were some ports between the frames. Those frames—or those parts, rather—that had no side-lights or scuttles in them were as good as the day the ship left the builder's hands. They heard a good deal about builders' paint, and of rush and tear in shipyards, but he thought it was possible to get a ship from the builders that had been properly treated. It seemed to him that if the members would take up the various parts of the ship they might be very easily dealt with. When they came to the tanks it was another matter, and under the boilers it was worse still. He was sure they all appreciated that in the painting of a ship everything depended upon it being done thoroughly. In one instance he had the hold of a vessel painted out, and it lasted good for a couple of years. Then a steam pipe gave out, causing one or two parts to be repainted, and absolutely that portion was rusted while the part that was put on two years before was good. Why was that? It was simply a matter of workmanship.

Mr. W. J. R. MUSTO (Visitor) suggested that the rust was in that instance prevented in the first place owing to the ship being properly painted. Mr. Lawrie told them that the steam pipe burst, and the parts repainted—which were spoilt by the steam and water—rusted sooner than the old painted surface; that was to say, the remedy was to prevent rust forming in the very first place.

The CHAIRMAN: If you leave any moisture between the paint and the plate it won't last long. If the surface is thoroughly cleaned in the first place, then painted, it will stand good for years.

Mr. MUSTO: In that case the iron is thoroughly cleaned before the paint is put on. That seems to be the whole crux of the question.

Mr. FLOOD referred to the corrosive action which took place between the spaces where metal sidelights were fitted, and questioned if that corrosion could be avoided by the use of paint, even if it were put on a dry surface.

The CHAIRMAN: Corrosion would go on quicker there, undoubtedly.

Mr. FLOOD: That goes to prove that where you get dissimilar metals you will get electrolytic action, and I think that particular case is one of the finest illustrations we have where the corrosive action of steel plates, when exposed to salt water, is due to that which you mention—that is, two dissimilar metals together.

The CHAIRMAN: It is a very simple thing. The plate gets wet and the air plays upon it, then the moisture forms the rust.

Mr. FLOOD: Do you think the deterioration would take place so rapidly if that particular portion of the hull were not in contact with a dissimilar metal, such as gun-metal, of which the side-lights are made? I think you get a chemical action from the first day the ship goes to sea. The effect of the electrolyte running between the side-light and the salt water would be sufficient to score the steel plates of the hull. Is it possible for deterioration to take place without electrolytic action? This action is due to salt water attacking the plate.

The CHAIRMAN: We have so many copper pipes in the ship that we have an action constantly going on.

Mr. FLOOD: That is demonstrated by the zinc protections that are put on, and which are eaten away. The fact that they are eaten away shows that we have extreme electric action going on between dissimilar metals.

The CHAIRMAN: As the Holzapfel Company pointed out, if you paint a bronze propeller, that action, to a great extent, may be lessened.

Mr. W. MCLAREN asked if the electrolytic action were not general where the iron sweated. It might take place when they were clear of salt water, or through a leak with fresh water. So long as there was sweating going on they would find that the metal would always corrode. He would like to know if any member had had experience with beams that were coated with cork dust. Did they find that paint and cork dust were satisfactory? And what was the surface of the beams like after some years' service. Cork dust was generally used in cabins where no decoration was put up.

The CHAIRMAN said nearly all engineers could give a couple of hours' speaking of what they had done under the boilers and in places of excessive heat. He knew of a case where an engineer took it into his head to plug up the fore ends of a stokehold and allow no water under the boilers at all.

He got the place painted, and although some of those parts corroded very rapidly before, after that painting the corrosion was utterly stopped. It was as good as any portion of the ship. In the old days their coamings were only 12 or 13 in. above the deck level, but now the fiddley coamings were often 6 ft. high, and there was therefore no necessity for the water to get into the stokehold. If the engineer did not allow so much water in the bilges he was sure there would be less corrosion. His experience led him to the opinion that the drier they could keep the steel, and also by keeping a fairly decent paint on, the less trouble they would have from excessive corrosion. But, if they allowed water to wash about, corrosion would go on very rapidly. He did not know much about the tank tops, but he had had a little experience with the tanks under the boilers. He was of opinion that if the tanks could be painted under the boilers it would be a very good thing, for it was a difficult matter to keep them from corroding. He knew of an instance where they dealt with a tank top before corrosion set in. They cemented all the top of that tank, dried it thoroughly outside, and painted it. They carried fresh water for the boiler, and deterioration set in. If the water for the boiler had been carried in some other section of the ship there would have been less corrosion going on. It certainly seemed strange that builders would not lag the bottom of the boiler unless compelled to do so.

Mr. K. C. BALES said that the Chairman's illustration seemed to prove that if they kept the surface dry they prevented corrosion. The question then arose: What was the best preventitive of corrosion when they could not keep the surfaces dry?

The CHAIRMAN said that when they had got the surface thoroughly dry they should apply a really good oxide paint. There was nothing else that would protect steel. If they had a thoroughly good oxide paint, containing good materials, they ought to be successful in preventing corrosion.

Mr. BALES said they could not have a better illustration of a metal being wet and dry alternatively than the strake of the vessel which was along the water-line. That strake was continually wet and dry in turn, and it was always the part of the vessel which was worst corroded.

The CHAIRMAN : Take the outside of a ship and the strake along the water-line. Galvanic action should not be stronger there than at any other part of the vessel. I have had that part chipped when the ships are lying up, and then painted with the best oxide paint. Then, after four months' running, I have found pitting going on. Why should that be all along the water-line? Simply because it is the continual wetting and drying of the plate. It goes right from stem to stern. I cannot see any other reason to account for that pitting. If our boats were running twelve months each year I do not know what we should do.

Mr. EDWARD W. ROSS (Member): Possibly when you remove the scale mechanically there is still a certain amount of moisture in the remaining scale, which moisture continues the corrosion, and so you are merely covering over elements which continue to work on the plate.

The CHAIRMAN: We listed the ship and got it open to the atmosphere, and the only moisture was the moisture of the atmosphere. After the plate was chipped we rubbed it along with pumice-stone to get a clean surface. Then we used the best oxide we could get; but it was a failure to this extent, that the corrosion came on again very quickly afterwards. I see an explanation here in the paper regarding the pitting of a plate, and suggesting that it had been caused by some air being lodged in the pit-holes, and the brush, in applying a surface of paint, leaving globules of air. There was nothing of that sort in the case I have just mentioned. The paint was put on with a short stiff-haired brush and well rubbed in. There was no chance of air being left behind the paint.

Mr. W. McLaren: Try a rag, the same as they do in the Navy when they are short of paint brushes. They do their painting very successfully with a rag.

Mr. Adamson suggested that Mr. Brandon had advocated the plan of wetting the surface of the plating and dusting the cement on in preference to the usual one of mixing the cement with water into a wash and painting the surface.

The Chairman said he would like to call attention to the fuel testing, which was conducted on Monday evenings. On Monday, October 17th, tests on oil fuel would be carried out, and he thought that interesting branch of the work should be supported, as it entailed a good deal of labour on the part of the Experimental Committee. Mr. Adamson had just mentioned to him that one of their members who had attended those fuel tests had been the applicant for a shore appointment, and amongst his other qualifications he had produced some of the coal test results in which he had taken part, and this fact led to his appointment.

Mr. Adamson said he had referred to the brine pipes in the holds of ships in order that they might have an expression of opinion on that part of the subject. It was pressing upon them more and more every year, and it was of vital importance to them as engineers to know the best means of carrying brine through pipes in the holds where there was a valuable cargo, and also what were the best means they could adopt for preserving those pipes from corrosion, both inside and outside, but more especially inside. He would like to induce some of their members who had had some experience in the matter to read a paper thereon. Mr. Brandon's paper was really on a very important subject. Even the paint on the funnel casing was of sufficient importance to form the subject of a paper in itself. He thought, however, there was no use in adjourning the present discussion. There were many points involved in the question, and if members would volunteer to take up one or other of these, such would form very good bases for several short valuable papers. He might say that he had approached two or three members with a view to obtaining a paper on the brine pipes, which he considered to be a matter of great importance in view of the number of ships that were now being fitted with the system.

Mr. JOHN WEIR (Companion) raised a question as to the action of ammonia in the coils in refrigerating machinery. He had, he said, seen valuable coils condemned when there were only slight pin-holes in them. The action of water in condenser tubes was also another question within the scope of the general paper.

A vote of thanks to the Chairman terminated the meeting.