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The President's Address

ON

Tuesday, October 20, at 6.30 p.m.

Having regard to the roll of distinguished men who have preceded me in filling the Presidential Chair of the Institute of Marine Engineers, I realise and appreciate the high honour you have conferred upon me in electing me as your President for the ensuing year.

I recognise, however, that your motives have been influenced entirely by virtue of my position as a shipowner, and not in any sense from scientific or mechanical engineering qualifications, which, needless to say, I do not possess. I have, nevertheless, always studied with great care the economic aspect of shipowning, and in this connection it is a most obvious fact that the question of motive power is of outstanding importance.

Prior to the advent of steam as a means of mechanical propulsion we were dependent entirely on the elements, and I am inclined to believe that the difficulties confronting us by reason of our inability to keep them under proper control influenced our artificers and shipwrights at the time to apply their skill and scientific knowledge to harness energy in a machine of which they would be the masters.

During my life as a shipowner I have owned a considerable fleet of sailing ships. I began at the time when rope rigging was going out, and heavy pumping every watch at sea was becoming a thing of the past. The vessels were then nearly all being built of steel, and although sail was still the main source of propulsion, the change from wooden ships to iron and steel, and hemp ropes to steel, was to my mind the most vital change in the life of our seafaring men. My advisers in seafaring matters at that time were, of course, men who had spent their lives in sail, and the first of our vessels had fine lines and good speed, but with the resulting poor carrying capacity inseparable from a fine block coefficient. Rapid progress was made, however, in building a fleet of sailing ships, each succeeding vessel being larger with more sail power, and shortly before I decided to begin building steamers my firm had one of the largest fleet of sailing ships then afloat. I think, therefore, that I am in a position to cite with some accuracy the trepidations as to the actual financial result experienced in these days when we were forced to do battle with the uncertain elements with such comparatively puny weapons as canvas, rigging and spars. Seagoing men in the days to which I refer were always wont to look askance at any craft which did not look for life to the four winds of Heaven, and considerable time was required to educate the new staffs to the steam idea; our sailing ship men not taking too kindly to the dirt and discomfort in the early days of the tramp steamer. Opposition and popular prejudice confronted the engineering community at this period, and the very considerable strides which they have since made in spite of potential opposition and discouragement elicit my profound admiration and respect.

The rapid progress from sail to steam and again to the internal combustion engine is well known to all our members, and in my opinion we are again at the beginning of a new period. Our members are continually improving on the means of propulsion, and to enumerate in order of sequence the various types of engines employed throughout the various periods of ship construction would be a somewhat arduous task, but it all goes to demonstrate that the shipbuilding and engineering world are ever in perpetual motion towards the discovery of the new, and improving upon past methods in construction, speed and economical operation of ships. The titanic results they have accomplished in producing ocean palaces of comfort and safety in passenger vessels of enormous engine power enabling us to still hold the Atlantic record, not only show their great ingenuity and skill, but also a determination to maintain our premier position and supremacy as a maritime power.

I am, however, desirous to discuss briefly the commercial aspect of the marine engine. Speed in itself is relatively a minor detail where engines are considered solely from an economic point of view. In certain trades the necessity for high speed is not essential as the extra cost and expenditure of fuel required is not justified or counterbalanced by the time conserved. This being so, the activities of engine builders were centred at the outset upon the cutting down of running costs, and for this purpose it had to be determined what was the best economic speed at which ordinary cargo carriers should steam, compatible with a moderate fuel consumption, and the minimum of wear and tear in the material employed. The figure decided upon was something in the neighbourhood of 10 knots per hour, at which speed high boiler pressure and excessive engine revolutions were naturally reduced.

In order to appreciate fully these improvements from a financial point of view it is essential to observe the very considerable sum which is involved in increasing the speed of a vessel. As an example let us take a vessel of 8,000 tons deadweight, designed to steam at 10½ knots per hour, for which purpose her engines would be approximately of 2,500 I.H.P. To augment the speed by 1 knot, engines of 3,500 I.H.P. would have to be employed, which would mean an initial increase in price of about £1 4s. per deadweight ton; to which, of course, would have to be added the consequent increase in fuel consumpt. It will be obvious, therefore, that speed and consumption represent the main items in relation to running costs, and in its determination a shipowner is called upon at all times to ensure that such costs are maintained at an economic level. For this purpose it is essential to watch closely improvements in engine design, as the only way to obtain good results in shipowning is by the employment of the most economic type of ship conforming with the demands of the trade for which she is intended.

The question of running costs will always remain an open one, and it was with the object in view of obtaining some reduction that led to the substitution of oil fuel for coal. The employment of oil fuel under boilers represented a remarkable and important change in the running of steamships. The fact that fuel of such a nature could be carried in the double bottom tanks, thus permitting the use of a large proportion of the coal bunker space for cargo, made a very considerable difference in the carrying capacity of vessels fitted for this purpose.

Furthermore, the extra cruising radius permitted by the smaller consumption of fuel of this nature saved much in the way of bunkering time. The life of boilers was also prolonged as by reason of so constant a heat they were not subjected to the same degree of expansion and contraction as when coal-fired. There is also the reduction in the engine room staff, and the elimination of all coal bunkering port delays, and more reliable steaming.

The high price of bunker coal made the oil burning for steam purposes at the outset an asset of some value from a shipowner's point of view, but the gradual return of foreign competition in coal bunkering has greatly reduced the price, and consequently brought about a temporary dislocation of the running costs of oil fuel burning, and for the present, at least, the economical aspect is again changed. However, the question of supply and demand will doubtless adjust itself in time, and if the price of fuel oil was lowered to compare more favourably with the present price of coal, I venture to say that oil fuel would have immediate preference. The salient fact of the saving in space and/or deadweight would upon a rise of freights naturally enhance the value of this space with equivalent financial advantage to the oil burner.

I am now going to deal with the advent of the internal combustion engine, as at the moment I am particularly interested in this unit of power, and am confident it will prove to be the marine engine of the future.

My decision to construct a fleet of Diesel vessels was made after most carefully studying the economic aspect of this means of motive power, together with the requirements of our trades, and I was fully convinced that great advantage would be gained by as far as possible standardizing the ships and their engines, including all auxiliaries. By this means officers and engineers can be transferred to any of the vessels quickly and agents abroad are put to the least possible trouble. From my experience of twelve motor vessels employed, each carrying 9,000 tons deadweight, the most satisfactory results have been achieved from all of them. Upon long voyages the speed averages $10\frac{1}{2}$ knots per hour, with under 10 tons of Diesel oil consumption per day for all purposes, and 10 gallons lubricating oil per day.

We have only to reflect upon the great uses and successes of the motor engine in other channels of industry to be convinced of its great utility. What marvellous advances have been made in the air by airship and aeroplane, on the land by motor transport, and motor machinery propulsion in every phase of application as the greatest economisers of labour, time and expense yet discovered! It need occasion little surprise, therefore, that the highest achievement of all should be directed towards making the motor engine also the success of the sea. The rapidity of the change from steam to the motor ship has almost taken the marine engineer unawares, so far as his knowledge and experience are concerned in the construction and manipulation of these engines. It will be readily apparent that the best motor engine could be rendered inefficient if subjected to negligent handling, or the lack of the necessary mechanical and practical knowledge thereof.

It has been found advantageous to give facilities for special training of engineers ashore to acquire the additional experience required to cope with the conditions of the modern engine. Also to keep continually changing the engineers from ship to ship for provisional qualification, and in this way every assistance is being given to the marine engineer to acquire the requisite knowledge to master the Diesel engine, and I am glad to say he has proved equal to all emergencies.

It is satisfactory to observe that our Universities have demonstration units of the internal combustion engine at work in their engineering laboratories. With scientific and practical forces at work we are bound to find greater discoveries in the perfecting of the Diesel engine.

The initial extra capital outlay of a Diesel engine compared with the steam engine on say an 8,000 ton deadweight vessel is about £25,000. This, doubtless, causes shipowners to hesitate in its adoption, because it adds say £3 3s. per ton deadweight to the cost of a steam vessel, but the many advantages of the marine internal combustion engine over the steam engine have to be considered. Diesel engines are capable of burning almost all known liquid fuels, provided they are sufficiently free from sand, earthy matter or water. Internal combustion engines convert the heat energy of the fuel into work in the cylinder itself.

The mechanical means most frequently adopted for obtaining pulverisation or spraying is that of injecting the heavy oil into the cylinder through a pulveriser by means of a blast of air, at a pressure higher than that present in the cylinder. The fuel is thus divided into minute particles, and forms a kind of mist. If the air in the cylinder at the instant when the injection takes place is at a sufficiently high temperature through compression the oil mist ignites, and a gradual combustion takes place.

The internal combustion engine owes its rapid development to its increased heat efficiency over that of the steam engine, in other words, for a given combustion of fuel a greater percentage of useful work is produced at the shaft and thence transmitted to the ship. The following advantages may be claimed for the internal combustion engine over the steam engine:—

1. *Fewer men in engine room.*—The boilers being dispensed with for ship propulsion, no firemen are required.

2. *Less fuel consumption per day against a steamship of same power.*—In the case of a Diesel engine the consumption runs from 9·5 to 10·5 tons per day, against the possible consumption of 30 tons in oil-fired boilers, and 43 tons in coal-fired boilers.

3. *A larger deadweight carrying capacity.*—The total weight of the Diesel plant compares favourably with a corresponding steam plant. All bunkers can be carried in the double-bottom tanks, thus leaving more space for cargo, which represents at least 10 per cent. saving, and which increase is a vital factor in the earning power of the vessel.

4. *A longer steaming radius.*—The capacity of the double-bottom tanks is usually sufficient that without rebunkering a motor vessel will run about four times as far as the steamship, and save the time and expense of extra coal bunkering ports.

5. *The saving of fuel.*—No "Banking of Fires" being required, Diesel engines are ready to start at short notice; consequently obviating all stand by losses.

6. *A great saving as regards speed.*—Where we have a loss at the beginning and end of each watch due to cleaning fires in coal-fired boilers, a fixed speed can be maintained in a Diesel engine at all times up to the mean effective pressure limit.

7. *Saving as regards electric winches.*—Where electric winches are in use the Diesel consumption for a working day averages about ·6 of a ton, against $1\frac{1}{2}$ tons on oil-fired boilers, and four tons on coal-fired boilers.

Linked up with the advantages of the Diesel driven vessel as against the steam driven vessel, engineers count the absence of dirt and discomfort as of the first importance in maintaining the personnel, and this also is a considerable saving both on deck and below in the matter of upkeep and repairs, and I think it would be rare to find any of the engineers wanting to change over to steam. I have found all our Diesel driven vessels making much steadier passages than the steam driven vessels and through all weathers, the revolutions being maintained regularly throughout with almost complete absence of racing and its attendant troubles.

As regards their commercial advantages, I have now had the experience of working several motor ships during the past two years, and I have not the slightest hesitation in saying that even in these hard times, the high-priced motor ships show a decided advantage over steamships. This is not in trades particularly suitable to Diesel boats, but in trading generally all over the world. For instance, two boats of similar size, one a steamer, the other a motor ship, on a recent voyage from Japan in ballast to Australia, thence homewards with wheat, the motor ship will make about £1,500 more profit than the steamer, and the above voyage is a very favourable one for a coal burning steamer, by reason of the relative high cost of oil in Japan and Australia and *en route*.

I have allowed nothing for saving in wages, and the stand by losses of main engines which in the ordinary course of trading might result over a period of twelve months to a considerable saving in favour of the motor vessel, have not been taken into account.

Messrs. Harland and Wolff, Ltd., have given particulars showing the comparison from ascertained performances of a steamship and a motor ship built by themselves. As the figures are interesting and accurate, I take the liberty of quoting them :—

	Steam Vessel.	Motor Vessel.
Types of Engines	Quadruple Expansion.	Four-Stroke Cycle Diesel.
Dimensions	477' x 62' 9" x 43' 9"	450' x 57' x 37' 6"
Loaded Draft	28' 9"	28' 0"
Corresponding Deadweight	10,830	10,300
Bale Capacity	599,700	569,300
Sea Speed (actual service figures)	12½ knots.	12½ knots.

Cargo capacity on voyage of approximately 10,000 *nautical Miles*:—

	Tons	Tons
Bunkers (34 days—10 per cent.)	2,918	580
F. W. Stores, etc.	435	330
	3,353	910
Deadweight total	10,830	10,300
Cargo capacity in D.W.	7,477	9,390

It will, therefore, be seen that the cargo carrying capacity has improved by nearly 2,000 tons, or 25 per cent. greater than in the case of the steam vessel. It may be mentioned that the cubic dimensions of the steamer are 32·5 per cent. larger than those of the motor ship, while the bale capacity, including reserve coal bunkers, is only 20 per cent. larger, thus giving a gain of 12·5 per cent. in favour of the motor ship.

Insurance.—The risk is now looked upon as quite as good as the ordinary steamer of the same size, class and age. The Institute clauses applicable to vessels with internal combustion engines certainly stipulate for an excess of 10 per cent. of the insured value of the machinery section in respect of each accident as against the ordinary franchise of three per cent. in the Institute clauses on steamers, but it is doubtful whether any owner would agree to these clauses. Furthermore, it is not likely that underwriters would insist on these clauses in view of the great strides which have been made in the perfecting of the internal combustion engine in recent years. These special clauses may be considered a dead letter, save perhaps in the case of small motor vessels. As a matter of fact underwriters usually give a cheaper rate on Diesel vessels because of the equivalent increase in value.

Comparative freedom from repair has been so far conspicuous in the motor vessels, that I cannot yet formulate any data concerning upkeep and repairs, but generally speaking, I would not be surprised if the motor proved even the more economical in this respect also. The facts, therefore, from my practical experience, places the motor vessel in my estimation as offering the best return as a productive shipping investment.

The largest motor driven passenger vessel constructed and in commission up to the present is the *Aorangi*, belonging to the Union Steamship Company of New Zealand, Ltd. Her first sea voyage is particularly interesting, as the average power developed in bad and in fair weather was between 11,500 and 12,000 B.H.P., and the speed averaged about 16½ knots with a consumption of fuel for all purposes, including galleys, heating, etc., of 55 tons per day. A similar ship of the same Company with steam engines, burning oil, consumed about 120 tons per day, which shows the enormous gain of the oil engine over the steam engine for high-powered passenger vessels.

There has been launched, as you are aware, the twin screw Royal Mail Liner *Asturias*, of 21,700 tons gross, with double-acting four-stroke engines, each capable of developing 10,000 I.H.P., the highest powered engine yet constructed. This, the largest motor ship afloat is being eclipsed by the Cosulich Line of Trieste, who are presently building two Diesel motor vessels of 23,500 tons gross, also with double-acting four-stroke engines, each developing 12,000 I.H.P. These are the largest motor liners yet laid down, but it is reported that even a more powerful Italian liner is to be built of 30,000 tons, quadruple-screw, double-acting, two-stroke propelling machinery of 35,000 I.H.P. This will be considerably in excess of the power of the machinery of any motor ship now under construction. I mention these vessels as demonstrating the increasing extent which the motor ship is going to play in the world's cargo carrying tonnage of the immediate future, as also in respect of high speed liners. It amounts in effect to a challenge from foreign owners.

The possibilities of further development of the motor vessel are many, and I imagine the time is not far distant when we shall find the motor engine generally standardised and the initial cost, therefore, considerably reduced. My opinion is that we are at the commencement of a new era in the history of marine motive power, and I am confident, Gentlemen, that your success in this direction is fully assured if the necessary encouragement and assistance is afforded to you.

The enterprise which has made us second to none as highly skilled mechanics and engineers still predominates, and will lead us to the same degree of perfection in motors as was attained by us in steam. Progressive methods, however, are at the moment seriously handicapped by the unprecedented depression in international trade, and also by reason of the fact that in spite of this state of affairs, the cost of production still remains abnormally high. I am inclined to believe, however, that employers and employed are beginning to understand each other better, and I venture to hope that this will lead to the elimination of the unfruitful apathy and distrust prevailing in the past on both sides, and which really sums up the unsatisfactory state into which various industries have been relegated.

In this connection I am sure that we have all observed with great regret the considerable volume of construction which of late has been diverted to other nationals by reason of our inability to meet competition. I am convinced that this is not by reason of any material difference in wages, but is mainly attributed to the fact that our competitors can produce so much more in the same period in consequence of more efficient labour organisation, coupled with a greater degree of knowledge and skill on the part of the employees of the economical appliances at their disposal. Employers and employed must get together and solve existing problems between them, and the longer they remain estranged the more difficult will these problems become. I sincerely trust that the inborn common sense which is one of our greatest characteristics as a nation, will ultimately come to our aid, and thus enable us to regain, without further hindrance, the position to which all great peoples aspire, namely, to be regarded as the leading power in the world of commerce.

Shipping is still, and will always remain by virtue of our insular position and the extent of our dominions beyond the seas, our most important national asset, and there should be no conceivable reason why it should be wrested from us. Efficient communication with our many colonies is a duty which is expected of us, and it is only natural that those lands which come within our Empire should be served by tonnage flying our flag.

A revival of trade must be sought within the Empire, but can only be rendered feasible when normal conditions of life are resumed.

Political, social and labour unrest must be abolished, and substituted by that bond of sympathy and good fellowship which has enabled us to find solutions for many weighty problems arising in other times of national emergency.

The following poem was composed by my friend Mr. William Blane in 1904 and indicates the prophetic instinct of the composer at the time of writing :—

THE PASSING OF STEAM.

Muffle the drums of progress—
 Their roll of triumph and doom!
Let the doors awhile be shut in the street
While Science and Art, with reluctant feet,
 Bear a giant to the tomb—

The engine that Watt invented,
 That Stephenson put on wheels,
That Fulton harnessed to furrow the seas
And circle the globe with titanic ease
 On a hundred thousand keels.

I smiled at Internal Combustion—
 Producers and gas and oil;
Their faithless ignition, their odour and jar,
Bye-products of sulphur, ammonia, tar,
 High tension, magneto and coil.

For a row of chain-stoked boilers,
 Welsh coal and a super-heat,
Triple expansion, true lap and lead,
Vacuum steady and constant speed,
 Will foster a fine conceit.

From furnace front to discharge pipe
 It's a living, throbbing thing—
A living, throbbing thing, with a soul,
Which a fiend might fear and a child control,
 And the fabled Muses sing.

But, reckoned in calorifics,
 Internal Combustion wins,
For twelve per cent. of the B.T.U.
Is the best, in effective work, we do,
 And with twenty gas begins.

What though it wrought such wonders
 In the space of a hundred years!
Before a question of L.S.D.—
The cost of a Unit or B.H.P.—
 All sentiment disappears.

Hark! 'tis the knell of its passing—
 The end of the reign of Steam!
And sad, like a lover whose jealous eye
Confesses the truth he would fain deny,
 I follow as in a dream—

Follow and dream of problems
 Of balance and power and speed;
Of what will equal the final 'x'
When thermo-dynamics no more perplex
 And the wish commands the deed—

Of nature and art and science,
 Of thought and desire and will,
Of energy and its primal source,
Of motion without a moving force
 And the power of being still.

We have begun the business of the new session with a very important Agenda, assuring the prospect of an interesting and prosperous Session, and I feel sure the opportunities offered will be taken full advantage of by the members.

In conclusion, I have to congratulate the Council and Members that the Institute continues to flourish and is doing a great and useful work in helping young men to firmly plant their feet on the ladder to success.

The CHAIRMAN OF COUNCIL: Our President has favoured us with a very excellent address. He speaks with humility as regards technical knowledge, but I venture to say that he shows a very good knowledge of the essentials. The manner in which he has dealt with the commercial aspects of the Diesel engine gives us a great deal of food for reflection. The history of oil and its application to power production is certainly almost a romance, and it is such a short period since oil came in as a power medium, that I think we agree with the President that it is undoubtedly the power, or at least one of the great sources of power, of the future.

We appreciate his very kindly reference to the work which is being done by the Institute and the call to all of us to do all we can to facilitate cheap production. The Institute is largely composed of members who have no other idea than this in their minds, and I can assure the President that our members stimulate the trade of the country all they can.

Eng. Rear-Admiral W. M. WHAYMAN: I should like to say how much we appreciate our President's address. We are always conscious of the demand for economic efficiency of the power plants which have to be produced for the shipowner so that he can use his ships to the best advantage for the trade of the country.

One other small point I would like to express my agreement with the President, namely, that the nation's future development lies, at any rate in the first place, within the Empire rather than elsewhere.

The PRESIDENT after making a few appreciative remarks: said, "I am very grateful to the proposer and seconder and to you all for the very kindly welcome you have given me to-night."

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Discussion on Mr. A. I. Nicholson's Paper: "Recent Developments in Marine Propelling Machinery," read on Tuesday, September 29th, 1925.

Chairman: JAS. CARNAGHAN (Vice-President).

The Chairman: Mr. Nicholson, the author of the paper to be read to-night, is connected with the firm of Messrs. Scott's Shipbuilding and Engineering Co., Ltd., of Greenock, famous as the makers of the Scott-Still engine. In giving us this paper he is following in the footsteps of some of his colleagues, one of whom recently gave us a most interesting paper on the Still engine. I think that is sufficient to indicate that Mr. Nicholson will be listened to with much interest to-night.

Mr. Nicholson then read his paper, which was printed in the October issue.

Mr. B. P. Fielden: I think that the paper has been very interesting and that it has covered a wide field. Mr. Nicholson prophesies that in 20 years time ships may be equipped with other types of engines. At the present time there are many varieties, and I think it reflects great credit on our marine engineers that they can change so readily from one to another type of engine. It is rather remarkable how well we get along in the midst of all these changes, and I doubt whether the marine engineer is given the credit to which he is entitled for his adaptability.

There is a point in regard to propellers, where the Author, referring to the Gill Propeller and the Star Contra Propeller, states that these propellers will have a restricted application because of rough weather conditions. I think that his remarks may apply to the Star Propeller, but as regards the Gill Propeller, I would like to know whether Mr. Nicholson thinks it would be damaged under rough weather conditions.

*On proof page 2, Mr. Nicholson says: "At the termination of the war there was a swing over towards geared turbine machinery, but since that, a distinct reaction has occurred, and certain superintendents have been frightened back to the well tried and cheaper reciprocating triple expansion engine." Why was there a swing over at the termination of the war from reciprocating to turbine machinery? And secondly, was it fright or was it the demand for economy which made those superintendents revert from the one type to the other? I think

* Page 296 October issue.—J.A.

that the turbine is a more expensive engine than the reciprocating in first cost and the proper thing is to have machinery which suits your ship and its trade. In the case of road transport, one man might use a steam wagon, another a horse and cart, another a motor van. In the same way the turbine may suit some and the steam reciprocating or internal combustion engine suit others. When one considers the tramp steamer, it is very doubtful in my opinion whether the turbine will ever be suitable on account of its cost, and as regards its efficiency, I have heard of two small vessels of equal size where the triple expansion reciprocating engine beat the turbine in all-round results. I note that Mr. Nicholson says that the triple expansion engine is not passing without a struggle; I do not think it will.

Further on in his paper, Mr. Nicholson says: "In spite of this there are some superintendents who still adopt a conservative attitude to the use of superheated steam." In reply to that I would say that it is the duty of a superintendent to be conservative as it is not his business to exploit turbines, superheat, or anything else, and in my opinion, conservatism or moderation in the use of superheat is good for marine purposes.

As regards water tube boilers, on proof page 3 it is stated†: "There is a growing realisation that cleanliness in engineering work is as nesessary as in the human machine, and when once boiler waters are kept really clean and are freed from air by methods now available, marine engineers will get over their traditional dislike to the water tube type of boiler." The word I take exception to here is "traditional." I do not think the marine engineer worries about tradition at all. He may have a dislike of the water tube boiler because in his opinion it is not so reliable as the cylindrical boiler, but I fail to see how this can be termed traditional. The real trouble is due to condensers. If we had reliable condensers there would be more water tube boilers in the mercantile marine than there are. The condenser troubles with turbines seem to be more than with reciprocating engines, and the combination of turbine and water tube boilers causes anxiety and expense when the condensers are leaking.

I am rather disappointed that Mr. Nicholson did not say more about the electric drive. It seems to be a flexible drive and I understand it is fairly costly to fit, but if it is going to be economical in upkeep it may be worth fitting. It has been

† P. 299 October issue.—J.A.

fitted into some vessels of the United States Navy, but I would like to have more information as to its value for mercantile vessels.

I would like to know whether Mr. Nicholson has any figures on the length of life of double reduction gearing, as that is the important point. If he has comparative figures relating to both single and double reduction gearing it would be useful if he will quote them.

Regarding the turbine rotor wheel being solid with the shaft, I would like to know the size of the largest wheel which has been turned out of the solid.

Mr. E. C. POULTNEY (Visitor): As a visitor, I wish to thank the honorary secretary for inviting me to be present to-night, and to congratulate Mr. Nicholson on the excellence of his paper. I am interested in all forms of steam engines, particularly in the marine field, and I concur in Mr. Fielden's remarks regarding the reciprocating steam engine. The part of the paper which attracted my attention most was Mr. Nicholson's remarks regarding the poppet valve engine. I have some slides illustrating this engine and would like to show them on the screen with the service of the lantern.

The engine shown is that known as the Lentz Standard Marine Engine.

The chief feature of this engine is the arrangement of the cylinders and the type of valves and motion used.

The cylinders, as you will see, are four in number. There are two high pressure cylinders and two low pressure. The high pressure cylinders are in the centre, the low pressure being at each end. From this you will see that the engine is really a double compound. Adjacent high and low pressure cranks are on opposite centres, and the high pressure cranks are at 90 degrees with each other. This arrangement makes for ease in manœuvring and starting.

In all, twelve poppet valves are used to distribute the steam in the cylinders. Two are fitted to the H.P. cylinder top and bottom for steam admission, and a further two control the H.P. exhaust, and simultaneously, the L.P. inlet, whilst a further two for each L.P. cylinder, control the exhaust from these cylinders.

The arrangement of the valves and cranks enable a very simple type of valve motion to be used. In fact, there are only two motions required for all four cylinders.

The arrangement of the poppet valves enables comparatively short steam passages to be obtainable, and the passage-ways between the H.P. and L.P. cylinders is as small as possible.

In practice, these engines have proved themselves to be exceptionally economical in the use of steam. In fact, the steam rates per I.H.P. hour are as low as 9 lbs. for superheated steam, whilst with saturated steam the steam rates vary between 11 and $12\frac{1}{2}$ lbs.

In regard to reliability no difficulties of any kind are experienced with the poppet valves, and this is shown by the fact that the engines of the SS. *Bilbao*, which are of this type, have made over 36,000,000 revolutions since the ship was built in 1922, and so far the original valves and piston rings are still in use.

With normal boiler power and when using steam at 200 lbs. pressure superheated to a total temperature of 600 degrees, coal rates with medium class fuel run to about 1·2 lbs. per I.H.P. hour.

Usually with this type of machinery a separate condensing plant is provided, the advantages of which I need not enumerate.

In concluding my remarks I would like to say that it has given me much pleasure to join the discussion on Mr. Nicholson's paper, and I trust that Mr. Nicholson no longer doubts the suitability of poppet valves for marine service.

Mr. A. Jobling: I would like to ask Mr. Nicholson for a little more information regarding the Star Contra Propeller and the shrouded propeller, and whether it is possible to adapt them to a present-day ship.

Engr.-Lieut.-Comdr. S. F. Dorey: Mr. Nicholson is to be heartily congratulated on his paper. Its special value lies in the tables and data given at the end of the paper which he has explained so well to us to-night. Exception might be taken to the statement that " a piston speed of 1,100 feet per minute has been forced upon engineers by the adoption of the oil engine."

In the mercantile marine, piston speeds are somewhat low, but speeds of 1,000 feet per minute have been quite common in the Navy and also in vessels for special services. The piston speed of the engines of the *Agamennon* and *Lord Nelson* and the latest type of armoured cruisers fitted with reciprocating engines were in excess of this, some of these engines being fitted with forced lubrication. No doubt the reason that a low piston speed has been adopted in the mercantile marine is that the engines do not require so much attention, are more reliable, and more economical (so far as upkeep and personnel are concerned) than those running at higher speeds.

The author mentions the maximum power of oil engines as being 15,000 B.H.P. There are at present under construction for two Italian vessels, double-acting Diesel engines having a total H.P. of 25,000 to 30,000, one being a two-stroke cycle engine to develop about 28,000 B.H.P. and the other a four-stroke cycle engine of about 25,000 I.H.P.

Mr. Nicholson in his brief reference to the Still engine mentions its high efficiency. Admittedly it is good to have a high efficiency, but it does not necessarily follow that this is all that is required. With the introduction of double-acting Diesel oil engines, weight will be considerably reduced and a saving of this nature may be of far greater importance than a slight gain of efficiency.

In this connection it would be interesting to know if any further developments have been made with the opposed piston type of Still engine.

The author's remarks and illustrations referring to reduction gears for steam turbines are much appreciated and certainly show that gearing troubles, like most troubles, are capable of being solved in time.

In a paper of this nature the Michell thrust block deserves mention, as chiefly by its introduction have the enormous powers generated in steam turbines been made adaptable to marine propulsion.

Perhaps Mr. Nicholson can tell us why it is that the electric drive has been so successful in the U.S.A. Vessels built in this country and fitted with this type of drive have certainly not been a success. No doubt very much better results would have been obtained if these installations had been fitted in much smaller vessels, and first hand experience obtained before fitting them in larger vessels.

Mr. W. E. Farenden: The author remarks upon quadruple expansion engines as being seldom constructed now. I do not agree with him. I consider that a well-designed and balanced quadruple expansion engine will hold its own with any other type, not only as regards repairs and economical running, but also in reliability, which is an important feature where ships have to maintain a regular seagoing programme.

It appears to me from a marine engineer's point of view that the claims put forward by the various Diesel engine makers regarding the reliability of their product is premature, as this type of engine in anything like a large power installation has not been running for more than two or three years, so that anything definite in this direction cannot be claimed.

With the Diesel engine, first we have the initial cost of same which is probably twice the cost of the reciprocating steam installation, its weight is probably the same, or slightly in excess of the plant.

Diesel engine oil is more costly than that required for burning in furnaces, and more difficult to obtain in large quantities. The lubricating oil used on a Diesel engine installation is approximately about ten times as much as that required for a steam reciprocating plant of the same power.

Regarding superheated steam and its advantages, I think it is doubtful whether the upkeep and the wear on the moving parts do not outweigh the advantages in reduced fuel consumption. *On proof page 6a some comparisons are tabulated with reference to triple expansion engines using saturated and superheated steam. The best figure given for coal consumption per I.H.P. per hour is 1·37 lbs. This is for a triple expansion engine using superheated steam. With a well designed quadruple expansion engine using saturated steam, the coal consumption could be reduced to 1·25 to 1·3 lbs. per I.H.P. per hour.

Mr. W. G. Cleghorn, B.Sc. (Visitor): Mr. Nicholson has given us a most authoritative and unbiased account of the present position of marine propelling machinery. To fulfil the expectations of his title regarding recent developments, there are, I would suggest, four points on which further information would add to the value of the paper. On one of these points, namely, the poppet valve steam engine, information has already been submitted by Mr. Poultney, and I would like to add that I have had an opportunity of inspecting a vessel fitted with the Lentz Standard Marine Engine.

The SS. *Bilbao* has been in service for some three years, during which period no replacements have been made to the valves or their actuating mechanism. An analysis of the information recorded in the engineer's log gave the following results as an

* P. 315 October issue.—J.A.

average over seven voyages. Stated in the same order as the headings in table 4 : —

Displacement	4,858 tons.
Speed	9·64 knots.
I.H.P.	926
Coal per day	11·8 tons.
Coal per I.H.P. per hour	1·19 lbs.
Coal coefficient	21,900
Admiralty coefficient	277

These results were obtained with coal containing an average of 15% ash, a boiler pressure of 200 lbs. per square inch, a superheat of 110 to 160°, a feed temperature of 240° and a vacuum of 27 inches.

The second point is the effect of superheated steam on double reduction turbine installations, and is one on which I am sure Mr. Nicholson can give us authoritative information. There appears at present to be a reversion to saturated steam in this type of machinery. I refer more particularly to the cases of the *Transylvania*, *Carinthia* and *Otranto*, which, I understand, are designed to use saturated steam, whereas their earlier sister ships used superheated steam.

The third point is the adoption of combination machinery in the case of the new White Star Liners, which I understand has now been approved. It would appear from these latest developments that superheated steam is not favoured for double-reduction turbines, but that the adoption of combination machinery is suggested as a means of gaining the greatest possible economies from the use of superheated steam. I think Mr. Nicholson's observations on these two recent issues would be of great interest

The last point which I would raise is the comparison of Diesel with steam machinery, but perhaps Mr. Nicholson is wise to avoid such a controversial issue. Reliable data of the performance of motor ships at sea is sadly lacking; the reports of the Marine Oil Engine Trials Committee lead one to doubt the accuracy of much of the data which is constantly appearing in the technical Press. In view of all that has been said in the paper and the discussion, I do not think it is necessary to offer further evidence to prove that the steam engine is far from dead.

Mr. F. C. Bates : I would like to thank Mr. Nicholson for his paper, particularly with regard to turbine gearing. He has mentioned two points concerning the smooth running of gears. The first is the accuracy necessary in cutting gears and the second is flexibility of shafting. There is one more point which I believe has contributed to the smooth running of gears; a nickel steel pinion in gear with a mild steel pinion on the gear wheel. I would like to know why this has resulted in smoother running. The text books state the fact but give no reason for it.

Mr. J. H. ANDERSON: Mr. Nicholson deserves our congratulations as regards the historical summary contained in his paper. He says, "One cannot foresee much further improvement in the steam engine, except in the adoption of the uniflow principle." I think we are already seeing an improvement carried into effect in the new steamer which is building on the Clyde. I think there has been a considerable lack of efficiency of steam engines due to the fact that there has been practically no competition at all, such as there is between electricity and gas. Now that we have the Diesel engine, steam engineers must look to their laurels to keep on top.

Some years ago we had a paper by Mr. J. D. McArthur*, in which it was made clear that we had achieved a greater efficiency in steam installations. Some of the many losses which occur are due to auxiliaries on deck. I came up with a friend to-day who told me that he had been carefully calculating the amount of steam used in a modern ship, and he found that 18% of the total steam used went to the auxiliaries. I was wondering whether that is taken into consideration in calculating the efficiency of the marine steam engine, also what is this percentage after a few years use similar to that one frequently comes across in practice?

As regards the boiler, I do not agree that the Scotch boiler is the best. It is bad for coal burning, but worse still for the combustion of oil. There is one new development in steam generation, namely, the internal combustion boiler. Perhaps Mr. Nicholson can tell us something about this boiler, which is similar in principle to the diver's use of acetylene under water. I hear that experiments now in process are fairly successful. If working pressures are increased to 500/600 lbs. we shall have smaller boilers and engines and the Diesel engine will meet with some keen competition, providing careful maintenance repairs are carried out. Another point well worth looking carefully to is that far too much cutting and carving is done in the capital cost of ship's plant, often by people who have no

* May 8th, 1899 and November 9th, 1916.—J.A.

engineering experience:— as when efficiently designed machinery has to be altered whereby a small reduction in price is obtained in the capital cost.

This is a big mistake and should not be tolerated by firms who desire progress in mechanical efficiency. I am hardly so pessimistic as the author of the paper regarding steam, but consider we have met a very strong rival in internal combustion engines, therefore we are just at the point when we are forced to get ahead with steam.

THE AUTHOR'S REPLY.

MR. NICHOLSON: Mr. Fielden remarks that marine engineers have not received the credit they deserve for adapting themselves so readily to changes in marine propelling machinery. I agree with Mr. Fielden and think it is well that this question should be emphasised at the present time, for the demands upon the marine engineer are more varied than ever, and are likely to be still more varied in the future. The response to the demands upon them has been very creditable and will, I am sure, be maintained.

Mr. Fielden asks why the geared turbine was taken up after the war and then in some cases dropped. This was due, in my opinion, to the good impression produced upon shipowners by the excellent performance of single reduction geared turbines during the war, both as regards reliability and economy. Owners at the same time were attracted by the rotary movement of the turbines and money was easy for some time after the war, so they were prepared to pay the extra cost involved. The reaction which set in later in some cases in favour of reciprocating engines was due largely to the adoption of double reduction gearing to suit the requirements of merchant tonnage where troubles were experienced which had not been anticipated, and also to the fact that money became less easy—due to trade depression. The question of the reliability of double reduction gearing has been dealt with in my paper. Comparative results are given in the tables in the paper to show that marine turbine machinery has given fuel consumption figures quite up to the anticipated values. Mr. Fielden cites two small vessels of equal size where the triple expansion reciprocating engine beats the turbine in all round results. This may quite well be so, but it does not mean that turbine machinery will not be superior when fitted to ships of suitable size and power. Steam turbines are not suited to the development of small powers. It is my opinion that geared turbine machinery, with single or double reduction gearing, may be accepted by shipowners, where the conditions are suited to them, without any misgivings about either reliability or economy. Regarding the life of turbine reduction gears, the ship H. in Table VIII. has covered over 200,000 miles up to the present, and the gears are in satisfactory condition. A Superintendent Engineer reports: "The general condition of all gearing (eight sets) is very good and at present rate of wear should give no trouble for years." These are all double reduction sets and numerous reports on similar lines have appeared in connection with single reduction gearing in the merchant service.

Mr. Fielden is undoubtedly right in claiming that superintendent engineers must be conservative. It is their duty to do the best they can for their Company, but they cannot do this by keeping in a groove. They must be progressive as well as conservative, and good judgment must be exercised so that they may draw the line between these conflicting elements. Mr. Fielden objects to the word "traditional" used with reference to the dislike of water tube boilers, but its use is justified in nine cases out of ten. Very few marine engineers have actual experience of water tube boilers. They have all heard of their failings in the past, and many refuse to even consider them when circumstances fully justify a reconsideration of the position. That is a traditional dislike. It is not a dislike based on a proper consideration of the matter in the light of present day conditions.

Mr. Fielden states that there would be more water tube boilers in the mercantile marine than there are if condenser troubles were eliminated. That shows that this type of boiler is not without its merits. The condenser difficulty is one that seems lately to have been growing worse rather than better, though I do not agree that it is due to the changes in design that have accompanied the development of turbine machinery. There are several expedients now in use to lengthen the life of condenser tubes, which will be familiar to the members. In the high pressure installation referred to in the paper, it is proposed to fit a condenser having two portions so that one portion may be overhauled without stopping the machinery. Precautionary measures of this kind, in conjunction with the use of a closed feed system to reduce boiler corrosion, should be important factors in minimising troubles generally associated with water tube boilers.

Turbine wheels of 30in. diam. have been regarded as the limit when turned out of the solid, but solid rotors of 36in.

diameter have been used where the stresses have been relatively low, that is when the rotational speed has been low.

Mr. Poultney's remarks about the Lentz engine with its poppet valves, are interesting. The length of successful service he quotes is evidence of what can be done, and we look forward with interest to this performance being confirmed by a number of other ships in the near future.

Mr. Dorey considers that the piston speeds of 1,100 feet per minute mentioned for recent oil engines are following naval practice of a few years ago. This may be so, but the conditions under which naval machinery was operated were exceptional and affected the design. No one in the merchant service was inclined to copy these high piston speeds until the demand for cheaper oil engines became urgent. Forced lubrication has been of great assistance in making continuous running at high piston speeds practicable. Efficiency in oil engines is of importance at present, as Mr. Dorey says, but the reduction of weight and of cost per horse-power is also a predominant element in oil engine design to-day.

Both Mr. Dorey and Mr. Fielden are attracted to the electric drive, and this is not surprising. It is a flexible drive, suited to ships with large auxiliary plant or for ships running frequently at low powers, as with cruisers and naval ships generally. There is little vibration with this method of driving and it seems on that account and because of its quietness, well adapted for yachts. It also has some features which make it suitable for tug boats, to which use it has been applied in America. Electrical propulsion has not made much progress in our own country, due to its novelty and, to some extent, to troubles experienced with auxiliaries which were not an integral part of the electrical installation.

I cannot say if it will prove to be suited to the ordinary run of merchant ship. It is probable the cost will be a factor against its development along these lines. In special cases, however, electrical propulsion seems to have distinct advantages.

Mr. Farenden makes some interesting remarks about the excellent performance he has experienced with quadruple engines. The results he quotes are much better than any I have ever come across and been able to check. If the installations he refers to were fitted with superheated steam, the results in coal consumption would be still better and the quadruple engine would then be nearly supreme among the steam prime movers. It almost seems too good to be true. It is satisfactory to be assured that well designed and balanced quadruple engines have been so reliable and economical to maintain and run.

Mr. Cleghorn's remarks are very interesting, and the summary of the results of the "Bilbao" shows an excellent performance for so small a ship. The coal coefficient compares very favourably with the best cited in Table VI.

Mr. Cleghorn, with others who have contributed to the discussion, expresses doubts about the value of superheated steam, and he gives examples of recent large ships in which the use of superheated steam has not been adopted after experience with it in previous ships. There is a very distinct cleavage of opinion among ship-owing firms on this point, and it is reflected in the policies they are adopting. Some are giving up the use of superheated steam. On the other hand, some of the most progressive firms, after considerable experience of it, are adopting superheat extensively for old and new construction. Two facts therefore may be definitely stated, one that superheated steam on board ship gives trouble and increases the cost of upkeep, and the other, that superheated steam reduces the fuel bill. It may also be concluded from the above that where the troubles have been greatest, the saving in fuel has been least, and where the economy has been considerable, the troubles have not been important. In other words, it seems certain that the decision has depended upon the personnel in charge and upon the point of view of superintendent or owner. In my view the decision to go in more extensively for superheated steam is the right one to take, if a higher standard of overall economy is desired.

On the question of fitting combination machinery to the new White Star liner, one cannot say much. At the best the system is but a half-way step which has been successfully and extensively tested by that Company. It is probable that use and wont have been the principal factors in the decision come to, rather than any question as to the most economical way to use superheated steam.

On the question which Mr. Bates raises about gearing nickel steel pinions with mild steel wheels, no real explanation can be offered. The pinion is always made of a harder material than the wheel, as experience shows that the same quality of materials seldom work well together. The answer is akin to the explanation of why mild steel parts are so liable to seize if they rub together, even very lightly.

Mr. Anderson speaks hopefully of the internal combustion boiler. Information on this subject will, I understand, soon be put before the members, so it will be better to reserve opinion about it. It is, however, a very ingenious contrivance, and must have required a great deal of experimenting. The figure of 18% for the steam consumption of auxiliaries is quite in order, and there is little doubt that the proportion increases as time goes on. There is undoubtedly quite a field for developments in the methods of driving the auxiliary machinery on board ship.

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Metallic Corrosion.

BY W. S. PATTERSON, M.Sc., A.I.C.

READ

On Tuesday, October 13, *at* 6.30 *p.m.*

CHAIRMAN : MR. R. S. KENNEDY (Vice-Chairman of Council).

FEW problems have troubled the practical engineer with such continued tenacity as those associated with corrosion. There have been many theories, there has been much experimental work, yet there is still great difficulty in solving many cases of corrosion.

In a previous paper[1] before this Institute I endeavoured to show the bearing of certain theories and researches upon the important subject of boiler corrosion. Outlined in that paper are the three main general theories of corrosion, namely, the carbon dioxide, the hydrogen peroxide, and the electrolytic theories, the latter being only briefly dealt with. During the last few years rapid strides have been made in the investigation of the mechanism of corrosion, and it is these newer developments I wish to discuss in this paper, indicating their practical interpretation.

Let us consider some of the facts which require explanation. There is first the local and apparantly capricious nature of corrosion. There is the layer of corrosion product which sometimes almost stops corrosion, whilst at other times deposits formed during early stages apparently accelerate the process of attack in later stages. There is the phenomena of pitting, so great a trouble to all practical users of metals and the mystery of continued action at the bottom of a corrosion pit.

Very few of these problems can be answered in a satisfactory way by theories which were brought forward prior to 1916.

[1] Boiler Corrosion. October 23rd, 1923—J.A.

This is no disparagement of the work done before this date, but rather it is a recognition of the formidability of the problems to be solved. There are two ways of approaching the study of corrosion phenomena either by investigating some particular case of corrosion with the definite object of effecting its solution without of necessity detecting or comprehending its causes. The other way is to investigate causes without endeavouring to apply them immediately to any particular problem, and then eventually to build the causes together until the real mechanism of corrosion is evolved. Many of the former types of investigation have been pursued with varying degrees of success. There have been the researches carried out under the auspices of the Iron and Steel Institute by Friend and others which have given useful practical information regarding ferrous corrosion and means of allaying it. The Institute of Metals through its Corrosion Committee has issued exceedingly valuable reports on condenser tube corrosion, the work being carried out by Bengough and his co-workers.

Because of time and the pressing necessity of some immediate solution of a practical problem no great part of any of these researches has been devoted to theory. It must be remembered that the examination of such single types of corrosion allows little for generalisation because of the enormous variations which almost any type of corrosion may become subject to by a change in one or several of the factors causing it. The deciding condition in a particular case of boiler corrosion for example may be completely altered if the feed water is changed, if access of air is prevented, or if the rate of steaming be varied considerably. It has become clearer as time has progressed that a thorough investigation into the general mechanism of corrosion independent of its application is the path along which new corrosion research must proceed. Once engineers, metallurgists, and chemists understand completely the primary principles which govern corrosion then more efficient means of combating all types of corrosion will be devised.

The latest developments of corrosion research have led to a modified electro chemical theory being brought forward to explain many important observations.

The Electro Chemical Theory of Corrosion.

The first development of this theory was probably due to Davy, and in recent years it has had many supporters. By this theory corrosion is explained by the development of positive (anodic) areas and negative (cathodic) areas on the metal surface. A mass of metal on which such areas are established being surrounded by an electrolyte will bring about the production of an electric current between the areas of different polarity. If, for example, the metal be iron then ferrous ions will pass into solution at the anode, causing corrosion there, whilst hydrogen or its equivalent will be set free at the cathode over which it may form as a film (see later), such a system is known as a corrosion cell. Corrosion then on this theory is very definitely bound up with the development of these positive and negative zones. Let us examine some of the ways in which these may be caused.

Ways by which corrosion cells may be established:—

(*a*) Definite impurities which are of different polarity to the surrounding metal, for example, slag inclusions in wrought iron, graphite in cast iron, and certain forms of iron carbide in steel, will set up electrolytic action.

Impurities which are practically insoluble in the dominant metal and which tend to segregate would probably induce serious local corrosion and pitting. Impurities which dissolve completely, forming homogeneous solid solutions and eutectics, would be less likely to cause local pitting, but would probably cause corrosion over a wide area, or in practice, what is called wasting. This is not to be regarded as so serious and usually is not so rapid as the action which causes pitting.

(*b*) Differences of stress in metals may cause the development of cathodic and anodic poles.

It has been demonstrated by various investigators[2] that an electric current is produced from a cell of the type.

Metal A (cold worked) | Salt Solution | Metal A (annealed)

the cold worked or stressed metal usually being the anodic pole that is the one passing into solution and therefore undergoing corrosion.

(*c*) Differences in physical structure in the same metal may induce electrolytic action. Large coarse crystals produced by burning or overheating in contact with metal of a normal structure may give rise to an E.M.F. with the solution of metal at the anode.

Where the metal has a distinct duplex structure such as occurs in certain brasses there is a tendency to corrosion of this type, and the so-called dezincification of brass so common in faulty condenser tubes, is probably partly due to this cause.

(*d*) The presence of a covering of corrosion deposit, which may be caused by direct chemical action, for example, the attack of iron plates by carbon dioxide and oxygen. Such a covering if it is electro negative to the underlying metal as often occurs in the case of rusting will promote electrolytic corrosion. The deposit may also function in another very important way (see *g*).

(*e*) The lodgment of foreign particles conveyed by water against a surface may have the effect of establishing areas of different polarity and initiating corrosion (see *g*).

(*f*) The effect of abrasion[3] on a metal surface otherwise chemically and physically uniform may result in the development of local corrosion cells.

(*g*) Work by Aston, and more recently by Evans[4] has shown that areas of differing polarity can be caused by the aeration or amount of oxygen over a metal surface immersed in an electrolyte being unequal.

If, for any reason, one part of a metal surface is not as freely supplied with oxygen as another, then the part which is most aerated becomes cathodic or electro negative, whilst that which is shielded becomes anodic. This results in electrolytic action, and the part to which oxygen has least access becomes corroded. This fact is of extreme importance in the study of corrosion. The discovery of this process of corrosion induction and its application is due to Evans, and in one direction it has completely revolutionised corrosion research.

He has called this method of developing a corrosion cell "Differential Aeration." It appears to be a generalisation that corrosion takes place on a metal surface at just those points where oxygen has the least degree of contact, provided there are also adjacent areas to which the gas has free access.

It will be observed that the methods noted under (*d*) and (*e*) are really special cases of differential aeration.

The practical examples of this generalisation are very numerous. Cases of corrosion do very often occur at the bottom of pits which have developed in plates, or in cracks produced by bending at angles, etc.

The shielded zones at the bottom of such pits and crevices become anodic to the surrounding more freely oxygenated area and solution of the metal proceeds. The rate of solution is really determined at such inaccessible places by the amount of oxygen reaching the cathodic areas surrounding them. The corrosive action is mainly confined to and concentrated on the small shielded anode, and the rate of attack may therefore be very high, resulting in perforation. The larger the aerated cathode and the more ready the access of oxygen to it compared with the shielded anode, the greater the velocity of the local corrosion concentrated at the anode. [5]Bengough and Stuart have pointed out that local corrosion at any selected spot can be initiated beneath cotton wool, glass, coke, etc., and marked corrosion is freqently observable in tanks where debris and deposits have covered the metal.

Evans draws attention to the fact that steel winding ropes used in mines sometimes become internally corroded, whilst the outer portion which has been freely exposed to air retains a bright unchanged appearance.

Abrasion may give rise to the same phenomena. If a scratch is made across a polished wrought iron surface and this be then immersed horizontally in an electrolyte, it will be found that corrosion develops rapidly at the bottom of the scratch to which the oxygen has least access and the polished surrounding cathode remains practically unattacked for a considerable time.

It is easy to appreciate that corrosion initiated either by direct chemical attack, or by impurity corrosion cells may be rapidly accelerated once pitting has commenced, by the phenomena of differential aeration, and actually concentrated by that process upon the pitted area. This is unfortunately quite in accordance with the practical observations of many engineers.

The Corrosion Deposit.

The corrosion deposit, if porous, may act in the same way as debris and shielding the surface on which it is resting from oxygen, cause it to become anodic and thus bring about corrosion.

A layer of dried corrosion deposit which has become impervious to the surrounding electrolyte might act by protecting the underlying metal from further attack and concentrating the corrosion on the surrounding area. As already indicated, where the deposit is porous and of opposite polarity to the metal, it may promote corrosion by a cell of the type.

Metal | Electrolyte | Deposit

Friend[7] has suggested the possibility of wet rust acting as a carrier for oxygen during ferrous corrosion. It is assumed that the rust is alternately reduced by the metal thus oxidising it, and then reoxidised itself by diffused or dissolved oxygen.

There does appear to be every possibility that under certain conditions the corrosion deposit on iron can act in this way, and in any metal deposit of such a composition that two states of oxidation are possible, this phenomena may play a part.

The character of the deposit in any case of corrosion will be largely influenced by the composition of the electrolyte in which corrosion is proceeding. Changes in the composition of feed water, condenser water, etc., must all therefore have consideration in any specific case of corrosion since such change may completely alter the nature and function of a deposit accelerating or diminishing the attack.

Deposits formed during corrosion must be regarded as of primary importance in the study of the mechanism of corrosion. It may well be that the capricious nature of corrosion is largely attributable to the effect of the deposits which it creates and more research is required to elucidate this important aspect of the subject.

Having referred to the electro chemical theory and considered its most recent development, we have still one or two other important considerations. In the corrosion of iron and steel the carbon dioxide theory[1] and the formation of soluble ferrous bicarbonate which is oxidised to rust by dissolved oxygen must still be considered as a source of prolific corrosion under certain definite circumstances. Corrosion may be started by carbon dioxide and intensified by electro chemical action which might have its origin in any of the causes I have outlined. The de-aeration of feed water is therefore of great importance in boiler practice, for oxygen is without doubt the driving force behind almost all cases of practical corrosion.

Types of corrosion media.

Broadly we may classify corrosion media as either acid, neutral or slightly alkaline. In the former we have many industrial waters and effluents and also a few natural waters which owe their acidity to peat acids, originating in the nature of the collecting ground. Probably, however, most corrosion media fall into the category of neutral. They consist of waters containing dissolved salts such as sodium chloride, calcium sulphate, magnesium chloride, etc., and oxygen is a primary requisite for metallic corrosion to proceed in such media.

Certain salts, for example, carbonates of lime and magnesia confer a slight alkalinity on water, but the process of corrosion in such a media appears to be somewhat similar to that occurring in neutral solutions.

Acid corrosion media.

The attack of a metal surface by an acid media is governed largely by the presence of impurities. It is possible that metals of absolute purity would not be attacked by acids. The presence alone of impurities does not determine the rate of attack. Some impurities are more active than others and the amount of impurity present is also of importance.

How does an impurity affect the corrosion of a metal by an acid? Impurities if electro negative to the dominant metal will set up a simple corrosion cell, and hydrogen be liberated at the cathode, which is the impurity, whilst the metal will pass into solution at the anode. The action of dissolved oxygen in oxidising the hydrogen and so preventing polarisation is of importance, and is one reason for the de-aeration of feed water.

Some impurities possess the property of liberating hydrogen from acid solutions, much more readily than others, and therefore they have a greater stimulating force on the rate of corrosion in such media. 0·5% of antimony present in zinc produces a much greater rate of solution in acids than the same amount of cadmium. This fact can be explained on electro chemical grounds by the over potential values of antimony and cadmium. The former is much lower than the latter and hydrogen is rapidly liberated from the small centres of antimony distributed throughout the zinc. So far as metallic impurities are concerned the over voltage factor seems to be the deciding one when metals undergo corrosion in acid media. Many impurities also fundamentally alter the physical or internal structure of metals, giving rise to changes in the capacity of the metal to resist acid attack.

The solubility of impurities in metals has been mentioned with the consequent tendencies to cause either wasting or pitting.

One should also appreciate the fact that as the dominant metal is corroded away more of the impurity reaches the surface to become active in stimulating corrosion. We thus find that in the case of zinc the rate of corrosion accelerates as the deposit of impurities accumulates on the surface.

I recently submitted specimens of zinc to attack in dilute acid for 10 days. In one set the deposit was removed each day by wiping. At the end of the period, the amount of zinc dissolved was 100 per cent. greater in the specimens where the deposit had been allowed to accumulate. Thus, if prolonged corrosion occurs in an acid media the influence of the impurities may increase with length of time owing to gradual exposure, at the surface of attack.

A practical example of corrosion in acid media is that of many cases of the external corrosion of economiser tubes. Here the acid is formed owing to the products of combustion containing sulphur dioxide and moisture, which mixture present with excess air will yield sulphuric acid, which attacks the tubes. A deposit consisting of ferrous sulphate, tar and soot is obtained, the tubes rapidly becoming pitted either locally or over a wide area. Dry sulphur dioxide alone does not attack iron, but only when moisture is present. The practice of always keeping the inlet temperature of an economiser above a certain figure (100° F.) is to prevent the dew point of the flue gas being reached with consequent deposition of moisture and formation of acid on the tubes.

Neutral media.

Electrolytes consisting of solutions of salts are the most frequent media in which corrosion occurs in practice. Oxygen is usually the dominant influence in this type of corrosion. Let us imagine a metal surface immersed in a neutral electrolyte, the case of a sheet of wrought iron in sea water.

A supply of oxygen will be available which will be governed by the quantity of dissolved oxygen present, which will be rapidly exhausted, and by the rate at which diffusion can take place from the surface of the liquid to the metal. Thus the upper edge of the wrought iron sheet will receive more oxygen than the lower edge, which is more deeply immersed. This is a condition of differential aeration, and corrosion of the plate will take place where the oxygen supply is poorer (anode) that is within the solution towards the lower end of the plate. If we have a rapid stream of oxygen diffusing to the cathode we shall have a correspondingly rapid corrosion at the anode, with a precipitate of rust formed at the bottom of the containing vessel.

When the oxygen supply to a metal surface immersed in an electrolyte is uniform and differential æration does not occur the process of the corrosive action is different. Anodes and cathodes may be developed by some non-uniform condition on the metal surface and the metal will pass into the solution at the anode whilst hydrogen or its equivalent will be produced at the cathode. The function of oxygen is to remove the hydrogen by combining with it and so depolarise the action. The oxygen may also function by forming insoluble oxysalts at the anode which are thus removed and the way cleared for solution to continue.

The addition of impurities to a metal corroding in a neutral solution will not greatly affect the rate of corrosion if the oxygen supply is the controlling factor, for if the pure metal is corroding as rapidly as the rate of oxygen diffusion will allow, then it is not likely to corrode more rapidly by altering the composition. Recently, in connection with experiments on the corrosion of zinc, I have obtained experimental evidence in complete proof of this. I immersed at an equal depth in an electrolyte (salt solution) some fifty specimens of different compositions, and at the end of three weeks the amount of corrosion was practically the same in all cases. It had been determined simply by the rate of oxygen diffusion, and as the specimens were all immersed to the same depth this had been equal in all the experiments.

The corrosion of cast iron in sea water is the result of oxygen diffusion corrosion and its rate of corrosion is governed by this factor. Where the action takes place at the water line it is accelerated by differential aeration as explained elsewhere. It should be noted that the graphite in the cast iron remains unchanged during the action, and acts as a binder to a curious corrosion deposit, consisting largely of oxides of iron. The corrosion may not alter the external shape of the metal to any great extent, and it is only when the deposit is cut away that its depth is realised. Corrosion in neutral electrolytes is mainly associated with oxygen supply to the surface; if there be no oxygen, corrosion will in all probability be reduced to a minimum.

The function of oxygen may be summarised here—

(1) Direct attack, usually the character of the deposit formed would stop the reaction by inhibiting further access of oxygen.

(2) By differential æration.

(3) By depolarising the cathode, both in acid and neutral media.

(4) By oxidising soluble salts formed at the anode, converting them to insoluble oxysalts and so facilitating their removal from the anodic area.

Water line corrosion.

This is mainly a case of differential aeration. Evans[6] has shown that if the surface of the metal is wet above the water line, corrosion proceeds more acutely.

We have a freely aerated surface above the water line, and we have a surface shielded by the electrolyte below the water line. The corrosion localises at this point just below the water line where the anodic area of the corrosion cell develops. The ease with which the accumulated solution of the metal at the anode can be removed by gravity leads to the action being rapid and severe.

This removal of the soluble metal salt is of course important; if a large accumulation occurred it would stop the action at the anode completely.

Thus in a tube half filled with moving water the water line action would be stimulated by the stream of water removing the products of the action from the anodes.

Finally, there remains another point of interest to engineers, that is the production of a corrosion cell by inequalities in the velocity of the flow of water in the same tube.

If for any reason two distinct water velocities occur in a tube, say at the ends and the middle, then that fact alone may produce corrosion. A cell of the type:—

Copper in slowly moving water	Copper in rapidly moving water	being set up.

Bengough and Evans have both drawn attention to this fact and pointed out its importance to those entrusted with the design of condensers, etc.

I have brought forward sufficient evidence to indicate the difficulties that beset the investigators of corrosion phenomena. There are many factors and so many variant conditions in the study of corrosion that it might seem an endless task to complete it, yet, however slowly, I think nevertheless surely the basic facts of the mechanism of corrosion are being established and the completion of this knowledge with its application will lead to a considerable measure of immunity from metallic corrosion.

1. Trans. Inst. Mar Eng., Nov., 1923.
2. Evans—Journal Inst. Metals, 1921.
Moore & Beckinsdale, Journal Inst. Metals, 1922.
3. Evans—Journal Inst. Metals, 1925.
4. Evans Journal Inst. Metals, Vol. II., 1923.
5. Bengough—Journal Inst. Metals, Vol. I., 1922.
6. Evans—Journal Inst. Metals, Vol. I., 1923.
7. Newton Friend—Journal Chemical Soct., 1921

Summary.

The electrolytic theory is of primary value in the study of corrosion. Absolutely pure metals would probably not corrode in acids, but impurities by developing positive and negative areas, stimulate corrosion. The solution of the metal takes place at the anode. Methods by which positive and negative poles can be established in practice.

1. Impurities.
2. Difference of stress.
3. Physical structure not uniform.
4. The influence of corrosion deposit.
5. Abrasion.
6. Foreign particles introduced as suspended debris.
7. Differential aeration.

The type of corrosion which persists in acid and in neutral media has been considered, and the influence of oxygen diffusion in the latter as a deciding factor.

Water line corrosion has been considered as a special case of differential aeration and the influence of variable water velocity in tubes.

The effect of corrosion deposits and debris have been discussed and cases of practical applications of the above theoretical considerations.

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This illustration is reproduced from a photograph forwarded by Capt. P. T. Brown (Member) to show the severe corrosion on a turbine

Annual Dinner.

The Annual Dinner was held on October 30th at the Hotel Cecil, presided over by The Right Hon. Lord Inverforth, P.C., who submitted the *Royal Toasts* at the conclusion of the menu. These were loyally applauded, as usual, by the assembly.

The Toast of the Naval, Military and Air Forces of the Empire was proposed by the Right Hon. Lord Kylsant of Carmarthen, who said that without the services of marine engineers the war could not have been carried through to a successful conclusion, and the close inter-relation with his Majesty's forces by sea, land and air led them to appreciate perhaps more deeply than other civilians what the country owed to its sailors, soldiers, and airmen. Mention might be made in particular of the collaboration of marine engineers and officials of the Admiralty in many matters during the war. There was difference of opinion as to the element in which another war would be fought, but he would be a rash man who expressed any definite view on the question. Personally, he thought it would not occasion much surprise if, in spite of all the great developments that were taking place, any future war in which this vast sea-girt British Empire might be involved was, as in the days of our forefathers, decided on the sea.

The President (Lord Inverforth) recently delivered a very interesting address to the members of the Institute, in the course of which he dealt with the progress of internal combustion engines, and outlined some of the aspects in which they had decided advantages over steam engines. Anyone who examined the quarterly returns published by Lloyd's Register of Shipping, giving the number and tonnage of vessels, both steamers and motor ships, under construction throughout the world, must be profoundly impressed by the steadily increasing proportion of vessels being built with motor engines. Taking into consideration the great strides that had also been made in the development and use of the internal combustion engine on land and in the air, those who looked ahead must come to the conclusion that the motive power of the future lay in the internal combustion engine, whether at sea, on land, or in the air, and the days of the country being dependent upon miners or mineowners might before long be a thing of the past. There was, no doubt, still considerable scope for progress and improvement in the design and operation of marine engines, and all marine engineers were alive to the possibilities in that direction and were giving earnest thought to this matter of the future means of marine propulsion, with a view, if possible, to evolving something even more economical than existed at present. These were difficult times for shipping, as well as for other leading industries of the country, but if, as a result of the keenness and resource that were necessary to bring the country through this period of trial, new or revised methods were employed leading to increased efficiency and economy, they might look back upon the present period of adversity as a blessing in disguise.

Mr. J. C. C. Davidson, C.H., C.B., M.P., Parliamentary and Financial Secretary to the Admiralty, in responding for the Naval Force, said that one of the main sources of strength to the Empire and facts in its development had been the close association between the Royal Navy and the Mercantile Marine. There were two great bonds between the Navy and the Merchant Marine, the art of navigation and the science of engineering. Great Britain was supreme in both.

The Navy had recently been attacked in the Press in every direction except one. No one had said that the Navy was not prepared to pick the unequalled brains of British marine engineers. It was obvious that naval requirements in certain respects differed from mercantile. There were some advances of research essential to the Navy (e.g., maximum power and minimum weight in motor engine), which would be unprofitable to the Merchant Service.

As representing the Admiralty he could not too strongly emphasise the fact that naval officers of the engineering branch were always anxious to encourage and to benefit by the inventive genius of the members of the marine engineering profession, which has created and is maintaining British supremacy in marine engineering. We do what we can to reciprocate where our researches, which go on ceaselessly side by side with those of the merchant navy result in some discovery useful to us both. Marine engineers are fortunate—criticism they give and receive is to help and not hinder, to make more perfect, not to destroy.

I should like to see some of the critics of the Admiralty aboard a merchant ship. Instinctively they would find their way to the engine-room, where if a gale should spring up they would be found with their heads next the supercharger and their feet in the refrigerator.

Talking of superchargers—although it is almost presumption on my part, I cannot refrain from paying my tribute to the immensely fruitful labours of Sir Charles Parsons.

What Newton's name is to gravity the name of Parsons is to turbines, but with this difference; gravity remains fixed; turbines are always improving.

Brigadier-General J. S. WYLIE, D.S.O., M.V.O., K.C., in responding for the Army, said that but for the Marine Engineers it would have been impossible for the army in the late war to take the field, or to remain in the field, and thus enable the Mercantile Marine, in combination with the army, to bring off the great victory.

Major-General Sir FREDERICK SYKES for the Air Force, mentioned that among those who served the country in magnificent fashion during the war were three who came straight from the Institute—Lord Weir and Lord Maclay, two former Presidents, and the present President, Lord Inverforth. Speaking of the recent scientific development which had taken place in connection with aeronautics—the auto-gyro—the greatest he considered since the Wright brothers made their conquest of the air—he regretted that the development was not a British invention. There was too great a tendency for developments to come from foreign nations.

The Toast of The Mercantile Marine was proposed by Sir BURTON CHADWICK, M.P., who said: I have often spoken to this toast in audiences of seamen, shipowners and others, but this is the first time that I have had the honour of speaking in a community of marine engineers, and being an old seaman myself I find myself rather searching for an atmosphere common to both of us in which I can say to you, so that you will understand, all that is in my heart about this great service to which we both belong. For it is as a great national service that I think of the Mercantile Marine to-night rather than as a trade or profession. The marine engineer was always ready to face all emergencies with a spanner!

After paying a tribute to the way British owners supported marine engineering advances, notably Lord Inverforth, who had passed from steamship to internal combustion work, Sir Burton said he once heard an American Ambassador state in proposing this toast: "I deem it no exaggeration to say that whether in war or in peace the British Mercantile Marine has rendered more service to more men of more nations than any other human agency." Well, there is nothing very original in saying that, and as to its accuracy I suppose it is arguable, but the sentiment is sound; it is probably as true as any general statement of the kind could be, and to those who heard the speech it had that rather impressive booming quality, produced by the deep voice and the slowly enunciated ambassadorial pronouncement at the dinner table. This particular dinner table was at the Chamber of Shipping, and as an Englishman I accept the tribute with pride and gratitude.

Now, if what the Ambassador said is true in a broad sense, how much more true is it in its application to our own country, for of all people we Britons are the most dependent on our sea services.

I have been listening with much enjoyment to the speeches which have been delivered on the toasts of the three fighting services, and I have decided to take rather an unusual line, and with great respect, I am going to throw out a suggestion. That suggestion is, that it would be appropriate that the Mercantile Marine Service should be included (where it is not already a separate toast) as a matter of common practice in this country, with the toast of the Crown Forces.

There will, no doubt, be those who would not see eye to eye with me in this matter, as they might not unreasonably say that the Mercantile Marine is not one of the Crown Forces, and it is a commercial service. However, I will give you my reasons, and as it is, I think, a very interesting and important matter, others will, I hope, deal with it, as opportunity offers or perhaps through the Press.

We have a fine old custom in this country, on every important public occasion of this kind of toasting the forces of the Crown. I think it is a good custom because it is an expression of the national confidence in those forces, and it is an expression of loyalty to the Crown and it carries with it the dignity that should accompany any reference to the Crown. Of course, on such an occasion as this the Mercantile Marine has a place of honour by itself, because this is a Mercantile Marine dinner, but on most occasions I feel that it would be fitting that, bracketed with the toast to the Navy, both in proposal and in response should be the Mercantile Marine, and, of course, that need not involve two separate sets of speeches, as the toast could be dealt with by any officer responding for the forces.

It is true that the Mercantile Marine is a commercial service, but it is much more, and that has been demonstrated in a most remarkable manner during the past ten years, when the Mercantile Marine has proved itself to be an essential part of our first line of defence. When we toast H.M. forces we have in mind, more particularly the men in those forces, and I claim the right of the British Mercantile Marine to share in this toast on account of its personnel and because it has so much in common with the Crown service.

The war contribution of the Merchant Navy is now history, but it is interesting to remind ourselves of the scope of that contribution. Remember the strength of the R.N.R., a fighting mercantile marine. Remember the wonderful fighting record of the merchant ships, and all those essential war duties of convoy, mine-sweeping, coast patrol, and so forth. Concurrently with all that actual military duty you were running your ships through the war zone and maintaining the very arteries of the Allied nations, and as a measure of this war contribution of the Mercantile Marine you lost between 15,000 and 16,000 men killed, and nearly 4,000 ships, with all that that meant in strain and suffering and patriotic service.

That is a remarkable contribution for a service which is not included in our toast-list. It would hardly be relevant to say that we have common ground with the Crown Forces, inasmuch as we have our own special Department of State—the Marine Department of the Board of Trade, of which the President of the Board of Trade is equivalent to the First Lord, and my old friend Mr. Hipwood to the First Sea Lord—a Department quietly and efficiently watching over the ship and everybody on board of her during peace, and in which Department, mark you, on the first sign of national emergency the whole supervision and much of the administration of our Mercantile Marine forces would be concentrated.

Another feature of the national character of the Mercantile Marine is this, viz., that it is constantly under the watchful eye of my friend, Sir Acton Blake, and that grand old institution (semi-Government and wholly regal in character), Trinity House, which is embedded deep in our great British sea tradition. Neither the Navy, nor the Army, nor the civilian people of our country can move hand or foot, in peace or in war, without the British Mercantile Marine. That cannot be said with truth of any other service or of any other unit that I can think of in the world.

The first to acknowledge the service of the Mercantile Marine in war is the British naval officer, who is the best judge, and although he may not agree with me in the suggestion I make, I know that as a seaman he will understand the spirit in which it is made. You may say to me that I am making too much of it, that I am carried away by sentiment, that in any case it is unimportant. Life would be a poor thing without sentiment, and as to its unimportance—to one who has been born and bred in its atmosphere, and who has a deep love in his heart for the men of the Mercantile Marine, nothing is unimportant that will do them honour.

Sir Frederick Lewis, Bart., said, in reply, that during the last few years it had frequently been his pleasure to respond to the toast. It was one that had been proposed by divers individuals—by Cabinet Ministers, Judges, Barristers, Commercial magnates and so on, but somehow or other their good wishes never seemed to materialise. We heard a great deal about "rosy dawns" and "radiant morns," but those epithets might be freaks of nature for any good they seemed to do. He felt inclined to suggest that these oratorical Jonahs should be replaced by, say, some high dignitary of the Church, for example, the Archbishop of Canterbury or the Bishop of London, in the hope that he might be more successful. Certain it was that the Mercantile Marine required all the health that this or any other audience might be able to bestow upon it. We were still suffering from a paucity of international trade and a superfluity of tonnage, principally the latter. The shipping industry had a very keen perception of the fact and of the realities of the situation, and, so keen was that perception, and so much did they realise the fact that there were too many ships, that they were actually building more, with the financial assistance of that Government of which Sir Burton Chadwick was a distinguished member. To an audience of this kind it is almost an absurdity to quote statistics of building, but a study of these figures discloses a remarkable variation. For instance, in 1913 the world's tonnage under construction was $3\frac{1}{3}$ million tons, in 1919 it was 7·14 million tons, and in 1925 it will drop to under $2\frac{1}{2}$ million tons. In the United Kingdom alone, in 1920, the tonnage contracted reached over $3\frac{1}{2}$ million tons, and in 1925 it will be just over the million. These figures clearly emphasise the depression in the shipping industry, and, unfortunately, there is little shipowning as an industry can do to create a better situation. We are entirely dependent upon the success of other industries, and, in the absence of that success, we can only suffer in silence. At any rate, we do claim to bring in the necessities of life and commerce at mere fractions of the c.i.f. prices, and it may be safely said that if we carried the goods for nothing it would have very little effect on the retail prices in this country. We go on doing the best we can, and if we do sometimes manage to make a little profit we are almost ashamed to disclose it. If we make any money we are called profiteers; if we do not make any money we are called incompetent. That, unfortunately, is the tendency of the present age. If a man goes to church he is a hypocrite; if he does not go to church he is an atheist. Exponents of that same kind of thought would probably say that if a shipowner presided at a banquet of marine engineers he is a blackleg.

Amidst all our discontent, we have one supreme cause for gratification, and that is that we have to deal with a Union which takes a broad-minded view of the situation. I venture to suggest that if every other Union were led by men of the type of Mr. Havelock Wilson the cost of living would be much lower, and there would be much less unemployment. The effect of the recent trouble with some of the men abroad, a trouble instigated by malign and hostile interests outside the men themselves, has simply been to impose heavy losses on the shipping industry and to divert the cargoes to foreign ships, whose sailors receive about one-half of the remuneration paid to British sailors and firemen. There is the absurd side of the situation that ships should be held up, that cargoes should be detained and allowed to deteriorate, resulting in ships ultimately carrying the cargo which pay much lower wages than those in force on British ships. Surely, it is to the interest of Dominion States to assist in the enforcement of contracts. Depend upon it, if security of contract is withheld, and if intimidation is permitted, the revival of trade, for which we all long, will be eternally postponed. On the other hand, shipowners have an obligation, and I hope we will never forget the heroism of our sailors and firemen in the war, and that we will not hesitate to increase the remuneration of loyal seamen when circumstances justify it. I wish all industries could get rid of their mutual suspicion. That, I am more than ever convinced, is the root of the trouble. What Burns said over 100 years ago is true today: "Man's inhumanity to man makes countless thousands mourn." At this moment we are rejoicing in the Locarno Security Pact, which we hope will influence an improvement in the industrial situation. With the excellent example by the Governments of the world, why should there not be, as well as an International League of Nations, a National League of

Industries? With all round goodwill, such a thing could have tremendous possibilities in the commercial situation. Industrial conferences have already taken place, notably in the shipbuilding trade.

At last year's banquet, in proposing the health of the then president, Sir Westcott Abell, half jocularly and half seriously said he wished the engineers would stop making new inventions, because no sooner did shipowners order a new vessel than in a few months' time she was out of date. But there was one direction in which their energies and abilities might well be concentrated, and that was in developing the motor engine, so that the cost of production would be no higher than the reciprocating engine. When that time arrived, coupled with economies of production in other ways, he ventured to predict that the shipyards and engine works would soon be filled with orders. When they had done that, might he express the hope that they would play Rip Van Winkle and go to sleep for 100 years?

P. G. Mackinnon, Esq., Chairman of Lloyd's, who also replied, said that Sir Burton Chadwick had, with good reason, expatiated upon the merits of the mercantile marine, and all would agree that every word he had said in praise of that wonderful service was more than justified. Sir Burton had an inside knowledge of the mercantile marine, and was better qualified than most people to speak of the immense service that it rendered to all. A sailor himself, he held an extra master's certificate and had served in sailing ships, tramps and liners. Now he was engaged in helping to navigate a craft mightier even than the biggest liner—the Ship of State. She was not having a very easy passage. The sea was rough, coal was giving trouble—not oil, Lord Inverforth would please note—there was much ominous redness in the sky, and there was a good deal of nervousness among the passengers. But they were comforted with the thought that the ship was a well-built ship. She was classed "100 A1." She had passed through many bad storms before, and there were other much less well-equipped ships which were battling with similar weather.

Just as we were confident of the future of the Ship of State, so were we confident of the future of the mercantile marine. There was no surer indication of the prosperity, or otherwise, of the trade of the country than the condition of its shipping. Any improvement in trade was very quickly reflected in better freights, which in their turn must react on the coal and steel industries of the country. Sir Burton Chadwick, in a speech at the Mansion House the other night, spoke of the reasons he had for taking a more hopeful view of our trade. He said that the trade barometer was, in his opinion, rising. Few men were better qualified than he to express an opinion upon the subject, and he therefore felt full of hope in his having felt justified in making such a statement. Lord Kylsant had referred to Lord Inverforth's most interesting address to the Institute, in which he told his audience how happy had been his experience of oil engines, and how hopeful he was of their success. These remarks of his suggest to me that it is to you engineers, to a large extent, that we must look for the future prosperity of our mercantile marine, and I feel confident that your inventiveness and skill will provide means of making it so efficient that its future prosperity is assured.

The Toast of The Chairman.—The Right Hon. FRED G. KELLAWAY: It was my privilege to be associated with Lord Inverforth when he was Minister of Munitions, so that I was in a position to form an estimate of his work. I doubt if the country yet realises how much it owes to Lord Inverforth for the great business knowledge, qualities of character, vision and imagination which he showed during the war. It is not too much to say that he was responsible for transactions which saved this country at least six hundred millions of money. Those transactions were carried through with a sole eye to the public interest, and of all the men who served the State as business men, there was no more loyal or conspicuously successful example than that of Lord Inverforth.

Lord INVERFORTH, in responding, said that the Institute was helping young men to get a firm footing on the ladder of success. The Council and its able secretary were doing everything they could to help forward the object in view, and if shipowners and other people connected with similar trades would visit the Minories occasionally, they would find out what was being done in a work by which the Empire would benefit in the future. He desired to thank the Dinner Committee and Mr. Robertson for all the trouble and the work they had undertaken.

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Contributed by J. L. RUTHERFORD, Senr. (Member).

Some Practical Experiences of an Engineer.—There are many vessels in the mercantile marine which have no lathes, and very little material in hand for dealing with break-downs and making good possible defects.

Things happen, and the engineer in charge is often at his wits end to overhaul and repair the details to make them at least sufficiently reliable to enable him to get his vessel to the port of destination. Even when reaching that port, it is sometimes impossible to have defects made good without serious detention of the vessel, or from an economical point of view, as the chief engineer must always bear in mind that his particular ship is not run simply for the benefit of his health, but as a commercial proposition, and a paying concern for the owners.

One likes to believe that an engineer, whether senior or junior, is an engineer, and not one who goes to sea because it's a fine opportunity to see the world and its sights free of charge.

The writer has had experience in different classes of vessels, and for the past 15 years has been in tank steamers. Tank steamers are vessels where one has not time to hesitate and consider the many view points which may arise, and give justice to the work committed to his care, as his time is fully occupied keeping things going till the next general overhaul comes round.

For the benefit of all, a few personal experiences are detailed in the hope that they may be of service to some. Each experience has proved of value and the writer has never had the misfortune to have his vessel towed into port because of defective or disabled machinery. The greatest experience of all was a broken "Thrust shaft" and "Thrust block." The shaft was temporarily repaired at sea and the vessel brought into port without assistance from any outside sources.

Pump Seats.—One of the most common defects to be met with is due to loose seats in pumps, and this may be very serious in its results. A horizontal "Worthington" feed pump, drawing from the hotwell and delivering direct to the boilers (the boiler pressure being 180 lbs.) had a cast iron water end, with brass seats screwed in. The screwed part of the seats being slightly tapered it required very little to cause them to come out of their places. By the time the defect was discovered the cast iron threads were so damaged as to be of no further use as holding agents. To replace the seats of the suction valves in the usual way was the first operation, then in place of the valve stems or stoppers, extended studs were screwed through the seats of the delivery valve plate, till they were firmly set in the lower seats. The delivery valves were easier dealt with because a strong back of suitable size can usually be fitted with very little trouble.

Pump Barrel Liners.—A "General service and fire" pump of the horizontal "Worthington" type had one of the barrel liners worn through on the bottom side, causing the bucket packing ring to foul and stop the pump. Being the only pump in the ship for its purpose, it was essentially necessary to get it into working order again as quickly as possible. A temporary liner was made out of $\frac{1}{8}$in. sheet brass bent and hammered to shape over a mandril, then cut to the full length of the barrel so that when the end cover was on, no movement of the liner could take place. The liner was made a light driving fit, with the joint on the upper side, and pieces cut out to correspond with the water ports of the chamber. It took just over four hours to effect this repair, and it worked exceedingly well for over a period of some months.

Direct-Acting Plunger Feed Pumps.—Two of these pumps were arranged at the same end of the "Pump crosshead," driven by levers from the main engines. The screw ends of the plungers that passed through the crosshead were continually breaking, particularly after any heavy racing of the engines. $1\frac{1}{4}$in. dies were the largest on board, and the screwed ends of the plungers were $1\frac{5}{8}$in. However, a $1\frac{5}{8}$in. bolt was found in the engine room stores. The head was cut off and a hole was drilled a trifle smaller in the plunger end. Then the plunger end heated over the forge fire to red heat. An air grove filed in the stud end for obvious reasons, and when ready, the stud end was driven into the red-hot plunger end, and then allowed to cool down. As a precautionary measure a set pin was fitted through the plunger end into the stud. When the vessel arrived home some three weeks later, so firm was the stud in the plunger end that a new plunger was made and the repaired one kept as spare.

Main Steam Pipes Fracturing at Neck.—A defect of this nature which occurred in my experience, was rather serious in the case of a vessel fitted with three boilers and two pipes out of three fractured at the necks of the flanges attached to the boiler stop valves. The third one showed signs of weakness after an

Atlantic gale, which had caused some very heavy racing of the engines. The pipes were $5\frac{1}{2}$in. dia. and 5in. bore. One pipe was flawed round both fore and aft sides of the pipe. It may seem incredible, but by the time the engines were stopped and the boiler steam shut off it was found that the fracture had travelled round to within $\frac{3}{4}$in. of meeting, *i.e.*, roughly $1\frac{1}{2}$in. out of $16\frac{1}{2}$in. lineal inches. The other pipes fractured for $3\frac{1}{2}$in. of the circumference. The two pipes were taken off, and the flanges of the engine stop valve blanked off, to enable the vessel to proceed under one boiler to maintain at least good steering speed.

There was not material to make distance pieces, and shorten the pipes and make Pope's joints, so some other method had to be devised. The only thing that seemed possible was to fit a tube made out of sheet brass, because there was no other material at hand. The heaviest sheet brass on board was $\frac{1}{8}$ in. thick. One section was cut off, bent and rounded over a mandril, then driven into the pipe. Then a second one was made, and driven inside the first one. After bending and truing up these tubes or ferrules as near parallel as possible by hammer (not by filing, because to do so would reduce the thickness of the metal) the joints were sawn with an ordinary hack saw to ensure a good and true joint till the required diameter was obtained. When the tubes or ferrules were in place, they were riveted in position. The ends were beaded over the flanges, which had previously been chamfered with this object in view. Two bolts were then passed through holes opposite each other in the tubes and pipes, which was, with the addition, some $\frac{1}{2}$in. thick. A clip strap with extended ends was placed round the pipe, and rested on the bolts. Long studs were made and brought down from the clip to a strong-back under the stop valve, and the whole tightened up.

So successful was the job, that the vessel was carried back to the home port, where the pipes were permanently repaired. The writer had 11 such breaks in a period of five years in the same vessel, then a new design of pipes was fitted, and not before time.

Loss of Power in M.P. Engine.—A new design of slide valve had been fitted to the M.P. engine, and new Ramsbottom rings fitted to M.P. piston. Indicator diagrams showed a great loss of power in this engine, and it was somewhat difficult to trace the cause. Finally, the cause was traced to the piston rings.

Gauging these rings, showed that they were on the full side of the true measurement. Being a built-up piston, paper thick brass was placed under the carriers of the rings, and the next set of diagrams showed the engine doing its usual work. On arrival home these rings were dealt with.

Circumferential Cracks in Furnaces.—Such cracks in modern furnaces are not quite uncommon, and when dealt with at sea by the engineer, it is always advisable when chain studding these cracks, to see that the studs do not interlock each other. It is better to just slightly countersink top and bottom sides of the holes. Leave the studs full length to rivet over. A space of about 3/16ths inch being left between each stud. This space can easily be caulked up with a punch of suitable size. Should any particular stud or studs give any trouble they can easily be removed without disturbing those adjoining, and if necessary, larger studs may be fitted.

Hole between Suction and Delivery Sides of Main Circulating Pump.—For quite some time the writer was puzzled about the auxiliary circulating arrangement of the main condenser, when preparing for sea; entering or leaving ports. The main circulating pump was of the usual design as fitted to engines that drive main air, circulating, feed and bilge pumps from levers connected to one engine to suit the designer's point of view.

When the machinery was placed in the ship it was in such a position that it took a man capable of contorting himself to any shape to really see all parts as they should be seen from time to time when overhauling. The auxiliary circulating pump delivered through the condenser on the delivery side of the main circulating pump. The trouble was, that with the main injection valve open, water would not pass through the condenser tubes. Repeated examinations were made, and always with the same report "Everything O.K."

However, there came an occasion when through corrosion of the cast-iron about the bottom suction valve seating, the valve seating had to be removed so that a false seating might be fitted, and then the original seat replaced over that. As one so often notes things without any apparent reason, I happened to grope with my fingers under the casting, and much to my surprise found a hole almost large enough for my hand to pass through. Transferring my discovery to a sectional elevation sketch of the pump, I found this hole was really through the division wall between the suction and delivery side of the pump.

At first thought, one would naturally say that the pump would have shown this by a jerky delivery overboard. There was a slight difference between the top and bottom discharges, as though the pump was getting more air on one side than the other, but no more than that. I attributed such a constant flow of discharge entirely to a large air vessel which was attached to the pump. One had in this case to work by touch and not by sight.

A knee-like plate was made and held in place with a through-bolt in the cast iron part of the suction valve seating base, and then Portland cement was poured into the recess. This made a good sound and solid job, and as far as the writer knows it is still the same as when last seen by him. It answered the purpose, and saved a new set of pumps.

Bad Vacuum and Feed Pump Troubles.—The writer had another remarkable experience whilst trading in the Eastern Mediterranean Sea, when the engines were running on from 5 in. to 7 in. of vacuum, at times it was even as low as 3in. You can be assured that it was not at all comfortable in the engine-room at such times. What with the normal temperature of 100° F. plus the heavy vapour issuing from the Hotwell overflow and, as such resultants will get to unwelcome places, it will be realised the engine-room was far from comfortable. The vacuum, however, was a mere detail. The greatest worry arose from the feed pumps and feed pipes. The feed pumps were direct acting to the boilers, and with the feed water temperature round about 200°F., the pumps often became choked with vapour, as there was not sufficient head of water to keep the pumps charged. The consequences were that there was much overflowing and loss of feed water. Then when the feed pumps did get the water again, the feed pipes vibrated so heavily that several times in the course of a few weeks they gave out at the neck of the flanges. One remedy was to file out the bore of the flange a little larger than the pipe; chamfer the joint side of the flange, and lead over the pipe, thus making a "Pope's joint." It was found advantageous to run soft solder between the pipe and flange, as in brazing. By using these expedients the engines have run for 6 to 7 weeks with four flanges repaired in this manner.

When the pipes became too short to allow for jointing up without undue straining, a distance piece was made out of a piece of old pipe of similar size and some flanges found amid the old scrap that so often accumulates on board ship. An advantage too, was obtained by raising up the overflow pipe to increase the head of water in the hotwell and also partly closing the master suction valves to the pumps, and opening the vapour cocks from the pump barrels to the condenser.

When the humidity of the engine-room, due to the vapour from the hotwell overflow got too much, and the weather permitted, the air pump overboard discharge valve was opened to allow all the vapour to go overboard. Care had to be taken in doing this because if the vessel were rolling, or the seas splashing up the vessel's sides, salt water would flow back to the hotwell and find its way into the boilers.

The loss of vacuum was due to two reasons. First, to a leaky joint between the two halves of the condenser; and secondly and the principal cause, foul condenser tubes (internally). The tubes were so choked up that many of them had barely $\frac{1}{4}$ in. passage through. The growth in the tubes was of a coral nature and very hard. So hard that it required a drill to remove it, but as the tubes were 16 ft. long it was a hopeless task for the ship's staff to even attempt it. The writer learned, too late to be of any use to him, that an acid, known as "Urity Acid," was largely used in the Eastern Mediterranean and Red Sea trades to remove this coral and calcie deposit. It is reputed, after many years of tests in vessels in these trades, to clean the tubes equal to new, at the same time being perfectly harmless to the tubes or the metal of the condenser.

Tubes, however, which have become thin through pitting and corrosion would of course be doubtful, and some little trouble, such as leaky or split tubes might be looked for after the scale had been dissolved, because the circulating water would be in direct contact with the tubes, and its full pressure felt, as the protection afforded by the scale was removed.

The greatest and most interesting experience of all was a "Broken Thrust Shaft and Broken Thrust Block" which took the writer and his staff eight days to repair at sea. This was inserted in the "Monthly Transactions" of some 10 years ago. (See page 367, Vol. 1914/1915.)

Notes.

The following letter, which sets the case clearly for all, was printed in "The Times," November 3rd:—

Efficiency in Industry.—Higher Production at Lower Costs.—A Mutual Interest.

Sir,—The present position of many of our industries is so serious, and unemployment is so widespread, that any method under our control which could improve the situation should be carefully examined. The impoverishment of many of the nations who were our best customers, and the increased competition from countries with a depreciated currency, are entirely beyond our control. Apart from these two serious factors, the chief cause of our unemployment is the high cost of the goods we produce and the services we render.

The employers, faced with fierce competition from countries with low wage rates, see their profits disappearing or impending ruin. They desire a radical change, and some employers wish to reduce wages. The workers, on the other hand, are naturally opposed to any reduction of wages, as they wish to maintain, and if possible to increase, their standard of living. Apparently these views are irreconcilable, but is not the solution to be found in greater efficiency and higher production?

In the Far East wages and the standard of living, as well as efficiency, are low. In the Far West, America has shown how high wages and great efficiency can produce commodities at prices low enough to compete with countries paying much lower wages. Europe stands midway between these two extremes, and in England the wages are higher in most trades than in any European country. The problem before all our industries is how to increase rapidly our efficiency and to lower costs, so as to extend our trade and lesson unemployment. The problem is one that can only be solved by the hearty co-operation of employers and employed. If all the workers and the great trade unions could only realize that they would gain by increased efficiency, a new movement in industry would be developed which would have great and far-reaching effects.

No one would be so foolish as to affirm that every factory is efficient and well organised. or that every worker is doing his best. Low costs due to high efficiency can only be obtained if both sides co-operate. It is the responsibility of the employers to see that the most modern methods and the best labour-saving machinery are used, and that efficiency in the widest meaning is continually sought for in making, marketing, and transporting the commodities produced. The workers must endeavour to save waste of time and material, to obtain high outputs, and remove restrictions and rules which raise costs unnecessarily and often defeat the very objects for which they were introduced. If anyone visits a score of organisations in any industry, the range from high to low efficiency would show how much can be done to reduce costs by greater efficiency.

The workers think only of their wages in terms of money, when what they really desire is *greater purchasing power* for the money they receive. Higher efficiency would lower the cost of the goods they purchase, and they would thus attain their desire for a better standard of living. The employers would benefit by securing more trade and better profits. The community would gain by lessened unemployment and a general revival of trade. All would benefit and none would lose if employers and employees would realise that the total cost of production is of supreme importance to all concerned, and that wage rates are of less importance than the total cost.

It is not only in the exporting and unsheltered trade that a strenuous campaign for lower costs should be waged. The cost of the product of most industries affects the price of others. Coal and transport, building and engineering, clothing, printing, and many other commodities and services affect the final cost of all trades or the standard of living of the workers. When the workers realise that high costs are as harmful to them as to the capitalist, and must cause unemployment and tend to lower wages, their attitude and outlook will be changed.

This solution of some of our present difficulties is under our control. Employers and workers individually, or collectively as associations, joint industrial councils, or trade unions, should co-operate wholeheartedly to find the best and quickest means of lowering costs, so as to extend our trade. Co-operation of this kind is not a foolish chimera, but a sane and reasonable ideal. It rests with the employers and the workers to decide whether the trend of our industries is to be Westwards towards a higher standard of living, greater efficiency, and lower costs, or Eastwards towards less efficiency and a lower standard of living.

Yours truly,

W. HOWARD HAZELL,

President of the Federation of Master Printers of Great Britain and Ireland.

From "The Times" of November 3rd:—

Training of Engineers.—For the first time in the history of technical education in Derby local firms contributed gifts of plant and appliances for the equipment of the new workshops and engineering laboratory, which were opened by Sir Charles Parsons on Friday.

Sir Charles said that in the training and qualifications considered necessary to enable a young engineer to follow a successful career a great change had taken place during the last half-century. Nowadays, with the advent of motors, everybody knew something of mechanical principles, whereas our grandfathers approached no nearer to engineering than the blacksmith's shop. Engineers of to-day had a far wider range and greater depth of thought at their disposal, with superior text-books and stores of knowledge. The assimilation of this knowledge must be accompanied by technical practice on systematic lines under definite guidance.

Dr. Bemrose, chairman of the Education Committee, stated that Derby was to be linked up with the new Midlands University.

Boiler Explosion Acts, 1882-1890, No. 2712A.—While the SS. *King Cadwallon* was at Montreal with steam on the centre and starboard boilers, and the port boiler empty, being cleaned, preparations were put in hand to shift ship on September 24th, 1924. At 7.30 a.m. the 3rd engineer was ordered to open the centre and starboard boiler stop valves, these valves he had shut on the ship's arrival. The ship was about 5ft. by the stern. The steam pressure was about 140 lbs. in the boilers, the maximum allowed being 180 lbs. The 3rd engineer opened the two stop valves, just off the faces, and closed the drains to about ¼ turn open. He opened one of the valves very slowly one turn, then the other very slowly about five turns, and afterwards opened the former full. The drains were still open. The 3rd engineer left the boiler tops for the engine-room to get a wheel spanner. On returning, he oiled the starboard whistle valve spindle. As he was about to open the valve, the port stop valve chest exploded. The 3rd engineer and the firemen escaped, except one who was unfortunately overcome by the steam and unable to get free to the deck. While the 3rd engineer was engaged opening the boiler stop valves gently, the 2nd engineer eased the engine stop valve and the impulse valve to drain the condensate from the pipes, When the explosion occurred there was evidence that the pressure was rising at the engine-room end, but it was not clear to what extent of the boiler pressure, yet it was manifest that the boiler valves were full open before the engine-room valve was much more than eased. There was a drain valve and pipe 7/16 in. inside diam. on each stop valve, these were open; the vessel being 5 ft. deeper aft, however, the water in the pipes would flow down and accumulate in the pipes. When the steam was opened under these conditions, turbulence would be brought into the water in the pipes and water hammer result. Mr. J. H. Morgan, Board of Trade Surveyor, South Shields, when examining the details stated: "The port steam pipe which was the longest of all, had a partially open drain at the stop valve end, and the stop valve was shut. It is probable the water was distributed in all three pipes, but in no case would it be sufficient to fill the bore, and the steam would pass over the surface. The action of partially opening the engine stop valve would disturb the position of the water by tending to draw it towards that valve, and conditions favourable to water hammer action were thus set up. The nature of the fracture supports this view. The casting, except for a few minute blow holes, was sound and of fairly uniform thickness. It was fractured into several pieces, the principal damage being sustained immediately opposite the opening to the main steam pipe and in way of same."

The report made by Mr. Morgan was commented upon by Mr. Thos. Carlton as follows: "In the absence of a drain cock on or aft of the junction piece at the after ends of the pipes, the provisions made for draining the steam pipes were inadequate, especially when the vessel was down by the stern. As a consequence, although the drain cocks on the stop valves were opened until steam passed, a considerable quantity of water remained in the pipes owing to the trim of the vessel. The presence of cool water in any pipes under steam pressure is always a potential danger, but in the present case there was the additional risk, due to a branch of the main steam pipe line being connected with a boiler not under steam. It has been shown frequently in these reports that under these conditions branch pipes are very liable to water hammer, and great care should be exercised to keep such pipes clear of water when under steam.

Explosions of this kind are of a particularly dangerous character, and unfortunately in this case a fireman was killed."

TITANIC ENGINEERING STAFF MEMORIAL—BENEVOLENT FUND. —£5 has been received with thanks from G. W. Atkins (Member No. 785).

Books Added to the Library.

FOUNDRY WORK. Bennett's College, Ltd., Sheffield. Vol. III.—The latest volume in this well-known series is worthy of its place, and a treatise dealing with this subject will fill a gap in the bookshelves of students and engineers. We have noted that workers in wood usually take some pride in acquiring at an early stage a wide knowledge of timbers, their origin, nature and sphere of usefulness, but in general, young engineers, and some who are no longer young, have but a smattering of knowledge on the subject of metals. This book will provide ample information on one phase of the subject, for the chapters dealing with the foundry processes are splendidly complete. We could have wished that at least one chapter had been included dealing with ores and their reduction, instead of starting with the pig, but a book on Foundry Work is quite legitimately begun at that stage, and the manner in which the chapters are arranged and illustrated, in conjunction with the clear large type, makes the reading of the book a pleasure. The writing is that of an expert, not only on his technique, but at teaching it also, for we did not find it necessary to re-read a single paragraph, the smooth clear diction carries its import to the mind without a conscious effort on the reader's part; this is the teacher's special gift and it is here displayed to admiration. We strongly recommend this book to all engineers for all the above reasons, and especially as a good example of lucid English, which is not always associated with the writing of technical books.

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Election of Members.

List of those elected at Council Meeting of 2nd November, 1925:—

Members.

Hugh Barr, 12, Kelburne Drive, Paisley, N.B.

Archie Liviston Donald, 19A, Upper Addison Gardens, Kensington, W.14.

Arthur Morgan Evans, 81, Needham Road, Edge Lane, Liverpool.

John Dennis Harris, Eng.-Lieut., R.N.R., retd., 73A Oakmead Road, Balham, S.W.12.

Eric Silva Jones, 63, Norbury Avenue, Thornton Heath.

R. H. Martin, 31, Oxford Avenue, South Shields.

William Allardyce Robb, 71, Preston Street, Govanhill, Glasgow.

Alexander Shaw, S.S. *Warlu, c/o* Mackinnon, Mackenzie & Co., Calcutta.

William Henry Taylor, Engineers' Office, Eastern Telegraph Co., Electra House, Moorgate, E.C.2.

George Edward Windeler, 4, Devonshire Road, Davenport Park, Stockport, Cheshire.

Associate-Members.

Sidney Bertram Jackson, H.M.S. *Resolution, c/o* G.P.O., London.

William Wilson, Alexandra Place, Oban.

Associate.

Cyril Walter Clark Turner, H.M.H.S. *Maine, c/o* G.P.O., London.

Student-Graduate.

Arthur B. Brown, 1, Baltic Place, Aberdeen.

Graduates.

Thomas Edmund Pyne, 46, Stapleton Hall Road, Stroud Green, N.4.

Stanley Richard Rose, 23, Vansittart Street, New Cross, S.E.14.

Transferred from Associate-Member to Member.

Arthur Turner, 28, Shrewsbury Terrace, South Shields.

R. T. Yeates, 204, Devonshire Road, Forest Hill, S.E.23.

Transferred from Associate to Member.

W. Hulbert, 21, Gladstone Avenue, East Ham, E.6.

The death of Hugh Rennie, Member of Council, occurred on November 19th, at Southgate, and deep sympathy has been expressed to his daughter and sister, who were present with many old friends at the funeral. He was born at Coatbridge in 1861, and was at school at Calder. He served his apprenticeship with Messrs. Speedwell, Coatbridge, and Messrs. Denny and Co., Dumbarton. He made his first voyage at sea to America in the Anchor Line, and afterwards joined the British India S.N. Co. about 1883. He was second engineer of the *Malda*, and then served on the Indian coast as chief engineer of the *Palamcotta*, *Perulia*, *Purnea*, *Umta*. During the period of his service in India, he was granted leave to take a temporary appointment in Rangoon, while the Engineer of Works there was absent on account of illness. When his time expired in India, he came home, Chief Engineer of the *Jelunga* in 1901, and shortly after his arrival in London he was appointed Supt. Engineer of the Bucknall Line, having thus occupied this position for about 24 years. He joined the Institute as a member in 1903, and was elected a Member of Council in 1919.