INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1908-1909

President : James Denny, Esq.

Institute of Marine Engineers

The eighteenth Annual Dinner was held on Wednesday, October 28 1908, in the King's Hall, Holborn Restaurant. The gathering was a record one in point of attendance, and the list of guests was representative of almost every department of marine engineering and of naval and mercantile shipping.

The President, Jas. Denny, Esq., occupied the chair, and was supported by the Hon. Lord Inverclyde, Sir J. Fortescue Flannery, Admiral Hon. Sir Charles E. Fremantle, Sir Geo. S. Mackenzie, Hon. C. A. Parsons, Sir Jas. L. Mackay, Sir Thos. Sutherland, Sir Walter J. Howell (Marine Department, Board of Trade), Sir Wm. H. White, Sir John Gunn, Sir James Mills (New Zealand), Engineer Vice-Admiral H. J. Oram (Engineer-in-Chief, Royal Navy), Engineer Rear-Admiral R. Mayston, Engineer Commander W. M. K. Wisnom, Professor Elgar, Professor J. H. Biles, Capt. A. J. G. Chalmers (Board of Trade), Captain Dixon, Messrs. James Adamson (Hon. Secretary), Jas. Bain[1] (Cunard Line), Thos. Bell, W. J. Willet Bruce (White Star Line), R. J. Butler (Admiralty), Robert Caird, LL.D., Robert Clark, H. Cosmo-Bonsor (Chairman, S.E. Railway), Jas. Dixon (Chairman, Lloyd's Register of Shipping), D. J. Dunlop, A. Gracie, M.V.O.,[1] John Inglis, LL.D.,[1] J. Foster King (Chief Surveyor to the British Corporation), A. Laing,[1] W. MacLeod MacMillan, J. C. McKechnie,[1] James Knott, J. T. Milton (Engineer-in-Chief, Lloyd's

[1] Prevented by intervening circumstances from being present.

Register), J. M. Ritchie, Andrew Scott (Secretary, Lloyd's Register), A. Simson, Horace J. Spence.

The President, after submitting the loyal toasts, called on Mr. H. Cosmo-Bonsor, who said: Mr. President, my lord, and gentlemen, I consider it a great privilege on this occasion to be allowed to propose the toast "The Shipping Interests," the most important toast of the evening. When I look around this distinguished company I wonder why I have been selected—I cannot help thinking that it is because I have a reputation for seldom speaking more than two minutes, but possibly another reason may be that, although I happen for the moment to be a mere landsman, still, I am the commander of a Channel Fleet, and in that respect it is possible that I might be giving a record which is absolutely new in an assembly like this. There is a certain spot in the Straits of Dover where, when the sea is choppy, the toast of the "Shipping Interests" would not be altogether received with satisfaction, but, my lord and gentlemen, in a gathering of this kind, I can quite understand that the toast needs little encouragement. The very fact that the shipping industry in the past has been prosperous is the reason why we are here at all to-night, and that the shipping industry will continue to be prosperous in the future is the keenest hope of all of us. Since I have been in the room, I have been endeavouring to observe some feeling of alarm, some show of trepidation, at the great competition that we all understand is to take place shortly against the shipping interests—I naturally allude to airships—but at the present moment I can see no signs of any gentleman wishing to change his present profession to go up in a balloon. Let me make a confession. Before coming here this evening, I studied all sorts of statistics which I expected to have given to you in connexion with the subject of this toast, but your hospitality and good-fellowship have absolutely driven every figure out of my head, and I excuse myself with the knowledge that my friend, Sir Fortescue Flannery, who is full of figures, as he is of ability, will be able to supply all that are necessary. And now, gentlemen, all I have to do is to propose this toast, which I am sure you will heartily receive, "The Shipping Interests."

Sir J. Fortescue Flannery: Mr. President, my lord, and gentlemen. Your courtesy, confirmed by the eloquence of my old friend and colleague, Mr. Cosmo-Bonsor, has placed me in a position of great difficulty to-night, because I have to respond as well as I can to the toast of "The Shipping Interests," and many shipowners will tell you at the present time that there are no interests in shipping. They are like a character of the late J. L. Toole, who said that it was against his interests to pay any principal, and against his principle to pay any interest, and in like manner there are many shipowners to-day who pay no interest because the ships are earning nothing. This is a state of affairs that you, sir, and myself, young men though we are, have seen before, and it is probably a state of affairs which I hope we may, after a time of improvement, live long enough to see again. We have seen these continual cycles of prosperity and adversity in the shipping trade, and we have known that when there is depression, as there is to-day, there is one means that the shipowners always look to to raise them out of the slough of despond, and those means are the improvements that are made from time to time by shipbuilders and marine engineers, which have the effect of lowering the cost of transport at sea, and thus making low freights payable freights, notwithstanding the fact that at first no profits could be got out of them. It is to that progress made by men such as belong to this Institute that shipowers will continue to look, and not in vain, for improving their position, and for making freights paying and profitable freights which otherwise they could not possibly be. Now, I observe around this table some gentlemen more or less connected with Government affairs, and there is one aspect of this shipping interest which I feel ought not to be overlooked upon an occasion of this kind, and that is the systematic attempt, nay the systematic practice, of foreign governments of assisting their shipping industry, whilst our own shipping interest does not always receive the assistance from Government which many of us think ought to be given to it. I have had several instances before me of the policy of foreign governments in assisting their mercantile marine. I remember some years ago a distinguished Japanese statesman, who has been the guest of this Institute, Viscount Hayashi, formerly Japanese minister in London, was about to give out an order, or it was rumoured that he was about to give an order, for several vessels. It fell to my lot to interview Viscount Hayashi, and try by all means in my power to get him to decide to build the vessels in this country. I said to him : "Your Excellency, the ships can be built in this country cheaper, they can be built quicker, they can be built, I do not doubt, lighter, and therefore able to carry a little more, and undoubtedly, with so much greater experience, we should be able to build the vessels so that they would cost less to maintain after you begin to run them ; therefore, on account of early delivery and these other advantages, I sincerely hope you will order them to be built in this country." What was his reply ? He said : "I recognize with you that the ships could be built cheaper, quicker, better, and more economically in every way in this country, because we have not attained to the power of shipbuilding which you possess ; but I must tell you frankly that my Government are determined that these ships shall be built in Japan, and for this reason, we want our men to be educated in shipping affairs, we want them to understand as they can only be trained to understand by actual practice, and the Government are going to make such sacrifices as the shipowners in this instance may require in order to ensure that the work may be done in Japan, for the purpose of educating and teaching the people so that they may be able to carry out similar work in the future." That was a definite policy, a policy which, unfortunately, we cannot imitate, and which we do not want to imitate in this country, but which is very much against the interests which you and I, gentlemen, are mostly concerned in, that is, the construction and actual mechanical running of ships. There is another case with Germany and Russia also worth remembering, because it only occurred during the last two or three days. The Russian Volunteer Fleet were about to order five vessels, in fact they actually gave the order to a firm of Greenock shipbuilders, when a German firm of shipbuilders came along, and, by reason of a subsidy, which it is rumoured was specially obtained from the German Government, were able to undercut the Greenock shipbuilder and take away, at a time when additional work is very much wanted, a very valuable contract which was gained in fair competition. I mention these things in connexion with the shipping interests because I want to emphasize this truth. which I believe my friend on the left, who has so much experience on these matters, agrees with, because he suggested it to me, and that is, that we do not as engineers and shipbuilders and shipowners ask for assistance from our Government as these other foreign shipbuilders and shipowners and engineers have obtained, but we do ask very largely to be left alone, we ask to be allowed to work out our own improvements with as free a hand as we can. If we have that, and if the shipbuilders and shipowners work hand in hand and in unison, adopting those improvements which, from time to time, engineers may be relied upon to put forward, we shall have that revival in the shipping interests to which we look forward, and continue with a faith in the shipping interests as our means of livelihood and the occupation in which we take so much pride.

The Hon. Lord INVERCLYDE : I feel it is a particular honour that the toast which I have to submit to you has been entrusted to my hands to-night, and it is a special gratification to me that I should be allowed to propose this toast on the occasion when you have one of the great firm of Messrs. Denny as your president, because long before my time, and I think before your president's time, too, the firm with which I am connected had a great many business transactions with the firm of Messrs. Denny. As far back as 1849, steamers were built at Dumbarton for the Cunard Company by Messrs, Denny. In the year 1870 they built the *Parthia* and the *Batavia* for the Atlantic trade, ships of about 3,000 tons, which were regarded as large vessels in those days, and it is interesting to compare them and their dimensions with those of the *Lusitania* and *Mauretania* of the present day. We shipowners know how much we are indebted to you engineers for supplying us with tools to carry on our trade, because, after all, it is upon you that we depend to a great extent for the economy and efficiency of the engines which you supply our steamers with. These two things, efficiency and economy, are the most important things we have to look to. Our steamers have to be efficient so that they can be relied upon to do the work we call upon them to do, and they have to be run with economy, so that, if at all possible, we may make a profit, which is a very hard thing to do at the present time. At the same time I hope you marine engineers will not go too fast for us, because I think we must blame you engineers, to some extent at all events, that our ships become so quickly obsolete—or rather, not obsolete, but outclassed by these new contrivances and inventions which you are continually bringing forward. Marine engineers certainly now give us great confidence in the engine-room. It is not so long since the time when we would not think of sending a steamer to sea unless she was equipped with sails also, but I think we have now such confidence in the engineers that we do not rely upon sails as a stand-by in any way whatever. In this connexion it is interesting to refer to the advertisement of the *Comet*, which sailed between Glasgow and Greenock in 1812. The advertisement read that "she was to sail by the power of wind, air, and," lastly, "'steam.'" These are anxious times for all of us who are engaged in large commercial concerns. The cost of production is increasing and we look forward to the future with anxiety, because there is a feeling of uncertainty of what may be our future; but, gentlemen, I think there is one thing that we are determined upon, that this country is by no means done yet, and we shall not allow it to lose its position as the greatest "nation of shopkeepers" in existence. There is, however, at the present time a great danger of too much interference—outside interference—with our commercial concerns. The great commercial undertakings of this country were never built up either by Government regulations, enactments or Government settlements or interference in trade disputes. They were built up by the indomitable energy, the foresight and enterprise of the men who have gone before us, and who have laid the foundations of the great works of which this country is so proud. I think, therefore, those who interfere in the trade matters of this country do not always realize how serious that interference may be. To my mind, whatever views at the present time may be put forward to the contrary, in any successful commercial undertaking there must always be masters and servants, and I do not believe that, either from the point of view of the masters or of the servants, any concern will be a success unless it is carried out on those principles. I, myself, am no believer in a business which is conducted on the basis of employer and employed. In referring to these matters I would just mention the court of arbitration which has recently been announced by the President of the Board of Trade. I am sure that the President, in establishing that court, did it with the best desires and intentions in the world, but I think we must realize that there is a great danger in the establishment of such a tribunal, which I think we must recognize is very apt to encourage disputes and to bring those disputes forward when many of them might be settled by the ordinary laws of supply and demand and ought never to be arbitrated upon at all. I am afraid, gentlemen, that I have rather digressed from the subject of my toast in these remarks I have made to you, but my only excuse is that the subjects I have mentioned are of prime importance to you who are engaged in the great engineering trade of this country. It is not for me to speak of what the Institute owes to your Honorary Secretary, but I desire to couple the name of Mr. James Adamson, your Honorary Secretary, with this toast. I give you the toast "The Institute of Marine Engineers," coupled with the name of Mr. James Adamson.

The Honorary Secretary: Mr. President, Lord Inverclyde, and gentlemen. The possessor of what is termed "a good thing" usually endeavours to hold on to it for what it will bring to himself, and, in the nature of things, his aim is to retain the cream within his own holding for his own purpose. Of such is the commercial business of life or the commercial life of business, whichever way we may like to put it. We have heard to-night, as we have heard on many former occasions, that the Institute of Marine Engineers is a good thing for the country, and we know and acknowledge it to be so, but, unlike that which regulates the principles of commercial life, the mainspring of our vital force and energy is not set for the purpose of enriching or aggrandizing the controlling few by means of the labour, or at the expense of the many —which is legitimate, within certain limits, for commerce and trade—but the reverse. We may therefore claim that our aims are distinctly national and altruistic in character, and, being so, we can advocate as worthy of the support of every one connected with the maritime interest, the Institute, under whose auspices we are met to-night, and whose President occupies the place of honour at the celebration of another year's work accomplished since last we met to welcome his predecessor in the chair. Our objects and aims are to encourage the advancement of marine engineering and its exponents, and we seek to enlist in the service all who are in any way interested in that advancement. The wider the area to which our operations are extended, the better for our engineers and the nation; as we take it, the more that technical knowledge and the interchange of experiences are diffused, by so much the more will economy and gain be advanced to the community. It is pleasing to the Council, and I apprehend it is no less pleasing to all who are assembled here, to know that our membership has increased during the last two years especially, and has been increasing in increasing ratio, in addition to which sign of vitality the syllabus of meetings upon which we have entered shows that, on the part of the more energetic portion of our membership, the Institute is flourishing. A year ago at our Annual Banquet, a proposition was shadowed forth by Mr. James Dixon, the Chairman of Lloyd's Register of Shipping—whom we gladly welcome at our board to-night in restored health and strength—which has since taken effect, and we have now the first scholarship of £50 per annum in operation, gained by a Clydeside apprentice, who is now attending the Glasgow University, while the original proposition, by the kind liberality of the Committee of Lloyd's, has been doubled in the result, so that we are looking forward to the settlement of another scholarship of like amount next year. This opportunity is taken of expressing our thanks to the Committee for their handsome liberality and encouragement to diligent young men—engineers—whose circumstances in life do not admit of their otherwise pursuing their studies by attendance at College day classes. The question of having premises in the centre or West of London has been exercising the attention of the Council and is still under consideration, so that I am not in a position to make any official announcement meantime, except to say that, when the time comes and the season is ripe, we look to every one to do his best to establish a building which we may look upon with pride and satisfaction, very much in the spirit which was referred to by our President in his presidential address in connexion with the sentiments of patriotism and the desire to hand down to those who are following as our successors, a legacy which they will not only be proud of, but strain every nerve to maintain and uphold. The exactions of business demand the first consideration of our time and attention, but the minutes devoted from the spare gear of the after time to the business of such Institutions as that we call our own, are well recompensed in the consciousness of a good work done, in the minutes of the proceedings, a volume of which I hold in my hand, and the study of which will well repay every reader who seeks knowledge of matters pertaining to his profession. Our finances have been firmly based on sound principles, and at no time have our liabilities been a cause of anxiety; our annual subscriptions are small, yet our present financial position is good, because we have conducted our affairs on true business maxims, and this we intend to continue to do in the future as in the past. Lord Inverclyde has referred to the fact that in former days, Messrs. Denny built for the Cunard Company, and we hope there is another *Mauretania* of the future which may be built within the limits of the expanding Leven. Reference has been made to efficiency and economy; it is the aim and object of the Institute of Marine Engineers to consider and discuss means for increasing the economy of our steamships among the marine engineers of our nation, that we may be able to back up the efforts of our shipbuilders in building advanced steamers to compete with those of other nations. Lord Inverclyde has, and speakers at our former dinners have, desired engineers to hold back improvements, but as it has been proclaimed to us that shipowners find it hard to make their ships pay, what can the engineer do but design to improve and strive to economize in order that the shipowner may reap that advantage to which he is looking forward? The education of the young engineer is a matter which occupies the attention of the Institute and Council, and I know that the graduates and the young men in connexion with the Institute are anxious to learn, and we regret that more apprentices do not come forward to take advantage of the opportunities placed within their reach on all hands. We know there are many engine works throughout the country where the utmost is done to put before apprentices a system of education and a system which, if taken advantage of, would make excellent men, and I apprehend that on such an occasion as this we ought to encourage one another to help forward such movements, so that our apprentices may see and do the right thing in taking advantage of all the opportunities placed before them. It is said there is nothing new under the sun, yet there is something new every day, and many of these new inventions are not confined to those produced by the technically trained, but it is our privilege to consider and discuss the details. Our President in the closing words of his presidential address, referring to competition, considered that we were quite able as a nation to hold our own. Now, if that is the case from a shipbuilder's and engine builder's point of view, I apprehend that we can play a good second, and that as engineers we will do our utmost—and are doing our utmost—to back up the improvements made from day to day. It is our duty to take advantage of those improvements and make the best possible use of them. I have to thank Lord Inverclyde for the words he has spoken in connexion with the Institute, and I thank you, gentlemen, for the way you have responded to this toast, and in closing, I hope this meeting is but an augury of the future success of the Institute of Marine Engineers, which next year enters upon its majority.

Mr. W. Lawrie (Chairman of Council) : Mr. Chairman, my lord and gentlemen. It is my privilege this evening to propose the toast of " Our Guests," and it will presently be your pleasure to give it a reception befitting its importance and the influential character of the gentlemen gathered at the President's table. Successive years have not adversely affected our Annual Dinner; in fact it is an increasing force, and the list of guests shows no decline in any of its essential features. Our members fully appreciate the support and assistance given to the Institute by the presence of so many gentlemen whose influence is felt wherever steamships are known. The aim of the Institute is, as you are all well aware, the advancement of the marine engineer, so that he may bring the fullest knowledge, and the very best scientific knowledge to bear on his profession, and I think it will be generally admitted that all efforts in that direction must necessarily increase the efficiency of the machinery under his charge, and to that extent assist the shipowner and benefit the mercantile marine of the country generally. Our objects are of more than passing importance, and they deserve the support of every marine engineer in the country, either ashore or afloat, because there never was a time when it was more necessary to be on the alert and to concentrate our energies on the business of our lives. We are reminded of this in many ways. A short time ago I read a newspaper article, in which the writer demonstrated to his own satisfaction that we, as a nation, were degenerating. In that connexion I could not resist the temptation to look back to some of the steamers of my early days of 12 lb. steam pressure, jet condensers and dry-bottomed boilers, saloons aft and a deadweight capacity of about 1,000 tons. Now, if we compare steamers of that class with the liner of to-day, it cannot be said that our shipowners, at any rate, have degenerated, in fact it is quite the reverse, and we fully realize the honour conferred on the Institute by the presence of Lord Inverclyde, Sir Thomas Sutherland, Sir James Mackay, Sir Geo. Mackenzie, Mr. James Knott, Mr. Robert Clark, representing in the very highest degree the shipping interests of the country. Lloyd's Registry of Shipping has assisted the Institute very greatly, not only by the presence of its chairman at our Annual Dinner and his initiation of the Scholarship recently founded, but also in the very practical and able support we derive from many of the members of its technical staff in contributing papers to our transactions, rendering incalculable service where it is most required, and I only express the thanks of the members when I acknowledge our indebtedness towards them. From time to time we have also received the assistance of the Board of Trade ; Sir Walter Howell and Captain Chalmers have helped us most consistently. We regret that illness has prevented Captain Park being with us and we hope he will soon be restored to his usual health. The policy of the Board is different from that of Lloyd's Registry, and the results are not quite so apparent ; however, we welcome all assistance and even moral support is very acceptable. British admirals and naval officers are everywhere welcome guests, and more especially is this so at a gathering of marine engineers. Britishers the world over place reliance on their Navy ; they think, and rightly think, that their officers are unequalled for courage and ability. The traditions of the Navy fully justify that confidence, and we may rest assured that if any of our European or other friends care to test the material they are made of, we will find the Navy give a good account of itself. The presence of leading naval architects and marine engineers from the various shipbuilding centres of the country is very satisfactory, although they forget the respect due to the capital of the Empire by taking the lead in all that concerns speed records in the ships they build. They think nothing of creating records, smashing them and setting up fresh ones in a most remarkable manner. The Tyne and the Clyde seem determined that the Thames shall not have a look in. However, we cannot blame them for their activity and we welcome the gentlemen who uphold the fair fame of their country, in spite of quill-driving degeneration. Our past-presidents have, as usual, given a good account of themselves. We can always rely upon their sympathy and support, and, if I may be allowed to say so, I think our first president ought to take a leading place. Even indifferent health cannot keep him away from our annual re-union, and I have known him in his place against the advice of his physician ; to-night he looks as buoyant as ever, and we hope to have the pleasure of his company and genial presence for many years to come. Finally, we thank every one of the guests who has assisted in making this a record dinner. There are two factors in the success of the dinner which I think, departing for the moment from my subject in proposing this toast, ought to be noted. The first is the popularity of our President, and the second, the organizing skill of the convener of the dinner committee. As a member of that committee, I do not include it in the reckoning, but it is the most remarkable body that ever I have served on. What happens is this. We had a polite note from the convener asking if we would consent to serve on the committee. We replied that we would be pleased to do so, and then—well, that's all, Mr. W. I. Taylor does the rest. Gentlemen, I give you the toast of " Our Guests " and couple with it the names of Admiral Sir C. E. Fremantle and Sir Walter J. Howell.

Admiral Hon. Sir C. E. Fremantle : Mr. Denny, Lord Inverclyde and gentlemen, I do not know why I have been selected for the honour of returning thanks for the guests when there are so many here present, I believe, who are much more competent to do justice to such an important toast. When I was told that I would have this honour I thought I would look in the dictionary and see if I could get something, at all events, which would give me a lead, and the first definition I found of the word " guest " was " a stranger." Now, I objected to that, so I got nothing out of the dictionary, for I cannot consider that the Navy can be a stranger to the Institute of Marine Engineers, and, personally, I may say I have the honour, not only to know several of the marine engineers here present, but I have had the pleasure of accepting their invitation to dinner on a previous occasion. I should not have been very much astonished if the ubiquitous gentleman who has assumed to some extent the position of the ancient mariner had stopped me on my way to this banquet, but if he had done so he would certainly not have asked me anything which is in the ordinary purview of the British taxpayer ; he would not have asked me about the Navy, whether building to the half-power standard was keeping up to the two-power standard, nor any question on which the body politic is competent to judge, that is, whether our material is sufficient and efficient; but probably he would have asked me whether it was true that one naval officer turned his back on another or refused to shake hands, or if naval officers were on the best of terms. I should have answered him that this was mere gossip. I had the pleasure a few nights ago, on the occasion of the anniversary of Trafalgar, to dine at the Navy Club. We had one guest; we are not so generous as you marine engineers, but that one guest was Mr. Rudyard Kipling. He made us a speech—of course, we always make the guest make a speech—and it was very inspiring, but the whole point of his remarks was that, so far as he knew it, and I think you gentlemen will agree that he knows it pretty well, the spirit of the Navy was all right. I am glad to find that that is also the opinion of the First Lord of the Admiralty, who in a recent speech said we might be living on the morrow of Trafalgar so far as the spirit of the Navy is concerned. That being so, I think if the *matériel* is kept up to the *personnel*, if you build us, as you have done, the very best *matériel*, I have no doubt the Navy will continue to do its duty. I thank you very cordially for having asked me here; I thank you for having given us such a magnificent entertainment, and I can only hope that this great Institution, which has done so much for the Navy and the nation, may continue to prosper, and that the numbers which I see here to-night, and which I believe are unprecedented, will only be a record for this year and not a record for future years.

Sir WALTER J. HOWELL: Mr. President, Mr. Lawrie and gentlemen. After the admirable speech to which we have just listened, I feel that there is little left for me to say in response to this toast. I am sure that I and my fellow-guests are always pleased when we are able to be present at the dinner of this distinguished body of engineers, not only because we are in such complete sympathy with its aims and objects, but because most of us, in some way or another, are grateful for its help. Speaking for the great department I have the honour of representing here to-night, I can say how helpful your Council and your able and courteous secretary, Mr.

Adamson, have been to us on many occasions. Gentlemen, I think it is a matter for congratulation that, when the President of the Board of Trade was forming an Advisory Committee under the latest Merchant Shipping Act, he asked this Institute to nominate a representative engineer for appointment upon it. Mr. George Shearer was chosen and he is now a member, and I am sure a very useful member, of that important committee. Well, gentlemen, it is not necessary for me to refer, before such a gathering as this, to the magnificent achievements of the designers and constructors of modern marine engines and boilers. They are admitted and admired by us all. Personally, nothing impresses me more than a visit to the engine-room of one of the big steamships of our mercantile marine, a mercantile marine of which, I believe, we are as proud as we are of that splendid Royal Navy which exists primarily for its protection. But, gentlemen, with regard to our engineers and their subordinates at sea, will you allow me to say one word ? I have perhaps unique grounds for knowing, and I say without hesitation that there is *no* body of men more distinguished for their quiet and unostentatious devotion to duty and bravery often under peculiarly trying circumstances. Their gallantry seems to me, indeed, to come to them as part of their ordinary duty, and to be so regarded by them. Only the other day two steamers collided in the North Sea, and this is what happened, and, gentlemen, I am not giving a newspaper report, this information is on sworn testimony —

> " When their vessel was rammed most of the crew were asleep in their berths, but in response to a summons from the captain all came on deck, with the exception of the engineer and three firemen, who determined to remain below in the hope of keeping up steam. These men displayed much bravery, for despite the fact that the ship was sinking, they refused to leave their posts. For some time they worked with the water gradually rising in the engine-room and stokehold, and they only came up after the sea had extinguished the fires."

Now, gentlemen, that appeals to me as bravery of a very fine kind, and I am sure you will agree with me that all honour is due to the men who did their duty in that way. And that is no isolated instance. I am constantly hearing of such conduct, and I only give this as an instance, not in any way as an extraordinary event. Gentlemen, at this late period of the evening I will not trespass longer on your patience. I will only add, on behalf of my fellow-guests as well as for myself, how much we thank you for your hospitality this evening. You have given us an excellent dinner, charming music and interesting speeches. We thank Mr. Lawrie for all the kind things he has said about us, we greatly appreciate the cordial manner in which the toast of our health has been received, and we wish the Institute of Marine Engineers all the success and prosperity that it so richly deserves.

Sir WILLIAM H. WHITE : Lord Inverclyde and gentlemen, it is my privilege to propose to you the health of "The President," Mr. James Denny. There is no need to say much in commendation of this toast. Mr. Denny comes of a good stock ; he is a good fellow. The name of Denny will always be honoured in this Institution. He is the third president of that name. Many of us remember when this Institution took its new departure after its first two years of existence, and it was Mr. Peter Denny who helped greatly to forward its progress. Some of us listened to that wonderful speech which he made at what, I think, was the first public dinner of the Institute, when he gave us his reminiscences of shipbuilding and engineering experiences. Later he assisted the Institute in founding the Denny Gold Medal. He was followed some years later by Colonel Denny, and now we have his nephew here, a worthy successor, a man in every respect admirably qualified for the post. It has been my privilege to know Mr. Denny for thirty years. The more I have known him, the better I have liked him and the more completely I have trusted him. You all know that in saying that I say the simple truth. His professional record as a member of that great firm is one of which any man might be proud. Now in the fourth generation of the Denny family, we find that firm, which has always been distinguished, which, Lord Inverclyde told us, fifty-nine years ago was building ships for the Atlantic service of the Cunard Company, still in the van of progress. In the early application of steel for steamers, the Dennys were there ; in the application of turbines to the mercantile marine—that wonderful invention due to the genius of Mr. Charles Parsons, whom we have with us to-night—the Dennys again came to the front.

In having Mr. James Denny in the chair, the members of this Institute have the greatest hope for the future, they trust its interests to his hands with confidence, they look forward to a year marking many advances made under his direction, they look forward to his presidential year with great expectation. Gentlemen, the health of Mr. James Denny.

The PRESIDENT : Lord Inverclyde and gentlemen, I have to thank you all exceedingly for the manner in which you have received the flattering remarks that have been made by Sir William White, and I have especially to thank him for the kind things he has said. One can only wish, on such occasions as this, which come more or less to most of us, that one really deserved the complimentary things that are said of us. We all have proud moments in our lives, and there has no doubt been for all of us one particular moment which we can call the proudest moment of our lives. That moment has come to me this evening—and now. I do not think there can be a purer or cleaner gratification for any one than the well-founded belief that we stand well in the estimation of our neighbours and of our friends. Such remarks as have been made, coming as they did from a gentleman of Sir William White's standing and with his great reputation, are especially gratifying and encouraging, but one may be permitted to suggest that Sir William had in view more what a president of your Institute should be than what the president of your Institute actually is. With reference to this Institute, we have had from Mr. Adamson in an eloquent speech an account of the needs it has supplied, the good work it has done, and the excellent position in which it stands financially and numerically ; and the best proofs of the success and importance of your Institute are shown by the large company gathered here this evening, and especially by this platform, which is occupied by many gentlemen who have come here specially to do honour to your Institute. It is always invidious to specially mention any one, but I would call your attention to the fact that you have here gentlemen who are at the head of the largest and most enterprising firms of shipowners in this country and in our colonies. You have also official representatives of that great official body which deals with the trade of our country. The registration societies, Lloyd's and the British Corporation, are also represented, and on the scholastic side we have a past occupant of the chair of naval architecture, and the gentleman also who at present holds that very honourable position. While if we turn to the direct representatives of marine engineering we have Mr. Parsons, whose achievements in marine engineering during the last few years hardly require mention. It is a matter of regret that there are a few absentees who had fully arranged to be present. To-day I unexpectedly met Mr. Andrew Laing, who had come all the way from Newcastle specially to be at this meeting, but, on very urgent grounds, he had been called to Liverpool and was thus unable to be present to-night. Mr. Gracie, head of the Fairfield Company, is ill and could not attend. If these gentlemen had been present we should have had a trio of very distinguished engineers, Mr. Andrew Laing, Mr. Gracie and Mr. Thomas Bell, gentlemen connected with the greatest works in marine engineering of recent or, indeed, of any years, they having been responsible for the engineering side of the *Mauretania* and *Lusitania*, and of H.M.S. *Inflexible* and *Indomitable*. I should also include Mr. Bain, whom I now miss from his allotted place. Over and above all this, we have on our platform one whose official position, apart altogether from those personal qualities which all who know him admire, makes him specially welcome, Admiral Oram. Admiral Oram is responsible for the engineering side of His Majesty's Fleet, and that being said, it is not stretching facts to add that he is at the head of the marine engineering profession all over the world. We are very much indebted to these gentlemen for joining us, and from the way in which the toast of "Our Guests" was received it was evident that we, as members of the Institute of Marine Engineers, very much appreciate their presence here this evening. It is an especial compliment coming at a time like this, for those who are actually engaged in our business have, owing to dull trade, to strain every nerve to carry on their undertakings successfully; under these circumstances time is an asset of considerable value, and time has been sacrificed to be with us this evening. For trade, as you all know, is bad, and its very badness has evoked certain suggestions in the hope of bettering it. One—that of co-operation; but as far as one can understand this scheme it means isolation from the rest of trade, both employers and employed, as far as concerns those who are engaged in this scheme. There is another proposal that seems to be in the air —a combination of various interests. Well, we should welcome both these experiments, and not least the latter if it is to be devoted to legitimate aims, if its object is to be more efficient management and reduction of the cost of production, but if it is to be used to maintain, or try to maintain, artificial prices, then it is to be feared that if it has any success at all, that can only be of a temporary character, because all artificial props for our trade must in the long run be for its disadvantage, and might only be another spoke in the wheel of the present much abused capitalist. We all know that the capitalist is regarded with disapproval of a more or less active nature by a not inconsiderable portion of the community; but, after all, is it not possible that there may still be so many righteous men found in all Israel that there may be among the capitalists some to whom the making of money and the squeezing of the last farthing out of their employés are not the first objects, that there may be capitalists engaged in the industry of the country who are endeavouring to use such talents as Providence has given them to the fostering of our trade, so finding employment for large bodies of our people, and thus serving the community to the best of their, perhaps mistaken, lights? Our present system may not be an ideal one, but it has served, and under it our country has prospered, and has become the freest and greatest trading community in the world. With regard to this trade of ours, we have the very highest authority for believing that the mystery of the winds had not been solved in ancient days; we are told that they blew where they listed, and no one knew whence they came or whither they went; but now we have changed all that; we do know, more or less, where the winds are coming from, and if to a dangerous extent we hoist storm signals, warning mariners and miners beforehand, so that when dangerous conditions do arise they may have been able to take some precautions. Now, is it not possible that the problem of trade storms or cyclones might be solved? Is it to be supposed that their mystery is so great as to be quite beyond the wit of man? Is there to be no hope that by a more careful investigation than has ever yet been given to this question, we may be able to trace the reasons why trade is good at some times and bad at others? Many reasons are given; some suggest that a good going war would stir up affairs; otherwise that a good harvest will bring good trade; others make the almost impious suggestion that a change of Government would bring about the desired effect, but it should be added that this latter suggestion comes mostly from those who are of the opposition way of thinking. Those in power at present recognize that trade is bad, and are giving out what, when the matter is fairly faced, are really nothing more than charitable doles; they are endeavouring also to create artificial employment, neither of which in the long run can be of permanent advantage to the community. Would it not be better that some of this money should be devoted to investigations that would get at the very root of the matter, so that when bad trade does come we may, in a measure, be warned and prepared for it. The suggestion does not seem at all an impossible one, at least it is very necessary that something more should be attempted than merely tiding over the evil time. We have led the trade of the world in most matters, and it would be to the further honour and glory of this country if we could solve this problem of unemployment. I fear I have taken up too much of your time; I thank you very, very cordially. I have already thanked the Institute for the honour done me in electing me as president, and I thank you all very heartily for the welcome you have given me and the manner in which you have received Sir William White's toast.

SESSION 1908-1909

President: JAMES DENNY, ESQ.

Adjourned Discussion on the Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulation.

BY MR. WM. P. DURTNALL (MEMBER),

November 2, 1908.

AT THE LONDON INSTITUTION, FINSBURY CIRCUS, E.C.

CHAIRMAN: MR. WM. McLAREN (MEMBER).

CHAIRMAN: I am sorry there are so few members here to-night to resume the discussion on Mr. Durtnall's paper. This will give some of you an idea of the attendance we may expect if we carry out the suggestion to centralize in the City. I regret that I cannot get to the Institute as often as I would like, as I am living further away from it than I used to; but is it reasonable for us to expend money on city premises only to see this meagre attendance? It is not fair to the other members and to the Institute as a whole. I am afraid I must come under the category as an absent member for some months back, and my excuse is that I am so far away from the Institute, yet I would not be so far away if the Institute were in a central part of the City. We ought to weigh and consider the matter carefully, whether it is advisable for us to expend money and not get any results from it. I will now call upon Mr. Durtnall to open the meeting with a few remarks.

MR. DURTNALL: I should like to mention that the whole thing in connexion with this power transmission, as our President remarked in his address, is to form a suitable gear between turbine and propellers. Of course it could be done mechanically, or by hydraulic power, or by compressed air, but I prefer to do it electrically, a conclusion I have come to after deep and extended study of the subject. I had considerable trouble in getting particulars of the existing vessels, both in turbine ships and in those fitted with reciprocating engines, until I received a copy of the paper read by Mr. Bell at the Institution of Naval Architects, in which was published the results of the steam trials of the *Lusitania*, which, of course, gave the particulars I desired to get. In my paper I gave the steam consumption for 3,250 K.W. output at 16 lb. of steam per K.W., including auxiliaries. They were figures obtained from one of the London central stations, with a well-known make of turbine. Since reading the paper, I have visited Germany, Switzerland and France, and I have there witnessed tests with the Curtis type of turbine which were very interesting to me. In one instance, with a 3,000 K.W. generating equipment, including the auxiliaries, feed-water, boilers, circulating pipes and air-pumps, the steam used was 13·7 lb. instead of 16 lb. as I stated. It shows that with different turbines different results can be obtained ; certain classes are more efficient than others. It does not affect the generator, they are about the same in each case, so, as it is a rather better result, I could have claimed more than 41 per cent. as mentioned in the paper. There is a reduction right throughout, if the steam consumption is reduced, and also the capacity of the boilers, there is a lighter draught, consequently ; and for the same power delivered to the propellers, of course at the same speed, with a slightly different pitch, you get a higher vessel speed. I think that is all I would like to add to my previous remarks at the present time. I feel sure the discussion will bring out some very interesting points, which I sincerely hope, as that was my object in reading this paper.

Mr. W. E. Farenden (Associate) : I cannot see how the system advocated by Mr. Durtnall in his paper can save coal. It appears to me that the more parts there are in connexion with a ship's machinery the lower the efficiency. With an ordinary ship the propelling plant may be considered as being made up of three parts, namely the boilers, the engines, and the propellers. In this system proposed by Mr. Durtnall there are five parts, namely the boilers, the turbines, the generators, the motors, and the propellers. I fail to see how the introduction of these additional parts can result in a saving of coal. The saving in coal is the principal point, and when Mr. Durtnall can prove to shipowners from actual results that this system does reduce the coal consumption, and is as reliable as the reciprocating engine, I think they would then have no hesitation in adopting it.

Meanwhile I would like to have something more definite on this point, for I fail to see how a saving could take place, also from the point of view of weight and space occupied by this method of propulsion.

Mr. F. M. Timpson (Member): With regard to the point raised by Mr. Farenden in connexion with the loss of power from the boiler to the direct driving of the propeller, I do not know that there should be so much difference between marine and land work. We generally find similar conditions and the same number of parts to go through, although the general installation is, perhaps, not so big. One can see throughout the country a general movement towards the use of motors, even small sizes for individual work. Perhaps the economy is gained by the motors being more spread over in the workshop, still, the system, I should imagine, is somewhat similar. It gives economies in factories and it may give economies in marine practice, but of course very large units are required. In that respect small installations may not show to advantage and there is great difficulty in getting the shipowner to adopt very large installations at the beginning. It is a question that requires some enterprising individual to take up. Electric launches have been in use for some time, driven more or less with accumulators, but I do not know of any propelled by a dynamo driving a motor; perhaps Mr. Durtnall could give us information on that point. Of course where we have large electric stations distributing power all over, economy is obtained and the cost per unit brought down. One point I should like to ask Mr. Durtnall about. Some time ago I read an article in relation to transmitting power from a land station, the ship gathering up power on the Marconi principle. Is that within the range of possibility?

Mr. Durtnall: Yes, the power could be obtained but in very minute quantities. The possibility of it being applied is a very long way off.

Mr. J. H. Redman (Assoc. Member) : It would be very interesting if Mr. Durtnall could give us some idea of the size of motor that would be required to drive a ship at present fitted with reciprocating engines of 3,000 H.P. with a 15-ft. propeller. I should also like to ask whether he considers a great deal of the diameter is lost owing to the depth of the draught, and whether a motor could be got of reasonable size and with a moderate speed of shaft revolution, say about 60 to 70 revolutions per minute.

Mr. F. Broadbent (Visitor) : I came here to-night to hear the views of marine engineers on this subject, rather than to give my own opinions. When I first heard the idea mooted of transmitting power electrically from the marine engine to the propeller, I thought, as some of you no doubt thought, that it was the hare-brained scheme of some mad inventor ; but having looked further into the subject I think there is a great deal in what Mr. Durtnall has said. The tendency for the high speeds in marine propulsion is towards the more general adoption of the steam turbine in place of the reciprocating engine, as many times more power can be obtained in a given space with the turbine than with the reciprocating set. There is a good object lesson on this in the Manchester Corporation Electric Generating Station, which I had an opportunity of visiting recently. There, a marine engine coupled to an alternator of 3,000 to 4,000 H.P. takes up the whole width of the engine-room. A turbine set of 6,000 K.W., that is to say about 9,000 H.P., takes up a small corner of the room, and about six sets of that description could be put in the space occupied by one of the reciprocating sets. Besides the great saving in space the economy in steam consumption is another great advantage. The turbine has shown itself to be a most efficient power generator, when given a high vacuum, which it is possible to get on steamships, and when run at a suitable speed. But if the speed of the turbine is reduced, we lose in efficiency, because the steam turbine is essentially a very high-speed prime mover ; the higher the speed, the more efficient the turbine. But that does not suit the propeller at all ; there are certain practical limitations to the size of the propeller, and too high a speed introduces the difficulties with which, as marine engineers, you are familiar. For this reason the steam turbine has had to be brought down in speed to suit the economical speed of the propeller. That is to say, instead of running the turbine at 1,000 r.p.m., it is run at, say, 250, which, for a turbine, is not economical, although even at that speed it may be more economical than the marine reciprocating sets. Another disadvantage of the turbine is that it is not economical on variable speeds. In other words, if it is designed for a given speed and it has to run at half speed, as steamships have to do occasionally, it is being run uneconomically, as Mr. Durtnall pointed out in his paper. He gave the figures for the *Lusitania* at 14·46 lb. per shaft-horse-power per hour when the vessel was going at 25·4 knots, and 26·53 lb. when the vessel was going at 15·77 knots ; which means that for a reduction of 38 per cent. in the vessel's speed the consumption per shaft-horse-power rose about 84 per cent. Now if the turbine could have been run at full speed all the time, and the propeller only reduced in speed corresponding with the low vessel speed, the efficiency would have been kept up ; and it is just here that the electric drive comes in. You can run the turbine the whole time at its highest efficiency, at any speed you like, regardless of the propeller speed ; and you can have the propeller running at 250 while the turbine is running at 1,000, if that is its most efficient speed. In the paper the steam consumption of a 7,500 K.W. set (say 10,000 H.P.) is given as 13·5 to 14 lb. per kilo-watt hour, or about 10 lb. per electrical horse-power hour. By transmitting this through a motor with 95 per cent. efficiency you would get a consumption of 11 lb. of steam per shaft-horse-power hour on the propeller shaft, which is 25 per cent. lower than the results on the *Lusitania* with turbines of twice the size. I have not gone closely into all the author's figures, but there is little doubt that a saving of 25 per cent. in coal consumption could be effected on sets of half the size of the *Lusitania* sets by electrical transmission. Accepting the principle of the electric drive, the question as to the nature of the electrical equipment comes in, viz., whether it should be continuous current or alternating. That is a question which has been discussed at length in some of the electrical papers. It has been assumed that the series-wound continuous-current motor would be the right thing to use for a propeller because it is good for tramways. But that is not at all the case. The torque-speed curve of a series-wound continuous-current motor shows that this motor is particularly suitable for vehicles on the road; that is to say, the maximum torque occurs when the vehicle is starting and falls off as the speed goes up. But this is not the condition on board ship; there is very little starting torque required, but the torque increases with the speed. These conditions suit exactly the torque-speed curve of the polyphase motor. There is very little torque at starting, but as the speed runs up the torque increases. The polyphase induction motor, therefore, lends itself very well to marine propulsion. I do not think I should inflict upon you any more electro-technical points, but will in closing say that after studying Mr. Durtnall's paper, and after having looked at it from the point of view of the slow-speed propeller running with the high-speed turbine so as to get the best results from both, I am of opinion that the adoption of this system will effect very large economies in coal, space and weight.

Mr. H. H. B. Deane (Visitor): As an electrical engineer I came here hoping to have this question thrashed out from a marine engineer's point of view more particularly. I rather hoped to have heard some data given as to the efficiency of the propeller at various speeds, and as to whether propeller speeds could be obtained sufficiently high consistent with efficiency—which, as far as I can see, is not able to be obtained at the present time—to get the full value out of the steam turbine. I notice the steam power seems to have increased enormously when the steam turbine is used against the reciprocating engine, but it seems there is very little difference between the speeds attained by the *Deutschland* and the *Lusitania*, although there is a vast difference in the steam power. I have not had the opportunity of discussing the matter from the point of view of gross weights or masses moved, but it strikes me that it would be a most interesting comparison and a very suitable standpoint from which to tackle the problem, and I think the electrical engineer has a great opportunity to come in and help to solve some of the difficulties from the propeller end. One of the gentlemen who opened the discussion stated that he did not see how this system could come in when the reciprocating engine was in use. Well, that is quite right when the steam engine only is considered, but I do not think we are limited to the steam engine. The internal combustion engine seems to be advancing with rapid strides; we hear a good deal of it in moderately sized vessels, and I believe there is some matter now being published with regard to a vessel on the Clyde. She seems to have done a very good performance, but as I only heard the figures I should not care to repeat them. I got the impression that it was something like 300 miles for about 14*s.*; personally, although I am an enthusiast as to the possibilities of an advancing profession, that is rather more than I would hope for at present. Still, I think the internal combustion engine will, undoubtedly, come into the field as a very serious competitor to steam. One thing that occurred to me in talking the matter over with a gentleman in the north is that there is a vast amount of inertia to be got over among mechanical or marine engineers; they are not particularly keen to discuss the question of making improvements. Certainly the steam turbine, for instance, emanated from an electrical engineer, and he has had great difficulty in bringing it up to the point it has been brought up to, and I think it has been done at great sacrifice to himself and to his friends. One must say that one would like to see that work of his brought up to the maximum point of utility by still further showing that it can do more for marine propulsion than it is doing at present, and I think the only way we can do so is by working it in conjunction with the electric drive. I must say the system Mr. Durtnall has adopted is, from an electrical engineer's point of view, certainly an ideal one, as Mr. Broadbent pointed out. The conditions appear to me to absolutely suit the polyphase, and especially the short-circuited rotor motor, of which I see Mr. Durtnall has brought a specimen, and I think it should go a long way towards relieving the minds of mechanical and marine engineers of a dislike they have very naturally got to a continuous-current armature for the processes of reversing and reducing the speed. As far as I understand the system, Mr. Durtnall also proposes to change his speeds, and also the direction of rotation when there would be no current in the system. That is certainly, I think, a very important feature in it, because I should not care to have to reverse a 12,000 H.P. ordinary machine with current on, but there could be no objection under no-current conditions. Of course it can be done; we hear of rolling mills where they can reverse using 5,000 H.P. There is one case in Germany where the whole mill can be brought from full speed in a forward direction to rest and started in the reverse direction within eight seconds. That is, practically, from the marine engineer's point of view, from full speed ahead to full speed astern. I do not say that could be done under marine conditions, because there is too much momentum through the mass of the ship for her to be pulled up in that time, but it simply shows what a splendid braking action there is with a polyphase machine. That particular case of the rolling mill is also under continuous-current conditions. One of the gentlemen who discussed this subject on the Clyde deprecated the proposal to use continuous-current machines. I might answer that it may be seen at work in the rolling mills under as bad and even more severe conditions, as reversing does not take place every half-minute under marine conditions as it does in the rolling mills. The next point brought up was the question as to what would be the action when you started braking. Well, of course, you have to brake the mill motor in the same way to bring that speed down. But every one seems to have looked at it from the view of the continuous-current machine, and I certainly do not think the continuous-current machine can compare with the polyphase machine from the electrical and from the mechanical engineering aspects, because more attention is required with the continuous-current than with the polyphase. There is very little attention required with the latter, and I think the example on the table shows that almost the only thing that needs attention is the lubrication of the bearing. That should be an easy matter, at any rate to marine engineers.

CHAIRMAN : We are very pleased to hear the views of our electrical friends. Mr. Deane has said we are rather shy in taking up matters of this kind. Well, I think we are entitled to be shy. We have repeatedly asked for information on the principle of the turbine and the saving it was able to effect, but it has been a long time in forthcoming, and, considering the cases of the two new racers referred to, the *Deutschland* and the *Lusitania*, I do not think we have had a good enough experience to justify us in rushing headlong into adopting new systems of this nature. If a superintendent engineer of steamers outside the fast liners were to propose such a thing now to a shipowner, it would be a bold proposal, and I do not envy him the task of bringing it forward; but I think we are quite prepared to work along with the electrical engineer to solve the difficulty that Mr. Deane has alluded to, the variation of the speed between the turbine and the propeller, and the best method of bringing the turbine up to its highest efficiency. I hope other gentlemen will express their views before I call upon Mr. Durtnall to reply.

Mr. A. Robertson (Member): Not being well up in electrical matters I naturally hesitated before taking part in the discussion on the subject before us this evening. Of course I have had the usual sea experience with dynamos, but that is very little, and that fact, which applies to most, places us marine engineers, at a disadvantage in discussing this question in its fullest aspect. We ought really to study electrical science before giving our views on the whole thing as it stands. But there are one or two remarks I should like to make concerning the turbine and Mr. Durtnall's system of electrical transmission as compared with the reciprocating engine. I take it that Mr. Durtnall wants to come near to the conditions that exist on land, that is, he wants to place the efficient turbine he has ashore aboard a steamer, and thereby get the most efficient results which could be utilized for the propeller; but with the results we already have of turbines ashore, I do not think they appear in such a very favourable light in comparison with the reciprocating engine as to induce a shipowner to adopt this particular system. I do not think you can show an efficiency of 25 per cent. in a first-class land installation over a very efficient marine job. Mr. Durtnall puts down the loss of power in transmission between the turbine and the shaft as 10 per cent. I have been asking one or two electrical engineers their opinion as to what, in actual practice, is the loss in transmission, and they say it is nearer 15 per cent.

Mr. Durtnall: What amount of power?

Mr. Robertson: Small powers, probably from 1,000 to 1,500 kilo-watts.

Mr. Durtnall: Yes, that may be, but I am not referring to such small powers.

Mr. Robertson: Another point is the question of capital outlay. In summing up the saving in running a vessel we have to consider the capital outlay, and I should like to ask whether Mr. Durtnall could give us any figures as to the probable cost of installing this system on board a ship, comparing it with a high-class cargo steamer fitted with reciprocating engines. As to the question of saving in space, I hardly see how that applies, because there is the turbine to consider, then the dynamo, and, in addition to that, the motors driving two, three or four propellers as the case may be, and, I take it, these would all need to be on the bottom platform, and whatever space there was above could not be utilized for putting the machinery into a smaller area. Then there is the question of its reliability. Shall we be able to rely upon motors at sea in rough weather to the same extent as we rely upon the reciprocating engine. With the reciprocating engine we know that it will go as long as you can get the steam if everything is in order, and if a breakdown does occur the marine engineer can generally effect a repair in a very short space of time.

Mr. R. H. Willis (Visitor): Those gentlemen who have spoken up to the present have, perhaps, not looked sufficiently ahead. Their remarks seem to have been based upon existing conditions without sufficient consideration of developments, actually now in progress. Until very recently we have been accustomed to consider all screw vessels as fitted with the same general type of machinery with differences of degree only. Larger or shorter stroke, lower or high rate of revolution, but the elements of the machine the same for all ships. And the machinery being elastic (in the marine engineer's sense), it would work with high or low rate of revolution at will.

Nowadays this is changed. We find at sea at the present moment three classes of propelling machinery: steam turbines ranging between, say, 5,000 and 70,000 H.P. collection for fast vessels and very large ships; piston engines of the old type still in use in cargo boats, say 3,000 to 5,000 H.P., as well as in larger and smaller craft of all sorts; and internal-combustion engines in vessels of up to, at present, say 500 to 700 H.P. as a maximum. This last a rapidly expanding class and one in which the motive power is even more inelastic than the steam turbine. Besides these we have a class hardly yet got to sea; vessels in which the piston engine for high pressure is combined with the turbine for low pressure. This class, with modifications, may encroach eventually upon the ground covered by all three of the earlier classes.

So that in discussing proposals for electric transmission between prime-mover and propeller-shaft we cannot very well generalize for marine propulsion as a whole. We shall have to take into account the class of vessel for which we are specifying. The prime-mover also will have to be considered. Mr. Durtnall assumes that the steam turbine alone is in question.

One would like to hear that he had considered the combination arrangement for his prime-mover, piston engines combined with turbines. Would Mr. Durtnall confine the electric transmission to the turbine portion of the prime-mover, leaving the piston engine to be direct-coupled to its propeller-shaft, or would he propose to fit an all-electric drive to his propellers and run his power station with mixed generating sets, part driven by turbines and part by piston engines. The piston engines running perhaps on highly superheated steam for maximum economy. Vessels fitted with combustion engines should lend themselves to Mr. Durtnall's transmission method, but there again it is a piston engine that he would have to deal with as his prime-mover. Turbine is not the only word.

Mr. E. Austin (Visitor): With regard to the speed regulation, I do not know whether it is necessary to have fine-speed regulation in marine work, but if so, it cannot be obtained with the ordinary squirrel-cage induction motor which Mr. Durtnall proposes to use. There are three methods of varying the speed of an ordinary squirrel-cage induction motor, by reducing the voltage at the terminals, by changing the number of poles on the stator, and by altering the periodicity. The first method is practically useless for marine work, and, in fact, for most other classes of work, and can therefore be neglected. The method of changing the poles is fairly satisfactory provided a fine-speed variation is not required ; the speed can only be varied in big jumps by this method. With regard to changing the periodicity, this can, of course, be done by changing the speed of the generators, but this is exactly what Mr. Durtnall's system is intended to avoid. As Mr. Durtnall is probably aware, Mr. Mavor, of the Institution of Engineers and Shipbuilders in Scotland, has been working on this question of speed regulation. In the case of one patent recently granted to him he proposes to use a number of motors with a different number of poles, also to have a number of generators to get different frequencies. It seems to me that this would be adding to the cost considerably. On the whole the slip-ring induction motor lends itself more readily to fine-speed variation than the squirrel-cage motor, but there is the great loss due to the resistance in the rotor circuit to be taken into account when such motors are running at low speeds. I would like to ask Mr. Durtnall how he proposes to obtain a fine-speed variation with squirrel-cage motors ?

Mr. F. M. Timpson (Member): The turbine was adopted for high-speed steamers ; does Mr. Durtnall think the electric drive will lend itself to more general adoption for marine purposes ? Take the case of the voyage of a tramp steamer to the West India Islands ; when they don't want to take in coal they generally run at slow speeds between the islands ; would there be the same elasticity with the electrically driven job ? Could the main power be from one, two or three turbines as required to drive the motor at lower speeds ? That is the difficulty with the turbine engine, there must be maximum speed to get maximum efficiency, and if the speed is reduced economy in fuel does not follow as in the reciprocating engine. You can drive the reciprocating engine down to a lower minimum and get better efficiency than in the turbine at present. The turbine is limited, as far as I see, to high-speed steamers from practical results to date.

Mr. E. P. Hollis (Visitor) : Speaking on the subject of turbine efficiency, I have been connected with power stations where the turbine first came into use, and have seen the latest designs put down and know the results which can be obtained from them. With a good marine turbine you can get down quite easily to 13 lb. of metas per kilo-watt on full load, including auxiliaries, under test conditions with an output of 6,000 kilo-watts. Turbine engineering in its early days was hampered considerably by reason of difficulties due to the fine-blade clearances, but nowadays these fine clearances are being eliminated without loss of efficiency, and it will be possible shortly to get down to 12 lb. of steam per kilo-watt. Of course at sea there is always a good load factor and there you have the ideal condition for a turbine. In a medium-sized power station the steam turbine works under 30 to 40 per cent. load factor, although in a very large power station it may be as high as 80 per cent. but one cannot compare these results with a ship at sea where it is practically working at full speed all day. With regard to electric driving, I have had some experience with induction motors in shipyards, and I have seen them working day after day for years, and they have required practically no attention whatever No doubt as far as reliability is concerned the induction motor is the very best. If the author is satisfied that his system will give him the required speeds and that the speed regulation is fine enough, he cannot do better than retain the induction motor.

Mr. TIMPSON : Could Mr. Durtnall say what would be the result in case of the propeller racing, would it be better governed than under the ordinary conditions ? The last speaker remarked upon the load being constant in marine conditions, but of course it depends upon the load of the ship. Would the governing be better in a heavy sea ?

Mr. DURTNALL : It would be very much better and easier, for the simple reason that the inertia necessary to operate the steam-valve governor by increased speed in my methods comes into operation immediately before the propeller leaves the water ; the power gets less, the current gets less, and steam is gradually cut off by electro-magnetic means before the propeller leaves the water.

CHAIRMAN : It is very kind of our electrical friends to give us their views, and it is a pity we have not given them much to take away, as they have given us something to think about. A question was raised as to the variation of speeds and loads. I would like to see how the generator and the motor is going to act in a ship coming up Channel during the month upon which we have just entered. Mr. Redman mentioned an average number of revolutions, 60 to 70 per minute, but perhaps it would be better to state about what would be the average for the different speeds. Taking full speed at 60 it is general to drop to 40 for half speed, and quarter speed would be perhaps 20 revolutions, and dead slow would mean a drop to about 10 or 8. Perhaps the electrical engineer may be able to say whether the electric motor would be prepared to go at those speeds, or whether some auxiliary prime-mover would be required to give variations down to such low speeds. With regard to the reciprocating engine, it has given, and is giving, good service, but there is no doubt that a great deal of friction in that engine has been taken away by substituting the turbine rotary motion, and I have not the least doubt that, taking space for space, Mr. Broadbent is quite correct in describing the saving that might be effected in that respect. It would bring us low down in the ship, and I should think it would be possible for the generators to be worked at one part of the ship and the motors could be worked aft on the tandem system for one, two, or three sets of propellers or lines of shafting. But, as I remarked, we must hesitate and consider carefully before we rush into a change. No doubt electrical transmission is economical, or at least it has proved itself so for line shafting. No doubt the line shafting in a ship from the prime-mover could be reduced for the propeller. Mr. Robertson raised the question of utilizing the space above the generators. With efficient ventilation I do not see why this could not be done, and the motors aft of the generator could be so placed that there would be no question of disturbing the construction of the ship, either to replace them at any time or for the purpose of overhauling. But there is another danger. A few days ago we had a series burnt out in the works. I did not hear the full details of the mishap, but a large crowd gathered and volumes of smoke poured out, and I think if that had happened on a passenger ship the boats would have been ready for going over the side. We may have a burst steam-pipe, but there is a burst and it is all over. We may have a breakdown, but the reciprocating engine has brought out the marine engineer to be the best that Britain can produce in effecting a repair. No doubt that could be done with electrical machinery also, but the consequences of breakdowns are generally more serious. No doubt the electrical engineer will be able to give us the particulars asked for, and not only give us the information on paper, but also give us the actual results they have had in practice, and let us know how far they are prepared to guarantee the system. In these days we must have a guarantee—it is hard to put such a pressure or penalty upon a system, but the rule of to-day is that there must be a guarantee.

Mr. Jas Adamson (Hon. Secretary): I think before Mr. Durtnall replies to wind up the discussion to-night we ought to consider whether it would not be advisable to have another evening to discuss the points put forward and have them thoroughly dealt with. The great improvements that have been made in the marine engine during the last twenty-five years have brought it up to a high state of efficiency, and we know that for marine work the turbine has not yet proved so economical; but from the recently introduced combination of reciprocating engine and turbine it is hoped more efficiency will be obtained than with the turbine alone. A question was raised regarding the reversing of the marine engine, and when it is remembered that there may be as many as fifty to sixty reversals in two and a half minutes coming into or leaving port, it will be seen what strains and stresses the marine engine, and the marine engineer, have to be constituted to withstand in order to carry on the work in the engine-room. The *Rattler* has been referred to to-night. I had the pleasure of being on board to see the machinery after the trials about a year ago. I know they have made considerable improvements since then, and that it has done good work this season under the Marquis of Graham in connexion with the Naval Volunteers. The marine engineer knows what is going on in relation to the development of the internal-combustion engine and has been studying it for some time past, and questions are in preparation to be answered by engineers going up for their certificates, showing that the marine engineer is quite alive to what is before him in the future. In his presidential address Mr. Denny referred, not only to Mr. Durtnall's, but also to a similar system which had been fully considered, and the conclusion come to was that the cost was prohibitive, and that is one of the considerations before us to-night. Then we have to consider what the poundage of coal is per horse-power transmitted to the propeller, and remember that the speed at which the propeller is driven must be the most suitable for the propeller before that efficiency can be obtained. Mr. Durtnall's system is intended to get the highest possible results out of the turbine machinery, and transmit that power to the propeller shaft, so that the shaft may also go at its most efficient speed. The turbines lose largely by the drop from the high speed at which they are compelled to be driven for efficiency, and even then the propeller does not get its proper efficiency; that is to say, the present arrangement is a compromise to minimise the losses. Mr. Durtnall intends to get the highest possible efficiency out of the turbine and also out of the propeller, running the latter perhaps at 100 revolutions per minute. Our difficulty just now, I apprehend, is to get data, so that we might consider such along with what we know from our experience of marine engines, and we look to our electric friends to supply us with that data to enable us to form an idea as to whether the new system is going to be as efficient as the reciprocating engines. Our most recent types of reciprocating engine are giving exceedingly good results, and it will take a good deal of convincing to show us that we can improve upon it, but we come with open minds and are quite willing to receive any suggestions which will enable us to form a judgment on the whole subject. In view of that I think it would be well if we had another night's discussion. Considering the amount of information we have had to-night we shall be better prepared to discuss the matter and come to some determination on the subject.

Mr. Durtnall : I think it is a very good idea of Mr. Adamson's to have another evening's discussion. I must say I was in hopes of getting some confirmation of the data in my paper, not on the electrical side, but in connexion with the weights of boilers, cylindrical boilers, and weights of other materials that do not strictly concern the electrical engineer. The only information I have has been gleaned from literature, but I should have liked to have had the figures confirmed and to see if they are within the limits of practical experience. As to the electrical side of the question I will say that every bit is perfectly true, and I have confirmation from some of the largest firms, not only in this country, but abroad. I may tell you that the weights of the motors I give have been confirmed by one of the largest firms in this country within the last few weeks, and that is a firm who can make such large motors to my designs. The figures, they say, are well within the mark. As an instance I may say I give the weight for a 10,000 horse-power motor, 20 lb. dead weight per horse-power developed ; they quote 18 odd lb., but as to whether that will be a limit I cannot at present say. I should like very much, in our next discussion, if a few more of our members would be present. I have endeavoured to get a few of our electrical friends here to-night, and I should like to have the views of the superintendent engineers of the large steamship companies. I am sure there are very many of those who are members whose views would have been very helpful. Mr. Farenden, in his remarks as to the saving in coal, throws a doubt on the point as to whether it is possible to make a saving of 41 per cent. in steam. I think I make it quite clear in the paper. The steam consumption per kilo-watt I take as 16 lb. Taking motors transmitting the power to the stern, which is practically only a few feet, the loss is well covered by allowing 1 per cent.; and taking motors of the size I mention, 1,000 brake-horse-power at 250 revolutions per minute; and taking the mechanical efficiency of these motors at 93 per cent., it will be found to work out exactly as I say, about 13 lb. of steam per shaft-horse-power; 13 lb. of steam is what we get by driving electrically. The confirmation I have had from one of our largest marine turbine builders has been as follows. He quoted for a 4,500 indicated horse-power, or rather "estimated indicated horse-power" turbine, 17 lb. of steam. With a mechanical efficiency of 84 per cent., that works out at approximately 20 lb. of steam per brake-horse-power or shaft-horse-power—that is, in comparison to the reciprocating engine. Published at the end of the paper will be found the results of a test between the turbine ship the *Governor Cobb* and the *Nantucket* with reciprocating engines. In the reciprocating engine the steam consumption per indicated horse-power per hour was 19·41 lb., that is with 25 in. vacuum—of course that is a reduction as compared with the turbine, which was at 27 in. vacuum. The steam consumption per brake-horse-power or shaft-horse-power, including auxiliaries, on the turbine ship, which has a shaft-horse-power of 4,100 with an average number of revolutions of 447, was 22·87 lb. In my paper I gave the figure at 22 lb., which I considered to be a fair estimate of what should be the case in the ship of 4,000 shaft-horse-power, so that you see my estimate was on the right side. I do not think there is any doubt that, approximately, there would be a saving of 41 per cent., but certainly it would be from 35 to 40 per cent. on that particular size of vessel. Taking the case of a larger ship, such as Mr. Willis referred to, say the *Lusitania*, it must be remembered that although they get as high as 28·8 lb. per shaft-horse-power in the 4,000 horse-power boat it has been proved that the average steam consumption is 14·46 lb., including auxiliary plant, in the *Lusitania*. Of course that is due to the fact that the efficiency of the highest power is more than the lower when it is only 1,000 horse-power per propeller shaft in place of 16,000. I have been able to get confirmation from a large firm of steam-turbine makers, who quoted me the guaranteed figures—"guaranteed," please observe—

of 11 lb. of steam per kilo-watt, that is with 100° superheat and 28 in. vacuum. Taking 11 lb. of steam per kilo-watt hour, and using large motors such as are proposed for ships of that description, with an efficiency of 93 to 94 per cent., you get a shaft-horse-power of 160 to 170 revolutions per minute for 8·8 lb. of steam.

Mr. HOLLIS : Is that 11 lb. per brake-horse-power or per kilo-watt ? Mr. DURTNALL : Per kilo-watt. Mr. HOLLIS : At what speed ?

Mr. DURTNALL : At 750 revolutions per minute, with superheated steam. Mr. HOLLIS : What is the make of turbine ?

Mr. DURTNALL : It is the horizontal Curtis-Rateau. It is not the Curtis-Rateau Company who quoted me, but the figures I mentioned in connexion with the tests on the Continent were from the working of Curtis-Rateau machines. I have faith in it ; I think it is a step in the right direction. The steam consumption is 11 lb. of steam per kilo-watt hour for 12,000 kilo-watt sizes. These are the figures they give, and I have no doubt it is perfectly true, as their turbines have been proved during the last three or four years. They told me on the Continent that for marine work they can get a steam consumption of 13 to 14 lb. per shaft-horse-power, running the turbines at 700 revolutions per minute ; the consequence is that the propulsive efficiency instead of being 56 to 60 per cent. against the speed I have given here is more like 35 to 40 per cent. I mean the efficiency of propulsion from the owner's point of view—that is what I have endeavoured to make clear, what it is to cost him to take cargo or passengers certain distances. If you have a high-speed turbine running at its highest efficiency, and have a slow-speed propeller at the same time, the cost per ton of displacement per mile is cheaper, in other words the propulsive efficiency is much greater. As our President said, at present they simply take a turbine and calculate it out on known results and get its best speed and consumption ; then design a propeller to get its best efficient speed and cross the lines, and at the point where the lines of efficiency cross, that is the best mean, so they settle it at that speed. I know it is a compromise that works mechanically very well, but certainly not economically. That is why some engineers have considered the question of driving the propellers by electric motors. It is because they know where the turbine fails. They say, "We don't want turbines to drive our ships because they use such a lot of steam." I remember approaching a large company to interest them in this matter, and the first thing the engineer said was, "We do not run our boats like the *Lusitania*, at 25 knots; we run down to 15 or 10 to 12 knots; what are we going to do if we use the steam turbine only?" He did not reckon that large economies can be effected by using it. I can get the low vessel speed with the same efficiency as the top vessel speed, because you can shut down the plant and run with one generating plant instead of two or three, and so save steam, which means efficiency. I think that explanation with regard to the saving in steam is quite clear. Mr. Timpson compared the proposed system with the small plants used in land work. Of course if such a power is required for marine work, the biggest power units would be more efficient, as compared with the small private generating plant where the steam turbo-generator and motor of small powers are used. To give an instance, this rotor I have here is from a London motor omnibus, where the power transmission efficiency is about 70 per cent. on a 40 horse-power set. When the horse-power goes up to thousands the efficiency goes up, and the weight per horse-power goes down and the cost also in proportion. Mr. Redman asked whether a 5,000 horse-power motor with a 15-ft. propeller could be run at 60 to 70 revolutions per minute. Of course there are limits to this method, but you can reduce the speed considerably with an electric motor. There are plenty of induction motors made on this principle for reciprocating pumps, with cranks coupled one at each end of the motor and the motors revolving at 80 to 90 revolutions per minute, the weights being increased, so that instead of 35 lb. they go up to 80 or 90. lb weight per horse-power for the lower speed. It is possible to do it; but whether it is advisable is another question. I think for a reciprocating engine of 5,000 horse-power that speed would limit the engine at which it would be advisable to run it. It is quite possible to run it below that but I do not think it is advisable to do it. I think the best way would be to use, on cargo ships running at 10, 12 or 15 knots, high-speed turbines with low-speed motors on the propeller. Of course, as one gentleman remarked, there is a great variation in the ships; it would be impossible to speak definitely on one point because every ship will have to be designed to meet various conditions. Mr. Broadbent has very finely contributed to the discussion and, coming from Mr. Broadbent, I must ask you to think over what he has said. He is a gentleman of recognized ability on the subject of electrical power transmission, and I think his views must be taken with confidence. He spoke on the subject of high speeds, and mentioned, by the way, the impression that some people have with regard to the application of this system to the reciprocating engine. That is perfectly true. I may tell you that on the following Thursday after reading my paper I was in Berlin—I went there on business—and saw a certain paper there, and to my surprise I saw it stated by the engineering editor that the proposed system of electrical power transmission was for the marine engine. Of course it is absurd to think of applying electrical transmission to a marine engine at, say, 80 to 90 revolutions per minute. Mr. Broadbent referred to the figures, 14·46, given for the *Lusitania*. Of course that is the steam consumption at 25·4 knots including auxiliaries. Some people say that the auxiliaries should not be included, but I do not see why they should not, as that is included in the actual cost of working. Of course if they mean all the many hundreds of things done electrically that must be deducted—I do not want to appear in any way unfair in order to impress the fact that a saving can be effected. The steam consumption for the condensing plant feed-heater, and other auxiliaries of that class, should, I consider, be included, and I should like to have heard what is the percentage found in ships, that is, separating the ordinary necessary auxiliary plant from the actual feeding and condensing plant for the main power generator.

The Hon. Secretary: It depends entirely on the class of steamer.

Mr. Durtnall: It would have been a great help in considering this question, but I have given my figures on the electrical side, at any rate. Mr. Deane referred to the efficiency of the propellers. I notice that the curve showing the results of the trials of the *Lusitania* shows 48 per cent. at 25 knots and rises to 53 per cent. at 20 knots. Reference was also made to the internal-combustion engine. I agree that it is necessary to consider what will be the probable cost for internal-combustion engines. I know of one ship where they use hydraulic gear for reversing, but I do not see how they will ever be able to satisfactorily reverse the propeller with an internal-combustion engine in that way. With the weight of the ship and the propeller turning in the ahead direction, if you put down gear to reverse there will be a very great torque against the torque of the engine. It certainly wants braking down, and I should like to know whether they wait until the vessel stops or almost stops before reversing the propeller. If they do not reverse they must let it slip, and if they let it slip they won't get the power. In my application of the internal-combustion engine we do brake the propeller. I maintain that it is possible that if you hold the propeller still while the ship is under weigh, the efficiency of retardation is higher than if you actually reversed it down to a certain point. By holding the propeller still there must be more retarding effect. Mr. Robertson asked a question as to the probable cost. I have been going into that question as it is a very important one, because if the scheme is not commercially sound it is of little value. The cost of a 4,000 to 5,000 horse-power plant, including turbo-generators, motors and controlling gear, would be somewhere about £4 10*s*. per kilo-watt. I should like to have particulars of how that compares with a turbine ship of the same power. Time is getting on, and I shall not be able to-night to go into the further questions raised, but I have the figures here and will give a further reply at the next meeting. I was hoping to have touched upon the point mentioned by Mr. Austin. I have a method of altering the periodicity of the generators, and I can get any intermediate speed that can be obtained in continuous-current motors.

Mr. Austin: By altering the number of poles?

Mr. Durtnall: No, I work in on an electrical arrangement similar to an epicyclic gear. I can slip the field of the generator and vary the speed to any degree whatsoever.

Mr. Timpson proposed, and Mr. Robertson seconded that the discussion be adjourned, and the motion was carried.

Chairman: Mr. Adamson informs me that there is a date open on the second Monday in January and Mr. Durtnall is quite prepared to attend that night. It will take place in our premises at Stratford.

A vote of thanks was accorded to Mr. DURTNALL on the proposal of Mr. TIMPSON, seconded by Mr. J. E. ELMSLIE, and the proceedings terminated.

SESSION 1908-1909

President: JAMES DENNY, ESQ.

Adjourned discussion on the Lecture entitled The Corrosion and Decay of Metals,

GIVEN BY

MR. J. T. MILTON (MEMBER OF COUNCIL),

CHAIRMAN: MR. JOHN CLARK (MEMBER OF COUNCIL),

On Monday, October 24.

CHAIRMAN: As you are all aware, the purpose for which we are met to-night is to discuss the question which Mr. Milton treated of when he very kindly gave us the lecture on "The Corrosion and Decay of Metals." No doubt many of you have had an opportunity of reading the lecture over carefully, and anything which you wish further explained, any difficulty you may have met with, I am sure Mr. Milton will be glad to clear up.

Mr. MILTON: Before the discussion begins, I may say it was thought that very probably some of the gentlemen present to-night did not hear the lecture when it was given some weeks ago. You have already received the Transactions giving the lecture in full, but "seeing is believing" and is a good deal better than reading, and I thought, and the Council thought, it would be useful if I repeated the experiments showing the influence galvanic action has on corrosion.

(Mr. Milton repeated the experiments described in lecture.)

If there is any point that is obscure in the paper, or any question that any one may wish to ask, I shall be pleased to deal with them, but otherwise I hope we shall have a good discussion.

Mr. P. S. Doherty (Member): I have here pieces of two rods from an ordinary vertical duplex ballast pump, which of course you all know something about. These rods were sent in a pump to me some time ago for repairs, and in my absence the rod was sent down to the yard for report. The report came back that at some time or other part of the rods had been turned down and new metal burnt on. It seemed to me pretty obvious at the time what was the matter with them, and since Mr. Milton has given us this lecture it is still more plain. The decay has taken place between the top of the bucket and the underside of the gland, and there were signs of copper deposit on the rod itself. I had the rod cut up, and, as you will see, at the centre of the rod where the decay is worst the metal is about $\frac{1}{2}$-inch diameter, the rest of the $1\frac{1}{8}$ inch is absolutely rotten, and the nearer the gland the sounder it remains. In the centre of the rod the metal is absolutely sound. I took the trouble to keep some of the flakes so that you can see the perfect lamination of the decay, and also the very porous state to which the metal is reduced, and if you look carefully it will be found to be a very perfect sample of decay due to electrolytic action. That is the only feasible reason I can see for it. As you will see, it is still sweating after being out of use for about three months. With the consent of the firm to which I belong, I propose to leave some of these pieces in the museum of the Institute.

Chairman: Perhaps some of the members might be interested to know the description of the metal the rod is composed of.

Mr. Doherty: It is something between a Muntz metal and manganese bronze. I have not had it analysed yet.

Chairman: Can you say what it is commercially known as?

Mr. Doherty: I cannot. It is a strange metal to me altogether.

Mr. W. Lawrie (Chairman of Council): Mr. Milton's lecture is full of valuable information, and by a combination of scientific knowledge with practical illustrations he has invested his subject with greatly increased interest in my case, and I have no doubt that most marine engineers will be of the same opinion. In looking over the paper it appears to me like a fully equipped ironclad, and that you are putting an air gun into my hand and asking me to put a hole in it. It would be as hard to do the one as the other, but as I say, the paper is full of valuable information and puts the subject of rusting in quite a different light. Referring to the question of a rusty plate corroding more quickly than a clean one, the subject, as Mr. Milton says, is rather obscure, but he gives three reasons which may account for it. The first is the storing up of extra oxygen under certain conditions, and the releasing of it under the reverse conditions. Further on Mr. Milton says that it might be due to the oxide itself not being absolutely coherent and giving access to the oxygen in that way, or possibly it may be due to electrical action. I have had one or two cases under my notice in which the first does not apply; that is to say, I have seen cases where the rusting was so active between two plates that it bulged the plates out and put a considerable strain on the rivet heads—in fact, if we had not removed the outer plate and re-riveted it up, I believe it would have forced the plates off the rivets altogether. Of course there were favourable conditions towards rusting. Several of the plates were on the bulwarks and were washed down every morning, and the hot sun during the day made the plates very hot. In one or two other cases the same thing occurred in other ways. The sun had not the same effect, but still the corrosion went on just as quickly, and we had to remove the plates. A question occurred to me in connexion with the matter Mr. Milton refers to after explaining the action of the corrosion, about the zinc plates in boilers. I have not had much experience with this class of work lately, but I have seen it sometimes effective and sometimes not. I should like to ask Mr. Milton if the method generally adopted of connecting with studs, having studs put on and the plates screwed up tightly on the studs, remains very long effective, or if a coating gets between the studs and the zinc plates so that the effect of the latter is lost. One would think, from the paper, that they should be mechanically connected. Of course they are at first, but whether they remain so is another question. With regard to the question of galvanizing, in reading a paper in *The Steamship* last month I saw reference to a new system of galvanizing, whereby the plate was heated to a very slight heat and coated with zinc dust. It is said to benefit the plate and is expected to be more effective than the old process. Mr. Milton, of course, has not dealt with the subject of paint; as he said, it is too complex. That, I think, is a subject which follows on from the one we are considering, and perhaps we shall have the pleasure of hearing something more on this subject at a later date. The tanks under the boilers, as Mr. Milton said, get more attention to-day than in former years. I had some work, not long ago, in connexion with a vessel which was tanked everywhere except under the boilers, and the boilers were fairly well off the floors, so that everything looked in first-class condition. But there was this defect. The vessel had been ashore, and the damage occurred where the vessel was tanked. Had the same occurred under the boiler space the vessel would have been on the rocks, but as it was, the damage only came in about 6 feet of the boiler space so they were able to deal with it. Doing away with the tanks would be a very good thing for the ship's bottom, but under circumstances such as this the tanks prove very useful. Of course it may be said we have not to put the ship on the rocks.

Mr. H. Ruck-Keene (Member): I think we are all very much indebted to Mr. Milton for his most interesting lecture, and more especially because he has so clearly shown us the chief causes of corrosion. For it is a well-known fact in medical or engineering science that, if the cause of the disease is known, it is much easier to find a remedy for the same. Mr. Milton has told us that corrosion in metals is caused by a corrosive substance coming in contact with the metal, and that this corrosion is further intensified by the action of electric currents leaving the metal and entering the corroding medium. Now as to the remedy, I do not think there is any means of preventing the electric currents from passing through the metals, and consequently the only other remedy is to prevent the corrosive substance from attacking the metals. As regards iron and steel, Mr. Milton has said that the principal preservatives used on board ship are paint, cement, or other protective substances, and galvanizing. Now galvanizing is chiefly only used for deck fittings; paint is used for the greater part of the structure of the ship, and it is about the only preservative which, in my opinion, we can use for the outside and inside plating, frames, etc. For tank tops in holds a coating of Stockholm tar sprinkled with sand seems to give the best results. The tank under the boilers is the part of the structure of a vessel where the greatest corrosion generally takes place, and it is a great question for engineers to consider what are the best means for preventing corrosion at this part. We can to a large extent eliminate the heat, which is one of the necessary conditions for corrosion, by covering the underside of the boilers with a non-conductive material, and covering the tank top below the boilers with cement or a bitumastic solution. For the inside of this tank—if used as a dry tank—it would be a great advantage if the suction pipes could be placed in such positions that the tank could be pumped absolutely dry, and moisture, caused by some water laying in the bottom of the tank, being thus prevented from collecting; the dryness of the tank could also be improved by suitable air pipes or ventilating shafts. When this tank has to be used for carrying water ballast, or freshwater for supplementary feed for the boilers, many methods have been tried for preventing corrosion of the floors, etc.; some engineers use paint, some cement, others a bitumastic solution, but the best I have seen used is a mixture of white lead and tallow in equal parts, applied hot to the clean plating. The plating must be quite clean, free from scale or paint, before the solution is applied, or it will not adhere properly. It can be applied to the floors and girders and underside of the tank top plating, and has given excellent results in several cases that I know of. It requires to be renewed every eighteen months or two years, but, as it preserves the plating against corrosion, I do not think the cost of renewal will be considered by any one as excessive. Corrosion is also caused in the bunkers to a great extent by the moisture in the coal combined with the heat due to the proximity of the boilers. This can be best avoided by coating the bunkers with a bitumastic solution of some kind. With regard to the samples of decayed copper, brass and other metals which have been handed round to-night, I am unable to suggest a remedy, but I hope Mr. Milton will be able to suggest something to us, more especially with regard to the corrosion and decay of condenser tubes.

Mr. J. P. Halkett (Member): I had not the pleasure of hearing Mr. Milton give his lecture and have not yet read it. The subject is a very important one, and how corrosion is to be prevented entirely one cannot tell. With regard to this question of decay of metals, I have received from Mr. Milton himself—I think he will remember the case—a centre stay of a condenser which was all eaten away, the outside was all rotten except a little bit in the middle. I remember once we were cleaning a set of tubes in a condenser, and one which fell accidentally broke in two. That was the state of all in the box, you could take any tube and break it like pipeclay. When we sent the tubes to the makers to get a return upon their value I thought it best to tell them the state the tubes were in; I thought the practical nature of the metal was gone, but they wrote back to say they would take the tubes in the ordinary way. It showed that these old tubes had value in them the same as if they had not been in that condition.

Mr. F. M. Timpson (Member): The lecture covers the subject very completely, and the practical outcome is the question of preservation, and, it is for us to find out means of preventing the decay. Mr. Ruck-Keene mentioned tar and cement for use in preserving steel-work; I think this was mentioned when Mr. Elliott's paper was read; some members were in favour of mineral oil. In some steamers sailing out of Glasgow they use nothing but black oil coated between the woodwork and the ships' frames, and there is practically no corrosion of the iron. For hot and cold surfaces, paint mixed with graphite has a very firm grip on the metal and prevents the chipping of boiler shells usual with ordinary paints, when the paint, of course, is taken off along with the scale. With reference to tanks there are some ships which take a few gallons of oil into the ballast tanks with a view to prevent corrosion. I believe this is a Dutch idea, and it is claimed to have a very preservative effect. The oil is merely put into the tank and coats the iron-work as it rises and falls. As regards surfaces exposed to heat and cold I think mineral oils have a better effect than vegetable, and give better results, as they seem to adhere better to the metal, and thus have a more preservative effect.

Mr. J. Lees (Companion): There are two ways of approaching a discussion on Mr. Milton's paper; one, of course, is by way of practical experience, and the other the scientific method combined with practical experience. I should like to ask a question in regard to the action going on in the corrosion of these metals. A certain amount of polarization takes place in a short time; that is to say, if there is a couple in a corrosive fluid, after a short time the corrosion will cease owing to the deposition of nascent hydrogen on the copper plate, and according to that theory such conditions could hardly be an explanation of the corrosion that goes on on board ship; it would be so very complicated that it would be hard to arrive at a conclusion. I am more inclined to think that most of the corrosion is due to local action, or due to inequalities in one metal which set up local currents with all their attendant troubles. I once made a small experiment by immersing a thin strip of Swedish iron in distilled water. I bought the distilled water from a chemist, and quite possibly a little free oxygen was allowed to get into the water, but the result was that after immersing it for some little time a thin black film formed on the iron. Would that be a lower oxide of the iron? Of course I cannot say how the oxide was formed, but on taking the iron out after it had been in the water for three days, I saw this thin film. The vessel was closed.

Mr. MILTON: Was it possible for free carbonic acid to be present?

Mr. LEES: No, I do not think it was.

Mr. MILTON: If it were that would cause a black oxide.

Mr. LEES: Of course that is the chief feature in the formation of ferric oxide. Another question I would like to ask is in relation to the passivity of iron. I understand that if a piece of bright iron is put into concentrated solutions of nitric acid no corrosive action occurs. I do not know whether this test has been made in conjunction with an electrical couple, but I believe that the iron will remain bright in a concentrated solution of nitric acid, although if the acid is diluted the solution will attack the iron. It is a curious phenomenon. I think with Mr. Milton that the difference in temperature between the tops of the tanks and the bottom of the boilers is a great means of corrosion. You have there the corrosive fluid and all the necessary conditions which give rise to corrosion.

Mr. ROBT. BALFOUR (Member): The interesting subject before us affords me an opportunity to bring to the notice of the members, more particularly the juniors, a remarkable phenomenon which is to be found in connexion with main shafting on board ships. It has greatly interested myself and other surveyors for some years back; that is when any part of the shafting is taken adrift, say to admit of the drawing in board of the propeller shaft it will in nearly all cases be found that where the shafting is parted, say about two or three inches, there is an attraction between the shafts, in some cases more intense than in others, sufficient to hold in suspension between the couplings a bar of iron or steel weighing anything up to two pounds, and from my own observation this attraction is more pronounced in cases where the propeller shafts are fitted with two separate brass liners, as is also the corrosion between the liners.

In one ship where this phenomenon was very evident the propeller shaft had to be renewed within twelve months through acute corrosion; fortunately the practice of the Company to which the vessel belonged is to have the shafts examined every year, otherwise the consequence might have been in this case very disastrous.

As to the cause of this remarkable phenomenon, I am of opinion that it is magnetism produced by the torsional and bending stresses and hammering action of the propeller setting the molecules of the metal in motion, and the freed oxygen attacking the shaft between the liners where these stresses are local, but Mr. Milton will no doubt be able to solve the mystery which is certainly astonishing.

Mr. MILTON: Before Mr. Balfour goes further, would he kindly say if he has found that this magnetic effect is only to be found in the case of shafts with two liners.

Mr. BALFOUR: It is more pronounced in those cases. Where the shafts are fitted with a continuous liner the attraction is found to be very slight.

Mr. MILTON: There is magnetism in the other case.

Mr. Balfour : There is to a slight extent, but the amount is very slight compared with the double lined shaft. I was very interested in Mr. Lawrie's remarks on the use of zinc in the boilers. With regard to that, Mr. Duncan, who, unfortunately, is now on our obituary list, advocated screw tapping the zinc and screwing it on to a stud which ensured metallic connexion and this method gave excellent results.

Chairman : I might mention that the other day a gentleman came to me—apart from the subject of propeller shaft—and said he was troubled with the continued breaking of shafts in his mining machinery, and in the case he referred to there were seven or eight cams fixed on the shaft. I suggested a remedy on the assumption, which I believe Mr. Balfour was suggesting, that the trouble was due to the vibration. I advised him to get the shafts taken out and annealed, and when they were put back again, if possible to get another bearing introduced between the two supporting ends and so avoid the extreme shaking or vibration. That is in support of Mr. Balfour's theory that there is a certain amount of bending going on, and in time the shaft breaks off sharp. I do not know whether the question has arisen among any of you whether there was any variation in the composition of the metals between the forward and aft ends of the liner which would produce corrosion such as has been experienced in propeller shafts.

Mr. Balfour : I thought it might be due probably to the difference in potential between the two metals, but since I noticed the action of the Mudd sleeve I thought it could hardly be due to that. The sleeve prevents the corrosion and acts as a preservative in that way.

Mr. Jas. C. Brand (Member) : I believe the remarks you have just made, Mr. Chairman, apply to a stamper shaft for gold-mining machinery, on which a number of cams are fitted for lifting the heads, and from the experience I have had in removing stampers for gold-mining, I have come to the conclusion that the action is due to fatigue in the metal, and in most cases, if the shaft is made interchangeable, it will be more effective. In a belt-driven cam, if the two ends are made exactly the same, it is only necessary to reverse the shaft, and in that case the direction of the thrust is reversed and the disturbance of the molecular forms also is reversed.

Chairman : Do you find that the action of changing over adds to the life of the shaft.

Mr. Brand : It gives a longer life, although, of course, not the life of a rotatory shaft. I should say the length of life is only about two or three years in place of the fifteen or sixteen years of the ordinary shaft. With regard to Mr. Milton's remarks on the decay of cast iron, it is the most feasible explanation I have seen put forward, and it is a subject of great interest to marine engineers, because decay only seems to go on in salt water. I remember on one occasion the bottom of the circulating pump fell completely out—a piece of plating about 2 feet 6 inches square. The circulating water rose from the pump to the branch, then through an aperture in the condenser plate. The condenser stood about 6 inches from the tank tops, and we noticed for a considerable period water issuing. The water seemed fresh, and we thought there was a leak somewhere; the doors were taken off and a crack was noticed in the bottom of the circulating water passage. A temporary repair was made by scraping the plates clean and putting cement on them. The vessel then put to sea, and after running about half an hour at full speed the whole thing was carried away and the piece of plating 2½ feet square dropped into the bilges. Both the discharge and injection water rushed back into the bilges, and down the ashpit, and the fires were under water. In that case, by putting the cement on the top of the plate, not only was the weight on the weakened plate increased, but the area of the discharge lessened. The final repair was effected by cleaning the parts and filling up with cement to a depth of 8 inches, trusting to the stability of the tank top to give a tight job. In regard to Mr. Balfour's remarks I should like to ask if the ship to which he refers had an electrical installation on board—it may have been due to electrical action.

Mr. Balfour : There was not electric light on board the ship.

Mr. Brand : It makes the case all the more remarkable, and I am pleased for the information. In connexion with the boilers, I should like to ask Mr. Milton if he has any knowledge of the action of zinc paint in boilers. It is my practice to coat boilers over all heating surfaces with the purest zinc paint and kerosene, and after six or eight months' work the surfaces are as clean as when put on: there is no corrosive action whatever.

A MEMBER: Have you any preference for kerosene over terebene or water.

Mr. BRAND: Yes, kerosene is a metallic oil, and terebene is a wood oil, and acid is present in it. For the same reason I never make a joint on the boiler with any description of animal of vegetable oil.

Mr. W. LAWRIE: Regarding propeller shafts, I think propeller shafts of every class pit very badly. I had a case under my notice about ten months ago where the shaft had no liner at all; it ran in white metal bearings—there was a Cedarval lubricating box and the shaft was supposed to run in oil. That shaft, between the outer and inner bearings, was corroded all over; it pitted very badly, and the condition of the shaft between the two bearings when examined looked like a honeycomb, and it had to be condemned. The head of the bush, which was of white metal, was simply turned into black, lead or graphite. The shaft was of steel, and the engineer fitted a wrought iron shaft in its place, and when this was drawn out it was found to be corroding very quickly, although the corrosion was not the same as the steel—it was more of an oblong formation about $\frac{1}{8}$ inch wide and $4\frac{1}{2}$ feet long. I expect the wrought-iron shaft will last quite as long as the steel one.

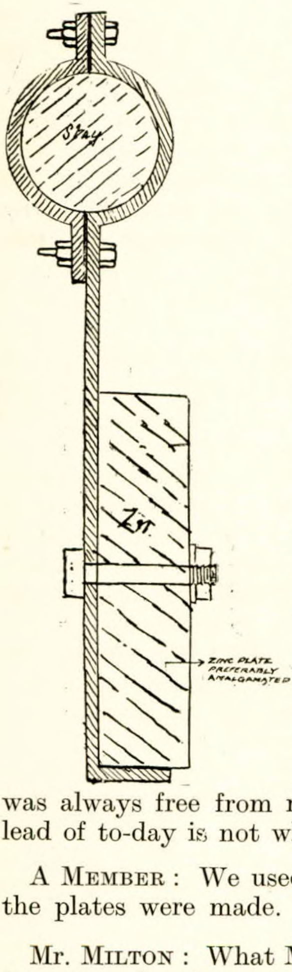
CHAIRMAN: Had the white metal any composition of zinc in it, the metal upon which the shaft ran?

Mr. LAWRIE: The metal used in the stern bush and the next bush is what is known as Parsons' No. 2.

Mr. D. HULME (Member of Council): One of the last speakers brought to my mind an instance which occurred in my experience in reference to pitting in boilers and the placing of the zinc plates in contact. I have under my supervision some Babcock boilers, and in the bottom of the shell in the water space I found pitting taking place very badly. There were several depressions, very small in some cases, and in others $1\frac{1}{8}$ inches or $1\frac{1}{2}$ inches in diameter. I came to the conclusion that the best way to treat them would be to plug them up, and for this purpose we made $1\frac{1}{4}$ inch studs, screwed $\frac{7}{8}$ inch on the heads. We drilled the holes right through, screwed the studs in, and put zinc plates on top. There has been no pitting going on since, so I think it proves that metallic contact has been obtained. The zinc plates corrode very rapidly. Mr. Lawrie has referred to the action on steel and wrought-iron shafts. We all know from years of experience, in the case of evaporators, that the life of an iron shell is very much greater than that of a steel shell. In one instance I know of, where the owners insisted upon the evaporators being made of steel, before the boats left the river the shells broke down. Another gentleman spoke of the action due to putting Swedish iron into distilled water. We had an experience a little while since where a somewhat similar thing occurred. We found that by putting condensed water through a cast-iron pipe, the first water coming through, was very much discoloured. Now if you put rain-water through the same thing does not occur. Our chemist and myself finally came to the conclusion that this was due to an alkali in the water and not to an acid. Although it may be infinitesimal in amount, still it is there, and to this we attributed the discoloration of the water.

Mr. Doherty : It has just occurred to me with regard to condenser tubes corroding or decaying that it has been the practice in certain work to put zinc plates in the covers. Recently we have been constructing condensers and pumps with gun-metal shells or bodies, for which we have had steel strips studded or bolted on to the covers, and the result has been excellent. I should like to add my quota of thanks to Mr. Milton for his extremely interesting lecture, to which I listened with great pleasure at the Exhibition.

Mr. C. M. B. Dyer (Member) : With regard to the fitting of zinc plates in boilers, I have noticed how frequent it is that the zinc plates are put in to no purpose and are simply wasted. The reason is that very often the fitting of the zinc plates is delegated to a junior and no instructions afforded him as to the importance of having perfect metallic contact between



the zinc and the boiler. In many cases I have noted they are hung on **S** hooks to a stay, and the contacts soon become more or less insulated, and the zinc waste is solely due to local action, especially if it is only cast-zinc; properly designed hangers to which the zinc slabs were securely attached, and the zinc slabs composed of the best rolled zinc treated with mercury to amalgamate it, would in the end be effective of a great saving, as it would prevent the wasting due to local action of the zinc itself, as per illustration.

Mr. Hulme: Mr. Milton will remember a paper given by Mr. Stromeyer at the Institution of Civil Engineers, in which the question of pitting arose, and I remember very well after a lot of discussion an old shipbuilder got up and said he did not know much about the matter, but he knew very well that wherever the number was painted on the plating with pure white lead, that part was always free from rust. Of course the commercial white lead of to-day is not white lead.

A Member: We used to see that at the steel works where the plates were made.

Mr. Milton: What Mr. Hulme said is quite correct, but he is wrong when he says that good white lead was used. They used the cheapest paint for the purpose, and there it remains, not because it is good paint, but because it is put on very hot.

Mr. F. M. Timpson (Member): With regard to the use of zinc, for some years electrogens were used for giving perfect metallic contact with the boilers. Why are they not used so much at the present time? The electrogen ball wears away rather rapidly, but certainly it is very effective when properly connected at different parts of the boiler. In boilers I have had to do with where it was fitted there were no signs of pitting or corrosion.

The Hon. Secretary: The first lesson we have to learn from Mr. Milton's paper has reference to rust. If we see rust it should be taken off, and I think that brings back the old saying that the more we chip and scale and paint the better will the ironwork be preserved. With reference to Mr. Balfour's remarks on magnetism produced between the couplings, one of the original members of this Institute somewhere about eighteen or nineteen years ago had a theory that the propeller shaft in revolving generated an electric current, and he had an idea that this current ought to be dispelled from the shaft, and constructed an apparatus in order to carry off the electrical current through the ship's side. We are all more or less familiar with the fact that there is magnetism somewhere about our shafts when they are disconnected. I have seen one or two cases such as have been described by Mr. Balfour. With reference to the use of zinc in boilers, pitting and corrosion inside marine boilers are almost practically unknown at the present day, and I attribute that largely to the use of zinc and to the care with which it is put on. There may be, as Mr. Dyer says, cases of carelessness, but I think chief engineers as a rule are well aware that there must be metallic contact. Electrogens were first used about twenty-five years ago, but when they were introduced the results were not what was claimed for them by the patentee. I was asked to look over a set of boilers in Glasgow about that time, fitted with electrogens, and I found pitting where I expected to find it, and where it may always be expected to be found, on the lower parts of the furnaces and fire boxes.

On pointing this out, I was told that the pitting was there before the electrogens were fitted, but as I had been previously told there was none I came to the conclusion that the boilers were not examined before the electrogens were put in. This was not the only case investigated, as I had the opportunity of watching the results in the boilers of three new steamers fitted. The view which presented itself to me was that there was not metallic contact between the electrogen and the boiler, and to test this an electrogen was cut through the middle, and as I expected, there was a scale between the zinc and the copper bar. Since then electrogens have been reintroduced, and with more care in the manufacture. From what I have more recently seen in several boilers fitted when new the results are much better than formerly witnessed. In one case where the electrogens were used twenty-five years ago the boilers were very badly rusted and looked as if they were painted with red from top to bottom. There were two similar cases with similar results, where one boiler in each set was fitted. The electrogens were, after six months' trial, taken out, and studs with zinc plates fitted as recommended by Mr. David Phillips—one of the early members of this Institute—as set forth in the Report of the Boiler Commission (a copy of which is in the library) published some twenty-eight to thirty years ago. There is one mode of protecting the iron which has not been referred to to-night, but was advocated at a previous discussion, that is by dusting cement on wetted iron surfaces, in preference to mixing the cement in water and laying it on with a brush.

Reference has been made to condenser tubes. I saw some recently which had been in use for about twenty years, and the bottom rows were wasted at the ends only, also the ferrules. In this case the circulating pump passage is very intricate. The water goes at right angles twice, then swirls through the tubes; the only corrosion is at that part where the water swirls as it enters the tubes from the circulating pump; the wastage in this case appears to be due to mechanical action, assisted probably by an extra amount of air. Some years ago, at one of our discussions on shafting, it was advocated that the propeller shaft, after being in use for three or four years, should be taken out of service for a time and given a rest, while the former spare one should be given a turn. I believe this plan has been adopted in some instances. I saw some bad wastages in boilers lately, due apparently to persistent leakage. I only judged from observation on sight, as a visitor. The plates were wasted away at the landings nearly to the rivets. It may interest members to know that these wasted parts were built up by the comparatively new process introduced to our notice by Mr. Ruck-Keene in his paper read at the Engineering Exhibition, Olympia, in September, 1907. Strips of iron were melted by the heat of the acetylene gas flame in the hands of an expert, and the landing was gradually built up to the original scantling. By request I saw a piece of the new landing chipped, and the metal was quite tough and ductile, it was not brittle. I was very much interested in this case and in others I have seen similarly repaired by this process to make up for wastage.

Mr. Brand : I should like to ask Mr. Milton if he has heard of the water theory of corrosion. If I am not taking up too much time I should like to read an extract from a paper on the subject : "If a textbook is consulted for an explanation of the rusting of iron, it will be found that carbonic acid has heretofore been generally held responsible for the formation of rust. Iron is supposed to be attacked by carbonic acid, with the formation of carbonate, which is then acted on by water and the oxygen of the air to form the red hydro-oxide known as rust, the carbonic acid being again set free to take up its destructive work. According to this theory, in an atmosphere which did not, like that of the earth, contain about four one-hundredths of 1 per cent. of carbonic acid, the rusting of iron would be an unknown phenomenon. That this, as well as the peroxide hypothesis which has lately been developed in England, must be relegated to the dump pile of abandoned theories, seems to be conclusively shown by these latest researches. According to the electro-chemical or electrolytic theory which Dr. Cushman upholds, the first attack on iron is not made by oxygen, even in the presence of water, but by hydrogen in the form of the hydrogen ion. According to the modern theory of solutions many substances when dissolved in water are dissociated into ions, which may be regarded as atoms carrying static electrical charges. Water itself, even when pure, contains a certain proportion of hydrogen ions, and the presence of many impurities, especially those which are by nature acid, increases the hydrogen ions, and thus the tendency to attack iron and carry on corrosion. The action is entirely electrolytic, being continually accompanied by an exchange of the electro-static relations between the iron and the attacking hydrogen. Such oxidizing agents as the chromate and bichromate of potash inhibit rusting by polarizing the iron to the condition of an oxygen electrode, thus preventing the approach or attack of the hydrogen ion. One of the most extraordinary points brought out is that this polarizing effect is to some extent lasting. That is to say, if iron is immersed or pickled in a concentrated solution of bichromatic acid, and is then washed and wiped, it is rendered passive, so that it resists electro-chemical attack, whether this take the form of rust formation, or the well-known plating out of copper which takes place if the chromated specimen is immersed in a dilute solution of copper sulphate. In short, the action which goes on when iron rusts is in every respect analogous to that which takes place when iron is immersed in a solution of copper salt." The writer then goes on to explain the action of this theory in boilers and boiler tubes.

Chairman: Who is the author?

Mr. Brand: It is an extract from the *Engineering Record*, and puts forward the theories of Dr. A. S. Cushman of the United States Department of Agriculture, and seconded by Dr. Charles B. Dudley.

Chairman: One point I should like to see commented upon is the difficulty which arises to the engineer when he sees a metal which in the ordinary condition of things appears to him to be a good sound metal. How often it happens in practice, although this metal seemed to be the best, after using it a short time it begins to decay. Nobody seems to have commented upon the fact of the differences existing in the alloys of a metal of a composite nature how the engineer is to distinguish between a sound and inferior mixture.

Mr. Lees: I think Mr. Milton's explanation is clear on that point. In all cases where there is a mechanical mixture in place of a chemical compound, when brought under suitable conditions there will be corrosion, and the more corrodible metal will waste away first, as Mr. Milton said, like the mortar from between the bricks.

Chairman: That is why I brought the question forward—I thought there would have been more comment upon that point.

Mr. Hulme: Speaking of metals of that description, in the ordinary high-pressure valves it has been the practice to make the spindles of rolled naval brass, and they are passed through an ordinary cast brass nut. The brass is very soft, and very often, although the spindle may be a good fit on the threads, after a while they "seize" in the nuts and it is impossible to move them without cutting or breaking them away. Why should these rolled naval brass spindles seize under the different temperatures or very high pressures ?

CHAIRMAN : Are we to understand that the metal is old, or is it new ?

Mr. HULME : They are new valves fitted to engines—steam stop valves.

Mr. MILTON : Does this "seizing" take place early in the life of the valve ?

Mr. HULME : In some cases it has taken place one or two hours after putting on steam, in some cases in the trials on the premises, and sometimes on the ship.

Mr. DOHERTY : May I ask the last speaker what class of metal the valve bodies are made of ?

Mr. HULME : 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc, and the metal used was rolled naval brass for the spindles.

Mr. MILTON : Admiralty gun-metal.

Mr. DOHERTY : A year or two ago that same phenomenon came before me under identically similar conditions.

CHAIRMAN : I think it would be to the advantage of all if we had more inquiries as to the why and wherefore of things. We need to go back to the original cause in cases of this kind. An engineer, say, gives a certain order for a pump rod ; he wants the pump rods of special metal and probably he gets a composition different to what he expects. How is he to determine whether he is getting good metal ? He looks at an ordinary section and good appearance, and even under chemical analysis he cannot tell whether it is good metal or not. Mr. Milton's lecture has brought out records where metal has been apparently sound to the eye of the ordinary engineer, and yet it has failed after being exposed for a short time to certain influences. Here is a piece of condenser-tube plate. You will see a line of demarcation showing where the water has been acting on that metal at one part while the other is perfectly free from such action. Whether it is that the water has that effect, or that it is due to the failure of the metal, I do not know. It is at points such as that where engineers are in difficulties in selecting metal. He naturally wants special metals for certain classes of work, and if after working some time a valve gets jambed, a thing that might occur with any one of us at any time, we want to know the exact reason for such an occurrence—it may be due to the different expansion of the metals under high temperatures, and when the temperature is reduced reaction does not take place, or it may be due to some other reason. In the case of some metals not in chemical combination which form a solid mixture, some portions of it wear away and other portions are left standing, due to the corrosive action going on in some of the component parts and not in others. The paper as a whole is of great interest, and I am sorry there were not more questions asked to explain these defects. Mr. Milton has gone to a great deal of trouble in showing how corrosion may arise, but in dealing with the whole subject we want to find out a way of preventing the corrosion in our everyday experience. Different causes and results will arise in different cases, the same rule will not apply for lead pipes as for copper pipes; if the corrosion, say, in the discharge pipes is not due to the action of the water solely, then the question of electrical action arises. In one case I know of the steel top ends of the connecting rods were badly corroded. We do not hear of many ships where there is a difficulty in keeping the top ends smooth, but at the end of the voyage in this particular ship the top ends were corroded very badly. It was not due to want of lubrication because there was ample lubrication in this instance. Some of the depressions had the appearance of pock-marks, as if the metal had been shaken out. Little experiences of this kind many of you engineers have come across, and the engineer wonders why a top end should be covered with small holes. The only thing he can say is that it is bad steel, but the whole thing remains a mystery to him as to whether it is due to some external cause or to the manufacture of the steel. Of course the explanation could easily be seen if the steel was made out of an ordinary chilled bar, and the metal was not pressed close enough. These are points I merely mention because they are so many similar details in the engineer's experience illustrative of the subject in some way or another. There are defects to surmount, and which can be surmounted, and it is for engineers to bring about some means of preventing the corrosion that is continually going on.

Mr. Brand: There is a rather interesting experience in relation to top ends which I might mention. When axiom grease or automatic oiling gear is fitted to the top ends those top ends pit very badly, but where it is fitted to the bottom ends and main bearings, and in all parts where white metal is used, there is no pitting observable, and on removing the automatic gear or axiom grease from the top bearings the action has ceased. Ordinary oil is now used in the ships I speak of, and the axiom is used in contact with white metal, but not on those surfaces in contact with brass, as it will not work between brass or ordinary mild steel.

Chairman: But in this case no axiom grease was used at all. In fact the result was attributed to the ordinary hydrocarbon oils which were used. I did think there was an acid in the oil, but on a chemical analysis nothing of that kind was found. On consultation with other engineers on the subject, they mentioned having had similar experiences with soft steel top ends but not with malleable iron. I shall now ask Mr. Milton if he will kindly reply to the questions that have been raised.

Mr. Milton: There have been a very great many points raised in the discussion, and there is so little time to comment upon them that I really do not know where to begin. Mr. Doherty showed us a corroded pump rod which was practically a replica of the pieces of yellow metal bolts I showed when the lecture was given. The corrosion is due, as in the ordinary Muntz metals, to the metal itself being of duplex structure, and probably under a microscope this would be clearly seen. Naval brass is really Muntz metal containing 1 per cent. of tin, the tin being supposed to prevent the decomposition of one of the constituents. It does, probably, have that effect to some extent, but it is not an absolute cure. The rod which is shown with the exfoliated leaves of spongy copper is naval brass, but it has not quite so much as 1 per cent. of tin in it. Mr. Doherty remarked about zinc plates in condenser ends to prevent the tubes corroding being replaced by steel plates. Well, zinc and iron are both on the same electrical side of copper and brass, so really the iron or steel preserves the brass in the same way as zinc, but the steel or iron is cheaper than zinc; and also, when there is good contact made between the studs and the plates the electrical contact is preserved much more readily with steel or iron than with zinc, especially if the zinc is fitted in the way Mr. Dyer speaks of. Several engineers have discussed the question of zinc in boilers. The Admiralty practice in this matter was arranged nearly thirty years ago on the recommendation of Mr. Phillips, a P. & O. chief engineer whom the Admiralty put on the Boiler Committee to inquire into the cause of corrosion. He found that although zinc, however it was put in, had a preservative effect, it had a much better effect if it was maintained in metallic contact, and from that time the Admiralty have required zinc plates in boilers and feed tanks to be put in on studs. The maximum time they are allowed to be in without special attention is three months; they are then taken off and the plates again put on in good metallic electrical contact. Stringent rules are given to the engineers that they must have so many inches of zinc surface in proportion to the boiler surface to be protected, and if it is shown that the surfaces become corroded in spite of that rule being observed, more zinc is put in near the point of corrosion. Electrogens are found, not to protect the whole of the boiler, they only have a preservative effect on the area round about them. An electrogen, however well put in, only affects a limited area, it has not surface enough to protect the whole of a boiler, and I am not at all surprised that it has not achieved the results which were claimed for it. When you put cast zinc into a boiler, before very long the action of the water seems to penetrate between the large crystals and make the metal friable and rotten. The Admiralty from experience, use only rolled zinc sheets $\frac{1}{2}$ inch thick—they cost more than cast zinc, but give better results and last longer. I am rather surprised that Mr. Adamson should say that pitting is practically unknown in boilers at the present day; I can only assume that he means it is unknown in the steamers he looks after. We have heard it said by Mr. Dyer that the pitting does take place in many boilers where the zinc is not in metallic contact. No doubt there is a vast difference in the treatment of boilers between to-day and twenty or thirty years ago. When steel first began to be introduced for boilers, eight years was thought to be a long life for a boiler; nowadays boilers are running which are twenty-eight years old. Certainly steel boilers last a great deal better than the old iron boilers did, but not because they are steel, but because they are better looked after nowadays. In the days when steel boilers first began to be made—in 1879 or 1880, the early eighties—engineers were rather frightened about using steel. They found the lower quality plates used for shell plates seemed to last longer than the better quality of iron used for furnaces and flanged plates, and they had an idea that steel would be less durable than iron. I was then assistant to Mr. Parker, who determined to make some tests on this question. Some steel and iron plates of ordinary quality were obtained, including some of the best Yorkshire quality, and they were put under certain corrosive conditions. Mr. Phillips had made experiments for the same purpose, but he had fixed his test pieces with iron distance pieces between them, putting them all into electrical contact. Mr. Parker and I fixed the pieces so that each was absolutely insulated from its fellows. We took pieces of iron rod and covered them with gauge glass, and fixed the pieces on these glass-covered rods with a series of glass distance pieces between the pieces of metal. It fell to my lot to see that they were properly fitted up in different places where they would be subjected to corrosive influences, and one of them was put into a boiler. I admit that I had not properly appreciated all the conditions at the time. I had the boiler specimen suspended to a stay right over the water space between the two nests of tubes. After they had been in the boiler for eighteen months they were taken out and cleaned to see what corrosion had taken place, and to my surprise there was no corrosion whatever on either the iron or the steel, but the glass was corroded a great deal. I ought to have known better than to put them where I did, but as soon as I saw the result I knew the reason at once. In that position the plates which were under the water line never got corroded at all by reason of the fact that the water coming in contact with them had previously been circulating past the heating surfaces of the tubes and had there given up every particle of air; the plates therefore had been acted upon by inert water. It was the worst place they could have been put in. The hot water, however, actually dissolved away some of the glass. I mention this because it is rather interesting and shows that we all sometimes make mistakes. Mr. Parker's experiments all proved to be practically valueless, because corrosive action was prevented in each case; one set placed in the bilges became covered with engine-room grease, and that prevented any corrosive action, and another one, which was fitted at the Brighton Chair Pier, immersed in sea water became covered with barnacles which prevented action in that case also. At that time I conducted another experiment at the Royal Naval College. I had some test pieces turned in the lathe; in some cases they were polished, and in others rough turned. Each piece was insulated and immersed in a trough of salt water, and the electro-motive force between each of them was measured. I could not find one pair which did not give a distinct deflection on the galvanometer; the rough turned were in each case more acted upon than the polished specimens, and I came to the conclusion that the condition of the surface has a very great deal to do with the question of corrosion. Several gentlemen have talked about paint. I expressly debarred paint, as it is a subject upon which two or three lectures could be given. The whole subject is one to be dealt with by experts, and I am quite sure that those responsible for the use of paint ought to know more about it than they generally do. They, however, know that it does not follow that the most expensive paint is the best; but on the other hand they also know that the cheapest is not the best—probably it is the worst. I think it would be a good thing if some of those gentlemen who study the subject of paint would favour the Institute with a paper. It would probably be a very good thing, even for their own business, to have light thrown on the subject. It was mentioned that paint was good for the inside of boilers. As far as I am concerned I would not put paint of any kind inside the boilers; engineers have so many troubles through what is roughly called "oil" in the boilers. Where we have paint on the iron, or anything that prevents actual contact of the water with the surface of the plate, there is a chance of overheating the furnaces. The cleaner it is kept the better the boiler does its work. The surfaces should be kept clean—no paint—no grease. That refers to boilers working at full power; of course if the boilers are kept only just simmering, not boiling, you may have a little paint or grease without serious consequences, but in long voyage steamers the cleanliness of the boilers is the first consideration.

An interesting thing was mentioned by Mr. Lawrie about

Cedarval's gland. The object of this is to keep the stern tube full of oil, and if corrosion is found in the shaft it is clear proof of the presence of water in the tube. In my office I have records of Swedish ships which have used Cedarval's glands, and year after year many of the shafts have been found as bright as silver when the stern tube has been kept full of oil. In one case, however, a Cedarval's gland was used for the shaft of a new steamer built on the north-east coast. She went round to Liverpool, and at Liverpool they had to take out the shaft. The shaft had worn down in the bush and cut through into the metal of the stern tube. I believe the reason in this case was that they forgot to put oil in. I think Mr. Lawrie will find that in the case he mentioned the packing box has been neglected, the oil has been allowed to run out of the stern tube and the water to run in. Another point of Mr. Lawrie's was very interesting to me. He referred to the question of white metal in the stern bush, which he says, I understand, was Parsons' No. 2.

Mr. Lawrie : I was given to understand that it was.

Mr. Milton : I have no doubt it was Parsons' white metal. There is a case of a small twin-screw steamer built on the Clyde which was sent to the Cape but did not get there—her iron shafts and white metal bushes all came to grief. The white metal used was one of those much-advertised metals which have a fancy name given to them : their actual composition I know ; it is as nearly as possible 80 per cent. lead and the remainder is tin and antimony. Metal of this kind will not stand in sea water. Our Admiralty, to secure the best results in the torpedo boat destroyers, where everything is made as light as possible, insist upon having a special white metal for stern bushes. This metal is found to be good and the Admiralty will not depart from it. I have a record of its composition, and this is the only white metal I should recommend for such bearings in view of the Admiralty experience and the difficulty met with wherever metals are used in which there is lead. The Admiralty also prohibit the use of lead in the white metal used for main bearings. They use vegetable oil—olive oil—for lubrication largely. If there is acid in the oil, and there is a considerable amount in olive oil, it affects white metal containing lead. Now lead is deliberately put into some white metals even up to about 10 per cent. It is not an adulteration, it is deliberately designed to be put in, and such metal, I believe, is a very good metal for very many purposes, but it is not suitable for use with acid oils. With regard to Mr. Clark's question in reference to top ends, I am not sure that a solution will be found in any one thing. There was once a good deal of difficulty in one of our warships where a particular top end gave trouble. It was taken out and filed, but it could never be got to a proper surface again, and it had to be changed altogether. In the next ship the specification required that the top-end gudgeons should be of Swedish iron, and it was specified that they had to be case-hardened. They caused a great deal of trouble, and it was eventually discovered by the Admiralty chemist that the specified metal was not used, but that a very soft mild steel was supplied, and in the case-hardening process very minute cracks were formed in this. Since then I think the practice has been to require Swedish iron gudgeons and to have them case-hardened, and afterwards brought up to an absolutely true surface by grinding. It was mentioned that mineral oil was used. One thing to remember about mineral oils is that when hot they lose a great deal of their body. I had a good deal of experience at one time with a feed-pump, fitted with a crankshaft but no connecting-rod; the crank worked in brasses sliding in a slot, formed in a crosshead connecting the piston-rod and pump-rod. The crosshead used to get hot from the steam temperature because it was connected to the piston-rod, and when olive oil was used on it, it ran off like water, but when castor oil was used it still retained a good body at the high temperature and ran all right. I am not sure that it is not the case that the mineral oil loses its body too much for use on a bearing which naturally runs hot. You want something different for a top end which is always comparatively hot than for a bearing that remains cold.

With regard to the question of Mr. Balfour as to whether the magnetism in the shaft is the cause of the corrosion, personally, I do not think so. I do not think if you magnetize a bar it will corrode away more rapidly than if there is no magnetism. I do not think so, but I am not quite sure of it; at any rate I have never before heard it mentioned that it is so. Some scientists say, however, that if you put a considerable amount of stress upon iron, for some reason or other the stressed part of the iron is subject to much more corrosive effect than the other, and undoubtedly the screw shaft does get a good deal of stress, and in addition is subjected to the action of sea water and also to electric currents. The magnetism of the shaft is caused by induction. This is described in any ordinary book on magnetism, where it is pointed out that if a piece of soft iron is hung up nearly in line with the magnetic axis, it becomes, pro tem., a magnet, but on removing it into another position it loses its induced magnetism. If, however, it is subjected to considerable stress for some time, the induced magnetism becomes fixed. Now the ships which I believe Mr. Balfour referred to make long voyages from north to south, keeping nearly on a meridian of longitude —and no doubt this intensifies and fixes the magnetism first induced. When they get south the shaft is highly magnetized, and on the return voyage this magnetism will first become neutralized, and then it will become reversed. I have no doubt shafts with continuous liners would get similarly magnetized if the magnetism does become fixed in this way.

Mr. Balfour: The most pronounced cases are those where the vessels travel practically east and west.

Mr. Milton: I am very surprised at that; I thought it was most marked in vessels running north and south.

With regard to Mr. Brand's question as to fatigue in the metal, it looks very plausible at first sight. Well, there is a Parliamentary Blue Book to be obtained, it is several years old, containing a long report on the reason why steel rails give way. In one instance a rail which had been in use for several years broke into seventeen pieces. A lot of scientists were asked to investigate the matter, and they made a great many experiments to know what was the best kind of steel for rails. A steel is required that is hard enough to resist wear, and not too hard to resist shock; and so they tried to get a metal between the two, which would be sufficiently ductile to resist shocks, and hard enough to resist wear. They made numerous experiments, and it was found that after a rail had been strained continuously by running over it in one way it actually got stronger; but when the strain was put on in the opposite direction by reversing the rail, it had a bad effect; therefore reversing the stresses is a very detrimental thing to do, and that idea is now generally given up. With regard to the question of rust gathering between surfaces, I think it only bears out what I said—that if you get rust, it forms more rust, it absorbs oxygen, and the oxide of iron occupies more room than the iron from which it was formed, and at last it strains the rivets and force the plates apart. An instance of rust forming more rust is shown in railway rails. Invariably a rail suffers most through the corrosion of the web and not of the crown of the rail. The rail that is used keeps bright on the crown, but gets rusty on the web, whilst an unused rail soon gets rusty all over. It is a fact that bar iron and cast iron become passive in concentrated nitric acid. A somewhat similar result takes place with a very concentrated sulphuric acid and lead. A dilute solution attacks the lead, but the concentrated does not, it seems to form a film which prevents further action. I know nothing of what Mr. Lawrie said about galvanizing by throwing zinc dust on to the plates, but there is more than one way of galvanizing. The electrical deposition process puts on a uniform coating—one coating of one metal—zinc. The method of galvanizing by dipping into molten zinc makes two coats. You will see them in a galvanized hand-rail on a ship. You will notice after a time the zinc outer coating wears off and a dark grey metal, which takes a polish, is seen to underly the zinc, and by and by that also rubs off and you come to the iron. The grey metal is an alloy of iron and zinc. I cannot explain why the water should be discoloured after coming through the pipes referred to by Mr. Hulme, and do not see why the same effect should not keep going on while in use. It seems to me that probably through the pipes being left wet they get rusty inside, and then the first flow of water washes the rust off. A little while ago an inquiry was made as to why some oil pipe lines corroded badly. It appears that in this case when an oil cargo arrives they pump the oil through the pipe lines into the tanks, and after this is done there is a stop and no more oil goes through the pipes for a considerable time. In this case the pipes were then washed out with sea water, and the alternate use of water and oil apparently gives a condition favourable to corrosion.

As Mr. Lawrie has said, the ballast tank under the boilers is sometimes a preservative to the ship under certain conditions, but on the other hand the shipowner says he does not build ships for going ashore. In the Royal Navy they use the tanks under the boilers for reserve feed tanks. They have no trouble with them in the Navy; but the Navy is very different from the mercantile marine. They have plenty of time in port, and the men go into the tanks periodically and clean them out, or rather paint them with white lead. There are very stringent rules on the matter of periodical inspection and painting. I do not know why Mr. Hulme's naval brass spindles in particular should seize in the nuts when a great number do not. For many years past stop valves have been made with rolled naval brass spindles and gun-metal valves, and they do not seize—at least the great majority do not. It may have been due to their not fitting properly, but there may be other causes. If there is a steel nut hardened up on a steel piston-rod it will seize. It is found to be better to use iron nuts on steel piston-rods. Mr. Doherty referred to condensers having brass water boxes at the ends and zinc plates in them. I think I should mention that some time ago one large steamer had the ferrules at both ends of the tubes corroded very badly, not uniformly wasted, but great lumps eaten out of them. To get over the difficulty they now have aluminium plates fitted in the water boxes at one end where they are accessible; half of them are fastened directly on to the tube plate at that end, the other half are fastened also, but are insulated with vulcanite and insulated cables connect them to the other end. That was done more than a year ago, and the engineer tells me that these plates have been an absolute cure for the corrosion on the condensers.

A hearty vote of thanks was accorded to Mr. Milton on the proposal of Mr. A. Robertson, seconded by Mr. Doherty; also to the Chairman on the proposal of Mr. Timpson, seconded by Mr. Ruck-Keene, and the proceedings terminated.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1908–1909

President: JAMES DENNY, ESQ.

VOL. XX.

DISCUSSION ON TIMBER USED IN MARINE INSTALLATIONS FOR THE CARRIAGE OF REFRIGERATED CARGOES,

Monday, November 23rd, 1908.

CHAIRMAN: MR. E. W. ROSS (HON. FINAN. SEC.).

LECTURE ON SCIENTIFIC BOILER CONTROL,

By MR. G. A. H. BINZ,

Monday, November 9th, 1908.

CHAIRMAN: MR. J. T. MILTON (MEMBER OF COUNCIL).

LECTURE ON VENTILATION BY INDUCED CURRENTS,

By MR. ROBERT GREGORY,

Monday, December 7th, 1908.

CHAIRMAN: MR. JOHN McLAREN (MEMBER OF COUNCIL).

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INSTITUTE OF MARINE ENGINEERS
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President: JAMES DENNY, ESQ.

Adjourned Discussion on Mr. C. M. B. Dyer's Paper on Timber used in Marine Installations for the Carriage of Refrigerated Cargoes.

On Monday, November 23, 1908.

CHAIRMAN: MR. E. W. ROSS (HON. FINANCIAL SECRETARY).

CHAIRMAN: We are met to-night to continue the discussion on Mr. Dyer's paper, and in reply to some of the remarks made after the paper was read, I have pleasure in calling on Mr. Dyer to open the discussion.

Mr. DYER: Mr. Ross asked at the former meeting how we are to stop decay. I cannot answer this more explicitly than by referring to the remarks which were afterwards made. These were to the effect that the best method to adopt would be to impregnate the wood with a solution which would make it impossible for bacteria and fungi to live in or upon it, and which would not directly or indirectly weaken or destroy the cellulose, this being the skeleton or framework of all kinds of wood, and on its permanent soundness the strength and elasticity of wood depends. I have already stated in my paper that the chief and obvious attributes necessary to any compound or substance used for the infusion into or impregnation of insulating timber are : it should be odourless and non-evaporable ; it should lessen the ignitibility of the wood and if possible render it non-inflammable ; it should be non-corrosive, or otherwise the fabric of an insulation might become unstable although the wood remained sound ; it should be capable of easy application without requiring special plant or skilled workmen ; and, finally, the completed process should be at a cost low enough to produce direct economies through the increased life and soundness it imparts to insulations. A compound of fluorine called Hylinit was mentioned by Mr. Balfour as having been under discussion at the recent International Refrigerating Industries Congress at Paris, but I cannot trace that it has yet been practically tested for the preservation of insulating timber, or for analogous purposes from which its suitability might be deduced. I have recently had my attention called to a compound which it is stated renders wood, impregnated with solutions of it, immune to the depredations of the numerous insects which infest wood in tropical and semi-tropical countries, such as borers, white ants, etc., and I have seen testimony from Indian Government Forest Officers and others of its proved efficacy. I have also evidence that it is used with good effects on ships' decks, which it hardens in the process of cleaning; that in Japan it is now generally applied to the structural timber, of which the numerous cotton and other factories are now entirely constructed, to lessen ignitibility and impart non-inflammability ; and that it is generally used for these purposes on mining timber in South Africa. I am also informed that it is now being applied to a large quantity of Indian timber destined for the construction of railway carriages and trucks. I therefore feel justified in submitting for your inspection some small samples of treated wood, which are evidently odourless, and it may fairly be assumed are non-evaporable. I will make an experiment to test its non-inflammability. Taking an ordinary bunsen burner, the temperature of which of course is considerably higher than that of an ordinary flame, I will submit to its action this strip of wood stated to have been treated with the preparation, and a similar piece of wood untreated. (Mr. Dyer then submitted the strips to the action of the flame.) As you see, the untreated material readily ignites and burns, whilst the treated material appears to be only charred. Taking a second pair of strips and suddenly removing the flame it will be found that the untreated wood continues to burn, while the treated remains black, thus conclusively proving that as far as inflammability is concerned it answers very well, or as well as we could hope for. I am told the preparation is easily applied. Fence posts as used in Calcutta, after being immersed in a 25 per cent. solution for thirty-six hours and then dried and fixed in the ground, have remained immune from the attacks of insects and white ants during a period of two years: and what a white ant refuses to eat must be something very indigestible. Its cost, I am informed, is very moderate considering the advantages it appears to possess. Mr. Farenden asked whether the rotting was confined to white pine. I do not think white pine, which term is used to denote what is known as *pinus strobus*, and which is grown chiefly in North America, is more immune than the red pines, white firs, or deal timber which come from Norway, Sweden and Russia, and which, on account of their cheapness, are more largely used. Certainly they do not always get the seasoning they should have. One to two years' seasoning under shelter roofs, allowing free ventilation, is necessary to evaporate the water and dry the liquids contained in the cellular structure, as timber, like most organic substances, contains a considerable proportion by weight of water free and combined. About eight or nine years ago 30 per cent. of the white pine cut in America was imported here ; to-day, in many places, it is practically unobtainable. With regard to the remarks of Mr. Milton and Mr. J. Robertson, who stated that they were of opinion that the bruising and tearing of the fibres by the use of nails was one of the causes of deterioration in their vicinity, as the bruising allowed of the freer admission of moisture, I quite agree that this is a probable cause after Mr. Milton's explanation of what takes place when a nail is driven into wood. We have to ask ourselves, why does a nail hold in wood ? i.e., why does it require more force to withdraw a properly driven nail than was used in driving it ? Of course I am not speaking of the old cut nail which was wedge-shaped and crushed the fibres apart the deeper it was driven, but of the ordinary modern nail known as the French nail, which, although a beautiful production, smooth, highly polished and burnished and parallel throughout its length excepting the extreme point, yet holds very well. Mr. Milton explains it as follows :—

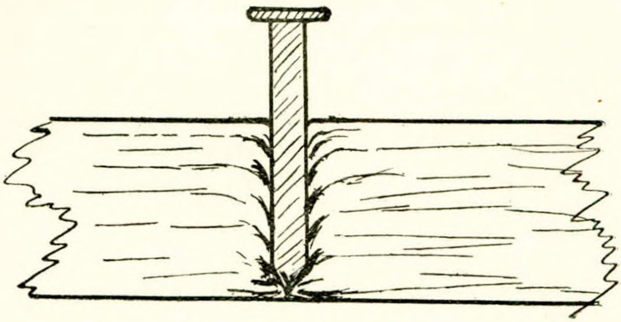


FIG. 1.

The nail, on being forced in, tears and draws the adjacent fibre in its progress as shown, and by the elasticity of the timber a series of barbs press on the surface of the nail, which thus becomes locked in the same way as if a series of pawls were acting on a capstan wheel, or as an arrow or fish-hook head when once it has struck in. This, although a very minor point, becomes in the aggregate a large factor when the number of fastenings used for constructional purposes is considered, and the point is worthy of attention, without mentioning the effects of the finishing taps of the hammer on the surface of the wood. We can thus see that wherever a nail is driven, the wood adjacent is torn and rended, and makes a nest or breeding-place for the spores to start in. Mr. Brand spoke of the drip from brine pipes causing decay. I think we might confine that entirely to the moisture due to thawing off, or where higher temperatures are carried as in cheese chambers. In all installations leaky brine pipes can never be tolerated, as they would destroy any cargo if they came above it, but the thawing-off is responsible for most of the rapid decay which is prevalent in the outer linings, especially in the first layer of outer linings where the air cannot get at it to dry it. To properly thaw off and clear up a refrigerated compartment is work that requires considerable attention and labour. The snow as it falls from the brine grids must not be allowed to accumulate on the hold floor. Although a certain quantity of sawdust may be laid to absorb it, the sawdust speedily gets saturated and communicates the moisture to the linings. Every particle of snow should be cleared away. There is a solution of the unemployed question which has received so much attention of late, and one which will afford employment to a large number of unskilled labourers under the direction of a few experts, a method which is free from that objectionable form of work of which we have seen so many examples of late as a temporary respite, such as excavating model lakes and work of that description. I refer to the afforestation of the large tracts and areas of waste lands we have in our country. I should like to point out the necessity and the benefit that this country can obtain by thus utilizing at once the labour now available and adding to the supply of timber which is becoming more scarce year by year, and thus increasing the wealth of the land which is the wealth of the country.

CHAIRMAN : We are obliged to Mr. Dyer for his remarks and for the experiments he has made. The latter have been very interesting, and I am sure we would all be pleased to know whether this treated wood, which stands against fire, will stand against fungi of all kinds, the action of bilge water and other sources of decay.

Mr. DYER : I am not in a position to answer that ; I am only given to understand that it withstood the effects of the ants in tropical climates. Of course the non-inflammability of the wood is the chief point, but I should be inclined to think that organic substances that do not burn readily would be indigestible to microbes.

Mr. J. H. SILLEY (Member of Council) : Might I ask if the preparation is just put on with a brush ?

Mr. DYER : I believe the material treated is soaked for a certain length of time ; I was told that a section of wood, about 12 in., × 8 in., or about the size of an ordinary hatch coaming, required soaking for about twenty-four to thirty hours.

Mr. SILLEY : Then the wood would have to be treated before being used at all ? that is to say, it would have to be treated before being put on board, and not merely painted over when in position ?

Mr. Dyer : It would have to be soaked before being put in position. It would probably have some good effects if several coats were painted on it, but the effect would not be very great, as it would not have a chance of getting right into the wood.

Mr. Robt. Balfour (Member) : The points that are easily got at are not the points which require the greatest attention. It is the hermetically sealed parts, that is, the first linings at the grounds, that should be treated primarily to the structure of the installation.

Mr. Dyer : That is quite correct ; it is in the inner linings at the grounds where we find most of the decay sets in. It would be a very bad case where the outside linings would require to be treated for decay, caused, probably, by drip from the brine pipes, or rain, with an uncovered hatch.

Mr. Balfour : Have you any idea how far the solution penetrates into the section ? For instance, how far would it penetrate into 6 in. × $2\frac{1}{2}$ in. or 8 in. × 3 in. grounds ?

Mr. Dyer : This strip that I experimented with was cut from a plank about 1 inch thick and soaked for about three to four hours.

Mr. Balfour : Experience shows that the action of decay goes on from the ends, and as the timber has to be sawn up in section, what do you propose to do to ensure that the decay will not start from the ends ? would it not be absolutely essential in that case for the solution to penetrate right through the wood ?

Mr. J. T. Milton (Member of Council) : Would you make it clear whether these strips were treated as strips or sawn off a treated plank.

Mr. Dyer : I believe the strip was cut off from the treated board.

Mr. Milton : If they were treated as strips they would be very different to strips sawn off a treated board. It may be that the solution penetrates only a short distance from the surface, in which case it may be that the strip would be soaked throughout, but not the board. It is only necessary that the surface should not catch fire if you wish to make it fire-proof, but to make wood rot-proof, surface treatment is worth very little, the solution must go right through.

Mr. Balfour: Or something might be applied to the ends after the wood is sawn.

Mr. Dyer: Of course it is entirely a matter of time taken for soaking, but I believe the plan adopted in each case is to soak the wood right through; the time required for soaking would, of course, depend upon the thickness of the timber.

Mr. R. Morrison (Member): It would mean enormous expense for the boards to be dipped before being put in position.

Mr. Dyer: I am told it would cost, roughly, about 25 per cent. on the cost of the wood. Speaking generally, £100 worth of wood would cost about £125 after being treated.

Mr. Morrison: Do you include in that the extra time and labour required?

Mr. Dyer: That would include the drying of the wood.

Mr. Morrison: Not the extra time for fitting it?

Mr. Dyer: There would be no difference in the fitting, but there would be the labour involved in immersing it in the troughs.

Mr. Morrison: If there was a contract for, say, 300,000 cubic feet of wood, it would take a lot of time before it was all soaked.

Mr. Dyer: No, I was told about twenty-four hours was the average time required for dealing with the wood, and that it could be used twenty-four hours after it was treated.

Mr. Milton: But you could not deal with 300,000 cubic feet of wood without starting months beforehand.

Mr. Dyer: I suppose in some yards they would stock it and have it ready. Some profess to keep it for years.

Mr. Robertson: Might I ask if the preparation would have any bad effect upon the wood after it was treated; if it would make it brittle or sensitive in any way?

Mr. Dyer: I do not believe it affects it except to make the surface harder and less liable to be bruised. It has been applied for use in H. M. Navy for whitening the decks. For outside linings the hardened surface would be a good property for wood to have as we all know how roughly it is used sometimes.

Mr. R. Balfour: In respect of the quantity of timber mentioned, timber usually varies for this class of work from 16 to 18 feet in length, particularly for matching, and a bath could easily be fitted up so that a cart-load or more could be treated with the preparation at a time. Can that be done in the yard where the wood is getting seasoned?

Mr. Dyer: It could be treated on board the ship if the ends only were required to be done: they would simply need to be dipped into a cask containing the preparation.

Mr. Balfour: I was referring to the original treatment of the wood in the works first, the question of dealing quickly with orders for large quantities. For instance, if three loads were ordered, the three loads could be treated altogether in the twenty-four hours.

Mr. Dyer: Yes, if the bath were large enough.

Mr. A. Robertson (Member): Would it accelerate the treatment if the wood were subjected to pressure?

Mr. Dyer: I should think it would; Mr. Brand referred to such a process at the meeting when the paper was read. In that case, of course, comparatively elaborate apparatus would be required to force it in, air pumps or force pumps and cylinders capable of withstanding the pressure.

Mr. Robertson: It would probably save time when large quantities of wood were being treated.

Mr. Dyer: Yes, but considering the time supposed to be taken to "cure" this wood, I do not think there would be much gain in it. Again, some time would be taken in putting the wood into and withdrawing it from the cylinder.

Mr. B. H. Budding (Member): Is it absolutely necessary that the chambers should be constructed of wood? would it not be possible for some other material to take its place?

There seem to be objections as to the method of putting it up: iron nails damage the wood and cause decay; brass screws or nails cause verdigris, which also would lead to trouble with some of the edible cargoes. Is there no other material that could be used to take the place of wood for the inner linings?

Mr. Dyer: Yes, if we could produce something that could be attached firmly and would stand the rough usage that the linings have to sustain. Any other composition commercially as cheap would do, but the great factor with wood is that it is the cheapest thing to use. The wood is not insulation, it is simply used to hold the insulating material and at the same time to withstand the rough treatment, not only in connexion with the refrigerated cargoes, but with the outward cargo, often heavy materials such as rail iron, scrap iron and coal.

Mr. Budding: But I should think it would be possible to make the inner and outer casing of some other material than wood, the tremendous weight and space occupied by which cause a lot of room to be wasted. Is it not possible to use an inner casing of very light material and a substantial outer casing?

Mr. Dyer: Any material for the inside lining used with the other lining would require the same strength as the double linings. There may be other substances that would answer, possibly there might be something suitable that you might have heard of.

Mr. Budding: Silicate wool and asbestos boards are used for keeping the heat in; would they not be ample for keeping the cold in?

Mr. Dyer: Those are used for insulation, but the wood is used to keep the insulation in place; we do not look upon it as an insulator at all.

Mr. Balfour: May I ask how the last speaker would support the linings he speaks of, and of what material the supports would be made?

Mr. Budding: There are many ways of putting struts in;

they might be of iron and used similarly to those used in buildings on land.

Mr. Balfour: But would not the conductivity of the iron have to be considered?

Mr. Budding: If the iron struts were embedded in the composition used so as to form a bond for the structure and also to act as struts, the loss by conductivity would not be appreciable.

Mr. F. M. Timpson (Member): Would not hemlock wood be suitable for the purpose? The wharves in the harbour at St. John, New Brunswick, are constructed of hemlock, and I was told when out there that it was a very good wood. It is a cheap wood, and some sleepers made of it were taken out to Barbadoes, where they withstood the attacks of insects. It is, or was, generally used for wharf piles, etc., at St. John, and of course in that district they get severe frosts in winter and hot weather in summer, and there is also a big rise and fall in tide which produces alternate wet and dry effect. I believe the wood is fairly plentiful.

Mr. Dyer: Hemlock is a species of American larch. Our larch wood has much the same properties, and I believe hemlock is a very analogous kind of wood. I believe it is a very good wood; the only question is whether it would be commercially profitable to bring it across from Canada, and whether it is of sufficient size to cut up for the purposes of insulation?

Mr. Timpson: It makes whole wharves, so it must be of good size. What made me think of it was the fact that there seems to be a lack of wood in the market, and ten or twelve years ago, at any rate, there was an abundant supply of this wood.

Mr. Dyer: Many of the woods which were neglected ten or twelve years ago are greatly sought after now, and woods that are even now considered unsuitable will be sought after very soon.

Mr. Morrison: What is the weight of hemlock as compared with white pine?

Mr. Timpson: The weights are very much the same, but as there are poisonous extracts made from the hemlock, I do not know whether that fact affects the suitability of the wood for meat chambers.

Mr. Dyer: I think we may be quite satisfied that there are no poisonous properties in the wood itself; all the poison is confined to the fruit, the wood is not harmful.

Chairman: Is the preparation you mentioned poisonous?

Mr. Dyer: I am not aware of any poisonous attributes. Of course most things are poisonous more or less that prevent the action of bacteria and fungi, but it is not poisonous in the sense of giving out poison to the meat.

Mr. Balfour: One great point is to get a solution that will prevent the starting of decay at the ends where the wood is sawn in the holds of the vessel under construction. If the inventor of an antidote to this trouble will assure us that there is a means of producing the same effect on the ends of the wood when it is sawn up in course of construction on board the vessel—that is, having regard to the impregnation of the wood—it will go a long way towards solving the problem.

Mr. Dyer: If the wood is impregnated throughout, of course that would not be necessary.

Mr. Milton: May I ask Mr. Balfour and Mr. Dyer whether, in case anything could be found to make wood durable, it would be possible to put less wood in? Would the grounds have to be so big?

Mr. Balfour: In the majority of cases I think they would still have to be the same size.

Mr. Milton: But in the over-heading all you would have to do would be to fix up the lining to carry the weight of the charcoal or other insulating material.

Mr. Balfour: I am afraid not, the nails themselves give way from the end section.

Mr. Dyer: The wood gets nail sick.

Mr. Milton: But preserved wood would not get nail sickness.

Mr. Balfour: There is decay in addition to that.

Mr. Milton: But I am supposing there is no decay.

Mr. Balfour: If there is a bulb beam the shape of the wood to project over, the bulb sometimes demands an extra thickness. In a channel beam it might be reduced from $2\frac{1}{2}$ to 2 inches.

Mr. Morrison: Might I ask Mr. Balfour if he has any experience of treated wood, or if he has seen it fitted where it has stood better than the wood used at present?

Mr. Balfour: All I am advocating, in connexion with some of the substances brought before us at the recent Refrigerating Industries Congress at Paris, is that they might be given a trial. We are not in a position to give it a trial, and I can only suggest that those who have the power should do so. If we had some bilge hatches lined underneath with the treated wood, and the adjacent hatches lined in the ordinary way, there would be a fair comparison, and the results would speak for themselves.

Mr. Silley: I think it would be interesting if a hatch were given one or two coatings of this preparation and the result at the end of a voyage compared with the ordinary hatch. It would not be so expensive an experiment as providing a new hatch.

Mr. Dyer: That is for the owners to say; we have no power to recommend any composition, and we can guarantee nothing. We only invite them to allow the experiment to be tried, and I think it would be for the benefit of all if it turned out well.

Mr. Balfour: There are three or four processes in the market. There are different kinds of paints for use on ships' bottoms, and they get a fair trial, and I think it is quite as necessary to see if any of these preparations will help to minimize the great expense incurred.

Mr. Morrison: We hear a lot about these experiments, but they do not get beyond the experimental stage as a rule. However, I am perfectly willing to allow Mr. Balfour to experiment on our ships if he chooses, and to use any patent he likes and to what extent he likes.

The Hon. Secretary: The address recently given by the President of the Liverpool Engineering Society was a very interesting one, and was also a very impressive one, not only for engineers, but for the whole country, as showing the importance to which the refrigerating trade has attained and is increasingly attaining at the present day. We all know the economics of the subject which Mr. Dyer has kindly brought before us, and I apprehend that every one realizes the difficulty of treating wood so as to avoid the current expenses of every voyage in connexion with repairs and renewals. Mr. Budding has referred to what might be done with other substances. There is a material which has been brought before us quite recently. I do not know what properties it has as an insulator, but it is being used now for covering iron decks instead of wood, and I was wondering if it could not be utilized in place of wood in the neighbourhood of the bilges, where we find the greatest decay going on. I hoped representatives would have been here to-night, to have answered any questions on the subject of these materials, so that we might have some information to guide us. Perhaps it would be well, in view of the discussion and the open mind we have upon the subject, to get a few particulars from the makers in regard to the various substances, with the object of seeing if any could be utilized as insulators. Possibly Mr. Brand, in his remarks at the last meeting, meant the decay of the woodwork in the presence of brine water; I do not think he referred actually to the sweating or thawing-off of the pipes, but that it was the brine itself he referred to; at the time, the impression was that he thought the brine may be an active agent in causing the decay of the wood. Since our last meeting I have been told by one who is interested in the paper trade that a microbe has appeared in connexion with the wood used for paper-making, and he told me of a serious loss sustained on the appearance of this microbe. The matter is now being investigated in some of the leading laboratories, and I was in hope of having a communication from him saying how far they were able to discover the nature and the cause of the appearance of the trouble. I understand when wood is prepared for paper-making, it is treated under water, under a considerable head of water pressure, and the wood is ground to pulp under this pressure, after which it goes through various processes until it becomes paper, and the microbe or species of fungus actually went through all this and appeared in the paper after it was made up, leading to the loss. That being so, it shows that not only are we as engineers interested in this matter of the wood being attacked by microbes, but that other industries are quite alive to the importance of getting a preservative to resist the action of these destructive organisms. I understand one or two experiments have recently been made showing how a piece of decayed wood, put between two pieces of sound wood, actually caused the sound wood to decay after a certain specified time. I do not know whether the experiments have been carried on to such an extent as will enable us to have the results put forward to-night.

With regard to tree planting, several proprietors and the Arboricultural Society have been working in this direction.

Mr. Dyer: I believe that some perfectly sound wood, being placed in contact with wood already well infected, showed traces of decay in a fortnight. The test was made at a temperature of 75° F. and in a moist atmosphere. The sound pieces of wood on either side showed distinct traces of action having commenced within the fortnight, showing how rapidly these organisms can propagate themselves. Mr. Adamson referred to Mr. Brand meaning that the brine water was a possible source of decay. I do not know what Mr. Brand's experience has been, but I do not think we have ever had experience of brine water running over the insulation sufficiently long to cause decay. I do not know whether Mr. Balfour has seen any, but in the work under my notice I have never had that brought before me. I do not think it could very well effect decay, as I do not think it is favourable to the growth of anything. It may, of course, if the brine is very weak and not up to the requisite strength. In respect to preparations of the class referred to as for ships' decks, I believe the great difficulty is to get them to adhere to the deck in many cases, and I do not know but that there might be trouble in getting them to adhere to woodwork. There is the possibility also, I should think, of a space being formed between the composition and the wood which would be a breeding-place for any decay to start in. The point that Mr. Adamson mentioned with regard to the appearance of the microbe in the paper is certainly very interesting. It is a serious matter, and if anything is discovered that will prevent its action it will be the thing we are wanting, so that in time we may have a perfect preventive.

Mr. Morrison : If the story of the decayed piece of wood causing the two sound pieces to decay is correct, what is the benefit of treating the wood chemically ? If the microbe is going to start from the centre we are just as well off as before.

Mr. Dyer : This was not treated wood.

Mr. Morrison : No, but I take it the microbe began from the centre and worked out.

Mr. Dyer : The affected wood was placed in the centre between the two sound pieces and the whole lot screwed together.

Mr. Morrison : And your point is that if the wood were chemically treated there would be no microbes in it at all ?

Mr. Dyer : No microbe could live on or in the wood.

Mr. Balfour : With reference to Mr. Adamson's remarks regarding patent compositions which have been used for the purpose mentioned, I do not want to condemn such, but the result has been in some cases, when placed on the deck and the deck becomes warm, the composition rises in places as much as 3 or 4 inches from the deck. A boat to which one composition has just been applied left port recently, and we are waiting to know the results. These compositions are apt to rise in places according to the temperature, but of course in dealing with holds we do not look for excessively high temperatures, and it would hardly be fair to condemn such a substance although it may rise when placed on decks and under very hot conditions. In examining the holds on the ship I referred to, I noticed that on the margins next the ribbons there was a strip of composition, and in the course of a few months I shall be able to ascertain the result. Decidedly there is a great deal in what was said in reference to the necessity for some suitable substance for the bilge, but the question is, what is the base to be composed of ? If it is a wood base there is the same trouble again. It is the bilge that requires most attention.

Mr. Silley : I understand in some cases where such compositions are used Z bars are applied to bind it together and keep it down. They had to do this to keep the substance from rising from the deck. I have seen it rise several inches.

Mr. Robertson: Are any of these substances used as insulating material?

Mr. Balfour: I referred to two strips along the margins of the bottom insulation. I might mention that in a well-known line sailing out of London the ribbons gave a considerable amount of trouble, and the strips of composition have been put in instead of the insulation that was formerly used. This is said to have given good results.

Mr. Morrison: Do you mean instead of the woodwork in the insulated holds?

Mr. Dyer: The position Mr. Balfour refers to is as per sketch.

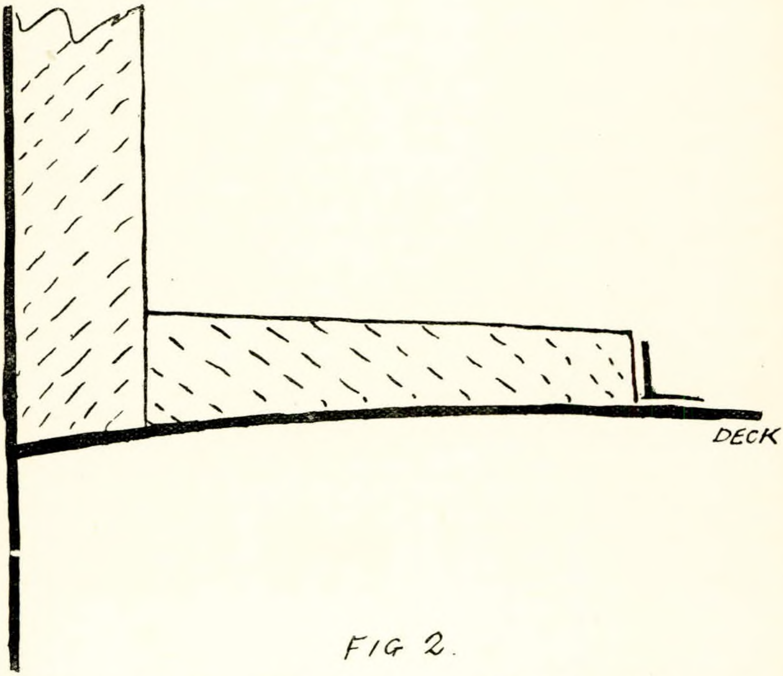


FIG 2.

Mr. Balfour: With the ordinary insulation the water sometimes collected just at the edge and saturated the non-conducting material.

The Hon. Secretary: Is there any insulating property in connexion with it?

Mr. Balfour : I believe the makers claim there is.

Mr. A. Robertson : Mr. Dyer's paper deals more particularly with timber as used in marine installations, but it might be of interest to refer to a material called "Corkstone," of which there are two different varieties, "Reform" and "Emulgit." It is impregnated with different solutions, and after being impregnated with one solution it is suitable for temperatures from centigrade zero to 20° below, while the other is used for temperatures from zero to 150° C. It is very largely used for cold storage ashore, nailed on to a wood background, but I hardly think it would be suitable for use on board ship, as the ship does not usually carry a frozen cargo both ways. If any other cargo is used the Corkstone is liable to get damaged unless it is covered with wood.

Mr. C. A. Flower (Member) : I have not had the pleasure of hearing the paper read, but I should like to ask the author whether a preparation called formalin spread on the chambers does not help to prevent fungi forming ? I believe experiments have been made in some ships in the chambers to see if this won't keep down the fungi.

Mr. Dyer : As far as I know it does answer all that has been asked from it in the way of preventing any decay going on where the formalin is in contact with the substance. Of course we cannot treat the inner linings with it, but as far as the surface is concerned, it appears to prevent decay.

Mr. Flower : If it were used in the upper parts of the hold, between the brine pipes and the outer lining of the wood, it might be of some effect. I have noticed a great deal of decay in that part in different ships.

Mr. Dyer : Due to the intense cold of the brine pipes adjacent to the wood.

Mr. Flower : I understand where it is used in cold storage it has a great effect in preserving the outer lining of the installation.

Mr. Dyer : There is not the least doubt that it would have a good effect.

Mr. Milton : But is not formalin a volatile substance ?

It might kill the germs on the surface, but the next day it is gone.

Mr. Dyer : Of course it is simply a vapour, but I presume Mr. Flower means this would be done for every fresh cargo ; it would not last more than one trip.

Mr. Balfour : I was on a ship recently where the wood was treated by vaporizing with formalin. The method is to circulate air by fans over a formalin bath, the air carrying off the vaporized formalin with it through the chamber. This is done before the meat goes into the chamber on shore. Before the meat is taken on board the ship the chambers are similarly treated with the formalin to kill any microbes, and being gaseous, it is of a most searching nature.

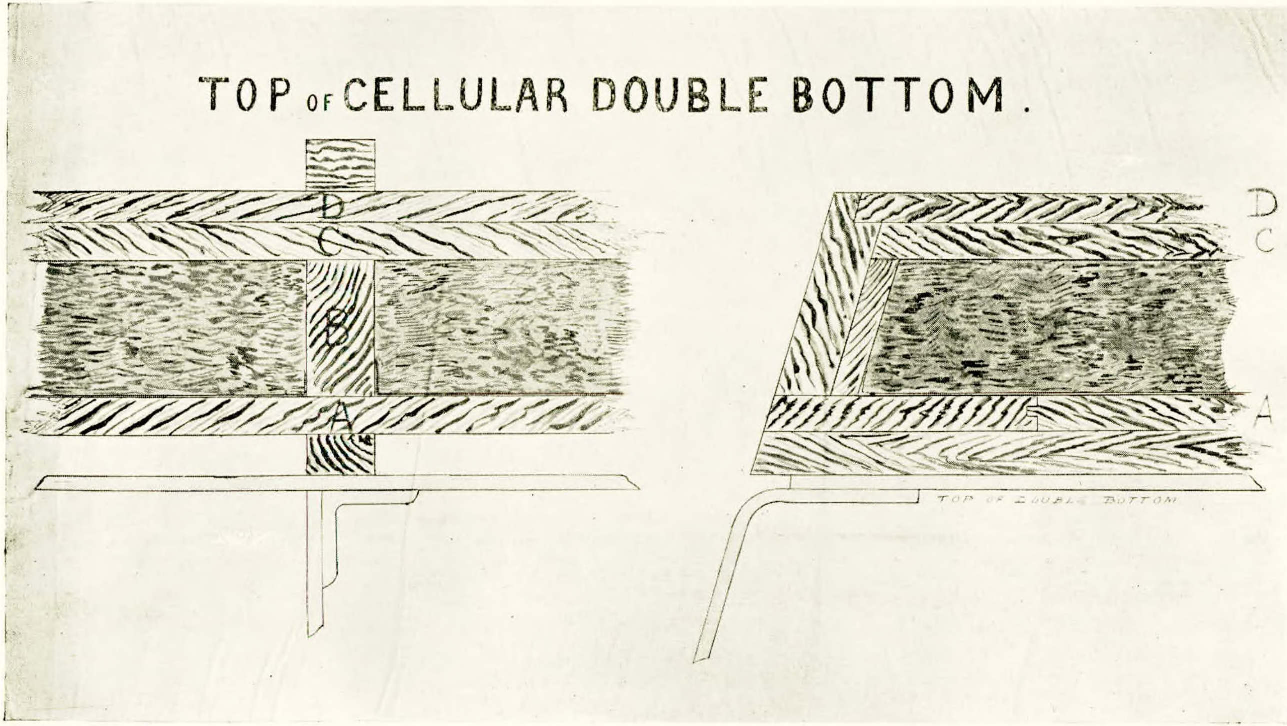
The Hon. Secretary : Is it not very inflammable ?

Mr. Dyer : Yes, I suppose it is, but being so very volatile it kills all the existing microbes, and even if you were to close the hold up almost immediately afterwards there would be nothing left to burn. It does its work and vanishes. But it does not penetrate into the wood, it will only prevent any evil that is about to commence due to the presence of fungi.

Chairman : I think we have had a very fair discussion on Mr. Dyer's paper to-night. There is an old saying that we are dying from the time we are born, and apparently the same thing applies in this case. We put wood into the ships for insulation work, and from the minute it goes in it begins to work its way out to its latter end. The solution of the problem of how to stop this decay is the chief interest we have in Mr. Dyer's paper. We have heard of several preparations for impregnation of the wood ; it is now for those interested to see which is the best, and as has been pointed out, it lies with superintendent engineers who have the power to permit these experiments, to endeavour to prove which is the best by actual tests.

Mr. Dyer : I should like to express my thanks for the kind attention given me, and I hope the remarks this paper has brought forward will result in some good being obtained. I think this subject is one which demands attention. The wood is going, and there will be a greater scarcity soon if we go on as we are and if we waste it as we do, unless some means are taken to preserve the wood already in use. In fact we should create new wood. I think, as I said, this is one solution of the unemployed problem. We have a large number of unemployed, and the afforestation of the waste tracts of England is a matter which is really worth taking up. The nation itself should take up the matter, other nations are doing so, and it is only the Government that could properly deal with it, it is not a matter to be left with the private proprietor.

A vote of thanks was accorded to Mr. Dyer on the proposal of Mr. Silley, seconded by Mr. Flower, and to the Chairman, seconded by Mr. Morrison.


TOP OF CELLULAR DOUBLE BOTTOM.
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RETURN AIR DUCT OVER HDC
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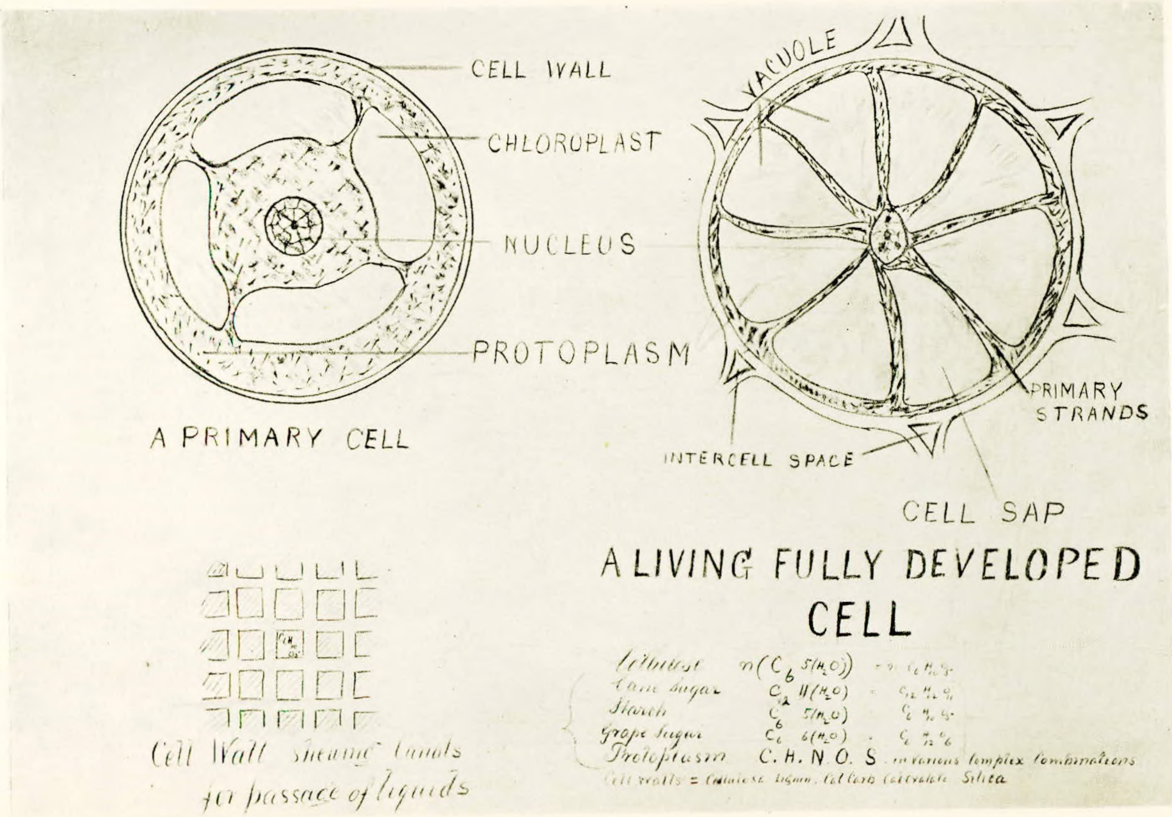

CELL WALL
CHLOROPLAST
NUCLEUS
PROTOPLASM
A PRIMARY CELL
VACUOLE
PRIMARY STRANDS
INTERCELL SPACE
CELL SAP
A LIVING FULLY DEVELOPED CELL
Starch $C_6\ 5(H_2O)$ $C_6H_{10}O_5$
Grape Sugar $C_6\ 6(H_2O)$ $C_6H_{12}O_6$
Protoplasm C. H. N. O. S in various complex combinations
Cell Wall showing Canals for passage of liquids

President: James Denny, Esq.

Lecture on Scientific Boiler Control.

By Mr. G. A. H. BINZ.

DELIVERED AT

The Institute Premises, 58, Romford Road,

On Monday, November 9, 1908.

Chairman:—Mr. J. T. MILTON (Member of Council).

Chairman: To-night we are to be favoured with a lecture from Mr. Binz on Scientific Boiler Control. It needs no words from me to interest a meeting of marine engineers in any question referring to the use of the boilers with which they are every day familiar. When one remembers the immense cost of the coal passing through the boilers every day, one can realize at once how very important it is to get the most out of the coal, and if Mr. Binz will show how this is to be done, I am sure you will be pleased to listen to him. I shall now call upon Mr. Binz to give his lecture.

When, some six months ago, you extended to me your kind invitation to read before your valued Institute to-night this lecture on scientific controlling devices for boilers, that invitation was gladly accepted, because experiments which were then in progress, and which had for their object the perfecting of certain special types of apparatus expressly for Marine work, promised to be completed successfully long before this. Unfortunately, however, unforeseen difficulties arose which have rather delayed matters, and instead of being able to confine my remarks, as far as the practical side is concerned, to experience with these special Marine machines, as I had hoped, I must be content to rely for my practical data principally upon experience gained in installations on land. I am able, however, to inform you that practical apparatus for Marine work of the type with which I propose to deal is now being constructed, and if Marine Engineers will but encourage designers by giving the subject the attention which it undoubtedly deserves, should shortly be found in successful operation on many of our ships. Whilst my paper will, therefore, not actually include detailed descriptions of adaptations of the apparatus in question, specially for Marine work, it will deal, in a general way, with a topic which concerns Marine Engineers certainly quite as much as their confrères on land, and I trust it will for this reason be none the less interesting.

Science, as you are aware, has in later years forced its way gradually into many of those fields of engineering practice which we had been formerly content to regard as purely and entirely practical, and we cannot deny that the movement in favour of scientific guidance and assistance in the execution of practical tasks has resulted in increased economy and efficiency in many ways. This general desire to abolish as much as possible rule of thumb methods and to turn to good account the many and valuable fruits of more recent scientific research is unquestionably responsible to a considerable extent for the amount of attention which is just at present being bestowed upon steam boilers and their furnaces. But few who have studied the subject will disagree with me when I say that steam boilers really needed this attention more than any other portion of a power plant. I go further to affirm that, although the boilers and furnaces themselves have been very much improved of late, there is still considerable scope for improvement in the methods adopted to convert the coal or other fuel thrown upon the grate into steam; it is to this special phase of the subject that I propose to devote my subsequent remarks. For years past the great bulk of steam users, with few notable exceptions, has been content to leave the problem of stoking almost entirely in the hands of the fireman, who was (and is by many to-day) supposed to be fully capable of dealing with so complex a material as coal undoubtedly is, entirely by virtue of his experience, which consists principally of following more or less faithfully in the footsteps of those before him, who, if it were possible, knew even less about what actually takes place within a boiler furnace, than himself. Nobody would ever seriously suggest that a good stoker should be able to tell his steam pressure without the use of a pressure gauge, and yet the idea is pretty general that this same stoker should be able to judge whether he is using the correct draught pressure and the right thickness of fire, whether he is feeding coal at the proper rate and whether he is obtaining the correct furnace and exit temperatures, simply by looking at his fire. That experience without guidance cannot teach these things, and that the difference between good and bad stoking is anyhow sufficiently alarming to warrant careful investigation, is perhaps best shown by the following remarks offered by Mr. W. Francis Goodrich in a paper read last year before the Association of Engineers-in-Charge.

He said: "Many trials have clearly shown that there is a vast difference in the results obtained by firemen, even when burning similar fuel and meeting a similar demand for steam. Firing the same boiler in turn, burning a similar fuel, and evaporating the same weight of water, it has been shown that the most inefficient of five different men has burned 29 per cent. more fuel than the best of the five firemen, there being such a marked difference in the results obtained between the best of the five and the four others, that the only possible course was to discharge the latter, who had demonstrated that they would waste or lose far more than they earned every week." This is an experience which will no doubt be borne out by many of you who daily handle firemen and could possibly relate similar or even more striking instances, such as for instance the winning of stoking competitions on the leading English railways by mere novices against old experienced men, and many others. Granting, therefore, that some scientific guide or indicator would be of real value to the man in charge, our next point is to investigate in what direction this is most likely to be found, and found in a shape which will be really practical and also simple in its application. As the burning of fuel in a furnace is purely a chemical process, it is not surprising that those in search of a remedy for existing conditions should have turned to Chemistry for it, where it has indeed been found in a continuous and automatic analysis of the products of combustion.

I am fully aware that the practical engineer is not anxious to be led into a labyrinth of chemical terms and symbols, which mean nothing to him—and I cannot myself confess to any particular affinity for them. I propose, therefore, to deal with the chemical side of the subject only in so far as it is necessary to explain the methods which I wish to bring to your notice, and as far as it forms a necessary part of the practical side of the matter. I mentioned just now that the remedy I wish to advocate is a continuous and automatic analysis of the products of combustion, and you will have gathered from this that I do not suggest that you should erect a laboratory in your stokehold, and instal therein a "full-blown chemist" to teach you what to do with your boilers. This would, of course, be impracticable, and it is not necessary; there are now to be had so-called Co_2 recorders, instruments which produce practically automatically a certain number of records per hour of at least one of the products of combustion, and the most important one, that which the chemist is pleased to term CO_2. You have heard of these CO_2 recorders, and you have probably wondered whether they are of any practical value to the firemen and engineers-in-charge. I hope to show you that they are, and what is more, that they must be considered, to use the words of a recent lecturer before the Institution of Civil Engineers, "quite as indispensable to the working of boilers as a steam engine indicator is to the care of engines." To prove my case I must needs explain first the meaning of the term CO_2, and the bearing of this constituent of the furnace gases upon the degree of efficiency of combustion. CO_2 stands for carbon dioxide, i.e. a compound of carbon $=$ C, and oxygen $=$ O, in chemical union in the proportion of one part of carbon to two of oxygen. We need not stop to fathom exactly what chemical union embodies; suffice it to say that CO_2 is formed when carbon, such as for instance the principal constituent of coal, is brought into intimate contact with a sufficiency of oxygen, as is done by forcing air over the grate in a boiler furnace, in the presence of a sufficiently high temperature. This chemical union is nothing more nor less than combustion, and this of itself explains the importance of reliable information about the percentage of this CO_2 gas present in the exit gases which pass to the stack. But let us examine further: The carbon in the coal (I do not deal with its many other constituents, as they do not affect us materially here) is not always burned to CO_2; it may be changed only to CO, or carbon monoxide, which is a chemical compound of carbon and oxygen in equal proportion. Or any particle of CO_2 may be re-transformed into CO, if it should, in its passage through the fire-bed and flues to the chimney, come in contact with atoms of highly heated carbon. Now both CO_2 and CO are colourless gases, and the proportion in which they are present in the furnace gases can only be determined by chemical analysis.

The following figures will show how important it is to those who would have their boilers operate economically and efficiently that such analyses be made constantly. A pound of dry carbon burned entirely to CO_2 gives us heat equal to 14,000 B.T.U., whereas the same weight of the same carbon burned to CO only yields 4,450 B.T.U. It follows at once that if we discover a low percentage of CO_2 in our exit gases, we must be losing a lot of the heat which should be transmitted to the water in the boiler, and inversely a high percentage of CO_2 should mean that we have secured the transmission of most of the heat generated by the combustion of the fuel to CO_2. Generally speaking, this has been proved to be true in practice. Two factors must, however, be taken into consideration if the conclusions formed from an estimation of the CO_2 contents of the exit gases are not to mislead us slightly. These are the presence of CO, when the percentage of CO_2 is high, and the temperature of the gases at the stack. Considering, as shown by above figures, that CO is a heat-absorber, appropriating as a matter of fact some 10,150 B.T.U. per pound of carbon from every particle of CO_2 which is reconverted into CO, it is obvious that it would be little use to produce a set of conditions which, whilst securing a high percentage of CO_2, also has a tendency to encourage the presence of CO in appreciable quantities. Although it is not at the present moment practicable to construct continuous recording machines for the estimation of CO—and occasional snap tests are of little value—this danger of CO may be readily guarded against.

As mentioned, CO is formed in the first place where sufficient oxygen is not available to complete the oxydizing or burning process, and form CO_2. It follows that all we have to do to prevent this initial formation is to admit sufficient air to ensure an ample supply of oxygen. As the rate of combustion in average plants in our present-day furnaces already demands an excess of air, if steam is to be kept up, cases of too little air are comparatively scarce. Moreover where the formation of CO is due to a shortage of air supply, the fact will be indicated by a low percentage of CO_2 shown by the CO_2 recorder. There remains the question of a transformation of CO_2 back to CO in its passage to the stack. This possibility has been shown to be comparatively remote, so long as the percentage of CO_2, as shown by the recorder, is not more than 14–15 per cent. The formation of CO under these conditions is most probably due to a low velocity of the gases in the furnace at a high temperature, which encourages contact of particles of CO_2 with highly heated carbon. Such conditions are decidedly undesirable; they are, however, very rare in practice, as they are only possible where the duty on the boilers is very light. We have thus established that we may safely accept the guidance of the CO_2 record, provided that we do not strive to attain results averaging more than 14–15 per cent. of CO_2.

Before showing now what it really means in figures to have a low, or on the other hand, to have a high percentage of CO_2 showing on the chart of a CO_2 recorder, I must add a few remarks regarding the temperature of the stack gases. Since economizers have become popular, at least with land installations, it is often erroneously considered an advantage to show a high temperature in the flues leading to the economizer. It is pointed out that this will mean a higher temperature for the water in the economizer, and the fact is quite overlooked that had the heat been utilized in the boiler itself, the total efficiency would have been much greater. I use this illustration to emphasize the importance of continuous records of the temperature of the exit gases, which temperature should be kept at the lowest obtainable limit consistent with a good draught, for this reason. A high temperature at the stack, which shows that a large proportion of the heat which should have been transmitted to the boiler is being wasted, is due either to conditions unfavourable to complete combustion of the fuel and the gases given off by it immediately over the grate, or to too high a draught pressure, causing the gases to travel at so high a velocity as not to allow the boiler sufficient time to absorb all or most of the heat carried in them. As far as the first cause is concerned, this would in all cases be clearly indicated on the CO_2 recorder by a bad record, but the latter possibility, though comparatively remote, renders it desirable for me to advise consideration of the temperature of the exit gases in addition to the analysis of their percentage of CO_2.

Let us now consider the losses actually occasioned in a boiler furnace in relation to the greater or less attention paid to the CO_2 contents, and the temperature of the exit gases. The following are figures computed from actual experiments by Mr. O. L. Peard in one of the large London power plants. Mr. Peard assumes an average coal to yield 14,000 B.T.U., which you will probably consider a little high; however, this will not affect the value of the figures for purposes of comparison :—

With 5 per cent. of CO_2 at 500° F. the loss is 35 per cent.; at 400° F., loss is 28 per cent.

With 7 per cent. of CO_2 at 500° F. the loss is 25½ per cent.; at 400° F., loss is 20 per cent.

With 10 per cent. of CO_2 at 500° F. the loss is 18 per cent.; at 400° F., loss is 14½ per cent.

With 12 per cent. of CO_2 at 500° F. the loss is 15½ per cent.; at 400° F., loss is 12½ per cent.

With 14 per cent. of CO_2 at 500° F. the loss is 13½ per cent.; at 400° F., loss is 10½ per cent.

Briefly this shows that if an engineer can by the use of a CO_2 recorder increase the percentage of CO_2 in the exit gases from 5–14 per cent., he will have effected a clear saving on his coal bill of 21½ per cent. If he can succeed in reducing his temperature at stack by a hundred degrees at the same time, the saving will amount to 24½ per cent.

Even if only 12 per cent. can be maintained it will be worth doing, for the saving will amount to over 20 per cent. It is well-known that temperatures of the stack gases, considerably higher than those given here, are frequently met with, when the loss is, of course, also proportionately greater; the figures given may, however, be taken as a fair average in up-to-date plants. I have chosen 5 per cent. as the lowest figure, because where reasonable care is taken lower percentages are not often encountered, but it must be said that where CO_2 recorders are not in constant use, an average of more than 7 per cent. is very seldom obtained. This is true even of those plants where the value of flue gas analysis has been to some extent recognized, and where occasional snap tests are made—

although these tests may show better results. Occasional tests cannot be expected to provide a reliable indication of the average conditions, as the firemen are well aware when they are taken, and there is no guarantee that the good results shown at the moment are maintained throughout day and night. Such a guarantee can only be furnished by a CO_2 continuous recorder. Now it might be said that it is one thing to show up bad results, but quite another to remedy them, and it must, of course, be realized that a tell-tale—for that is what a CO_2 recorder really is—cannot automatically remedy the defects which it points out. However, it is not difficult to see that such a machine is, nevertheless, of great value, when one remembers that stoking consists after all of but a few in themselves very simple manipulations; and given the means to know what is going on, good results can be obtained in a very short time even by the stokers themselves. The success with which CO_2 recorders have met during the last few years in land installations—there are probably now some 800 of various types in use in Great Britain, they are working in the dockyards at Chatham, Devonport, Portsmouth, Sheerness, Pembroke, Gibraltar, Malta, and Simonstown, and are employed by the United States Naval Department in their various test stations used to select firemen—is alone sufficient to prove this. Before referring in detail to the various ways in which a CO_2 recorder can assist in the improvement of the conditions of combustion, let me draw your attention to one of its functions, which is not generally recognized as important, but which has in my opinion a very great practical value—I mean its moral effect upon the men. In the words of an American engineer, "A machine which will show up attention as well as neglect, and waste of money at all times, night and day, which cannot be bribed or intimidated, meddled with or changed, giving a just and true record without favour or bias, is a good paying investment beyond all doubt." To this must be added that an intelligent stoker cannot help developing an interest in the records of his work, as made on the recorder, with the result that he will at once set about improving them somehow: and you may be sure that he will do it, even though he may not be able to tell you afterwards exactly how it was accomplished. Especially where a number of stokers are engaged on one plant, a friendly rivalry will be set up between them; each man will do his best to outstrip his rival; there will even be bets on the best CO_2 chart—all to the benefit of the employer. Let us now examine into the various manipulations which affect the CO_2 contents of the exit gases. There is first of all the air supply. This is undoubtedly the most important factor. I have already said that we cannot in practice feed only the quantity of air which would furnish no more than the required volume of oxygen, we must have an excess; but this excess should, as you know, be kept down as low as is possible, for every pound of excess cold air that we admit to a furnace not only lowers the temperature of the furnace, but in addition it must be heated to the temperature of the exit gases, which is an obvious waste. Particularly with forced draught furnaces the danger of furnishing a large excess of air is very great. In addition to the CO_2 recorder, which shows this excess, draught or pressure gauges to guide the stoker will be found extremely valuable, especially on ships where the conditions of load are comparatively constant, and are, of course, already in pretty general use.

The points next in importance are the thickness of the fire and the intervals between stoking, speaking of hand-fired furnaces, which concern you chiefly. The thickness of the bed varies considerably with the draught available, the duty required of the boiler and the class of fuel used, but the general rule applies that it should be as even as possible and free from holes through which great jets of air enter. Its thickness should be in any case so adapted to the periods of stoking that the fire is not on the one hand allowed to burn too low, and on the other hand it should not be so heavy that considerable time must elapse before the fresh fuel thrown on can be properly ignited. Considerable improvements have further often been made by accelerating the process of cleaning the fires (or clinkering), avoiding as much as possible the inrush of cold air when the fire doors are open. Finally there are such considerations as repairs to the settings, cleaning of the boiler shell, alterations to the grate, fire-bars or flues, stopping of excessive radiation and many others. Each adds its little share to the general improvement, with the inevitable result that after a month or two the CO_2 record, and with it the coal bill, will show that efficiency and economy have been very considerably increased, and this without material structural alterations or additions, and without any considerable outlay.

All this is perfectly well known to you, but every stoker does not know it, and if he has some ready means of verifying the results of his actions he will quickly improve in his work. The CO_2 recorder is a sort of automatic calculator or ready reckoner. It adds, divides, subtracts, and shows the *result* of a man's work whether good or bad, which is what one really wants. It might be added that CO_2 recorders are quite

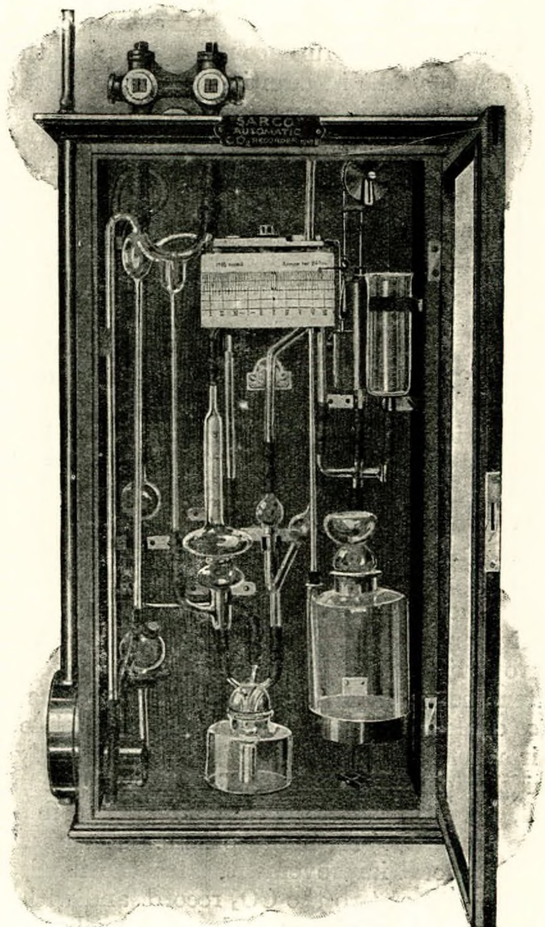


Fig. 1.—The "Sarco" Automatic Combustion Recorder. Type "B." General View.

inexpensive to maintain, costing only a few shillings per month, and their life is an exceedingly long one. Provided they are given a little attention, say as much as is bestowed upon a feed-water heater, an oil separator or other saving appliance, they can be relied upon to give accurate and reliable results.

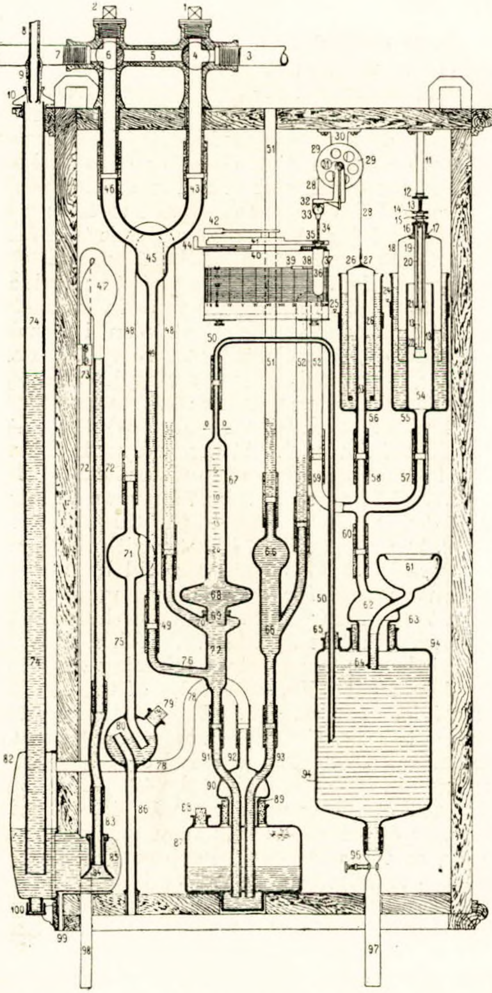


Fig. 2.—The "Sarco" Automatic Combustion Recorder. Type "B." Sectional Elevation.

I will now describe as briefly as possible one design of recorder, that known as the "Sarco," which was one of the first on the market, and is I believe the one most generally used. It is the only one of which, as far as I am aware, an adaptation for Marine purposes will be shortly available.

DESCRIPTION OF "SARCO" RECORDER, TYPE B.

The apparatus is erected in the stokehold itself or engine-room, preferably as near to the boilers as is convenient, so that the firemen can have it in continuous view. It does not, however, interfere with the accuracy of the records to have the machine any convenient distance away from the boilers. A pipe of preferably $\frac{3}{4}$-inch diameter is inserted in the smoke-box or combustion chamber of each boiler, and these branches are fitted each with a cock and run into a main pipe, which, after passing a special filter, takes the gases to the recorder, the connexion being made at 3 (fig 2). Another pipe is taken off the opposite cock 6 at 7 and taken to the base of the funnel or the suction side of the forced draught fan. This pipe serves to provide a continuous flow of gas from the boilers across the top of the machine, the cocks 4 and 6 being set as shown in the illustration, i.e. making a passage from 3 through 4, 43, 45, 46, and out by 6 through 7. From this stream constantly flowing, the machine secures samples at frequent intervals automatically in the following manner: A fine stream of water from a small supply tank erected about 2 feet above the instrument enters the tube 74 through injector 9. It gradually fills the vessel 82, compressing the air in the same above the water-level. This air pressure is conveyed to vessel 87 through tube 78, and as 82 fills, the air forces the liquid in 87 downwards and up in the tubes 91 and 93 and their various branches. The liquid in 87 is water with a little glycerine added to prevent evaporation. This water, as will be seen, does not come in contact with that used for driving. Communicating with vessel 82 is the syphon 72, and the water rising in the larger tube 74 naturally also moves upwards in this syphon 72. When it reaches the bend of the syphon this begins to operate, syphoning out the whole of the water contained in 82 rapidly, the outlet of the syphon being much larger than the inlet of injector 9. The effect upon the liquid in 87 and its connecting tubes of the syphon emptying is to cause the liquids to recede once more and to fill the vessel 87. This downward stroke acts as a gas pump in the case of the tube 49. In that tube the water rises on the upward stroke to the stirrup 43, 45, 46, and on the downward stroke a supply of gas is drawn in and enters the measuring tube 67 as soon as the water-level has dropped below the inlet 76. As soon as the power vessel 82 begins to fill again the liquids rise once more in the various tubes issuing from 87, and when the level reaches the point 69 in the measuring tube a certain definite quantity of flue gas is shut off in the same. As the liquids rise further this sample is forced along tube 50 and through the solution of caustic potash contained in vessel 94. In bubbling through this solution any carbon dioxide (CO_2) which may be contained in the sample will be eagerly absorbed. The residue will collect under the floats 18 and 26; of these 18 is larger and much lighter, and will consequently be raised first. Its travel is limited by an arrangement of thumb-screws 14 and 15, which define the length of its stroke. When it has come to rest the remainder of the gas will collect under the float 26, driving this up and causing the pen 36 to travel downwards on the diagram.

The adjustments of the instrument are so made that the pen will travel the whole length of the chart to the zero line if only atmospheric air has been forced through the potash and nothing has been absorbed. As float 18 will always require the same volume of gas to perform its stroke, any CO_2 absorbed in the potash will cause a correspondingly less volume of gas to reach float 26, which cannot then cause the pen to travel down the whole length of the chart, but will force it to stop higher up, according to the percentage of CO_2 absorbed in the potash. In this way the ends of the vertical lines made by the pen on the chart will indicate the percentage of CO_2 absorbed in the potash, and, therefore, that contained in the gas analysed. The moment the syphon begins to operate, all the liquids recede, and when the passage 52 is cleared, the gas under the two floats will be drawn out and escape to atmosphere through vessel 56 and tube 51. A fresh charge of gas will bubble into the measuring chamber 67 as soon as the levels free the inlet 76, and the whole process of analysis and recording will be repeated when the levels rise once more.

CHAIRMAN: We are much obliged for the admirable lecture Mr. Binz has given us, and we shall be very glad indeed if any of you would take part in the discussion. It may have been rather difficult to follow as we have not printed copies of the lecture before us, and I am sure there will be some points about which you are not quite clear which Mr. Binz will be very glad to explain.

Mr. G. W. NEWALL (Member): Can the apparatus Mr. Binz referred to be used on shipboard?

Mr. BINZ: It has lately been specially adapted for use on ships. The machine for shipboard would preferably be of cylindrical shape, and hung in such a way that it would be able to do useful work in rough weather. The pen would probably be actuated by a special arrangement which would keep it on the diagram.

Mr. NEWALL: I presume the instrument must be in the stokehold?

Mr. BINZ: The stokehold is the right place for it, but it may be erected in the engine-room.

CHAIRMAN: May I ask whether, in drawing furnace gases through the apparatus, there is any possibility of the gases analysed being different to those drawn from the furnace?

Mr. BINZ: After the first few minutes the gases are not affected by the pipe work.

CHAIRMAN: Would not some of the CO_2 be absorbed in the water used in the instrument?

Mr. BINZ: Slightly at first, but as the same water is always used, it has no effect upon the record after the instrument is once started. The water that drives the machine is used simply to compress the air above the power vessel; it is merely the air pressure that drives the liquid up. Once the sealing liquid is saturated, there is no more gas absorbed.

Mr. NEWALL: Is it necessary to have one recorder on each boiler?

Mr. BINZ: Only if it is desired to get separate analyses from each boiler, but branch pipes may be led from each boiler into a main pipe, from which samples of the gas may be drawn into the recorder. This is the usual course, and by this means separate results are got alternately from any of the series of boilers.

Mr. NEWALL: May I ask the cost of the instrument?

Mr. BINZ: I do not know what the cost of the marine type would be, but for land work they cost on the average from £30 to £40.

Mr. C. M. B. DYER (Member): With regard to the caustic potash used, is it a measurable quantity?

Mr. BINZ: It is a solution in distilled water of about 1·27 specific gravity.

Mr. DYER: Starting with the solution at this strength, would the constant analyses not have a tendency to weaken it?

Mr. BINZ: Yes, it does weaken it in time. If the instrument is constantly working day and night, giving thirty to forty analyses per hour, it would be necessary to change the solution every fortnight.

Mr. DYER: Would the record not be slightly incorrect due to this weakness of the solution?

Mr. BINZ: It could run four or five weeks without seriously affecting the record; but if the solution is changed every fortnight under the conditions I have mentioned, there would be no difference between the first day and the last.

Mr. J. G. RENDALL (Member): May I ask where you would take the gases from to be tested in the case of a marine boiler —the ordinary multitubular boiler?

Mr. BINZ: In the last combustion chamber, or, in the front of the boiler where there is a smokebox. Each engineer may please himself so long as he gets a good average sample where the gases are well mixed and as near the uptake as possible so as to get all leakages recorded. Of course the percentage of CO_2 will be slightly different in different places, but a relative reading is obtained.

Mr. DYER: Then you are relying on this chemical absorbing a constant volume of CO_2, leaving the instrument to record what remains.

CHAIRMAN: No, Mr. Binz, as I understand it, relies upon the caustic potash absorbing the whole of the CO_2, and what the pen records is the remainder of the gases, the unburnt air, and the nitrogen of the burnt air.

Mr. BINZ: That is so. Caustic potash absorbs all the CO_2 it can get hold of.

Mr. JAS. S. GANDER (Assoc. Member): What connexion is made between the instrument and the pipe containing the gases on the marine job?

Mr. BINZ: It is connected with flexible tubing.

Mr. J. R. M. FITCH (Member): Do you experience any difficulty on account of the vibration on board ship with regard to the record made by the pen upon the chart?

Mr. BINZ: Great difficulty has been experienced in that respect, but I think I may safely say it has been overcome now although, as you may see, it is not an easy matter. In one case a magnet is used to force the pen to keep to the diagram.

Mr. Dyer: With a large battery of boilers, say thirty to forty furnaces working at one time, would you be able to differentiate the bad stoking for the separate boilers when you take an average sample from the whole series?

Mr. Binz: You would be able to over a certain period, but if you wanted to make tests you would require to take one boiler at a time. For general running you will be able to tell a good day's work from a bad day's work by taking an average result from the whole series. The machine is so sensitive that when the door of the furnace is opened the pen goes down almost immediately. If it is recording 12 per cent., it may go down to as low as 2 per cent. when the door is opened for firing.

Mr. Dyer: Are the connexions of rubber?

Mr. Binz: Yes.

Mr. Dyer: How long do they last?

Mr. Binz: About twelve months. There are cases where they do not last so long, but it is then due to carelessness in allowing paraffin or other oils to touch the rubber.

Mr. Dyer: What is used for filtering?

Mr. Binz: In the range of pipework a large filter is provided and a variety of materials used, most commonly wood shavings; some have sawdust inserted, and a very good thing is horsehair.

Mr. Dyer: I presume there is no danger of any gas being generated in the filter due to the admission of air.

Mr. Binz: No, the filter is sealed to guard against that danger.

Mr. Rendall: Is there any limit to the length of piping that may be used between the recorder and the boiler?

Mr. Binz: Good results could not be obtained with more than 200 ft. of pipework owing to the danger of leakages, but other than that danger there is no limit. Of course that is a very long stretch, and hardly likely to be encountered in practice.

Mr. Dyer : Could the instrument not be placed in the engineer's cabin ?

Mr. Binz : On land they are very often placed in the engineer's room, but the right place, undoubtedly, is near the boilers where the firemen can see it, because it is intended as a guide for the firemen as much as anything else.

Mr. Newall : Do you consider the instrument is sufficiently sensitive to take the record in this room as against the air on a mountain top. There is a certain proportion of gas in this room.

Mr. Binz : It is less than $\frac{1}{100}$ per cent. ; the instrument records within $\frac{1}{8}$ per cent. The record is made on the chart in this way. (Mr. Binz illustrated by blackboard diagram.)

Mr. Dyer : Is $12\frac{1}{2}$ per cent. the highest practical result that has been obtained ?

Mr. Binz : No, the highest practical result is 15 per cent. It is possible to go even higher, but it is not advisable, because it means making artificial conditions which encourage the formation of CO as well as CO_2.

Mr. Dyer : Has the instrument been tried on internal combustion engines ?

Mr. Binz : Experiments have been made, but not very extensively.

Mr. Dyer : Are there any records of how oil fuel compares with coal ?

Mr. Binz : It compares pretty fairly, but the results are not so good ; there is a difference of between 3 and 4 per cent.

Mr. Dyer : The oil fuel showing worse than coal.

Mr. Binz : Yes, to that extent.

Mr. Dyer : It would be interesting to have the results of the internal combustion engines ; there ought to be a higher percentage there.

Mr. Binz : Yes.

Mr. Newall : How would you protect such an instrument from firemen who wished to damage it ?

Mr. Binz : The best way is to show the firemen how it will help to lessen their work, and they will then have no desire to damage it. If, for instance, a premium were offered for the best results, a wonderful change would take place. If it is necessary to protect it, that is an ordinary mechanical point that could be easily solved by making a suitable covering.

Mr. Rendall : Does the temperature of the engine-room affect the instrument ?

Mr. Binz : It does not affect the accuracy in any way.

Mr. Rendall : With regard to the water arrangement which drives the instrument, is there any limit to the amount of water in the tank above the machine ?

Mr. Binz : It would be arranged so that the water flowing in would be the same as that flowing away, so as to give an even pressure.

Mr. Rendall : Is the water running away finished with ?

Mr. Binz : As far as the machine is concerned, but the water is not soiled and may be used again.

Chairman : The water may be sea water ?

Mr. Binz : Yes ; it is only used as a pump, to get a sufficient air pressure.

Mr. J. G. Rendall : About what quantity of water would be used per hour ?

Mr. Binz : It depends upon the speed at which the instrument is moving, but it is usually from three to five gallons per hour.

Mr. Newall : Can the instrument not be used to do more work ; that is, to do something more than merely record ?

Mr. Binz : It has been tried, but any such arrangement is always too "cast iron." There is a system by which the dampers are adjusted electrically, according to the CO_2 shown on the recorder. The objection is that there is not sufficient flexibility to allow of the changes that constantly happen being followed. It is necessary to have a free hand to alter the conditions as necessity demands. Very frequently a little electrical device is attached, by which a red lamp is fixed so as to show when the CO_2 is too low. Immediately the pen goes below a certain limit the lamp is lighted.

Mr. DYER: Have you determined what part of the funnel is best for the best aspirating effect of that pump?

Mr. BINZ: Yes, the bottom part, but on board ship I do not think it should go into the funnel at all, at least where there are forced draught arrangements. It should go into the suction side of the fan; this would be more constant and more reliable than the stack.

Mr. DYER: I suppose it would only be a question of the number of records whether it is a good draught or otherwise.

Mr. BINZ: No, it means a longer time taken to show the results on the diagram. Each time the liquid rises, it depends on the speed at which it is running how long it takes to make the record on the diagram. The quicker the water is made to rise, the quicker is the operation right through. If there is a poor draught the velocity of the gases through the pipes is very low, and if there is a change in the firing it would not be shown immediately. For that reason there must be a suction so as to get the results quickly.

Mr. GANDER: I suppose the instrument could be used for determining other gases.

Mr. BINZ: Yes, any gases that can be absorbed by using different chemicals.

Mr. A. ROBERTSON (Member): Has the instrument been tried on shipboard?

Mr. BINZ: Yes, in two instances.

Mr. ROBERTSON: With what result?

Mr. BINZ: The results were good as far as the machines were concerned, with the exception of excessive vibration. The pen had a tendency to come away from the chart, and two or three times there was a spoiled record.

Mr. ROBERTSON: What was the comparison with land installations with regard to consumption of fuel?

Mr. BINZ: It was rather worse, but there is practically no difference if we consider the first installation of the CO_2 recorder in both cases. In some London plants the results were very bad until the use of the recorder caused the waste to be checked. So the marine records were not much worse than those on land under similar conditions, but there appears to be room for improvement.

Mr. ROBERTSON: What was the average result?

Mr. BINZ: The chart showed on the average a record of about 5 per cent.

CHAIRMAN: Would you kindly explain this one point? Suppose there are twelve records per hour, that is equal to one every five minutes. How long does it take for that record to be made; for what length of time is the sample being taken?

Mr. BINZ: About ten seconds.

CHAIRMAN: It acts every ten seconds?

Mr. BINZ: The whole process, from taking off the sample and putting it through the machine till the record is made on the chart, would occupy about one minute.

CHAIRMAN: The point I have raised is whether, in the event of a record being taken accidentally two or three times in succession, just at the time when the man is firing, the result would not affect the average.

Mr. BINZ: Yes, but the average would be for the whole time, naturally the result will not be equal all the time.

CHAIRMAN: I have had to do with a gas analysis apparatus on the Admiralty Boiler Committee, and it was of very great service in enabling us to determine the efficiency of the water-tube boiler as we now use it; it determined the best thickness to keep the fires, and how often they were to be fired; it led us to realize that "little and often" was the proper practice for firing. In the apparatus we used we took our samples from a continuous inspiration. We had a very gradual inspiration, and the vessel took three or four minutes to fill up. The apparatus recorded not only the CO_2, but the oxygen. It analysed the gases, but did not make diagrams.

Mr. BINZ: Of course the record is being made continuously, also in this case.

Chairman : But successive records might be taken at times when the firing doors are open.

Mr. Binz : That would not affect it very much if the average is being taken of a number of boilers. The point you raise is certainly good, that if the man happens to be firing when the record is being taken it will alter the record slightly, but the records would average out over a period.

Chairman : But you could not take an average over a continuous period; you do not take the gas for analysis out of a receiver, you take it from the main stream.

Mr. Binz : It is pumped through continuously; the machine merely picks it up from the constant flow of gases.

Chairman : But you said the firemen could see the effects immediately on the record.

Mr. Binz : So they can ; directly the firing door is opened the record would go down.

Chairman : Are any of these machines in the dockyards ?

Mr. Binz : Eight machines have been supplied to various dockyards.

Chairman : Was it for experimental purposes ? The other instrument I referred to was used only for experimental boilers.

Mr. Binz : In this case the machines are used for the ordinary boilers in the yard.

Mr. Dyer : What record does the machine give when used with the mechanical stoker, better than the average ?

Mr. Binz : No, not so good. The conclusion I have come to is that nothing can surpass a good boiler hand-fired, provided there is a good stoker. But poor men with mechanical stokers can sometimes get as good results as good men on hand fires. On the other hand, with mechanical stokers one cannot so readily alter the conditions to suit the class of coal used.

Mr. Newall : What is the theoretical percentage of CO_2 present in the products of combustion ?

Mr. BINZ : 21 per cent.

Mr. NEWALL : In a paper read before the Institute some time ago our friend Mr. Brand made a statement that "about 23 per cent. of the gas issuing from the funnel would be CO_2 and the remainder nitrogen." Is that the case ?

Mr. BINZ : It is putting it rather vaguely.

Mr. NEWALL : Of course there would not be that proportion if the combustion were perfect.

Mr. BINZ : 21 per cent. is the theoretical proportion.

Mr. DYER : It would not be possible to have more because nitrogen comprises 79 per cent.

CHAIRMAN : There is another point ; one may be percentage of volume and the other of weight. The figures in the two cases differ considerably owing to CO_2 being a heavy gas.

Mr. BINZ : That is a point I was about to mention, because as the percentage of CO_2 referred to in the paper is much higher than it is ever possible to obtain, it is quite possible that percentage by weight is meant.

Mr. NEWALL : I believe he does ; he takes the weights of the gases all the time.

CHAIRMAN : Could Mr. Binz tell us whether there is any reliable thermometer for testing the final gases at temperatures of about 500° to 600°.

Mr. BINZ : For measuring such high temperatures an instrument on a different principle to the ordinary thermometer is preferable, and for this purpose an instrument on the thermo-electrical principle has been designed. A junction of dissimiliar metals is used, and the current set up in that junction on being subjected to heat, is measured on a galvanometer. This instrument is exceedingly sensitive and very reliable, and registers temperatures up to 3,000° F.

CHAIRMAN : What is the cost of them ?

Mr. BINZ : About £10 as usually fitted, but of course there are more expensive kinds (recorders) which go up to about £25.

Mr. J. CLARK (Member): We have all listened with much pleasure to the explanations of Mr. Binz, and I am sure he has a good deal of experience in this subject, but I think we should be even better pleased if he would be good enough to tell us some of the defects in the ordinary, everyday working of the instrument. It is a true saying that we must "get the truth from the opposition man," but I think Mr. Binz might also give us a little information in that respect.

Mr. BINZ: There is nothing to conceal; if anybody feels a desire to suggest points where they think there may be defects, I shall be very glad if they will do so. I may say, however, that the greatest difficulty experienced in analysing the dirty gases was to keep that dirt out of the instrument, the real difficulty being to find some suitable filtering means to keep the soot out. That has been done very perfectly with this machine, and in addition a special little filter is fitted inside in which glass wool is used. Another difficulty experienced is in connexion with the pipe-work. It is not always all that can be desired. Sometimes when the machine has gone wrong, and after great difficulty has been experienced in locating the cause of the error, it has been traced to a leak in the pipe. At first there were mechanical defects, but these were overcome in course of time. At present I should say there is no drawback excepting that the machine requires a little attention, as, of course, all machines do. The machine, as you see, is very simple in its manipulation.

Mr. FARENDEN: Could the recorder be made to make a record for a week at a time?

Mr. BINZ: The recorder could be made for a week's work or over by making the diagram long enough, but I should think the tendency would be, if the machine was not looked at for a whole week, for that machine not to be looked at at all, which is hardly what is intended.

The HON SECRETARY: Have you tried the Orsat Gas Analysis Plant in conjunction with it?

Mr. BINZ: Yes, that is the instrument used everywhere to test this machine; the two are tested side by side, and this machine is guaranteed to be within $\frac{1}{2}$ per cent. of the Orsat Reading.

The Hon. Secretary: The convener of our Fuel Testing Committee is here to-night; I do not know whether he has any suggestion to make in reference to this.

Mr. J. Clark (Member): I do not know that I have any suggestion to make; it is more within the province of the chemist than that of the engineer, the analysis of fuel gases. Some of the statements made one cannot fully endorse, but on the whole we all agree with the remarks of Mr. Binz.

Mr. Binz: Might I ask what the statements are which cannot be fully endorsed?

Mr. Clark: In connexion with the statements with regard to the temperature of flue gases. For instance, it invariably follows, when the flue gases are going up, the shell is getting dirty; it is a feature well known to exist.

Mr. Binz: I quite agree with you.

Mr. Farenden: Could we have one of these instruments fitted up for the purpose of experiment?

Mr. Binz: If we could get the necessary water supply I think we could do it. If the necessary arrangements could be made here or anywhere else, I am sure I would be delighted to explain the machine.

Chairman: May I ask whether any modification in the instrument would be needed if liquid fuel is being used? Liquid fuel is a hydrocarbon, and the most valuable portion of it is hydrogen, and that burns up so much of the oxygen of the air that the analysis of the nitrogen and other gases left behind would not, perhaps, give a fair record of the combustion effected.

Mr. Binz: I may say that with liquid fuel the instrument would not give so high a reading.

Chairman: Is that one reason?

Mr. Binz: I should say that the presence of hydrogen is a reason why the result obtained is not so good as with the solid fuel.

Chairman: The same thing will apply, to some degree, with different coals. If anthracite, which is nearly pure carbon, is being burnt, the instrument will give a high result. With north-country coal there is more hydrogen, and with Scotch coal more again, so that this machine, which records only CO_2 will not give the same results with different coals, even although they are being burnt with the same efficiency.

Mr. Binz : The machine gives the same value, although it may start from a different percentage. If the amount of CO_2 can be improved, the same percentage, the final results as regards economy will be the same.

Chairman : Suppose, in using Scotch coal, for instance the firing is done in an irregular way instead of "little and often." When it is first fired part of the coal does not burn but distils off as hydrocarbon gas ; in that case there will be a greater proportion of CO_2 registered. If more air had been admitted to burn the hydrocarbon, the nitrogen in that air will remain and so lessen the percentage of CO_2 in the funnel gas. In this case, although the combustion would have been improved, the record of the apparatus would show a lower result.

Mr. Binz : If dense black smoke is being emitted, unburnt carbon is being sent out of the chimney, and also CO, consequently the CO_2 record will be low, and if the amount of black smoke is reduced the CO_2 record will go up.

Chairman : I do not think you are quite correct. I think that the smoke which goes up unburnt is from the distillation of the coal, and that there is not necessarily any CO. CO is formed where there is a deficiency of air going through the bright parts of the burning fuel, and there need not necessarily be much CO when dense smoke is being formed.

Mr. Binz : Not necessarily, but it means unburnt carbon, which, if burnt, would show in the way of CO_2.

Chairman : No, what would be shown by the instrument would be the CO_2 in proportion to the air passing through the fire, and not in proportion to the coal which goes on the fire. So, therefore, the unburnt carbon would not show on this instrument.

Mr. Binz : The machine takes out for analysis a sample of the gas containing the unburnt carbon.

CHAIRMAN : But it does not take the soot.

Mr. BINZ : Not directly, but the gases analysed are samples of what is being done, and it is impossible to show a large amount of CO_2 on the chart without good combustion going on. But I think the simple fact in practice is that where there is a good proportion of CO_2 black smoke is not made.

CHAIRMAN : It depends upon the fuel whether smoke is being made or not.

Mr. BINZ : You will improve the percentage of CO_2 if you do away with the smoke.

CHAIRMAN : What if there is a large percentage of hydrogen ?

Mr. BINZ : That does not show on the machine.

CHAIRMAN : And yet it is an important factor in obtaining good efficiency.

Mr. BINZ : With oil fuel the CO_2 recorder would be used as a general guide on the condition of the fires rather than on the exact constitution of the gases.

CHAIRMAN : I think you will find that with oil fuel, where there is a deficiency of air supply and dense black smoke is being emitted, there may be a fairly high percentage of CO_2, although there is very bad combustion ; and on the other hand, where there is perfect combustion of oil fuel, there may be an excessive air supply and no smoke and a very low percentage of CO_2. I was hoping Mr. Binz would be able to tell us what they are doing with this apparatus in the dockyards, I know, through the complete gas analyses made there, they have been enabled, in the Royal Navy, to burn liquid fuel with a comparatively small air supply, and still secure complete combustion and thereby get a high efficiency.

Mr. BINZ : I am not aware of what is being done in that way. The machines were ostensibly purchased for the boilers in the yards ; they may, however, have been used for experimental purposes as well.

CHAIRMAN : An important point with regard to the burning of liquid fuel in boilers is that by getting perfect combustion and no smoke with a small air factor, not only is there a higher furnace temperature, but by having a smaller volume of air the hot gases are longer in contact with the heating surfaces, and therefore more heat is being got out of them, and when you remember the total time taken by the gas in getting from the fire grate to the base of the chimney is only a fraction of a second, you will agree that the question of time is a very important one. It is only a fraction of a second from the time the oxygen combines with the fuel gases in the furnace of a marine boiler till it is right through the tubes. It is one of the marvels of nature that during that short time the heat is generated and transferred through the boiler into the water which it converts into steam.

Mr. Newall: It is with great pleasure I rise to propose that we give our friend Mr. Binz a hearty vote of thanks for having brought before us an instrument which we have long taken an interest in. I think I have used the Orsat gas analysis plant twice in this room and tried to show experiments, but failed on each occasion. It is a most difficult instrument to deal with, and if Mr. Binz will consent to give us a demonstration with this instrument, I think we could arrange to supply him with the water and gas necessary. Before the motion is put to the meeting I would just like to remark that I think that in the *Mauretania* and *Lusitania* we have two examples where, at least, there might be a room set apart in which instruments of this kind might be put. They are the first ships in the world for size and power, and certainly in the combustion of their 1,000 tons of coal per day, and I think it would be to the benefit of the engineering and scientific world to endeavour to get the owners to fit up such a room on board these ships where every conceivable instrument would be at hand recording the various things taking place with hydraulics, steam, air, gas, electricity, refrigeration, vibration of shafts and other matters. At Silvertown, where I am engaged, we have had to go into this question with regard to the CO_2 recorder on our boilers, but I cannot give any useful figures at present concerning it. I shall be pleased to do so if this matter is brought up at a later date. I am sure we will all join in giving Mr. Binz a hearty vote of thanks for his interesting lecture.

Mr. C. M. B. Dyer seconded the vote of thanks which was carried with acclamation.

CHAIRMAN: I am sure this vote of thanks to Mr. Binz has been well deserved. I think there can be no doubt that a recorder which will give any reliable scientific figures must be a useful thing to be fitted in any place where large quantities of coal are being used, not only in installations using 1,000 tons a day, but even when the consumption is 10 tons a day; if it will assist in saving coal it is a very important matter. I think Mr. Binz has given us to understand that this instrument is mainly useful in determining what a particular installation is actually doing at a particular moment, and if it records 12 per cent. of CO_2 in one particular case when the boiler is being used with a maximum efficiency, it does not follow that every other boiler of different type or using different coal should show the same figure. With the machine fitted on any installation, however, you would be able to tell after a little experience whether the maximum efficiency is being obtained from the coal that is being used.

Mr. BINZ: I have to thank you very much indeed for your attention to-night, and especially for the kind remarks that have been passed. I hope to meet you again at an early date to show you how the machine does its work.

It was arranged that the test should be held on Monday evening, November 30.

A vote of thanks was accorded to the Chairman on the proposal of Mr. W. E. Farenden, seconded by Mr. A. Robertson, and the proceedings terminated.

DEMONSTRATION OF COMBUSTION RECORDER.

Following upon the reading of Mr. Binz' paper, a demonstration of the "Sarco" CO_2 combustion recorder was given by Mr. Binz in the boiler-room of the West Ham Technical Institute, by kind permission of Mr. J. Duncan, Head of the Civil and Mechanical Engineering Department, on Monday, November 30.

The apparatus was connected by means of two branch pipes with cocks tapping the flue of the boiler, which is of the Lancashire type, immediately at the back of the flue tubes, and led to a main pipe which took the gases to the apparatus, being aspirated by means of a small chemical vacuum pump. The recorder was first of all started on atmosphere to show the method of adjustment, and when correct results were obtained the cocks on the boiler pipes were opened and the machine was thus connected with the flue gas from the boiler. The machine was adjusted to produce thirty analyses per hour; or one every two minutes. The first stroke shown on the diagram after the gas had been turned on registered 1·57 per cent. of CO_2, showing that already part of the air had been removed from the pipe system. Two minutes later the following stroke showed 6·8 per cent., the low percentage being due to the fact that the fires were in comparatively poor shape owing to the very slight demand for steam at the time, and three further analyses under the same conditions showed much the same result. The fires were then got into proper shape, the dampers opened a little, and everything done to improve the combustion, with the immediate result shown on the recorder of 12 per cent. of CO_2, and one stroke later even 13 per cent. It was then decided to open the fire doors to demonstrate the effect of an inrush of cold air into the furnaces. The effect was immediately shown on the record, the next analyses showing 9 per cent. of CO_2 and the one following 5·8 per cent. On closing the doors again, and adjusting firing conditions, the next record produced 8 per cent.

The lecturer explained, with the aid of diagrams, that 6 per cent. of CO_2 represented a loss, when comparing with the theoretical ideal, of nearly 30 per cent., whereas 13 per cent. of CO_2 represented a loss of only 14 per cent.; thus an improvement of 16 per cent. in the state of combustion had been recorded in the boiler in question. He explained very fully the details of the working of the machine, and replied to various questions raised on points of construction, conditions of working, etc.

After the demonstration the visitors, under the guidance of Mr. Duncan, inspected the extensive facilities for engineering instruction provided at the Institute, the equipment including boiler house, engine-room, machine shop, foundry, smiths' shop, pattern-making shop, and laboratories.

Before departing votes of thanks were accorded to Mr. Binz for his demonstration, and to Mr. Duncan for his kindness in allowing the demonstration to be held at the Municipal Institute, and in conducting the party through the various departments.

SESSION 1908–1909

President: JAMES DENNY, ESQ.

Ventilation by Induced Currents

BY MR. R. GREGORY.

Monday, December 7, 1908.

CHAIRMAN: MR. JOHN MCLAREN (MEMBER OF COUNCIL).

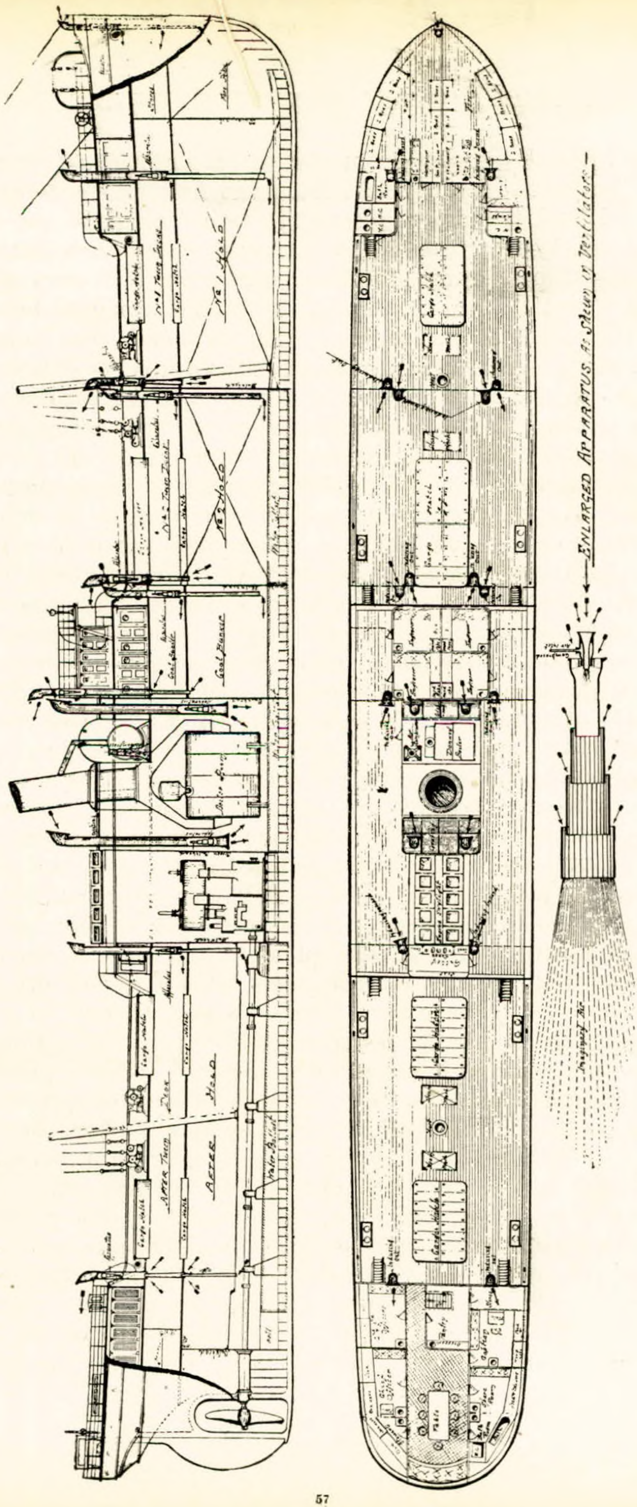
CHAIRMAN: The paper before us to-night is on "Ventilation by Induced Currents," by Mr. Robert Gregory. It is a very interesting subject and ought to call forth a good deal of discussion. I am sorry Mr. Gregory is unable to be present owing to illness and I will therefore call upon the Hon. Secretary to read the paper on his behalf.

The HON. SECRETARY: Before reading this paper I think it would be fitting to make one or two comments upon a recent unhappy event which could not readily be remarked upon at our demonstration meeting last Monday night. I refer to the loss of the *Sardinia*. It appears that the engineers were on duty below at the time and held on to their posts to the last, hence I think it is but fitting that we should take some notice of that fact, as a case à propos of the remarks made by Sir Walter Howell on the occasion of our Annual Dinner, referring to heroism in the engine-room. In this case the engineers and firemen seem to have been on duty below, expecting they would be able to run the ship until they could beach her, or until they got a ring from the bridge that all hope of doing so was gone. At any rate, whatever the circumstances we know they perished at their post, and I think it is fitting we should take notice of this at our meeting to-night and express our sense of the occurrence and sympathy with all concerned.

I have a communication here from one of our members referring to a mishap in the engine-room, which he has sent on in accordance with the promise made by members on joining the Institute, to contribute a paper or some notice of an event which has happened in their experience such as a breakdown, or to contribute a work to the library. Perhaps I may have time later on to read the communication as well as one from another of our members. Meantime we have Mr. Gregory's paper.

VENTILATION is one of those subjects which, although frequently discussed and disposed of from time to time with some show of reason that improvements have been and are being made, yet always returns for consideration with fresh data and with a pressing claim for more light. The ventilation of ship-holds, engine-rooms, boiler-rooms, sewers, halls, mines, etc., has received a deal of attention and has been consistently improved owing to sanitary and civic inspection. Sanitary institutes and congresses have been instrumental, not only in concentrating attention of the members on different systems, but giving information and warnings to the general public. Reference has been made by various authorities to ventilators fitted in the berthing of seamen's and firemen's accommodation, where those for whose benefit they were supplied nullified the intention by stopping up the ventilators at the opening to the quarters, and most likely this was done on account of a cold draft entering over a man sleeping in his berth. But with a perfect arrangement of ventilation there should be no perceptible draft, the vitiated air should be expelled or, better, induced to leave and give place to purer element, while the fresh air should follow with as little disturbance as may be, and according to the atmosphere of the confined space.

Several systems of ventilation have been tried with various improvements as experience has indicated, and attention is called to another adaption by induced currents. The adaptation consists of a nozzle placed in a series of corrugated tubes of different sizes telescoped into one another, and so arranged that at each diminishing diameter an annular space remains between the tubes of sufficient area for the vitiated air to flow in at the different junctions, and thus carry off the noxious air or gases, an obvious advantage over the usual upcast ventilator, whether in the engine-room, or stoke-hold, cargo-hold or coal-bunkers. In ships where the cargo carried one part of a voyage which gives off fumes detrimental to that carried on the succeeding run, this system can be applied with much success, and double bottoms or tanks cleared of gases in a very short space of time, therefore preventing explosions, which are becoming of frequent occurrence, especially on board war vessels. The nozzle is fitted into the smallest tube, and is connected to an accumulator or reservoir of compressed air supplied by a small air compresser; pipes are connected to the accumulator having a valve to regulate the supply according to the circumstances of each case. The pipes are carried to each compartment or hold, and there connected to their respective ventilators, which can be used either as a downcast for fresh air, or as an upcast for exhausting the foul air. The distance from which the foul air or gases can be induced by the apparatus is unlimited, and instead of having a large number of ventilators, one or two to each compartment or hold would be sufficient, by which to extract the foul air, or it may be brought to and expelled up the funnel. In case of sewers it is a well known fact that gases generate in the so called valleys, and low lying districts and naturally, when there is a flow of water into the sewers the gases rise to the highest point and therefore force their way through any leakage in the pipes into the houses, causing them to become unhealthy, likewise the gases ascend to the hills and so called healthy suburban neighbourhoods and there escape through the blow-holes and other outlets in the roads and pollute the atmosphere of our streets, whereas by the use of this apparatus the gases can be carried any distance to where a furnace or a dust destructor shaft is situated and there completely destroyed by burning. A minimum quantity of compressed air is only required for the purpose of inducing the foul air or gases from any distance, and which will cause a very large volume of air or gas to flow in any direction, or instead of using compressed air from a reservoir, a centrifugal fan driven by a motor may be used effectually for the purpose of supplying the air to the nozzles; the blast of air from the fan can be arranged to serve one or more compartments to suit the general arrangements. Again, suppose we take the case of a tunnel two miles long, an air duct may be placed between the rails or placed along the crown of the tunnel, and carried to the middle. By using fans one may



be fitted about ten feet from the outlet or discharge end, a second fan about twenty feet from the first, and a third fan about thirty feet from the second, so that there would be a length of sixty feet from the outlet or discharge, which would produce a plunger of air sixty feet long travelling in the direction of the outlet. This plunger of air would cause the whole body of air in the duct to move from the outside in the direction of the middle of the tunnel and so force itself into the tunnel at the various outlets, causing the foul air to find its way into the atmosphere by being displaced by fresh pure air. The foul air can be induced from the tunnel in the same way by reversing the action of the fans. The foregoing refers to tunnels where there is no possible means to get to the middle but from the ends. But in cases where it is possible to get a shaft either through the top or side of the tunnel, the apparatus could be arranged to induce fresh air into the tunnel by means of the shaft, or extract the foul air and gases from the inside of the tunnel in the same manner. Mines, houses, halls, hospitals and factories, etc., can all be thoroughly ventilated, and have always a good supply of fresh pure air by means of this apparatus. One inch bore of compressed air from a fan will remove a volume of air in a ventilator three feet in diameter by the use of this apparatus. A small air compresser is necessary to be provided on each ship, from which the air can be taken to an accumulator and led to the various ventilators in the holds or compartments. The pipes may be fitted with valves to regulate the supply to each ventilator to suit the requirements. By means of hot air chambers the air can be heated for the purpose of warming the cabins and saloons.

CHAIRMAN : We shall be pleased to hear the opinions of members on this paper. I am sure the subject will appeal to us all; we have all felt the want of ventilation at sea. I know I have often felt the discomfort of being boxed up in a small room, especially off the engine-room platform, where fresh air was seldom obtained. I think this idea is a very good one, and that the time is coming when we shall have something of this kind in the crew's quarters. The Board of Trade require ventilators to be fitted in the crew's quarters, but in very many cases these are blocked up, as the man nearest to the ventilator naturally objects to the cold draughts it causes. A large ventilator is fitted and a supply of air is brought down and it is assumed that this is all that is required, but there is no doubt such a system of ventilation is a very imperfect one.

Mr. C. M. B. Dyer (Member) : I think a paper of this kind is very much needed. There are several methods of ventilation in use, but none of them seem to be efficient that I am aware of, and if this method works well in practice I should think it would be very useful. Are you in a position to say whether it has been tested in everyday use ?

The Hon. Secretary : Only on land, I believe ; for sewers it has been successfully applied.

Mr. Dyer : I observe the author has not given sizes or the pressures necessary to give an induced current of air for the different sizes of pipes. Of course efficient ventilation cannot be obtained by natural means either in a house or on board ship, there must be some method of control. It might be possible in hot weather, but natural ventilation could not be effected in cold weather. I think it would have been an advantage if the author had given us more details so that we could get an idea of how the method he has submitted could be applied, and what plant would be used to generate the current. As I understand it, this method is evidently on the same principle as an ordinary injector works in feeding a boiler.

The Hon. Secretary : Mr. Gregory proposes to have an air compressor, and to put a pressure into the nozzle so as to induce the currents.

Mr. W. E. Farenden (Associate) : Is it intended to draw the air downwards or to extract it ?

The Hon. Secretary : If it is required to draw the air from the holds, the nozzle is put into the ventilator, having an annular space around it so as to induce the current up following the course of the compressed air. It could be applied in either direction according to the way the nozzle was placed.

Mr. Farenden : I think it is usual nowadays to fit up ventilators, using fans driven by motors to extract the air from confined spaces. If the foul air is extracted the fresh air will find its way in to take its place, and I think that is the best method to adopt, as it gives the best results for tunnels and similar confined spaces. With Mr. Dyer I should like to know the pressures of air and the sizes of these nozzles. I am sorry the author is not here to give us a little more explanation of the sketch; of course we cannot say much about this new arrangement until it has been actually applied on board ship, as the conditions there are quite different from those on land.

Mr. J. Clark (Member): Like others who have spoken I am sorry Mr. Gregory is not here to-night, and especially as he is not well enough to be present. From what he has written he has evidently gone into the matter thoroughly, but most of us know that air compression is not done for a trifling amount; it is a most expensive means of power, and if it is to be used for extracting air, or for taking air into a confined space, I think it would be very much more expensive than the ordinary fan. The two great systems, the plenum and the vacuum or suction have held their own, and as Mr. Farenden says, the suction fan evidently gives greater satisfaction than any other. The nozzle described by Mr. Gregory is familiar in principle to most of us. One often sees it as applied to increasing the draught of the boiler, and where it is used with steam I think you will agree that the steam jet for increasing the draught is about the worst ever invented; it is the cheapest to instal and the dearest to run. I think Mr. Gregory might have gone a little more into the subject of the expense of clearing holds and other confined spaces on board ship; the saving in cost is a thing upon which people need to be convinced. Another point he might have treated of is the necessity of a heated air system—the principle of which is to have a fan drawing the cold air through a radiator before it is used for ventilating purposes. In many cases it is used in the saloons, but I think it might also be introduced into the forecastles. I do not think you would then find the ventilators being blocked up as described by Mr. McLaren.

Mr. W. P. Durtnall (Member): This is a very interesting subject—the ventilation of ships—and one which has to be thoroughly considered, especially in relation to passenger vessels. The plan set before us in this interesting paper appears to be that the incoming air is simply localized in one place. It makes its entry at the bottom of the hold and is supposed to radiate its way around the hold, making its exit by another uptake at the other end. I do not think that will give a very unique system of ventilation, there will simply be a current of air passing across the cargo. It occurs to me that the system as proposed by the last speaker would be preferable, to draw the air down, using heaters or radiators where required, and then have a distribution system similar to that used in large buildings. In large halls ventilation never takes place from one point in the systems now adopted. In a large building recently built in the City Road, which contains a hall capable of seating 2,000 persons, the air is admitted from forty to fifty different places. In the summer time the air in the building is fresh and cool, the dust being filtered off. In the winter time the air is drawn through a system of radiators which warms it, and it is then forced by means of large fans into the room. This is done half an hour before the people come in, and in that time the temperature of the room has been raised up to 50° or 60° F. As soon as the temperature rises to 58° to 68° in the hall, a bell is rung automatically in the attendant's department. The pressure is eased off, and the number of people in the room keeps it at a constant temperature. In the middle of January cold air has been passed into the hall to keep it at a temperature of 60°. That is by a distribution system. It appears to me that the system proposed in the paper would be rather costly in operation, especially by compressed air, and it seems to me that a system of fans, either electrically driven or otherwise would be a better means. Of course the electrical machinery could be used, not only for ventilation purposes, but for loading, driving cranes, windlasses, starting gear and other machinery of that nature. Looking at it in that light, probably the electrical method of driving fans, inducing the air down and distributing it in the holds would be the most satisfactory in the end, especially in the matter of operating expenses, which, as the owner looks at it, is the most important thing. It is an important matter and Mr. Gregory deserves our thanks for bringing it before us.

CHAIRMAN : I may say that some time ago I was interested in a method of ventilating a hold, which was done by fitting electric fans in the existing ventilators. These fans were the exact diameter of the ventilator, being placed at the top and bolted to the side of the ventilator. One was put at the aft end and one at the forward end, one to pump fresh air down and the other to draw the foul air up. The air went right down and lifted the foul air from the bottom of the hold and the fan in the other ventilator, of course, drew it off. The results were very good, the first cost was small, and the cost of running these small fans at not very high speeds is very little. Unfortunately, after some dispute, the arrangement was not used, but to my mind it was a most effective method of ventilation. I think it would have been even more effective if the down draught had been conveyed in tubes and distributed all around the hold as suggested by Mr. Durtnall. I may say that it was calculated it would only be necessary to run these fans about six hours a day. I think it is better to induce and circulate fresh air. Some are of the opinion that if the foul air is extracted it is a matter of course that fresh air will take its place, but that method is not of a very searching nature. We found it was a necessity to have a fan to induce the air as well as one to remove it. On board ships at the present time there is something necessary in the way of ventilation, not only in the holds but in passenger accommodation. How often do we find that the passenger near the fan wants it shut off, while another in a corner away from it is perspiring and in need of fresh air. I think that is ample proof that the air is not distributed and of the necessity of some system of small pipes to distribute it. I think there was a paper read some time ago in which some one passed remarks about ventilating the engine-room and stoke-holds. The idea I had at the time was to use a fan and to run one main shaft through the stoke-hold and engine-room, to which branch pipes could be attached, one for supplying fresh air and the other for withdrawing the foul. If an engineer can make a perfect system of ventilation without causing draughts, with a good distribution and capable of being regulated, he will have solved the question. Mr. Battle read a paper here last year on "Ventilation and Sanitation," in which, I think, he treated pretty well the subject of ventilation on board ship. He went so far as to say that buckets should not be hauled up the ventilator; that the ventilator should be left perfectly clear, but a system of distribution through small pipes would be better than the large ventilator.

Mr. Dyer: I might say that for the principle of a perfect ventilation system we could not have anything better than what we have in the cold air refrigeration process. There we have, as you know, air ducts the full length on one side and return ducts on the other side, and if the ducts are shut off at any one point, that part will become heated. We cannot do without proportioning the distribution of the air, and the circulation must also be perfect, that is to say, the cold air naturally gravitates to the bottom and has then to be induced up, which is the condition stated by the Chairman as being necessary in a ventilating system, namely, not only to put in fresh air but to take the foul air out. I suppose up-to-date modern mail ships will not only be able to put warm air in, but also pass the air through a brine battery and put cold air through.

The Hon. Secretary: Some of the ships are already so fitted.

Chairman: The cold air system is almost perfect at the present day, as used for refrigeration, and I think if a fresh air system could be fitted up on a similar principle it would be what is required.

Mr. T. G. Jones (Graduate): A similar idea is carried out on the Greek torpedo boats built by Messrs. Yarrow and Co. this year, but instead of having compressed air they rely upon the speed of the boat to give a sufficiently strong current of air to be distributed throughout the engine-room.

Chairman: Does it give good distribution?

Mr. Jones: I think it acts fairly well, but of course the engine-room is very small. That is the only instance I have heard of.

Mr. Clark: I do not wish to appear hypercritical, but is it the case that the refrigerating system is a good plan to adopt for ventilation? In the refrigerating system you have air that helps ventilation, in the ordinary system you have heated air, which is very much lighter, as a rule, than the air dealt with in refrigeration. Although the system of distribution is good it does not appear to me that the refrigerating system would be at all applicable.

Chairman : I think Mr. Dyer meant the principle of distribution.

Mr. Dyer : I referred to the cold air system principally as giving a very efficient distribution of the air. This is especially noticeable in the case of fruit carrying, where the air is driven with a fan over a brine battery, and the discharges are proportioned so as just to keep the air at the right temperature. They are nicely arranged so that the air shall not discharge itself in any one spot.

Mr. J. R. M. Fitch (Member) : I am not in a position to criticise this paper, but we are all agreed that a good system of ventilation is needed on board ship. In the monsoon weather I have felt the heat very oppressive in the tunnel, where, of course, the air does not get the same amount of circulation as in the engine-room. On one occasion the thermometer only registered about 90°, while the engine-room was at a much higher temperature—110 or 120°—and it seemed to me that the want of air circulation in the tunnel fully made up for the difference in temperature.

The Hon. Secretary : The subject before us to-night is one which has recently occupied, and I believe is still occupying, the attention of the Advisory Committee in connexion with the Board of Trade. I was astonished when I was informed of the number of suicides of firemen at sea and that it was that fact which brought the attention of the Advisory Committee specially to the subject of ventilation. We have had it discussed here several times : I think one of the earliest papers we had in this room was on Ventilation and on a system which has been very efficient indeed in large halls, churches and other buildings difficult to ventilate without causing draughts. Those of us who are compelled to use the tramway system know well that the draughts are a source of discomfort, and I think if Mr. Durtnall—who I know is interested in the subject—could only design a tramcar with sufficient ventilation and without causing draughts, we should feel very thankful to him. Mr. Battle's paper, which we had about eighteen months ago, went very fully into the subject and described the thermo-tank system in which the air is heated before being distributed to the saloons and different cabins, and by this method also the air is cooled in hot weather and distributed throughout the ship. It is the engine-room and stokeholds which apparently cause the greatest trouble. When there is a good current of air coming down the ventilator into the stokehold the chief engineer causes it to be checked in order to save the boilers, and it seems to me there is a more efficient system of distributed ventilation required which will not do injury to the boilers. There are many steamers which have two ventilators to central parts of each stokehold but no provision for the wings, and if there are hanging bunkers in the stokehold, the heated air is held underneath the bunker. There are few ships where ventilators are carried to the wings to ventilate that part, and it seems to me this system with proper distribution will tend to draw the vitiated air from such places. We know that some method of ventilation is more necessary in the wings, because for the other parts, the fires, as a rule, are ventilators in themselves, with natural draught. The reference made to ventilation on torpedo boats is very much in the same direction that Mr. Gregory advocates, that is, the use of induced currents. Most of the Clyde steamers use that system, the open end of the nozzle being turned in the direction the steamer is going to induce a current, and the system has been very efficient in ventilating spaces other than the engine-room and stokeholds. Then, as has been said, our tunnels are very badly ventilated and the thrust block consequently suffers from overheating. All these things seem to point to the fact that the want of ventilation in the stokehold and engine-room really requires attention. We have been repeatedly calling attention to the subject for years, and yet we do not seem to be much farther forward. Even in the *Lusitania* and *Mauretania* I do not know that the ventilation of the stokeholds is by any means perfect. Therefore if we could come to some conclusion or to some understanding as to how the engine-room and stokehold can be efficiently ventilated we will help the Advisory Committee of the Board of Trade, as I know they are anxious to get any hints we may be able to give them. If, therefore, any one can give us further light on the subject I should be very pleased to forward it to the proper source.

Mr. Durtnall : Mr. Adamson's remarks have been very interesting, and I should like to make a suggestion in connexion with the use of electricity for ventilating apparatus. It seems to me that a great deal of the difficulty with electrical machinery on board ship is due to the use of continuous current motors. Instead of using continuous current motors with commutators and brush gear, it appears to me that a proper system of ventilation could be obtained by using alternating current, without any commutators, which is very often done. Such motors would run for weeks and months without any attention whatever. One was installed some time ago on the premises of a firm of horse-slaughterers at Wandsworth, where the offensive odour was so bad that the London County Council stated that if it were allowed to escape into the neighbourhood they would compel the firm to close down. The only alternative was a method of ventilation which would ensure the destruction of the foul gases, and in that case I advocated one of these machines to draw the air from the slaughterhouse, then forcing it under the boilers and so burning it. This was adopted out of six different schemes which were laid before the firm, and it has now been running night and day continuously for months. I think a similar system could easily be constructed for marine purposes on the alternating current principle and the motors would run for months with no attention whatever.

Chairman : Like the last speaker I do not see why alternating current generating sets should not be adopted on board ship, but of course it means money, and that is the first thing the shipowner thinks of—initial cost. About three years ago I had a similar experience to that described by Mr. Durtnall. It was in a large soapworks where it was very essential that the foul air should be burnt, and this was done very effectively. It was a very big installation, I think there were about nine or ten motors in different parts of the works, pumping and drawing the air. If there are no other comments on this paper I will ask Mr. Adamson to read the communications he referred to at the beginning of the meeting.

Mr. Dyer : I might describe a very simple ventilator I saw used when serving in H.M.S. *Fantome* in the Gulf of Mexico. It was designed by our first lieutenant and was used to cool the ward-room. It was simply an arrangement composed of canvas in the form of a cross, suspended by wooden crossbars over an opening in the deck so as to form four separate air passages, as shown in the illustration. We always found there was a downtake of the air through two of the vanes and an uptake in the two others.

Reply communicated by Mr. Gregory :—

From the remarks of some of the members I am afraid I did not make it as clear in my paper, as is done by the drawings, that my system is, in its leading feature, a case of double induction, i.e. the foul air is not only sent up the upcast shaft

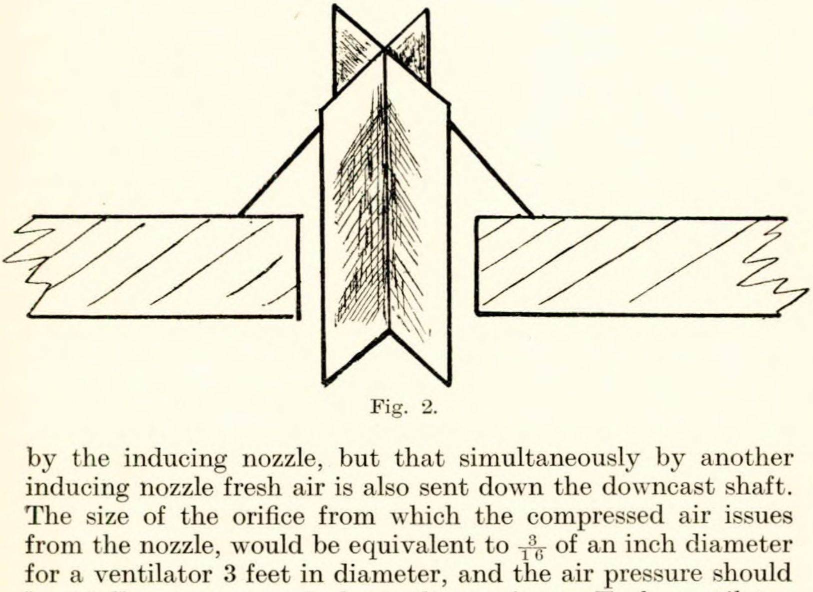


Fig. 2.

by the inducing nozzle, but that simultaneously by another inducing nozzle fresh air is also sent down the downcast shaft. The size of the orifice from which the compressed air issues from the nozzle, would be equivalent to $\frac{3}{16}$ of an inch diameter for a ventilator 3 feet in diameter, and the air pressure should be 10 lb. per square inch at the receiver. Each ventilator is arranged with a valve to turn the compressed air on or off as required, so that the induced draught would only be used when necessary, therefore I think my system would be found to be less expensive than fan blast, especially for ventilating those parts of a ship most remote from the engine-room.

As regards the distribution system mentioned by Mr. Durtnall, I think this might be a good method to distribute the incoming air for ventilating saloons, cabins, etc., but I do not think it would be needed for holds or other large spaces where a draught or strong current of air is not objectionable, because the incoming current of air passing to the upcast ventilator would induce the vitiated air to mix and flow with it, especially as the incoming air will be introduced at a lower level than the bottom of the upcast shaft.

The question of draughts moreover is met by the fact that the quantity of air entering the series of tubes decreases in velocity and increases in volume in passing from the smaller to the larger diameters.

The HON. SECRETARY: This is a communication from Mr. James Corner (Member):—

November 26, 1908.

Having been a member of the "Institute of Marine Engineers" for a considerable time, I feel duty bound to carry out the usual custom, and now do so in the form of giving a description of a mishap which occurred in my experience. The subject which I shall refer to, and which will very likely be most appropriate, is a mishap which took place whilst at sea. I was sailing at the time as second engineer on a voyage from the Brazils to New York, when, about 600 miles from the latter port, we had serious trouble with the main feed pumps. During the afternoon watch I was called out by the fourth engineer, who informed me that the water was disappearing somewhat quickly out of the boilers. I went round to the pumps and found one of the joints which connected the main feed pumps to the hotwell completely blown out, thus losing a large quantity of feed water, so much so that the other pump was not receiving a good supply. Being provided with a Weir pump which we only used as an auxiliary I at once put it on the boilers, pumping from the hotwell. This only lasted for a watch or two when the pump broke down completely; both sets of valves and valve seats had given way, caused through the corroding of the cast iron of which the valve box was made. We tried making a temporary repair of this to carry us to New York—a distance then of about 500 miles, but were unsuccessful. Wondering what to do for the best under the circumstances—for at the time there was a heavy beam wind and sea which took effect on the motion of the ship, causing her to roll heavily—we made several attempts to disconnect the pumps altogether and remake the joint, but the weather was so bad and we had so many connexions to break it was easily seen that it would mean at least a whole day's job. However, after spending much time in thought and making many attempts to move along, but without success, I then returned to the Weir pump and made another temporary repair by fastening the valve seats with bolts and nuts in the best possible manner. I then tried the pump on the boilers and found it to act fairly well—the pressure was by then reduced to about 70 or 80 lb. I filled the boilers up to three-quarter glass and started again under these conditions, thinking that by remaining with the reduced pressure we should stand a better chance of keeping the pump in order—less pressure to pump against and also less water to pump—I found that this proved very successful, for we arrived in New York without a stop or any assistance in a little under three days, which was equal to about seven knots per hour, and I may here state that I was never out of the engine-room from the time we stopped until we arrived in New York. We lay in port for about ten days, during which time we had the joint remade by an outside firm and when ready for sea again, thinking that all trouble was over, the engines only turned about a half dozen revs. when the same joint gave out again. The men were sent for from ashore to again remake the joint, but in the meantime I tried to find out what had really caused it to go; valves were drawn, seats tried and found to be quite tight, the latter being secured with a $\frac{3}{8}$ inch set pin. As one of the principals happened to be in New York at the time a surveyor was summoned. He examined everything about the job and concluded in advising us to make the joint with a different material instead of using insertion which had previously always given satisfaction. Canvas soaked in boiled oil was suggested—of course he was a stranger on the job, and nothing else could be expected from him, while I who had seen everything happen from the commencement was convinced that the simple joint was not the true cause, but that there was something wrong elsewhere which was causing the trouble. The joint, however, was remade again as suggested, but with only the same result. Another surveyor, after seeing the engines running, suggested blowing down the boilers and tracing the feed pipes from the pumps to the check valve. This we did and found everything right—no obstructions whatever being found—but being determined to find out what was wrong yet not knowing where to look I turned to the pumps again, took the delivery valve cover off, drew the valve and also the set pin which held the seat, then the seat itself, when the cause of the whole trouble was located, for I found the countersink in the seat extended vertically.

FIG. 1.

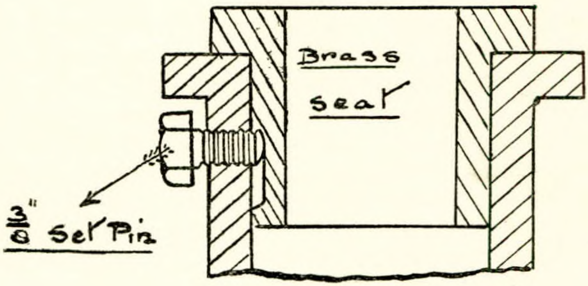
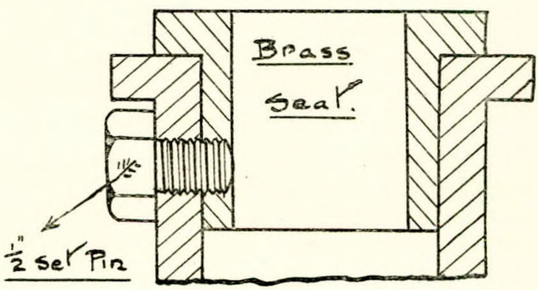


FIG. 2.



It will be seen from Fig. 1 showing the groove, that the valve seat had been lifting each time with the valve and the water drawn past the suction valve was unable to get away past the delivery valve—hence the cause of the joint being repeatedly blown out. Fig 2 shows the valve seat made secure to ensure it causing no more trouble. This mishap was the means of delaying the ship for seven to eight days. Trusting this small article may be of service to Engineers who may in future be placed in similar circumstances.

JAS. CORNER (*Member*).

CHAIRMAN: Seeing we have had a short discussion on Mr. Gregory's paper, would any of the members like to comment upon this repair job, or do they know of any similar experience.

Mr. DYER: In one ship which had been some years at sea similar trouble was caused by the main engine stop valve jamming up. The engine slowed down gradually no matter how much the throttle was opened. The main stop valve was opened out, the engines were opened up and overhauled and another start was made satisfactorily, but after they had gone for some hours the trouble commenced again. This went on for a few times until at last they thought of looking at the stop valve, when it was found that the seat was gradually working its way up the valve, with the same result as described in the member's letter. But I have never heard of the same thing happening with a feed non-return valve. I think we are very much indebted to this member for sending in this experience; it is very important indeed; it shows the importance of ascertaining in all cases where removable seats are fitted to see that they are adequately secured.

CHAIRMAN: We engineers always like to hear of other people's troubles and we are greatly indebted to the member who sent this on. It will be of interest more particularly to the younger members of the Institute.

The HON. SECRETARY: This is a communication from another member, Mr. James Macdonald:

Instances have occurred of steamers which have not gone far from port when they either lost their propeller or one of the shafts has broken. It is for this reason I give the following precautionary suggestion.

When in port and the ship is light, a straightedge is held against the sternpost and rudderpost as near the tip of the propeller blade as possible, with either the leading or following edge of the propeller blade touching the straightedge, the draught marked on the rudderpost where the straightedge is held to be made a note of. Then proceed to put a centre punch mark on the propeller shaft immediately in front of the stern gland, and another centre punch mark on the crankshaft at the after side of the after main bearing, also another centre punch mark on the crankshaft at the forward side of the forward main bearing, then make a strong trammel gauge that will equally suit for the three marks on the shafting, that is, the centre punch marks on the crankshaft and soleplate of the main engine, also the centre punch mark on the propeller shaft and a suitable part of the solid structure of the ship contiguous to the mark on the propeller shaft. These marks can be put on the shafting in its length and circumference to suit the gauge at as many points as may be desired and for one or more propeller blades lest one or other should get bent, broken, or lost. After the ship has been steaming for some time you arrive in port, and the cargo is discharged, the gauge can be tried on the shafting at the different points with the propeller blade in the same position as when the marks were put on the shafting originally. If you find the marks on the forward end of the crankshaft and soleplate do not correspond with the gauge marks on the after end of the crankshaft and soleplate, then you may assume that the crankshaft coupling bolts are loose or, if it is a built crankshaft, that either the crankpin or shaft is loose in the crank webs or that the crankshaft is overstrained; on the other hand, if the marks on the crankshaft fore and aft correspond with the gauge, and you find that the marks on the propeller shaft do not correspond with the gauge, then some part of the shafting between the propeller shaft and the after end of the crankshaft is overstrained or the coupling bolts are loose in one or more of the shaft couplings. Again, if the gauge marks on the shafting at each point correspond with the gauge, and the propeller blade is out of position, then either the blade is loose on the propeller boss, or the propeller boss is loose on the shaft, or possibly the propeller shaft is overstrained. There are some steamers even at their slightest draught when the propeller blades do not come above water; in such cases the propeller gauge marks could only be verified when the ship was in dry dock. A gauge as described would also be of service in works where there are long lengths of shafting. Say for instance that a propeller shaft, 10 inches in diameter, got overstrained in torsion one eighth of an inch, and the place where the straightedge was held against the sternpost and rudderpost was 10 feet from the centre of the propeller shaft, the edge of the blade would be round in the direction the shaft was overstrained about 3 inches from the position where the original gauge marks were put on the propeller shaft.

The HON. SECRETARY : I do not know whether gauge marks of that kind would have prevented a disaster which occurred not long ago ; it is quite possible. The propeller in that instance actually dropped off.

Mr. J. HOWIE (Member) : It seems to be a simple matter gauging by centre-punch marks ; the question occurred to me whether it would work in practice.

The HON. SECRETARY : If the centre-punch marks did not correspond with the gauge it would show that there was an apparent torsional strain on the shafting.

Mr. HOWIE : Yes, I recognize that ; it is a very good idea. The one point I was thinking of was whether it would act if the pin were loose. The centre-punch marks might be all right, but the pin might be loose, and no indication would be given of it.

The HON. SECRETARY : It would not show if the crank-pin were slack, it would show if the web were slack in the shaft itself. I had a curious experience not long ago. A ship had been ashore at the outward end of the voyage and evidently they had some trouble in getting her off, but the shaft had been examined right through by three of the engineers and they had found nothing wrong. When the ship came in, I knew she had been ashore and thought the engines might have been overworked and the shaft strained, but on asking the chief engineer he told me that every part of the shaft had been examined in detail and everything appeared to be all right. It so happened that an engineer visitor was looking around the vessel that afternoon and the second engineer was showing him through the tunnel when the light struck part of the shaft that looked doubtful, and on inspection after hammering it, the part showed a decided flaw sufficient to condemn it. The view put before the builders was that the shaft was bad internally and that the defect was gradually working out to the circumference. They agreed that if the shaft turned out as surmised they would pay for a new one, and they did so. The shaft was sawn through and found to be bad internally. Very probably if this system of Mr. MacDonald's had been applied they might have found that the shaft was overstrained although showing no visible mark. I remember the late Mr. Macfarlane Gray speaking about shafting and internal flaws and the question of examining them by means of the Röntgen rays. He said if we saw what the inside of the shaft was like it would not add to the comfort of engineers.

Mr. Durtnall: These tests are very interesting, in fact they are scientific matters. It is very important indeed with a shaft to make these tests or something similar, but it appears to me that it would be rather difficult and in some cases rather misleading. In this way; assuming everything is accurate when the voyage begins, something like this may take place. The shaft has been gauged in that manner, the ends gauged off and marked and when the vessel returns it is found that a distortion has taken place. In a ship with a very long shaft, it surely cannot be a rigid structure. That shaft has a bending strain, a tremendous braking effect might occur even momentarily, and the torsional strain might take place at that moment. The distortion takes place, but what is the cause of it? However much time was spent, it would never be found out by that method, the shaft might be damaged or it might be quite good. Once the shaft is twisted it generally stays in that position.

Chairman: Many years ago, when I was in the last year of my apprenticeship, a very large steel shaft came into the shop. On looking at it one could see nothing wrong, but the chief engineer of the vessel from which it was taken maintained that there was a defect in it. The Board of Trade inspector could find no flaw in it, and asked him how he came to believe there was something wrong with the shaft. The only reason the engineer gave was that one of the tunnel bearings could not be kept cool, or that they could not keep the oil on it, although the other bearings were all right. The question arose, if this shaft proved to be sound when cut open, who was to pay for it? but the engineer held to his opinion and the examination was made, when it was found right in the centre of the shaft there was a flaw, a hole full of black oil, and I think it was from that time they started boring shafts right through the centre. There was nothing showing outwardly, the observations of the chief engineer was all they had to work upon and I think it was very clever on his part. I quite agree with the last speaker that if a ship is fitted with a new shaft it takes time to settle itself. When the length of the shaft, a steel or iron shaft almost half the length of the ship, is considered, it is evident that it must settle itself to the torsional strain. When it gets to a certain stage that action ceases, but the trouble is to know when it does arrive at that stage.

A MEMBER: I have often wondered, in looking at shafts where there have been fixed bearings, whether it would not be possible to have some kind of bearing which would take up the rigidity of the shaft. Once when in Flushing I was on one of the vessels there and went down into the engine-room. I went through the tunnel and found the shaft to be quite steaming hot at many of the bearings. It was rough weather at the time and the engineer said they did not have the same trouble in ordinary weather. It occurred to me that it was nothing less than friction, not through the weight of the shaft but through the abnormal strain. It seems to me that there is a tremendous power, sufficient to twist almost any shaft under those conditions. Those marks would show at the end of the voyage that a change had happened, but they would not tell what had occurred.

MR. DYER: I understood a correctly designed ship was supposed to be strong enough to stand all shocks and strains, and the shaft is not to be regarded as the backbone of the ship.

CHAIRMAN: I am sure we are all indebted to Mr. Gregory for his paper and also to those gentlemen who have sent in their experiences. Before bringing the meeting to a close I would like to endorse the words of Mr. Adamson when he referred to the loss of the *Sardinia*. They come home to me in a particular way as I was personally acquainted with the captain, Charles Littler. He died a noble death on the bridge, but the men in the engine-room died as nobly. We do not know anything about them, but we know they held on to their duty to the last and I think we ought to place it upon our records.

The proceedings closed with a vote of thanks to the Chairman on the proposal of Mr. HOWIE, seconded by Mr. DURTNALL.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1908-1909

President: James Denny, Esq.

Vol. XX.

LECTURE ON THE GAS ENGINE AND PRODUCER GAS PLANT AND ITS ADAPTABILITY FOR MARINE WORK

By Mr. E. SHACKLETON, A.M.I.Mech.E.

Monday, December 14th, 1908.

Chairman: Mr. JOHN McLAREN (Member of Council).

ADJOURNED DISCUSSION

Monday, January 18th, 1909.

Chairman: Mr. JOHN McLAREN (Member of Council).

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INCORPORATED

SESSION 1908-1909

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INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1908-1909

President: JAMES DENNY, ESQ.

The Gas Engine and Producer Plant and its Adaptability for Marine Work.

BY MR. E. SHACKLETON, A.M.I.MECH.E.

READ

Monday, December 14, 1908.

CHAIRMAN : MR. JOHN McLAREN (MEMBER OF COUNCIL).

THE question of the gas engine and producer plant and its application to marine propulsion is one that has received a large amount of attention and interest from internal combustion engineers, marine engine builders and shipbuilders, some of the latter who, notwithstanding the fact that the gas engine and the gas plant is the prime mover in their own works, seem to be exceedingly chary of giving a trial to the gas engine in the boats they build or engine. It is natural that, after their intimate acquaintance with the steam engine and its traditions, which in many cases dates from over half a century back, they should be very reluctant to adopt a new type of prime mover which but a very few years ago was regarded as only suitable for operating light printing machinery where power was required, not exceeding 10 H.P. The greatest of poets, Shakespeare, may perchance voice their sentiments where he says, "'Tis better to bear present ills than face others we know not of." The natural opposition of the steam engine builder to anything in the nature of a gas engine was, up to a few years ago, very acute, and to-day, in many cases, is still existent. Still, the economic law must eventually prevail, and, by reason of severe competition, shipowners will be driven, in the near future, to ask from the builders a cheaper running type of boat as far as fuel consumption is concerned, particularly in the matter of the cargo type of four to five thousand tons gross.

The present steam type of engine employed is no doubt very economical, as far as steam goes, with a consumption, under very favourable circumstances, of slightly over 1 lb. per I.H.P. per hour. The more common range of consumption, however, is in the locality of $1\frac{3}{4}$ to 2 lb. per I.H.P. per hour. Even if "superheat" were employed, with its attendant wear and tear, it is questionable whether a consumption of 1 lb. per I.H.P. per hour could be maintained. The chief objections to a gas engine and plant, from the marine engineer's point of view, are—

Their inability to reverse. Unreliability. Pre-ignitions and back-fires. Difficulty in starting. Accumulations of dirt and carbon in cylinders and pistons. Poisonous gas from leakage of gas plant.

To these objections we would say in regard to—

Reversing Difficulty.—This will be dealt with in detail later on.

Unreliability.—There are gas engines at work and which have been at work for the last six years, with periods of from three to six months, night and day without stopping.

Pre-ignitions and *Backfires.*—In well-designed gas engines, such as those referred to in this paper, under all normal conditions these troubles are very rare.

Starting.—The use of compressed air for this purpose has now made the starting as easy as that of a steam engine.

Accumulations of Dirt and Carbon, as a rule, may be traced to an inferior lubricant or to excessive lubrication, an item that by a little intelligence, on the part of the engineer-in-charge, may soon be rectified. If not from this source, the plant, particularly the scrubbers, requires probably looking at, as, under the usual working conditions, a fairly clean gas is delivered to the engine.

Leakage of Poisonous Gases.—Accidents which have occurred under this heading are largely due to the neglect of common precaution and are extremely rare. The danger arising from the escape of poisonous gas (carbonic oxide) is more likely to occur in starting producer plants which work under pressure, and even during the running of such systems, should there be any leakage in the plant. In the case of suction plants, which are operated by suction from the engine, the period of danger from the escape of poisonous gases is limited to the ten or fifteen minutes during which the generator is raised to the necessary temperature by the fan. On ship-board a simple system of ventilating fans would reduce any risk to a minimum.

Wear and Tear and Upkeep.—This is certainly an important item, but, as far as the most up-to-date experience is concerned, the labour and cost have been found to be practically little, if any, more than with steam.

The gas engine and plant appear to be more directly suited to marine requirements than the large oil engine, notwithstanding the extra inducement which the latter offers as being self-contained. It is, however, very questionable at the present moment whether the problem of dealing with every description of crude oil, as a fuel in an oil engine, has been definitely solved, and even in such event, it is very doubtful if there is any real advantage over the producer plant in power cost. It must also be borne in mind that the most suitable type of engine for operation with crude oil is somewhat complicated and expensive to build. In the scheme proposed, the writer would like to emphasize the fact that he has no individual axe to grind for any particular type of plant, engine, dynamo or other accessory, and that while he has of necessity selected certain types as particularly suited for the scheme of marine propulsion brought before you, no reflection is intended by non-reference to other plants, engines, etc., of high merit. Specialization is extremely necessary to the ultimate success of the gas boat, and only by such blending of a combination of shipbuilders, marine engine builders, gas engine and plant makers, and electrical engineers, each bringing their varied experience to bear in construction of the boat and her engines, could the desired results be obtained.

With these prefatory remarks the scheme referred to will now be described in detail—

One main set of Westinghouse type, vertical tandem, enclosed gas engines, as illustrated, of 700 B.H.P. Two secondary sets Campbell type, crank chamber gas engines, each of 250 B.H.P. Each of the three engines coupled to a dynamo with two motors, either of 400 K.W. or of 500 K.W, and the usual main switchboard with accessories. The steering gear would be operated by electric motor of suitable design and power. The usual pumps, centrifugal type in this case, would also be operated by electric motors for bilge, ballast and circulating, the latter being employed for the cooling water of the gas engine. A Campbell Oil Engine, 6 B.H.P., to be used for ship lighting when in port as referred to later.

The writer has not attempted to go into the smaller details, as, of course, it is impossible to specify correctly until the dimensions, space and conditions of a vessel so fitted can be definitely decided on by the shipbuilders.

The Gas Plant suggested is of the "Suction" or of the "Semi-Suction pressure" type, in either case having four generators and capable of supplying gas for the engines, of the Dowson, Crossley and Mersey types as illustrated.

Repairs.—The low cost of repairs varies somewhat, but the following figures from the Dowson Catalogue may be taken as approximately correct—

For 100	horse power,	about	£4	per annum.
,, 200	,,	,,	£6	,,
,, 300	,,	,,	£9	,,
,, 400	,,	,,	£12	,,
,, 500	,,	,,	£15	,,

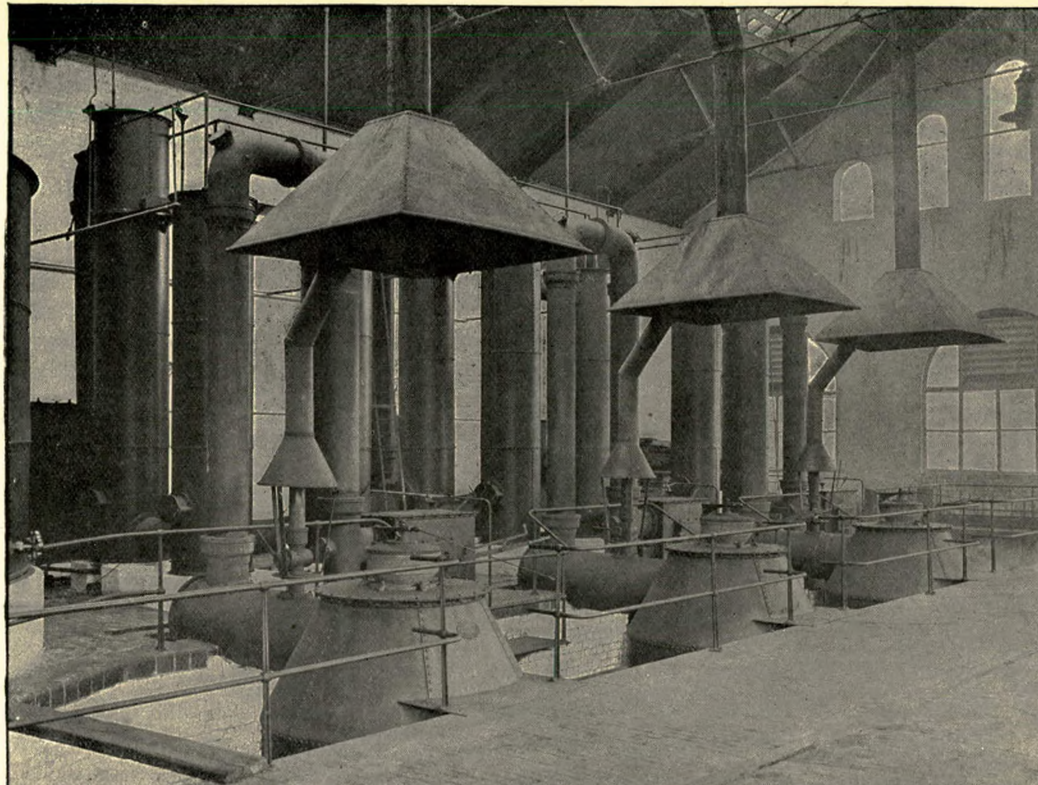
The cost of cleaning and repairing the boilers used for steam engines is much more serious.

Dowson Gas Plant.

Description.—The Dowson Gas is a *cheap fuel gas* used instead of ordinary town gas for driving gas engines, and for heating work of all kinds. It is also used for furnace work instead of coal fires.

Process of making Gas. The Dowson Gas is made by passing *superheated* steam, mixed with air, through red-hot fuel in a vertical gas producer. There is no outside fire, the cost of repairs is trifling, and the apparatus is simple and easy to work. The gas is made as quickly as it can be consumed, and its production can be governed automatically to suit a varying rate of consumption. When not required, as at meal times or at night, the making of gas can be stopped at once.

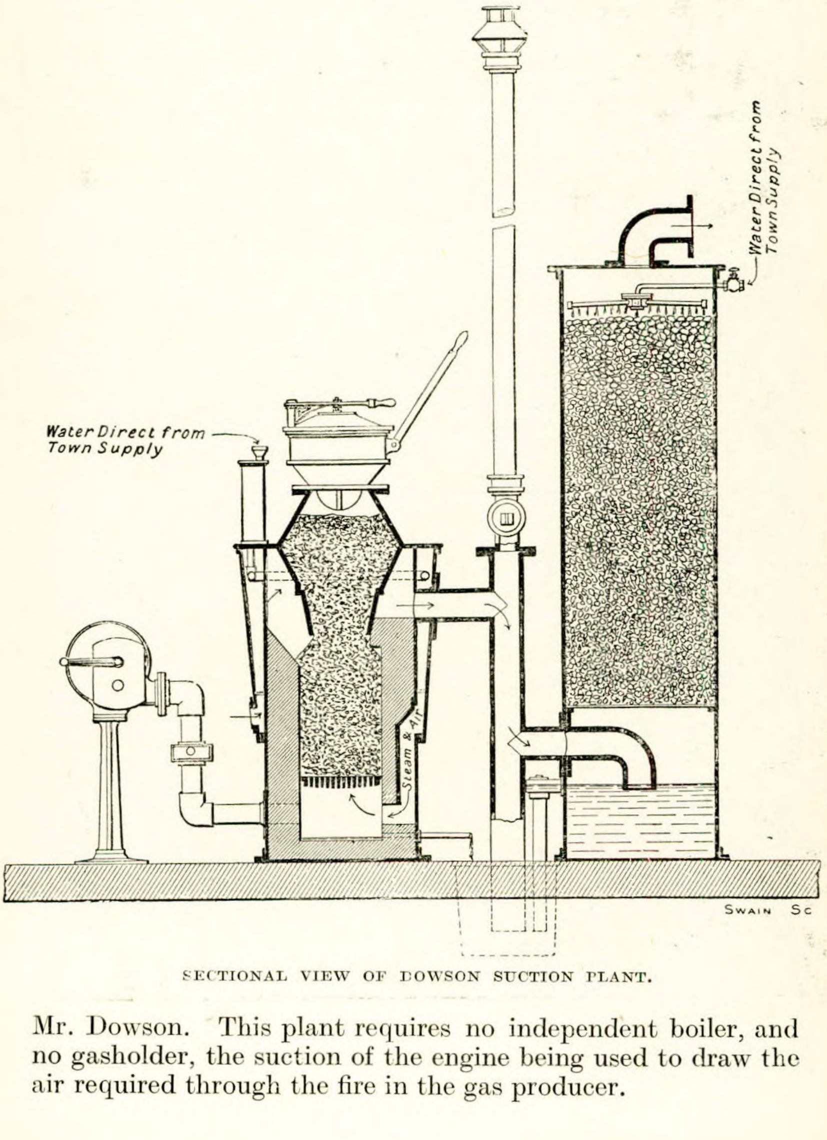
For engine work, or where cocks and burners are used, the



DOWSON GAS GENERATORS OF 300 B.H.P. EACH AT THE ELECTRICITY STATION FOR LIGHTING THE EUSTON STATION OF L. & N. W. RLY. CO.

gas is cooled, washed, and scrubbed, and in some cases it is passed into a gasholder.

Suction Plant.—More recently a suction type of plant, specially designed to serve gas engines, has been introduced by



SECTIONAL VIEW OF DOWSON SUCTION PLANT.

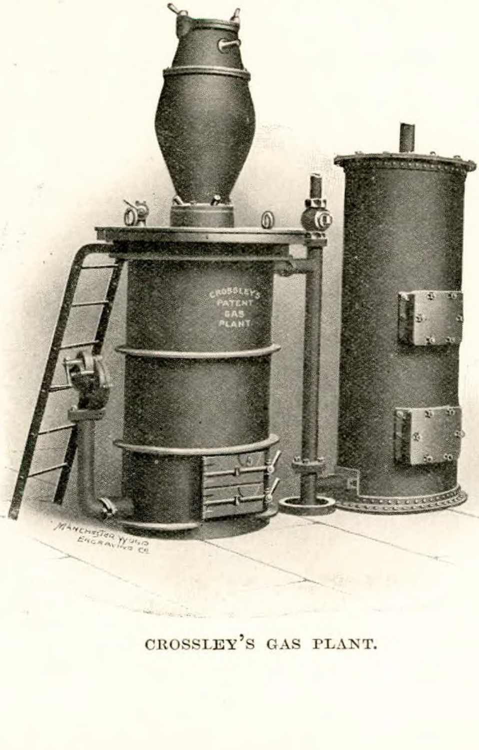
Mr. Dowson. This plant requires no independent boiler, and no gasholder, the suction of the engine being used to draw the air required through the fire in the gas producer.

The gas is made by passing a mixture of steam and air through the incandescent fuel, as in the other types of Dowson gas plant. The engine itself governs the rate of producing the gas, to suit its own varying consumption, and while the engine is working there *cannot* be any escape or waste of gas, as there is then a partial vacuum in all parts of the plant and in the piping.

The Dowson Suction Plant was specially referred to in Mr. Dugald Clerk's " James Forrest " lecture at the Institution of Civil Engineers, on April 21, 1904. Elaborate independent tests were made, and full particulars are given in Vol. CLVIII. of the Proceedings. It is remarkable that with a 40 B.H.P. plant, worked with ordinary commercial anthracite, the actual heat efficiency was proved to be as high as 90 per cent. In other words, only 10 per cent. of the heat value of the fuel was lost in the process of making a cheap gas suitable for driving a gas engine.

Description of Crossley's Gas Plant.

The producer consists of a cylindrical firebrick-lined chamber, separated from the outside metal skin by a coating of sand.



CROSSLEY'S GAS PLANT.

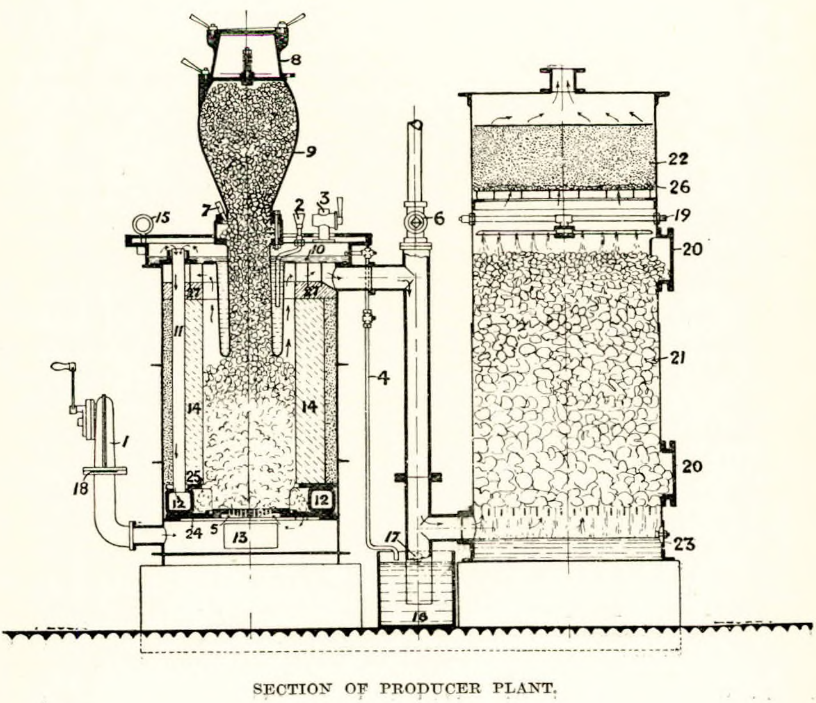
The firebrick lining rests on a metal ring supported on two cast-iron segmental-shaped boxes termed "superheaters," placed at the hottest part of the fire and mounted on a flat plate carried right across the producer. This plate has a hole in the centre in which rest the bars of the firegrate. In this way a pit is formed immediately below the firegrate, and in this pit the steam and air used in the gas-making process mix before passing altogether through the fire. On the top of the producer will be noticed a feeding hopper, through which the fuel is introduced. Around the cylindrical "bell," defining the depth of fuel in the producer, is formed the "well" of the vaporizer or boiler. Cold water is introduced into this well and fills the rest of the vaporizer to a level defined by an overflow pipe. The vaporizer is shaped like a flat dish extending to the outside shell of the producer. This dish has a series of baffle plates on its under surface which form passages through which the hot gas has to pass, giving up its heat to the water before going to the coke-scrubbers to be cleaned. Two vertical steam pipes form the connexion between the vaporizer and superheaters.

Producer gas is obtained by passing air and steam through incandescent fuel. Two simple reactions take place expressed by—

$$2C + O_2 = 2CO$$
$$C + H_2O = CO + H_2$$

That is to say, the oxygen of the air combines with the carbon of the fuel to form carbon monoxide, and the water splits up to form more of the monoxide and free hydrogen. In addition to this a certain amount of marsh gas, CH_4 and carbon dioxide, CO_2, are formed, so that the ultimate composition of the gas is —combustibles CO, H_2, and CH_4, diluted with the non-combustibles CO_2 and N_2. In the suction plant we are now describing, the requisite steam is raised in the vaporizer mentioned above by extracting the heat of the gas as it passes from the fire. All such plants to be economical must work on the "regenerative" principle. The older form of producer, in which even for small sizes a steam boiler was required, cooled the gas before sending it to the engine, by passing it through atmospheric coolers, or, in other words, coal was first burned under a boiler to add heat that was finally wasted. Messrs. Crossley Bros. make all their plants to work on the regenerative

No	DESCRIPTION
1	HAND FAN
2	FEED WATER FOR VAPORIZER
3	AIR REGULATING COCK
4	OVERFLOW FROM VAPORIZER
5	FIREGRATE
6	BLOW OFF COCK
7	POKER HOLES AND PLUGS
8	FEEDER
9	HOPPER
10	VAPORIZER
11	SUPERHEATER PIPES
12	SUPERHEATERS
13	FIREDOORS
14	FIREBRICK LINING
15	EYE LIFTING BOLTS
16	SEAL POT
17	OVERFLOW FOR SEAL POT
18	PLATE DAMPER
19	SCRUBBER WATER SPRAY PIPE
20	FILLING DOORS
21	COKE SCRUBBER
22	SAWDUST SCRUBBER
23	CLEANING DOOR
24	FIREGRATE SUPPORT
25	FIREBRICK SUPPORT
26	LAYER OF SHAVINGS
27	FIRECLAY



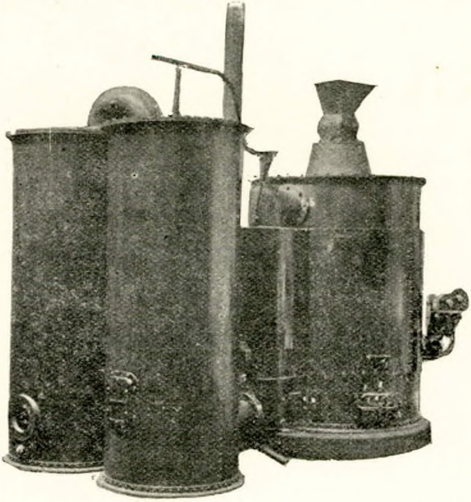
SECTION OF PRODUCER PLANT.

principle, and this is undoubtedly one of the causes of the great economy obtained. The Crossley Suction Plant has found favour on account of its extreme simplicity. The forward motion of the piston of the engine draws the air and steam through the producer. This does away with the necessity of a fan to force air through the fire, and has this further advantage, that when the engine governor cuts out the charge, no gas is made and no coal is burned in the producer. A great difficulty met with in designing suction gas plant was to obtain a uniform quality of gas with varying loads. When the engine governor cuts out a number of charges steam continued to be raised ; this filled the steam-spaces, and the subsequent charge was exceedingly inflammable. It moreover cooled the fire in its production, with the result that after the temporary richness had passed off, the gas produced at a lower temperature was of poorer quality. This difficulty is got over in the Crossley Suction Plant by having one or more cocks opening from the air-space above the water in the saturator into the open air. Through these openings the steam escapes at light loads. This is part of an important patent for the regulation of gas producers.

Very little attention is required. The hopper is designed to hold sufficient fuel for a four-hours' run at full load, and in actual practice plants are often left much longer than this without attention. With anthracite at 21/4 the cost of fuel per B.H.P. is one-tenth of a penny per hour. This is based on the firm's guarantee that at full load on the engine the producer will not consume more than seven-eighths of a pound per B.H.P. per hour. That the plants are well within the guarantee in this respect is shown by independent tests, in which so low a consumption as ·7 pounds per B.H.P. hour has been reached. A gas engine combined with dynamo running from a suction plant forms a very convenient set for electric light work. With such a combination the Kilowatt can be obtained for very little over one pound of coal per hour. Some coke can be used without special devices for getting rid of the tar, but in the majority of cases such is not possible. To attempt to take it out by means of a common sawdust filter is courting disaster, and in no case has such an arrangement been entirely satisfactory. With the experience gained in solving the problem of the successful use of a common bituminous coal for gas engine work, Messrs. Crossley Bros., Ltd., have attacked the question in a different manner entirely and can guarantee the use of any kind of coke, no matter what degree of tarry matter it contains, in such plants. This result is obtained by careful attention to various points of design, and by the use of what might be called a semi-bituminous Suction Plant and the necessary apparatus in connexion with it. As common gas coke can be obtained very cheaply in most places, a new field has been opened which should eventually be a boon for the manufacturer in providing power cheaper even than the use of an Anthracite Suction Plant, especially in those cases where the higher first cost of the bituminous coal plant proper is objected to.

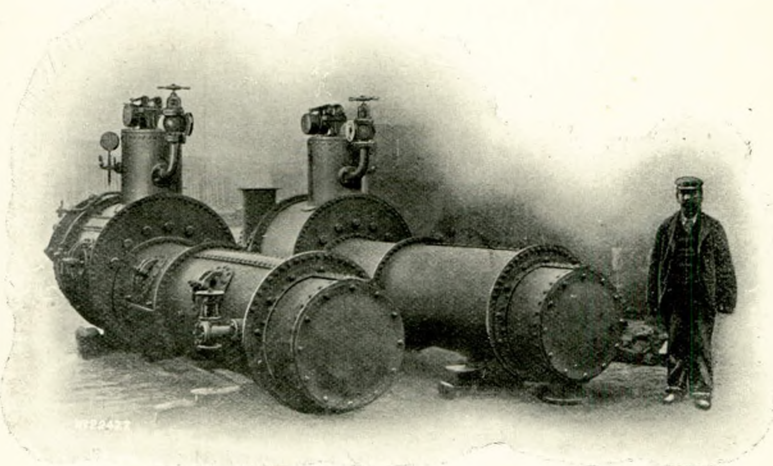
MERSEY PLANT SUCTION PRESSURE.

This producer is a suction producer to which is added a pressure fan and a pressure regulator. The suction side of the fan is connected to the washer, and on the pressure side of the fan a patent pressure regulator is fixed. By this means



the gas is kept at a constant pressure, the production of gas being automatically regulated to suit the demand. The advantages of this type of producer are numerous ; the first cost is exceedingly low ; the running cost is low ; it is not necessary to have a boiler (which usually requires a large amount of attention). The whole of the generating and washing portion of the plant works at a pressure below that of the atmosphere. It is possible to open the ash door, slice the fire, or do whatever else is required, without interfering with the making of the gas. If space is valuable, and it usually is in ships, then this plant possesses yet another advantage, as with this arrangement no holder is required. The fuel this plant consumes is non-bituminous, i.e. anthracite, coke, or charcoal, etc. This plant will

WILSON EXHAUST BOILER. MAKERS: Messrs. A. Barclay & Son, Engineers, Kilmarnock, Scotland.



Referred to by the author in his paper, and intended for the utilization of the gas engine exhaust gases, supplying steam to gas plant and using sea water.

generate a quantity of gas equal in work to 1,000 cubic feet of towns' gas for from 4*d.* to 8*d.*, according to cost of fuel, this includes labour. This low cost is due to the high efficiency of the plant, and the amount of attention required, the attendance in a plant of this kind being from five to ten minutes per hour. This time can be taken as being a generous allowance. Wherever there are a number of engines to be installed, it is advisable to use this type of plant, as the gas can be delivered almost any distance at a practically constant pressure and value. The temperature which can be obtained with this gas is about 2,000 deg. F.

This plant will run two weeks without a stop. The Power

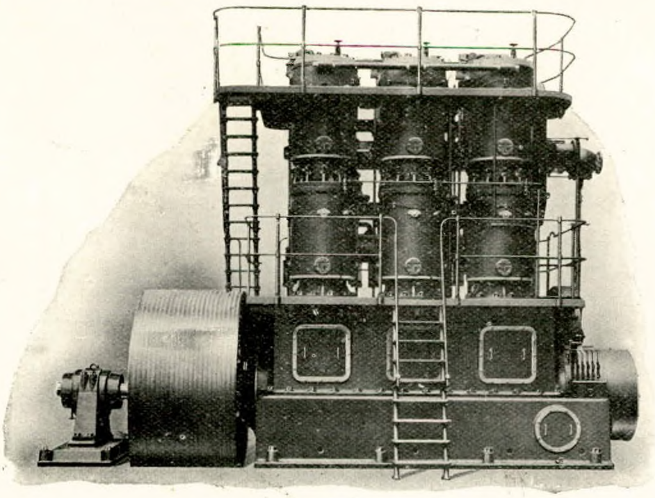
Gas Corporation (Mersey Plant) have a specially patented marine plant of which details, the author regrets, are not available at the moment.

Boilers of the Wilson exhaust type, also acting as silencers, supplying steam for suction plant and for condensing purposes, using sea-water, would be required, and one small boiler for raising steam when plant is started and when the Wilson boilers are not available.

The engine shown in the illustration is the latest type, tandem vertical Westinghouse, and the latest experience with this engine is that they are extremely steady running and reliable, and should prove in every way very suitable as a main engine power unit, having also the advantage of giving out a great amount of power for space occupied, an important feature in the scheme under consideration.

Description of Westinghouse Engine.

Westinghouse Tandem Vertical Gas Engine.

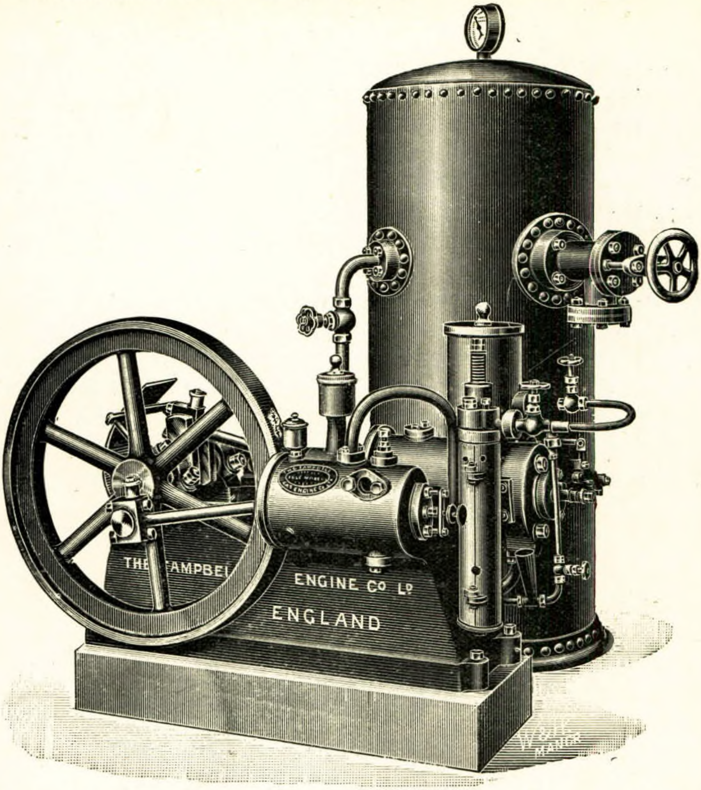


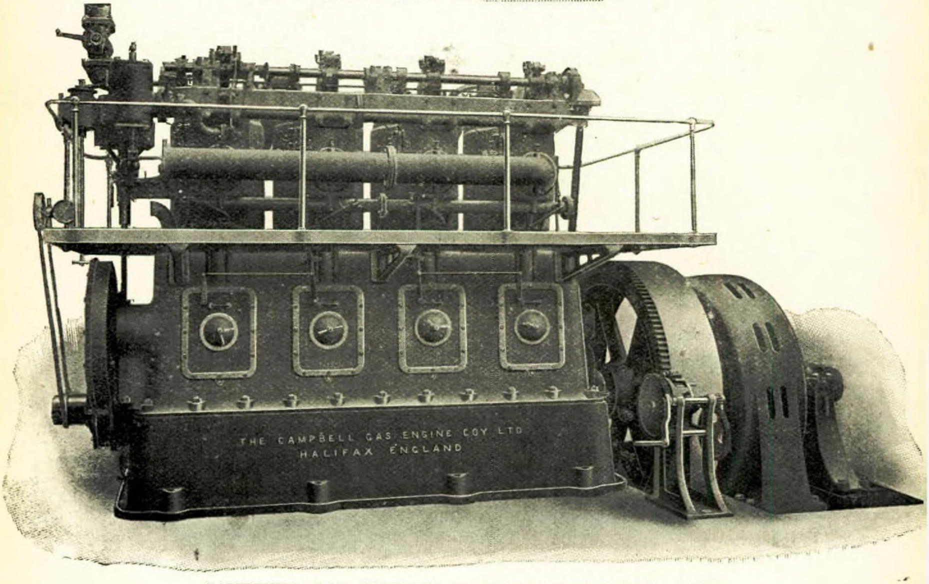
750 B.H.P., 200 R.P.M., WESTINGHOUSE TANDEM GAS ENGINE.

The advantages which are claimed for this new type of engine are briefly as follows :—

(1) Low cost and reliability.
(2) Ability to run long periods without adjustment.
(3) Compactness and small floor area.
(4) Accessibility of all parts.
(5) Easy to erect and overhaul.
(6) Stresses reduced to a minimum.
(7) No water-cooling of moving parts.
(8) Forced lubrication throughout.

CAMPBELL OIL ENGINE AND AIR RESERVOIR used for starting gas engines and also available for electric lighting (dynamo not shown).





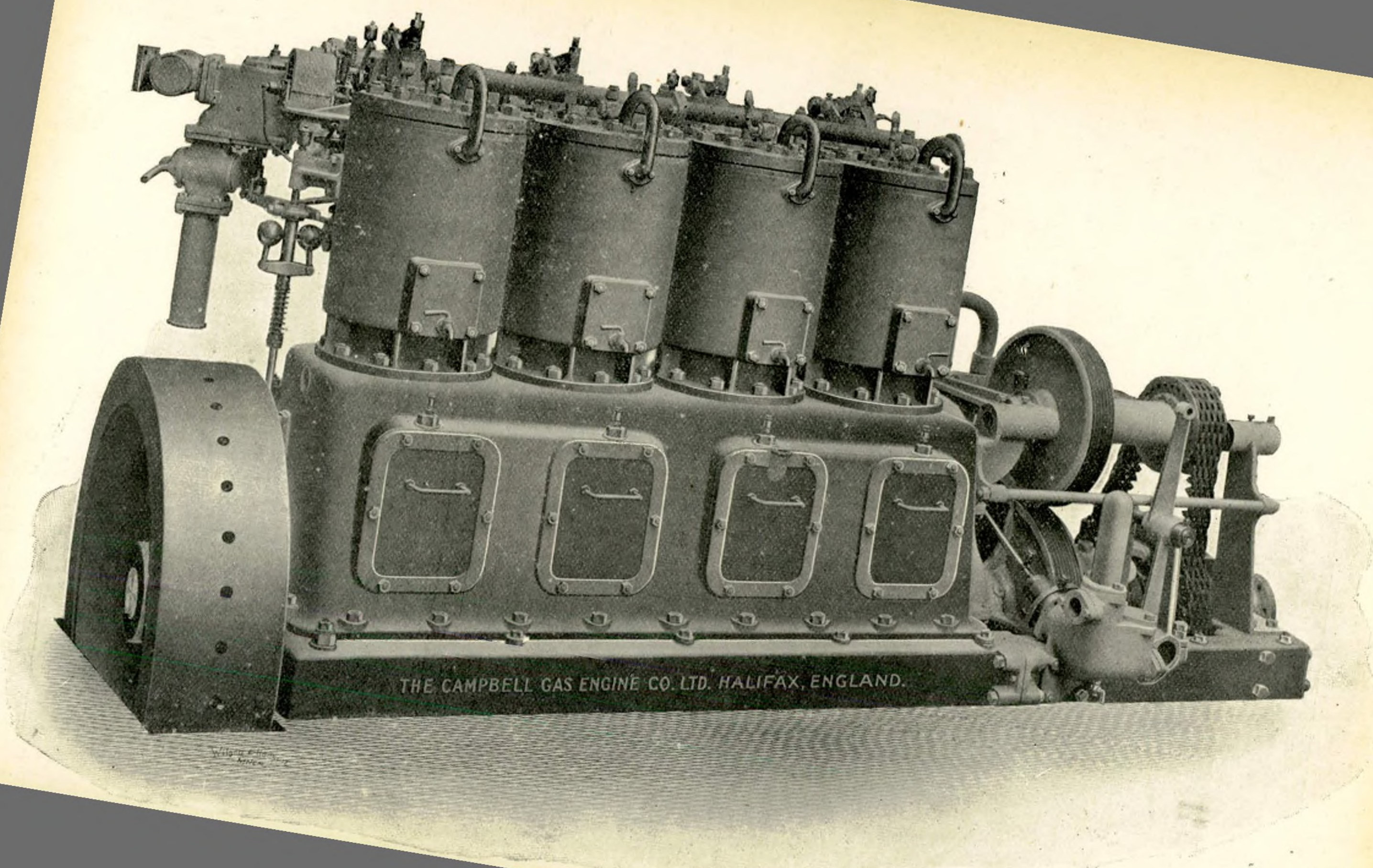
CAMPBELL GAS ENGINE: V RTICAL, ENCLOSED TYPE.

The engine shown (p. 16) is built by the Campbell Gas Engine Co., is of a similar type to the preceding one, and should also prove a very satisfactory smaller unit.

Description of Campbell Gas Engine, Enclosed and Marine Types.

Specification of 360 B.H.P., 200 R.P.M., Suction Producer Gas Engine :—The cylinders having liners of special hard, close-grained cast-iron, which may easily be re-bored when worn. The space between the liner and outside of cylinder forms the water jacket, which keeps the cylinder cool by means of a constant circulation of water. The piston to be of the "Bucket" type, made of hard close-grained cast-iron, fitted with metallic piston rings, and coupled to the connecting rod by means of a hardened and ground piston pin. The engine bed to be a massive hollow casting. In the horizontal engine it is prolonged under the cylinder to reduce the overhang to a minimum. This improvement prevents vibration and the working loose of the engine on its foundation, which so often occurs with engines having long overhanging cylinders. Waste-oil trough cast round base. The crank shaft to be of Siemens-Martin steel, forged from the solid and running in adjustable white-metal bearings, having ample wearing surface. Intermediate bearings to be fitted between each crank. The fly-wheel to be of extra weight in order to ensure steady running, and to be 8 feet diameter by 15 inches broad on face, rim turned and polished.

A sensitive governor of improved construction to be provided, and so arranged that changes in speed can be made without stopping the engine. The governor to control automatically the amount of gas consumed according to the work being done at any period. Independent magneto ignition with timing adjustment to be fitted. The air and gas valves to be fitted into loose cast-iron boxes or valve plugs, which can be easily removed for cleaning and repair. The joint between the valve plugs and the cylinder to be a ground metal to metal joint, no jointing material being required. Valves and covers to be hollow and water cooled. Lubricators to be provided for lubricating piston, crank pin, main bearings, and all moving parts. Forced lubrication to cylinders, crankshaft and connecting rod bearings and exhaust camshaft. Ring


THE CAMPBELL GAS ENGINE CO. LTD. HALIFAX, ENGLAND.

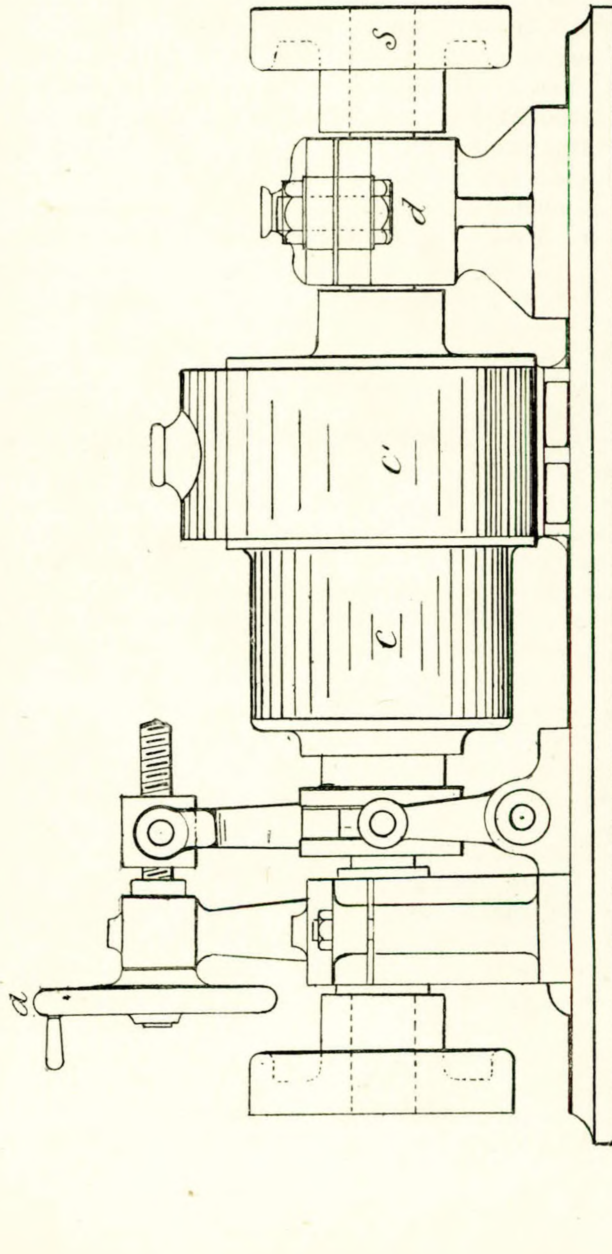
lubrication to inlet camshaft. Special exhaust silencer to be provided.

The engine to be well painted and enamelled when completed. The materials used in the construction of the engine to be of the best quality for the purpose for which they are intended. The workmanship and finish to be of the highest class, and the engine to be run under a test load previous to despatch. Barring gear, tachometer, indicator gear and working platform to be fitted.

Inability to Reverse.—Reversing is beyond doubt a most important function in marine work, and it must be an operation that can be carried out with certainty and without delay. To reverse a gas engine of any size would, and will be, an extremely complicated process. While it is recognized that a reversible gas engine is an accomplished fact, it is probable that, under the very onerous conditions of marine work, the increased wear and tear and complication, of reversibility, would only be obtained by a sacrifice of efficiency and reliability. Nothing could be more fatal to the progress of the marine gas engine than increased working parts where efficient simplicity is desired. As the safety of a vessel sometimes hangs on her ability to go astern promptly, it is at once obvious that this is a point which cannot be missed. With the electric drive proposed, the reversing process is, of course, carried out by the motors attached to the propeller shafts.

Reversing Gear for Propellers.—Although the writer advocates electric drive, it is clear that to shipowners who do not require more than 600 or 800 B.H.P. the expense of such type of drive would probably deter them from trying a vessel fitted with a gas engine. There are, on the market, several reversing friction clutches which should, possibly in a modified form, do all that is expected if the full power were not desired for going astern. There is no reason to suppose that they would not perform their duties satisfactorily. Where twin screws are employed, reversing might be confined to one propeller which, under all ordinary routine conditions, should prove satisfactory although being somewhat slower in action. In such a case as this the proposal submitted as to electrically driven winches would still be carried out except in the case of a sailing vessel.

The Coil Clutch Co., Ltd., now construct reversing gears up to 2,500 H.P., and have made several gears of heavy power transmission capability for marine work of a similar type to the one shown herewith. The gearing is always in mesh, consequently



THE COIL CLUTCH COMPANY'S (LTD.) REVERSING GEAR.

this clutch is perfectly silent when running ahead, and almost noiseless when going astern. It has one positive speed ahead and astern, both controlled by hand-wheel *a* or by a hand lever if preferred. When desirable the speed can be regulated and the boat run to dead slow by manipulating the starting gear.

C and C^1 are clutch and gear cases containing lubricants; d is combined ball bearing and thrust block; S is the driven shaft carrying propeller.

The enclosed type of gas engines recommended for consideration in the scheme appears to be admirably adapted for marine conditions. They are well balanced, positively lubricated and, being enclosed, any leakage of gas that might pass the pistons is confined to the case. Their speed is higher than certain types of gas engines, but at such speeds gas engines of the type referred to run as a rule steadily without great vibration. It is not anticipated that the sole plate or bed foundation for these engines on ship-board would present serious difficulties to the shipbuilder. The system of governing these, compared with steam engines, is decidedly in their favour, there being no hit and miss, but positive throttling by varying the quantity and quality of the explosive mixture. The engines of the tandem type have also proved themselves to be very reliable and also admirably adapted for the class of work.

For the purpose of starting these engines, i.e. charging the compressed air reservoirs, it is proposed to use the small oil engine which is also used for ship lighting. It is not intended, for the limited power required for a 3,000 to 4,000 tons gross gas-driven vessel, to introduce the bituminous producer. While it is recognized that such a producer would undoubtedly be a great advantage for marine purposes, the writer feels satisfied that anthracite is now sufficiently available to economically answer all the requirements of a cargo boat working on a fixed route. This fuel is available outside Wales, in America, New Zealand, and various parts of the Continent. If the same were not available, recourse could be made to good coke. As far as can be seen, it is, moreover, questionable whether for powers not exceeding 2,000 B.H.P. the bituminous plant would really be such an advantage as would otherwise appear. Outside its main feature, the ability to use common fuel, it is cumbrous, decidedly more complicated in its action, requiring considerably more attention, and is almost twice as heavy as the suction gas plant. Ammonia recovery would also be out of the question on ship-board. Whilst it is recognized that ability to use a common fuel is certainly a great deal in its favour, it appears to the author that the simplicity of the suction plant will, in the long run, outweigh such advantages for moderate powers and under marine conditions. In making comparative tables of costs of a gas-driven and a steam-driven steamer, the writer has in mind that anthracite is dearer than Welsh steam coal and also than North Country coal, but, taking into consideration the pros and cons, this is not an all-important factor. It would doubtless, however, be necessary to use a bituminous producer plant for powers exceeding 2,000 B.H.P., but as this paper recommends a trial of a boat of moderate powers, having in mind the maxim "learn to walk before you run," the plants shown are simple in operation, reliable and economical and, as far as can be foreseen, marine conditions and the motion of the boat are not likely to greatly affect its operation.

The fairly regular load in marine work would suit the producer plant, and the fact that such plants would require to work continuously is favourable to the producer; in fact, a more uniform gas of even quantity is likely to be produced with corresponding fuel efficiency than would be the case where the plant is shut down at the end of a day's work. The bogey of tar troubles, etc., is very much overblown, and under the intelligent eye of the average marine engineer little or no trouble should arise from this source. It is proposed to have the generators in four small units, this being considered desirable so that in the event of any repair or cleaning being required one may be shut down, till this has been effected, without interfering with the production of gas from the rest of the plant. In the event of anthracite not being available, good gas coke, which can be obtained almost anywhere, may be used with good results on a slightly higher fuel consumption. Coke, however, requires more attention at the generator, and the gas made from it is not so clean as that made from anthracite. The plants under consideration are suitable for either fuels and give a gas very free from tars. The scrubbers are made extra large to cope with such an emergency. Sea water would be quite unsuitable for direct use on the gas plant, as the vaporiser would quickly become encrusted with salt and cease to make steam. A small steam boiler is installed for starting steam, being available when the engines are running from the Wilson boiler, to which reference is made earlier in the paper.

Objection will no doubt be taken to the proposed speed of the propellers, 200 to 250 R.P.M., as this is, of course, much higher than the present cargo boat. While it is recognized that a low-speed propeller has certain advantages, it must be borne in mind that they are more or less in ratio to the present steam-engine speed, which could not well be higher. The writer is of opinion that where a high-speed propeller is found necessary the shipbuilder would quickly adapt himself to the exigencies of the position. The electric motors for driving the two propellers would, of necessity, occupy more space near the propellers than the present tunnel permits, but this is also a matter which the shipbuilder would allow for without any serious expenditure, when the boat was building. Doubtless the cost of the electrical equipment would be heavier than the average steamer, probably £6,000 to £7,000, but apart from the huge saving in fuel consumption over the steamer, the reduction of strain on the hull due to a short shaft at propeller end and electrical drive, together with the great advantage that in bad weather the very effective method secured by such drive against racing, would be invaluable, greatly minimising the liability of losing propellers in bad weather and giving great frictional reduction compared with the present steam-driven shaft drive. Another objection against the electric drive may be urged on account of the loss of power from dynamo to motor. This will doubtless be in the locality of 15 per cent., and is no doubt an item of some importance; but let it be considered that while, generally, electrical losses are a measured quantity, frictional losses from the present system of drive are bound to be fairly high, probably 10 per cent. to 12 per cent., and are practically unmeasured quantities. Mr. Durtnall's valuable paper on electric drive has covered much that the writer had intended to say on its advantages. One very strong feature of the scheme under consideration would be his arrangement for electrically operated winches, one of the smaller units in the engine-room driving a dynamo for the purpose of cargo discharging. Essentially the fittest place for any power generation is the engine-room instead of the present system of ten or more scattered winches.

Sea water would be used for the scrubbers attached to the gas plant. Doubt has been expressed in certain quarters as to the use of sea water in the engine jackets. As, however, large volumes of water are circulated and are not allowed to boil there is no reason to anticipate trouble in this direction.

Although, in view of the high efficiency of the electric motor of the present day, troubles are of rare occurrence with well-designed machines, provision ought to be made for even such a remote contingency as the "burn out" or "fusing" of the electric motor, and it is suggested that this should be accomplished by the addition to one propeller of an emergency shaft, the same being directly in line with one of the power units, so that, in the event of the tunnel becoming flooded, or the motor useless from other causes, the shaft could be brought into operation and, current being off the dynamo or motor, slow speed could be maintained by the emergency shaft for some time through direct drive from the engine. Although this paper is on gas engines, it is hoped that serious objection will not be taken to the inclusion in the scheme of a small oil engine, which, as hitherto explained, performs a double purpose. As, frequently, when a cargo boat is in port, and as would be the case probably with a gas boat, there are periods when light is desired for the use of the ship for which it would be obviously uneconomical to run one of smaller gas units. The oil engine under consideration will furnish about sixty 16 c.p. lamps with current for about $2\frac{1}{2}d.$ to $3d.$ per hour. This little question appears to have more in it than meets the eye, and it would be interesting to have figures as to the steam cost of similar lights for the same length of time. For the purpose of comparison the following table has been made :—

Ship in Port and no Cargo Discharge.

Small Oil Engine (Campbell).	Steam.
Sixty 16 c.p. lights for 12 hours.	Donkey boiler for 12 hours.
Consumption = 4 pints paraffin per hour at 5*d.* per gall.	Consumption = 1 ton coal.
= 2*s.* 6*d.*	= 15*s.*

This is, of course, a small item of saving, but it would be seen that, even where the present steamer is concerned and where constant steam is not kept, it would pay to instal a small oil-driven set for the purpose of lighting.

As to the type of boat where gas engines could be employed as auxiliary method of propulsion, one is of the opinion that an installation of 400 to 500 B.H.P. gas-driven plant could be adapted to one of the modern large sailing vessels, in which case, of course, the use of one or two propellers would be recommended, and there is every reason for belief that such an arrangement would prove exceedingly economical. The engines could be stopped when full sail was available, and the voyage could be considerably accelerated when in the locality of no wind or very light winds. It is, of course, obvious that there would be a slight reduction of the cargo space available and that also a skilled engineer would have to be carried, but the increased speed would doubtless prove an additional inducement to shippers who desired reasonable time voyages. With a boat of, say, 2,000 tons gross, 5 to 6 knots an hour under power alone should be feasible in moderate weather. Assuming engines were required for 18 days on a voyage to Australia, fuel consumption would be about, in sailing vessel with auxiliary gas engines :—

500 B.H.P. = 575 I.H.P. using $4\frac{1}{2}$ cwt. anthracite per hour = 5 tons 8 cwt. per day.

18 days @ 5 tons 8 cwt. per day = total consumed 97 tons 4 cwt.; 97 tons 4 cwt. @ £1 1*s*. per ton = £102 1*s*. 3*d*.

An average voyage time to Australia for sailing alone = 80 days. Sailing and auxiliary gas engines—1 week = 850 knots; 1 week = 630 knots; 4 days = 400 knots; giving an estimated time saved = 10–12 days. While the advantage of using engines, avoiding towage charges, and in cases of emergency, is a factor that should go far to lower the insurance rate of the sailing vessel.

	Gas Auxiliary. 500 B.H.P.	Steam Auxiliary. 500 I.H.P.
Fuel consumption, per day	= 5 tons 8 cwt.	= 10 tons 16 cwt.
Labour	= 2 men.	= 4 men.

Cargo space occupied with gas = 50 per cent. less than steam plant.

The consumption of fuel will be 1 lb. per B.H.P. per hour, a liberal allowance; but it is probable that it would not exceed 0·9 lb. per B.H.P. per hour. At 1,200 B.H.P. this would mean a fuel consumption of 1,200 lb., which is : 1,200 lb. = $10\frac{3}{4}$ cwt. per hour. Compared with Steam Plant, which usually bases its power on an indicated formula, fuel consumption for 1,200 I.H.P. at the rate of 2 lb. per I.H.P. would be = 2,400 lb. = $21\frac{1}{2}$ cwt. per hour, which, however, is frequently exceeded, particularly if the fuel is of bad quality.

The comparative fuel consumption, gas and steam, is estimated to be as follows :—

Gas.	Steam.	Stand by Losses.
1,200 B.H.P.	1,200 I.H.P.	
Actual 1,380 I.H.P.	Fuel consumption	
Fuel consumption	per day.	Steam 20 %.
per day=	25 tons 16 cwt.	Gas 4 %.
12 tons 18 cwt.		
7*s.* 6*d.*	15*s.*	

For cargo discharge in a cargo boat the following is a basis of comparison :—

Gas.[1]	Steam.	Stand by Losses.
200 B.H.P.	200 B.H.P.	
Fuel consumption	Fuel consumption	
for 12 hours=	for 12 hours=	Steam 20 %.
1 ton 1 cwt. 48 lb.	5 tons 7 cwt. 16 lb.	Gas 4 %.

[1] Using electrical winches.

Referring to the cargo discharge consumption the writer is of opinion that the majority of engineers are acquainted with the excessive fuel consumption of the average steam winch, which (on account of its very low efficiency, owing to condensation losses, etc.), may probably be put at 5 lb. per H.P. per hour, as not too high an estimate. Hence 10 days' loading or discharge under gas and steam systems is shown to be as follows—

Gas.	Steam.
Fuel consumption=	Fuel consumption=
10 tons 14 cwt.	53 tons 15 cwt.
Cost £11 11*s.*	Cost £43.

The cargo space economy of the gas-engined steamer may be compared with steam as undernoted—

Gas.	Steam.
1,380 I.H.P.	1,200 I.H.P.
50 days' passage.	50 days' passage.
Coal space=645 tons.	Coal space=1,250 tons.
Cargo space economy=550 tons.	

An estimated liberal allowance has been made for any contingencies arising from extra room being required for producers, engines, etc. Another element of gain on the side of the gas engine is in the time required for coaling. The estimated consumption of fuel for the gas system is, say, for a 50 days' voyage of a cargo boat £677, and for steam on the same basis £950.

The writer is confident that a well-designed steamer fitted with gas could show a profit of £1,000 over and above the steamer per voyage, irrespective of less labour costs, coaling time saved, cargo discharging fuel economy. Over and above this profit it is probable that from £200 to £250 would be saved in minor charges, which could be written off against the extra cost of construction of the boat.

In conclusion it may be said that the moderate power gas boat must take its place in the marine world at an early date, and the object of this paper is to attract the attention of owners and engineers to the subject with a view to elicit information and provoke discussion.

Much misgiving seems to possess the mind of the average marine engineer regarding the reliability of the gas engines which they regard as a delicate machine and not to be compared to the beloved steam engine. A well-constructed gas engine intelligently looked after will do periods of running that would not be credited unless actually seen by a marine engineer.

It is but natural that engineers who have had experience of the good work done by the steam engine should look with suspicion upon a system which has only been fully tried on land, but the entry of the gas engine is inevitable, and it is only fair to ask marine engineers not to anticipate difficulties before they arise. If science or progress did not demand a trial of this form of motor, there is the economic force represented by the ship owner who, in an age of competition with low freights and badly paying ships, is compelled to look for a cheaper type of prime mover in his steamers. This he can have in the gas-engined boat, or the auxiliary sailing vessel. Apparently, it is not so much a question of building, as inducing owners to leave the beaten track and pay a fair price for such a vessel, but it is to be hoped that a good trial will soon be made to demonstrate all the advantages claimed for the gas engines ; our German competitors have already commenced construction of three such boats. The results of the experimental boats fitted by Messrs. Thornycroft, Crossley, Capitaine, and Beardmore, are not fully available, and even were these available, might not afford much elucidation, as the field of such experiments have not generally been in cargo steamers of the type under review. Criticism may also be raised on the subject of this paper as being purely a paper scheme, which is in a measure quite true, as up to the present moment no gas boat has been constructed. It may, however, be pointed out that the engines and plant recommended are recognized, tried, proved and satisfactory component parts of the scheme under consideration, and are not machines unknown or untried for reliability.

CHAIRMAN: We are obliged to Mr. Shackleton for his interesting paper, and I am sure many of you will have something to say on the subject, which is now open for discussion.

Mr. F. M. TIMPSON (Member): Reference has been made principally to the gas engine, but I doubt if it would be preferable to the oil engine for ship propulsion. One item which would tell against it is the capital cost, which, in such a scheme as that put forward, would be very high. The initial cost of the gas producer is greater than that of the oil engine and the weight is more. No doubt the cost per B.H.P., which is taken as the unit for internal combustion engines, is less in the oil gas producer plant taking coke as against ordinary paraffin oil; but when crude oils, which are very cheap, are used, the engine will compare equally well. Then again there is the question of reversing, which is a very important item in marine work. With the gas engine in a vessel on the Clyde which has been widely referred to recently, the *Rattler*, the clutch was enormous and very complicated. The builders are also engaged in the development of the oil engine; they have succeeded in making a reversible oil engine which will correspond closely with the steam engine. Weight is important and I will give some data on that point. In an oil engine of 125 H.P. the total weight is only 6 tons, in a gas producer it is 13 tons. An oil engine of 150 H.P. weighs 7 tons 15 cwt., while the gas engine of 150 H.P. weighs 18 tons. In both cases the weight of the producer plant is more than double that of the oil engine. The cost of the oil engine in the first instance would be £1,100 against £1,500 for the producer plant, and in the other case £1,450 against £1,750. These figures are, of course, approximate. There is no doubt gas engines have done excellent work ashore, but a difficulty is still found in keeping the passages clean. The entire working costs depend upon the price of fuel. Paraffin is available in most parts, and I do not think anthracite is so easy to get as anticipated, while the price is very high. With the ordinary paraffin oil the cost of the oil engine would be about ·6 pint per B.H.P. per hour, and with the gas engine using coke about ·8 lb. per B.H.P. per hour, money value of each commodity varying. These are actual data taken in the one instance on the 160 H.P. oil engine and the other on the 500 H.P. gas engine. As Mr. Shackleton mentions the question of engining sailing vessels, this has been talked of in several quarters, and I believe a very economical means will shortly be brought out. It may be gas or it may be oil, but I think the trend is to simple self-contained oil engines rather than to the costly producer.

Mr. W. P. Durtnall (Member) : I came prepared to make a long speech on this subject, but I think I had better send my remarks in to the Secretary in order that they may be included in the Transactions, because Mr. Shackleton has touched upon a very important matter, I consider, in reference to the application of the producer plant and its bearing upon the question of reversing and also of fuel economy at various speeds. Of course, as the last speaker says, the oil engine is a very useful, light and efficient prime mover, especially the Diesel engine, but the fuel consumption of the producer gas engine is not so visible. For that reason I think it is absolutely essential to have some kind of reduction gear for the lower speeds. I have given some attention on the electrical side of the question with a view to effecting that for steam turbines and also for the internal combustion engine; this I will refer to at greater length in my written remarks. I cannot see why the gas engine should not be as reliable as the oil engine or steam engine. I feel sure our members have not yet become practically acquainted with the actual operation of the gas engine ; men who are used to the steam engine can be very easily trained to handle the gas or oil engine. Mention has been made of the latest gas-driven vessel, the *Rattler*, where, I am informed, there has been some trouble with the reversing arrangements, and I have a scheme of electrical power transmission for that very boat to submit to the Naval authorities and in connection with two or three other types of engine. Even with the oil engine it is preferable to have some kind of speed reduction gear between the engine and the propeller, because, although they may be efficient at constant high speed or full load, there is no doubt on some occasions there is a deficiency as regards dead slow, quarter and even half speeds. On the Continent, in Russia, there are nearly twenty boats now working using gas and oil engines with electrical power transmission. I must thank Mr. Shackleton for his very interesting paper, and I think such papers as this should be welcomed, coming from practical men who have had experience on land work. There is no reason whatever why the gas engine should not be economically applied.

Mr. W. Watson (Member): This is a very interesting paper and one that contains a great deal of contentious matter. We are all agreed, I am sure, that shipowners will eventually be driven to ask for a cheaper running type of engine than the present triple expansion unless the latter can be still further improved. I do not think the gas engine is the ultimate solution of the cheap power problem for marine work, especially as I understand there are oil engines in the market eminently suited for this class of duty, and which readily reverse. The gas engine has done excellent work in isolated plants, and would easily beat a steam engine in such an instance, but when we come to consider what its performances have been in larger central stations the result is one long catalogue of failure. Leyton, King's Lynn, Walthamstow, Johannesburg, are names which occur readily to me in this connection, and I have no doubt the list could easily be supplemented. In the first two places gas engines have been entirely dispensed with; at Walthamstow the new plant is to be steam. I am unable to say whether the existing gas plant will be removed, but the published coal costs of that station are far from recommending the gas engine, while at Johannesburg the engines have been rejected by the Corporation, and are, I believe, at present the centre of a very pretty lawsuit. The author apparently has based his estimates on anthracite coal costing 21*s*. per ton. This might be the price at a Welsh port, but I am afraid it would be considerably more abroad, as even in this country I know of a plant where 21*s*. was the price tendered for the first year's running four years ago, and the price has now risen over 50 per cent. and shows no inclination to fall. The electrical driving of propellers is apparently merely proposed as a way out of the difficulty of reversing, and is, I think, the best way, but this should not be confused with Mr. Durtnall's excellent proposals where maximum efficiency of both turbine and propeller would be secured by means of the electrical link between the two. My experience of suction gas plants would not lead me to recommend them for marine purposes on the further score of reliability when manœuvring, and I would ask the author if he thinks they would compete with the steam engine for speed and ease of handling, giving, say, full speed astern after having run for two hours dead slow, then stopped half an hour for a fog to lift.

Mr. Durtnall : I must say it is very kind of the last speaker to pass a remark about my method of reversing, but if the ship is fitted with slow speed motors on the propeller and high speed gas engines there is no reason to stop the engine at all, the transmission will always be in the ahead direction.

Mr. Watson : But the suction plant working on a very light load does not generate gas at all ; of course you would never have to shut it down while you have to shut down the motor occasionally and the engine would then be running on no load. It is going ahead all the while, but with the suction plant working for half an hour with no motor running, and having previously had the motor running dead slow for two hours, something would be required to fall back upon.

Mr. A. H. Mather (Hon. Treasurer) : I think the paper we have before us to-night shows that the Institute at any rate is keeping well to the front in considering those matters which are signs of advance in the profession with which we are particularly connected. This subject of the internal combustion engine is bound to become a more important one, and one more intimately connected with the members of this Institute, than it has ever been before, as it seems to be an opportunity of getting away from the present type of steam engine, which apparently has reached its highest possible efficiency. There has been very little improvement for a number of years past, and there is very little probability of reduction in the cost of power by that means. This paper deals very well with the subject and shows us one or two of the principal types of plant at present in use. It also gives an outline of a suggested scheme for, I take it, a marine installation, for which it is proposed to use the Westinghouse and Campbell types of gas engines. I should have liked Mr. Shackleton to have amplified this a little more, giving us a closer specification of the plant proposed to be put in the ship. He just mentions the Westinghouse type and two secondary sets of the Campbell type, but he does not mention how it is proposed to arrange them, or how many propellers or shafts, or how they are to be coupled up. The reversibility of the internal combustion engine and the variation of speed are, of course, the two most important points against it in its present form. In the newest type of motor boats with petrol engines, it seems to me a curious thing that the majority of these boats now in the water have not got a speed-regulating device. The motor has always had a regulating apparatus in addition to the variation of the engine itself, but until recently I do not think it has been possible to regulate the speed of these boats otherwise than by regulating the speed of the engine, and the speed of the engine must only be varied to a limited amount or the engine will become liable to stop at a moment's notice. Later on in the paper there is a specification given for a particular type of engine, which seems to me to have one rather bad fault from the marine engineer's point of view—of course if the electric drive is used the objection does not apply. It reads "the flywheel to be of extra weight in order to ensure steady running, and to be 8 feet diameter and to be 18 inches on the face." Of course that is for a particular size of engine, but with the direct drive a flywheel at all on an engine which might have to be reversed would be a very fruitful source of trouble.

Mr. J. Howie (Member): I thank Mr. Shackleton for the very good general view he has given of the whole subject, up-to-date, very simple and easy to comprehend. The general features of the paper I cannot take exception to; there are so many advances being made at present that one is very much afraid to condemn things, and I would not positively condemn this system as it is certainly worthy of trial. The author mentions that there would be poisonous gases escaping at the beginning, would this occur in the slowing up of the engines? I do not know whether it is possible to stop them altogether, but it is certainly a point against the engine to have them at any time. With regard to the question of starting, which has already been mentioned, I was talking to a continental maker of gas engines the other day, and he told me they make engines of 250 to 300 H.P. without air compressors for starting, but after that they would possibly have to adopt the system. The Diesel oil engine was mentioned, and in speaking to gentlemen familiar with both engines they absolutely condemn the crude oil engine. I have in mind a Government pinnace which, when on trial, about eighteen months ago, stopped in the middle of it, and they had to send for gas-compressing apparatus to start the engine ; the boat is still laid up with the engine. With regard to the crude oil engine I am also informed that the explosive effort at the beginning is tremendous, being something like 700 to 800 lb. That must have a very bad effect on the material. I believe these engines, including gas engines, after five or six years are unreliable owing to the crystallizing of the material of the engine, the impact being so sudden. The explosive effort following the piston is in continuity for only $\frac{1}{16}$ to $\frac{1}{2}$ inch, and this effort is, I believe, always condemnatory of the type. The author has evidently some difficulty in recognizing the amount of space occupied by these engines. Perhaps if he gave a rough idea of that it would be desirable. He has already told us of the space saved by the coal for working purposes, but that might be counterbalanced by an increase of space for the gas plant. I thought it a very remarkable statement in favour of the gas engine that it costs ·1*d.* per H.P. per hour, as I always considered the Diesel engine economical at ·1*d.* per H.P. per hour.

Mr. TIMPSON : The Diesel engine is cheaper than the ordinary gas plant, as regards fuel consumption ; I cannot say on total cost.

Mr. HOWIE : Another point that must be considered is as to whether coke can be had anywhere or everywhere. Coal is required to produce the coke and coal is dear ; in London it is at a very high price, and if a number of steamers adopted the suction gas system the price of coke would go up. In regard to the propeller speeds, I agree with Mr. Shackleton we have been used to slow speeds, and he states the case very reasonably when he says the present engine is made for slow speeds and not for high speeds, but if we had a high speed engine of say 250 to 300 R.P.M., that would be quite acceptable, and I think an efficient propeller could be made for that speed. I do not know whether, in giving the relative costs, the author increased the charge on the steam engine and gave the lowest computation for the gas engine as to economy, but I think the figure he gives is rather high for a given compound engine. With regard also to the freights I do not know whether we should admit that as an item in its favour, because if we put this matter of reduced freights before the shipowners everybody will reduce the freights and we will come back to the same level as before. The matter of starting has been referred to. This continental engineer I was speaking of was very favourable to the suction plant, but he said it was a well-known fact that in manœuvring, stopping going through fogs, etc., owing to getting bad mixtures, mis-firing and other causes, the suction gas engine could not be accepted in the merchant service at the present time ; he admitted this although he is a maker of different types of gas engines and also of oil engines. But I am in favour of these gas engines ; one cannot very well go against it if engineers are prepared to bring a matter like this upon the market. If we do not accept it, then others will, and if we have to accept it eventually we may as well be first in the field, or we may lose a certain amount of capital which might have been kept or drawn into the country.

Chairman : I have a note here that a remark has been made that the *Rattler* made a run of 300 miles at a cost of 14*s*. for fuel.

Mr. Timpson : I believe the actual fuel consumption was ·8 lb. of coke per B.H.P. per hour, or about the sum stated.

Chairman : If that is an actual fact one cannot go against it. As far as the gas producer for marine work is concerned, we have before us a good paper to start with. I think there is a big future in it, as even in the last ten to fifteen years the progress made in the gas engine has been very great. The great obstacle is the matter of reversing, and I believe the question is engaging the attention of some of the experts on the gas engine. It is in an experimental stage, and if that obstacle is overcome I think the engine may be adopted on board ship. If we study the history of the steam engine, we find it started in a very small way as an auxiliary, gradually developing into the compound, triple and quadruple engines of the enormous powers we find in existence to-day. The turbine also had a very small beginning ; all these new schemes have to grow, and I think Mr. Shackleton has brought before us to-night a new source of power which will develop into large proportions, and which will eventually displace the big boilers and steam engines. The shipowner is the one who has to face the expense in a case of this kind ; it is a big thing for the first man to " pull the chestnuts out of the fire," but this remark about the *Rattler* ought to make them consider the subject. I was once at a test of a large gas engine and was much impressed with a patent governor they had on by which the speed was varied from full load to any load required, even down to 5 per cent. One could not do that with the steam engine.

The HON. SECRETARY: I was struck with the remark made at one of our previous meetings regarding this amount of 14*s.* for 300 miles, and I am not quite satisfied yet. I should like to know if Mr. Timpson could tell us what was paid for the anthracite coal to produce that result.

MR. TIMPSON: I really could not say, but I know they are proposing to use coke in preference to anthracite at the moment, so the anthracite must be dearer. I may remark, in relation to suction plants, that nearly all the troubles Mr. Howie referred to have occurred because we have had land engines for marine purposes and the marine conditions were never considered, the difficulties are mainly in detail rather than in principle.

The HON. SECRETARY: In connection with the internal combustion engine we know that the Advisory Committee of the Board of Trade has under consideration the question of what has to be done with the certificates of the engineers who are to be placed in charge of these engines. I believe the question arose in connection with one of Messrs. MacBrayne's steamers on the Clyde. They are running under the Passengers' Act, and the question is, what engineers are to be in charge of that machinery to comply with the Board of Trade regulations? Of course we are aware that latterly a few questions have arisen in reference to the revision of the subjects of examination for engineers' certificates in order to lead up to what developments may take place in the future in the direction indicated by the new motive powers being introduced. There is no doubt we have to be alive to the possibilities of both the oil and the gas engines in order to meet the competition that is coming. I notice in Mr. Shackleton's paper he refers to steam being used, he might also indicate what kind of boiler he proposes to use so as to get the steam to mingle with the gas working with this Dowson plant. I have heard of failures in connection with the gas producer plant ashore in those cases that have already been cited, but I know we have a member present who has a very good knowledge of the working of the producer plant and whose experience has been very much in its favour. If Mr. Hulme would give us the benefit of his experience it would not only be of interest but of very great value. At the last Motor Exhibition I saw an ingenious system of gearing, which I had not seen before. Instead of having a gear with the two mitre pinions working into one another to change the direction of motion, there was simply a disc with holes in it, and into those holes a kind of sprocket engaged to give the drive. It seemed to work very well, noiselessly, and with less friction than the mitre wheel drive.

Mr. Durtnall: It is used for motor cars of small powers.

Mr. D. Hulme (Member of Council): I have not had an opportunity of reading the paper until this morning, and unfortunately I was prevented from getting out data which I intended to give so as to put before you the exact figures. I had hoped to give figures showing a direct comparison of the cost of gas engines run by producer plant and by town gas. In our case gas engines drive the generators and we have ammeters all over the works, and are thus able to tell precisely the power they are producing throughout the day. We have also a system of tabulating every half hour the results from the ammeters from each of the three installations we have running, also the amount of coal used for the generators, so we know exactly what is done. I have not had an opportunity, however, of going into a comparison with steam. I think the price we used to pay for coal was 29*s*. 6*d*. a ton, but recently we have had the cost reduced. We came to the conclusion that instead of paying a high price for large coal, the small pieces would do just as well so long as there was no dirt in the coal, and I therefore made arrangements to get smaller coal at a lower price. The analysis of this coal is as follows: Hydro-carbon and nitrogen 69·5%; CO_2 6·8%; CO. 22·4%; C. 1·3%. Calorific value 10371·4 cal.; fixed carbon 43·5; coke 71·5; volatile matter 28·5; ash 1·0; moisture ·46; sulphur 1·68. On one particular day the cost for 357·6 ampères, that is at 110 volts and 70 H.P., with the producer plant gas was 16*s*. 2*d*. Along with this we used about 200 feet of town gas, which we sometimes put on in the mornings. With the town gas only the cost for 319 ampères was £2 18*s*. Bringing this down to H.P. it would be very easy to get the cost of driving these engines by steam, as the consumption would come to about $1\frac{3}{4}$ lb. per I.H.P. One of the items mentioned in the paper was the saving in space. In my early days we were very much cramped up in the engine-room, but in the new ships there is plenty of room and the small amount of space that might be effected is not, in my opinion, a very important point. The question of reversing is a matter which will have to be taken up by engineers, particularly marine engineers, who are disposed to give their brains to the work. With regard to cleaning, the cost in our gas plant last year, 1907, was £15 6*s*. 8*d*. for cleaning the valves of the engines, and the ordinary repairs required on the three 350 H.P. engines cost £10 11*s*. 7*d*., making a total of £25 18*s*. 3*d*. for cleaning and repairs to plant and gas engines. For the benefit of the paper and the Institute itself, I shall, when I have a little time, get full particulars of this plant for insertion in the Transactions. The accumulation of dirt on the valves is not very great ; we have one engine now which has been running over four years. With regard to lubrication, I may be fastidious, but I do not believe in too highly refined oils for this purpose, I like the oil to have body in it. I would sooner take the trouble of having the engine cleaned a little oftener than see the oil running out as fast as it was put in under the piston. We have very little trouble in that respect, and as for residues, it is a thing unknown as far as we are concerned. We have a drain-pipe that takes the water off. Of course there is a strong smell indicating the presence of ammonia, but there is not sufficient of it to deal with for commercial purposes. I should like to know what difference there is in the comparative cost of the producer plant and the suction plant, that is the cost of running two plants, one with producer gas and one with suction gas. We had some little experiments some time ago—Mr. Mather was present on the occasion—when we tried to increase the weight on the gas from $1\frac{1}{2}$ inch water pressure and brought it up to 3 inches with a view to getting a greater volume of gas to the engine, but were rather surprised to find that we did not get any more out of the engine. We decided to take the pressure off and brought it down to $1\frac{1}{2}$ inch, and the engine went considerably better with a mixture of equal parts of gas and air. From these experiments we came to the conclusion that we could have gone still further and got a pressure. No doubt it would consume some of the rich gases, and in the suction plant these must drop off in the engine, so that I think the suction plant ought to give even better results than that again. The speed of the engine can be varied considerably, but there is no doubt for marine purposes there would have to be some other means of changing the speeds and reversing.

CHAIRMAN : As several gentlemen present have some information to bring forward and wish to take part in the discussion, it occurred to me that there might be a desire to adjourn the discussion. There is a date open on January 18.

Mr. DURTNALL : It is a most important subject and I do not think we have done full justice to it. I therefore propose that we adjourn the discussion till Monday, January 18.

Mr. MATHER seconded the proposal, which was carried.

The HON. SECRETARY : I might mention that about fifteen years ago I went to see a small marine engine worked by town gas and the projector of that experiment had visions of Atlantic liners with huge gasometers in the holds. The gasometers he expected would be filled at this end with gas sufficient to carry a boat across to America, where they would be re-charged.

Mr. HULME : With regard to the manner in which the steam is generated ; in the producer plant it is done by means of a boiler, while in the suction plant the water is placed surrounding the generator. In the case of our engines we take canal water for cooling purposes and also for the jackets of the cylinders. At first we had a series of tanks and circulated the water until it became very hot after long periods, and finally I put on the canal water. There is practically no deposit, only a little mud which can be let out of the pipe in a moment.

Mr. SHACKLETON : Mr. Timpson raised the point of the absolute, or almost absolute, victory of the crude oil engine.

Mr. TIMPSON : I said the producer plant was the cheaper at the moment, the producer plant being ·8 lb. coke per B.H.P. per hour and the oil engine ·6 pint of oil, but I mentioned that with crude oils the latter would be very much reduced.

Mr. SHACKLETON : As a matter of fact crude oil to pay at all must not be more than about 2*d*. per gallon. Mr. Timpson also referred to the first cost and weight. I think it is possible to buy a good gas engine and producer plant, and the ultimate cost of the two would not be more than 20 per cent. more than the Diesel engine, which is, of course, the most up-to-date type of oil engine. The clutches in the *Rattler* also, I observe, have come in for some consideration, but I do not see any reason to have a clutch as big as the main engine on a similar type of boat. A comparison of marine running between crude oil engines and suction gas is, of course, infinitely in favour of the gas engine and plant, and although we hear a good deal of talk about the 11 B.H.P. at 1*d*. an hour which the Diesel Company claim, those results are only obtained when a certain kind of crude oil is available at £2 2*s*. a ton, present price £3, and with the supply of crude oils largely in the hands of corporations, the price is likely to get higher than anthracite and coke. I think fairly good gas coke is to be obtained in almost any part of the world. The question of reversibility also was mentioned. While the Diesel engine has gone up to 100 H.P. the Company are by no means satisfied that they have got to the end of their difficulties with regard to reversing. I can only say that while I do not like reversing the gas engine—it is averse to the nature and construction of the gas engine to reverse—if the Diesel oil engine can reverse, the gas engine can reverse also. Largely the trouble with the gas engine depends for its solution upon money and time. It will be a difficult matter to patent anything pertaining to the reversing of the gas engine, and the gas engine builders have thought of various methods which would only have brought in their competitors to reap the advantages on bringing them to light; that is the crux of the position. In reference to Mr. Watson's remarks on central electricity station works we have certainly had the gas engine on its lowest level. We know the King Lynn plant never did well, and as for Johannesburg, I would rather not discuss the matter. But generally speaking, we know how a gas engine would be likely to be looked after in an electricity central station. If we ask an electrical engineer what results are obtained from a gas engine he would give us foregone results of the working prior to the trial. I think it would be more charitable to draw a veil over Johannesburg.

Mr. Timpson: I wonder if the steam engines working at Johannesburg are giving satisfaction.

Mr. SHACKLETON: With regard to the price of anthracite; I took it at a Welsh port, I may be a little wide of the mark, but I think the ordinary is 15*s*. a ton and I took it at 21*s*. Of course in London it is higher, but steam coal is also higher in London. We now come to the question of an engine going dead slow for an hour, then full speed astern or at variable speeds. The latest type of multicylinder gas engine is very flexible and I think is capable of dropping from about 250 to about 90; but it would be more favourable were the electric drive possible or allowable in point of cost to keep to that type of drive. There seems to be some apprehension as to these varying speeds, but the multicylinder gas engine readily adapts itself to the various conditions. Steam is generated from an independent source and the variations are not so marked as they would be from a single cylinder engine. Mr. Mather referred to the flywheel mentioned in the paper, but the flywheel employed in marine work would not be of those dimensions, and other precautions would be taken to meet any difficulties caused by the rolling motion of the ship. The arrangement which I had in view there was for the electric drive; my idea was to have one large main engine coupled to a dynamo, and two intermediate units; three dynamos running in parallel driving the two propellers. With regard to the question of reversing and the flywheel, as I have pointed out, if the electric drive could not be arranged for I would not attempt to reverse the gas engine; that would be done by gears, and I think it is only fair to point out that there are some very fine gears that would be suitable. The gears made by the Coil Clutch Co. stand an exceedingly great strain, they are used largely in rolling mills where armour plates are reduced from 6 inches thick to 3 inches, and I think that gives a good idea of the capabilities of the clutch. The poisonous gas was referred to. The speed, no load, light load or dead slow, would have no bearing on the poisonous gas question, and the leakage would be extremely slight; in fact it would only be by some unforeseen accident or carelessness that the leakage affected any one. The starting efforts were pointed out as being very great. It is very great on the crude oil engine. It starts at 120 lb., the movement is very steady, and the bad effects are very small. The question of space has also been touched upon, but I think I am quite correct in saying that the space occupied by a gas engine and plant would be well within that occupied by a steam engine. Notwithstanding that, in making up my cargo boat figures, I purposely deducted extra tonnage for any emergencies that might arise. The steam for the producer, asked about by Mr. Adamson, is generated from a small steam boiler. The steam is put into the producer slightly superheated and passes on in the ordinary way only under a slight pressure, but after starting with the small steam boiler and when the engines are under weigh at quarter load, the Wilson boilers will make all the steam that is required, in fact they will make too much steam. I hope I have traversed all the ground covered by the questions, but if I have omitted anything I shall be pleased if some one will call my attention to it.

Mr. J. H. Redman (Member) proposed and Mr. Timpson seconded that a vote of thanks be accorded to Mr. Shackleton, and the motion was carried with applause.

The proceedings terminated with a vote of thanks to the Chairman.

ADJOURNED DISCUSSION

January 18, 1908.

Chairman: Mr. J. McLaren (Member of Council)

Chairman: We have met here to-night to take part in the adjourned discussion on the Gas Engine and Producer Plant for Marine Work. I will first call upon Mr. Shackleton to open the discussion.

Mr. Shackleton: In the last discussion one point not very clearly answered was regarding the flywheel arrangement. I must say that in the marine gas engine, either of the types shown, if the electric drive is used the flywheel would probably be eliminated altogether in favour of the armature of the dynamo which would do duty as a flywheel, and in the case of direct drive where it is not electrical propulsion, the flywheel would be considerably reduced. With regard to the question of variation of speeds, in the case of the electric drive that is taken up by the motors. Of course the motors can be varied from dead slow to high speed as desired, but where the drive is direct from the engines to the propeller, the method would be with the coil clutch I have referred to. It is specially designed to allow for slipping so that the speed of the propeller may also be reduced when the coil clutch is in use. But there is also a third method; by using half compression cams on the tandem engine slow speeds may be obtained with the greatest of ease. On the point of fuel consumption, it was thought at the last meeting that my estimate of 2 lb. per indicated horse power was too high, that it might do for a compound but not for a triple, but I have found that with the type of boat we are dealing with an average of 2 lb. would be by no means an excessive estimate. I may also mention, with regard to my estimated figure of 5 lb. per indicated horse power for cargo discharged by the present winch system, that the motor correspondent of *Lloyd's Weekly Shipping Gazette* has been taken to task by some gentleman who says my estimate of 5 lb. per I.H.P. is ridiculously low, and if I had stated it at 10 lb. per I.H.P. it would have been nearer the mark. Of course I had an idea that this estimate was considerably understated, but I had a fear of over-stating the figures, and I have throughout attempted to reach the "happy medium." In both these cases the fuel consumption might be slightly decreased, but I have left a margin of safety also with the gas engine.

Mr. F. M. Timpson: There is one point Mr. Shackleton refers to regarding gas plant that I would like to say a word or two about. One objection to suction gas plant for marine use is that there is no really efficient producer for bituminous coal, and although suction gas gives, under factory tests, a considerably lower consumption than any other class of engine, still it is mainly limited to anthracite or coke, and of course anthracite is limited in quantity, and at many ports is costly or even unobtainable. Perhaps Mr. Shackleton could inform us whether there is an efficient producer for bituminous coal, as search has been made without success for such a plant, a fact that would go against the adoption of this system in ships of any size. In relation to the consumption of the suction gas plant I believe it varies considerably. I hear cases mentioned as low as ·13*d*. and as high as 1*d*. per H.P., the last experience being taken over a three years' trial. At the last meeting the use of a low grade anthracite was spoken of. Several firms I made inquiry of preferred to pay higher for the large coal as there was a considerable amount of wear and tear with the small class of coal.

Mr. W. E. FARENDEN: I should like to ask whether the engine under discussion could be made to reverse at all speeds, say, an engine of 2,000 to 3,000 H.P. for a cargo boat; I should also like to ask how the space would work out compared with steam reciprocating engines and boilers.

Mr. SHACKLETON: Mr. Timpson raises the question regarding fuel for gas plant. Well, I will be charitable to the steam engine, but I believe we have to send fuel out to the steamers from various parts of England even at the present time. The gas plant for marine work, say on a job of 2,000 H.P., can use either anthracite or common gas coke, and I think gas coke is to be obtained in almost any part of the world which is anything like civilized. I have not gone deeply into that matter; I had intended to get statistics on the subject, but I should think there are not many ports of importance where there is not a gas works, and if there is a gas works of course they make gas coke. The bituminous plant which I have referred to later on I propose to use only for an installation of not less than 3,000 H.P., but I may say that if a bituminous plant were installed it would also work on anthracite or coke. As to the cost, I am afraid if the 1*d*. per I.H.P. per hour which Mr. Timpson referred to, if I understood him rightly, were anything like the average cost of a producer gas plant, the producer gas plant would be absolutely useless. All that I can say is this, that the makers—not one but a dozen of them—will guarantee the daily running of their engines at practically 10 brake H.P. for 1*d*. The figures may sometimes be exceeded, sometimes a trifle under, but I think one cannot have a more open challenge than that. The maker does not ask you to take the gas engine unless it can do the work at that figure, the onus is on him to prove it and he daily does prove it. As to the fuel, I think it is better to keep on middle-class anthracite, but when I say that I do not by any means say that the cost must go up. In fact there have been several cases in London where people are using good anthracite at less than £1 1*s*. per ton by doing their own carting. One gentleman spoke about reversing. It is not proposed to reverse the gas engine; there are experiments being made in that direction, but there is nothing to be gained from it in the internal combustion engine. That is where the steam engine differs. The engineer who has been used to the steam engine goes by the rule of the steam engine and says the gas engine must reverse. But why ? it is not necessary if there are suitable gears. The amount of time spent in going astern is only a fraction of the time spent in going ahead, and it would not be advisable to reduce the efficiency of the engine simply to get the reversing movement. It is said that because the steam engine goes astern, therefore the gas engine must go astern, but new departures must be made, and all traditions opposing those new departures are compelled to go to the wall. I may say regarding reversing, there are, of course, several engines which do reverse, and it is not a very difficult thing to reverse the gas engine; but the trouble is that there is so much complication that it far outweighs any advantage that might be obtained. If it has not been found necessary to make the motor-car engine a reversing engine, surely the gas engine is not of necessity bound to be a reversing engine for marine work, although of course the conditions are somewhat different. In the matter of space, I think I may safely say that if a bituminous plant were installed, which is almost twice as heavy as the suction gas plant, we would still have 20 per cent. in its favour. As for the ordinary plant working with coke or anthracite, the difference is very marked, and I should think as a rule for moderate size plant there would be a saving of 40 per cent.

Mr. Timpson: The question as to whether a satisfactory bituminous producer exists has hardly been answered, and I have reason to know that this is a very essential condition. As regards reversing, I strongly differ from Mr. Shackleton; I think it is an absolutely necessary quality for a marine engine. With reference to clutches, I believe it cost in a recent case about £300 to make a clutch, which is a very heavy item in itself. A simple engine that would reverse would appeal more to the shipowner. The suction gas plant as put forward is not a direct drive at all, but something on the principle Mr. Durtnall proposes.

Mr. Shackleton: It is also direct, I think.

Mr. Timpson: In that case are the clutches required ?

Mr. Shackleton: An intermediate clutch, yes.

Mr. Timpson: These are heavy items of expense, I consider. Again, regarding cost per B.H.P., is the price quoted for fuel only or for upkeep as well? The instance I spoke of included all the working costs, which came to 1*d.* per B.H.P., and it is very seldom they go as low as $\frac{1}{10}d.$

Mr. Shackleton: I may say I quite accidentally omitted to refer to the bituminous plant. There are plenty of them; there are several plants eminently adapted for marine work—simple bituminous plants, not bituminous suction, that is not available. But if bituminous plants were installed there would still be 20 per cent. to spare in point of space. There is no question whatever about there being successful bituminous plants on the market. Mr. Timpson refers again to the cost. That cost is not typical; if 1*d.* per B.H.P. were a typical cost the gas engine would have absolutely no chance whatever. That is not the line upon which the gas engine makers are fighting, they are fighting upon the basis of a reasonable estimate on which the plant and engines were purchased, and you will be justified in saying that if this suction plant cost 1*d.* per B.H.P. it would be cheaper to put in an ordinary oil engine. Mr. Timpson's experience is an isolated one. If you take the running in the majority of works, up-to-date and well-cared-for installations, the results are nothing like the one he has quoted. Messrs. Brunner, Mond & Co. are producing the H.P. at $\frac{1}{20}d.$ It is a large installation, about 3,000 H.P., I grant you, but that is what it works out at and that in a bituminous plant, so I do think the case quoted by Mr. Timpson is an isolated one, and I do not think the oil engine could in any way approach the suction plant in cheapness. Many makers would put in a bituminous plant if necessary, but it is not necessary up to 2,000 H.P. I think the simplicity of suction and producer plant working on coke and anthracite so marked and apparent compared with steam that no shipowner would want to go farther.

Mr. J. Howie: A few days ago I read a report from the Gas Makers' Association in which it was stated that coke was going up in price and would likely be dearer still in the future. Mr. Shackleton says there are gas works all over the world and coke can be had where these exist. Perhaps there are, but they are very small in some places, and a case might happen where a ship went in for coke and took the whole supply available, and the next ship that went in would have to lie up for coke. Not only that, if coke were continually being wanted with these engines coming into vogue it would become a great deal dearer and scarcer when probably something else would have to be used. In regard to reversing, marine engineers do want the main engine to reverse; they have enough auxiliaries without adding to the number. The illustration of the street car is not applicable, because the street car has a very strong starting torque. Mr. Shackleton is right in saying that the engines are not wanted to back very often, but there are often cases where, in steamships, if there is a slight starting torque a big space would be required in which to turn, a condition which could not always be granted. The marine engine must be a reversing engine; in itself there should be no auxiliaries apart from it. That is a condition which applies not only to this but to other systems.

Mr. J. Newton: From the little experience I have of these gas engines on shore they are of a "touch and go" nature. At first one does not know what is the matter when the engine declines to move, and there seems to be such a little difference between successful running and absolute stoppage. I think that this is a difficulty to be got over. Mechanical difficulties, of course, can be overcome, but it appears to me the difficulty is with the gas itself. Very often the gas engine may stop for over half an hour, nothing appears to be wrong with it and the gas seems to be all right, but the engine will not go. I may say, as far as my experience goes in connection with the price, we used coke very often and changed over from coke to anthracite, or so-called anthracite. We had no difficulty whatever about using the low-grade anthracite, but the clinkering-up caused a little trouble sometimes.

Mr. W. Calderwood: Some years ago I had an experience with gas engines and would like to ask the author how he proposes to overcome the difficulty caused by the difference in the richness of the gas according to the material he is using. As he says, he might be able to go to any part of the world and be able to obtain coke from gas works, but the coke might be of quite a different nature to that previously used. He might get coke at Shanghai at one time, and, say, Ceylon at another, and there might be a great difference in the nature of the coke at the two places, with the result that the engine would not work well. Some time ago an engine made in Glasgow was erected in London and it failed to work. Ultimately a cylinder of gas was brought from Glasgow and coupled on to the engine, which then worked all right, and the difficulty was solved—the air adjustment was not correct to suit the London gas. So it appears to me that if this particular system is adopted, the chances are that it will be constantly found necessary to alter the air adjustment to suit the richness of the gases used, and I should like to know how the author proposes to overcome a difficulty of that kind.

Mr. J. Veitch Wilson: There are one or two questions I would like to refer to, one of which has already been partly answered. Personally my acquaintance has been with gas and suction engines in various forms on land. Ever since, in going to and from my business in Greenock, I saw a gas engine at work in a grocer's window there, I have taken a great interest in the gas engine, and when I became more intimately associated with them commercially, my interest gradually increased. One difficulty in adapting this system to marine use has already been mentioned, that if it is universally adopted the fuel may be found to be wanting. A friend of mine, Mr. W. McLaren, of the "Ardan" line, started experimenting with liquid fuel. He fitted up one of his boats to burn the residues from the Scotch oil works. After a great deal of trouble he achieved success, but at the same time some other man fitted up his boat for the same purpose, and when two or three boats came on the market the price of the fuel rose up to £2 10*s.* a ton, which, as compared with the price of Scotch coal, was prohibitive. The result was that Mr. McLaren turned his boat back to use ordinary coal again. In the same way Mr. Shackleton would probably find that he would be creating a demand for coke in the face of a diminishing supply. The use of electricity is even now diminishing the supply of gas and, consequently, of gas coke, and therefore if there is any sudden demand upon coke as a source of power I think very little of it would be available. On the other hand Mr. Shackleton strongly emphasized the fact that British vessels all over the world carry out coal for steamers at the present time, and it does not seem apparent to me why similar provision should not be made for anthracite or other cheaper form of fuel; it seems, indeed, to me to be very reasonable to suppose that such a course would be adopted. It is also very possible that anthracite may be found in other parts of the world; as a matter of fact it is found in large quantities in America, and as we find oil bubbling up in every corner of the globe it means that there are probably similar carbonaceous deposits which will be brought to light from time to time. You gentlemen visit different parts of the world and probably know more about the matter than I do, but I understand there is decent coal in Africa, India, China and Japan. I certainly know that in all those places oil is being found, and I think it is not improbable that there is coal in the neighbourhood of the oil wells; I think there is some connection between the two. The other point that suggested itself to me was that oil would be a very suitable and very portable form of fuel, and although Mr. Shackleton referred to paraffin or petroleum only being used, it is well known that there are oil engines made which will burn anything in the shape of carbon. The Diesel engine will burn coal dust, and if it will burn coal dust that engine must surely be very amenable to other fuels. Provision would have to be made for the cleansing, as there is a considerable amount of deposit, but apart from coal dust I know that makers of oil engines can burn in these engines almost anything. I remember being told by a maker of oil engines that they can burn olive oil, rape oil, and the heavier crudes. If it is possible to use olive oil these engines are not confined to the finer grades of hydrocarbons, and that material taps a cheaper source of supply, because there is in all oils intermediates, which are too heavy for domestic purposes and too light for lubricating. They are sometimes used for cleaning oil, and they are also used as a most economical means of producing gas. If it is used for that, is it not possible that it might be used for the oil engine, a generator being provided supplying the engine, dispensing with the large producer necessary in the suction plant and also overcoming the difficulty of finding suitable fuel at the different points where it is required?

Mr. B. King: I should like to ask the author a question. If a ship is going a long voyage of say six weeks' duration, would it be necessary to clean the internal parts of the engine during that time ?

Mr. W. WATSON : There seems to be a good deal of variation of opinion about the cost of anthracite. In the *Iron and Coal Trades Review* it is given at 23*s*. per ton at Swansea, and I myself have succeeded easily in getting 10 B.H.P. at 1*d*. with anthracite at 21*s*., but I am afraid it never is 21*s*. Mr. Hulme referred to the price as being 29*s*., and that of course is an increase of about 30 per cent. That naturally would increase the cost or decrease the B.H.P. for 1*d*. Again, in the gas engines I used to run I found it advisable to take the valves out at least every fortnight, although, of course, it was not absolutely necessary. The figure I have quoted was obtained with the fuel at the maker's price, but the cost of the fuel went up, although it was obtained by tender in the open market. That is rather an important matter, as coke would hardly give the same H.P. as anthracite, or at any rate it would mean that a bigger producer would be necessary if you were not absolutely sure of getting anthracite.

The HON. SECRETARY : Most of us have come to-night to seek information on this subject, and we are largely dependent on our members who have come into contact with central power stations to enable us to judge as to the capabilities of the gas engine. I had an opportunity on the Clyde of going on board and inspecting the *Rattler*, a name that has become famous amongst us since the discussion began on gas engines, and I must say I was very much impressed with the stokehold and engine-room arrangements ; but after inspecting the reversing system, I must say I thought some great improvement was wanted before this engine could be successfully utilized on board ship. We know the troubles with the reversing of the propeller even on small ships. We had a paper and discussion some years ago on the reversing propeller for large ships, and the consensus of opinion at that time was certainly adverse to its adoption. A good many of our members present to-night attended a meeting last week in order to get some light on the subject of the gas engine, that we might be able to discuss the subject here. The paper and discussion at the meeting to which I refer only dealt with small engines for the open boat, the half-decked boat, the cabin boat and the racing boat, and in this particular case the only engine that was discussed was the oil engine to which Mr. Veitch Wilson has referred. In connection with the petroleum engine I do not know if Mr. Wilson knows the disabilities under which we would go to sea with a large amount of petroleum stored in the ship. In the meantime we are not allowed to carry oils under a certain flash point.

Mr. WILSON: I do not think that applies to petroleum. The flashing-point allowed is 100° to 104°, but the flashing-point of heavy lamp petroleum is over 200°.

The HON. SECRETARY: In addition to the *Rattler*, there are several barges running with the internal combustion engine, and apparently even in these barges they have not been able to overcome some of the difficulties which have arisen. One would imagine if the internal combustion engine had proved in marine work, or even in canal work, to be so economical and so handy as is claimed for it, it would have been more largely adopted than it seems to have been at the present time, and I should be glad if the author of the paper could give us any data as to how far the boats in existence have come up to the expectations formed of them. This paper before us is a complement to the paper we had from Mr. Durtnall, and in this paper the electrical drive is referred to. I do not know in what way Mr. Shackleton would propose to have the electrical drive carried out, but I know in certain circles the hydraulic system of reversing is coming very much into favour so far as discussions are concerned. I do not know the details of the system of hydraulic reversing advocated.

Mr. DURTNALL: The *Rattler* has hydraulic now fitted.

The HON. SECRETARY: Perhaps we might be able to get some data on that particular system. Mr. Newton has referred to the difficulty often experienced with the starting of the engine. Seeing he and Mr. Calderwood have given hints on that subject, I think it would be well if Mr. Shackleton would elaborate the point and show us where the difficulty of starting comes into play. With the Priestman engine of about 7 to 8 B.H.P. the consumption of fuel is about ·9 lb. In view of Mr. Wilson's remark I notice that anthracite coal has been found in Australia. In connection with central station work, perhaps the subject had better not be referred to in great detail in our discussion to-night, but one point would be very interesting to know, which is the cheapest run station in the kingdom, and is that station run by steam or suction gas ? I am sorry Mr. Hulme is not here to-night to give us some further data from his experience, and we know it is very considerable in connection with the works over which he has charge ; but I am informed—I cannot verify the details—that the cheapest central station working in the kingdom is driven by steam, and that the second cheapest one is also driven by steam. We have heard that there is a central station not very far removed from us, where gas plant was installed with unsatisfactory results. I do not know in what way it has failed in its duty, but I have been told the results expected were not attained. I said Mr. Shackleton's paper was a complement of Mr. Durtnall's, but there is another to follow later on, and I do not know if the magnetic drive will help us in the matter of both, if proved satisfactory. I had an opportunity of seeing the magnetic drive at work a short while ago, and certainly it did its work exceedingly well on a small scale. When the paper comes on I hope we shall be in a position to criticize and get the full benefit out of it. I know Mr. Durtnall is a little dubious as to the results of the experiments made in connection with the magnetic drive, but I must say I was much impressed with the work done when I saw it in its experimental stage, and I was very glad to have the opportunity of securing the first paper to be read on the subject for the Institute of Marine Engineers. It is interesting to note that the *Rattler*, the pioneer sea-going vessel for internal combustion engines, was the steamer used to test the screw propeller against the paddles fitted in a sister vessel with the result which is ever before us for ocean traffic.

Mr. A. H. Mather : The remarks made by Mr. Newton appeared to hint at an important point upon which it would be very useful to have some definite information. Reference was made by the Hon. Secretary to Mr. Hulme and his work in connection with the gas plant, and I might say that one of the difficulties experienced with that plant was the trouble of not knowing exactly when the gas was at its best for use. When the plant was started—pressure plant, not suction—one did not get the best quality of gas at first. It took some time to get the gas at its best, and the only intimation to tell that was by burning a small flame of the gas and telling by the appearance of the flame whether the gas was up to the proper standard. Latterly an arrangement was made for having a visible flame so that the colour of the flame could be seen, and that was the only indication that the gas was right. If there was any way of automatically showing what the quality of the gas was it would be a great help for the engineer. There is a chemical apparatus for taking continuous readings for gases from the boilers to tell what the combustion is like, and if a similar apparatus could be devised for the gas engine it would be of great assistance. Perhaps Mr. Shackleton could tell us if there is anything of the kind in the field.

Mr. W. P. Durtnall: I think more attention should be given to this question of the internal combustion engine than has been given to it up to the present. I think these bogies that are constantly coming up, of non-starting and unreliability, are simply born of a want of experience. I am sure if our members could only have the experience of the internal combustion engine they would be more enthusiastic than they are at present, especially if they could be paid in accordance with the economies made. A ship designer and power engineer should be paid on the merits of cost per ton mile displacement on the carrying capacity of their ships. Mr. Adamson made some remarks in reference to the hydraulic gear. Of course hydraulic gears have been tried; I know one very skilful engineer in London who has got a very elaborate apparatus out, and, mechanically speaking, it is fairly efficient. He uses a gas engine, or any other prime-mover, to drive a kind of rotary pump of special design and a slow-speed hydraulic-motor driving a slow-speed propeller. Of course, as our President said in his recent address, the ideal conditions for marine propulsion are a high-speed prime mover, light weight, high efficiency and reduction in cost. The low-speed propeller, especially in slow boats, cargo boats, is absolutely essential for economy as regards commercial success. I do not think I can add very much more in support of the paper, but I hope at a later date to give you further particulars.

Mr. Wilson: Might I add a word more in relation to Mr. Adamson's remarks with regard to petroleum. "Petrol" or petroleum spirit is certainly under the ordinary flashing-point; it ignites at ordinary atmospheric temperatures, but lamp oils have a flashing-point about 100° F., while the "intermediates" to which I referred have a flashing-point of 250° to 300° F. I would certainly not like to be a passenger on a boat where there was any quantity of "petrol," but I spoke of oils of flashing-points from 250° to 300°.

Mr. Timpson: I would like to support Mr. Durtnall in his remarks regarding the starting of the engine. The difficulties in starting are all more or less due to "stage fright." The parts of the engine are really more simple than those of the steam engine.

Chairman: One point occurred to me in connection with this paper, and that is in relation to the clutch. I, personally, would rather have a reversing gas engine than one with a clutch. The big difficulty with the steam engine is to get the power as quickly as possible from the prime mover to the propeller, and when we start putting in an arrangement like this it is courting trouble. I had a conversation with an expert gas engineer the other day and he told me that there was no trouble whatever in making a reversing gas engine, but they were not called for. He stated they would be only too willing to make reliable reversing gas engines. I quite agree with Mr. Howie's remarks about the coke. If this new scheme were taken up for marine work, I suppose all the gas works would be supplying coke for the "gas boats" as they would be called, and it is evident that in a very short time the price of coke would go up to a great extent.

Mr. Shackleton: I do not think any trouble whatever should be experienced in respect to starting with an up-to-date gas plant, and as to going on to different fuels, that also is not likely to greatly affect the plant. It changes over from anthracite to coke with little or no trouble, and it would not be necessary to regulate the engines or gas plant every few minutes; that would be done promptly and without difficulty. This engine would also be capable of doing at least ten to twelve or more weeks' running at a time, and I do not suppose an engine will be expected to run longer than that without cleaning. Certainly it would not require to be opened up for cleaning to any extent for ten or twelve weeks. As I mentioned, one of the tandem engines shown in the paper, the larger size, 1,000 H.P., ran nineteen weeks, night and day without a stop. I think that as the demand for coke increased anthracite could be found, and of course if the price continued to rise, there are plenty of markets on the

Continent and plenty of competitors to keep the price at a reasonable level. There is not very much danger of an exceedingly great rise in the price of anthracite. Mr. Adamson raised the question of the *Rattler*. I think it is quite reasonable to believe that a firm who have only had experience of gas engines for three years may not be equal to firms who have had twenty years' experience. The question of gears has, I think, been too much emphasized. The coil clutch I have referred to is for moderate powers and has stood remarkable tests. It can be used for powers up to 3,000 H.P., where, of course, the electric drive would be an objection. There always is an objection where there is anything new or novel; in fact some say the more objections there are the quicker the thing comes to maturity.

The Hon. Secretary: It is the objections and the critics that produce perfection, the bad points as well as the good must come out.

Mr. Shackleton: At any rate you may depend upon it that when a gas boat is wanted and ordered from a reputed firm and in an orderly manner, that boat will not be a failure. It is the unpractical way in which gas boats have been treated under various circumstances that has led to their downfall. With regard to gears, if the Coil Clutch Co.'s gear will work up to 3,000 H.P. on a rolling mill, rolling armour plates 6 inches thick to begin with down to 3 inches thick, surely in a moderate power boat you would not get such a severe strain. Over that power the electric drive would be preferable, but the clutch is good for low powers. If people will experiment with untried things they must take the consequences, and I think Messrs. Beardmore's was an untried gear. With regard also to the oil engine it certainly has advantages, but the question of burning any kind of oil is not yet solved. It cannot burn oils containing 16 to 20 per cent. or more of pitch. It can burn them for the time being, but so far there is no method whereby pitch can be burnt clean out. Pitch and tar have been two things very bad for both the oil engine builder and the gas engine builder. In the large bituminous plant under land conditions, the tar from the bituminous coal would percolate and get through to the engines, and I must say that in a measure the same trouble has befallen the oil engine builder as regards the Diesel and similar engines. The best makers have been experimenting on the crude oil system for the last nine years. They have brought out stationary engines and withdrawn them, and it is only under pressure that they design an engine for crude oil. Even then they require a "free and easy" guarantee, and if a maker had to run twelve to fourteen days without a stop on crude oil I do not think he would take the order. I think, also, if large supplies of crude oil were drawn upon, a worse condition of affairs would take place than with either anthracite or coke. Reference has been made to the variety of gases for the gas plant, but the varieties of fuel in the case of oil engines would be very perplexing even in the best designed engine. In the most successful type of engine at the present time, the Diesel, the particulars of one item, the wear and tear and upkeep, are not thoroughly available. There may be an installation here and there which may be successful, but others have not, and even where they are successful crude oil may not be obtainable at £2 2*s.* per ton, which is the necessary price for it to compete with the gas engine and plant. I am quite sure that at some ports it would not be possible to get it at anything like that figure, and if it had to be carried out to different parts the carriage of it would be a more awkward thing than either anthracite or coke. Sufficient regard does not seem to have been paid to the fact that steamers at the present time call for coal at ports to which the coal is sent out from this country, and if this is necessary for the present type of engine, why should it be objected to for the gas engine? With regard to central electricity station work, it is true that gas engines in these stations in England have not been very successful, but in the multitude of cases it is not entirely the fault of the engine. At one central station referred to a number of gas engines were condemned as utterly useless; they could not maintain the load, they backfired, there were pre-ignitions; such were the statements of the officials. It is the old story of the man who does not know anything about the thing running it down. What is the history of those engines? They were sold and sent to various parts of England. One of them found its way to Stowmarket, to the station of the Norfolk and Suffolk Electricity Supply Co. The man in charge was not an expert, but he knew something about the gas engine. That engine was put down, some slight alterations were made, and from that day to this it is carrying a load equal to the best engine in the land. That was one of the engines thrown out as being utterly useless. It is unfortunate that in the shipping press one reads remarks about the gas engine and gas plant, often finishing up with the expression that the gas engine and plant are not suitable for marine work. The writer perhaps endorses the opinion of Mr. So-and-so, and Mr. So-and-so is usually the steam engine man who has had little or no practical experience of gas engine work. We are not going to take it lying down that the gas engine is such an unreliable machine as these friends make out. Another fact is that the shipbuilder who engines his boats is not going to help the progress of the gas engine particularly. If he decides to have gas engines he has to have them built outside for some years to come, and if he builds them himself it will take him some years before he can turn out a reliable engine ; so it is not to the shipbuilder who is also an engine builder that we must look. He has his money and plant for steam and steam vessels, and generally he ends in saying that the gas engine is impracticable and won't reverse. Some years ago the stationary steam engine makers found themselves in just the same plight, there was hardly a firm which did not feel the pinch ; but they said, " We shall simply have to face the inevitable," and now people who a few years ago said gas engines were of no use for large powers are producing gas engines and plant. Progress so far as the gas engine for marine purposes is concerned has been delayed also by another factor. Gas engine builders in this country have been absolutely at high water mark with the orders from various foreign and colonial sources. In fact they have been in the happy position to say, " We haven't time, we are too busy with land work to touch marine business." Now that gas engine builders are not quite so busy, they are looking round for new fields to conquer, and they will go to the various shipbuilders and say, " Put this engine into a boat, and if it does not pay take it out again and we will bear the expense." A maker of repute will put the engine into a boat on those conditions ; he will say, " Here is the engine of so much power, the fuel consumption will be so much, I will guarantee it on test and will promise you reliability, and if it does not do what I promise, do not accept it at all and do not pay for it." The other day I saw some figures which perhaps I may give for comparison. It appears that a modern 3,000 I.H.P. engine with boilers would weigh approximately about 560 tons. If a 3,000 I.H.P. simple suction plant for anthracite or coke is put in, the weight would be 354 tons; if a bituminous plant is put in, which is of course considerably heavier, it would be 434 tons, so that even on those figures there is 100 odd tons weight in favour of the bituminous plant. The bituminous plant giving 3,000 H.P. would work on a fuel not exceeding 9*s*. a ton, but it may occasionally be purchased as low as 6*s*. to 7*s*., and the cost for 3,000 H.P. is £13 10*s*. a day. Of course in certain parts of the world, working on brown Indian coal or lignite—which I believe is an experience a chief engineer has now and again but does not want to have often—the bituminous plant would work with very little trouble. For the best steam plant, I do not think it is overestimating the price in saying that the coal would cost about 15*s*. a ton, and with a fuel consumption of 42 tons a day it would work out at £31 10*s*. for the steam plant against £13 10*s*. for the bituminous plant. Fifty days' running at that would cost £675 for the bituminous gas plant, and with the steamer £1,575. Those are figures that must tell with the steamship owner. Many a steamship owner might say, "I do not know anything about the gas engine reversing, but if those figures are near the mark I know the difference it will make in the bank balance at the end of the year." The original plant referred to would weigh, exclusive of dynamos and motors, simply the engines and plant, 173 tons; with the bituminous type, 234 tons. I think a steamer would be at least 150 tons above that. As I have said, there are reliable first-class bituminous plants available, but another point may have escaped notice. On stationary work the plant is limited to the amount of water available, and water is a very great factor in a bituminous plant. The more water that can be passed through the scrubbers, the cleaner the gas will be and the less trouble, and so, where the water supply is inexhaustible, the question of producing a clean gas is considerably modified; in fact the majority of the difficulties in dealing with a bituminous plant disappear. Owing to the large volume of water available at sea that could be passed through the scrubbers, any tars that might be produced would be absolutely removed.

A MEMBER: Would the salt water have any bad effect.

Mr. SHACKLETON: I have reason to believe that salt water will scrub the producer gas more effectually than fresh water, and it will have no detrimental effect on the plant. On the point of reversing, the electric drive, which I mainly advocate, is a sufficient reply. The other evening, at the meeting Mr. Adamson referred to, I was rather struck with Professor Hele-Shaw's remarks regarding reversing. He said, "If I had my way I would not even reverse the steam engine, I would let it travel always ahead." The reversing of the engine in his opinion was a thing that ought to be entirely eliminated.

Mr. Timpson: In the case of a steamer close upon another where it was necessary to prevent a collision, what would be the result then?

Mr. Shackleton: The electrical system would cover that, or in smaller powers the coil clutch. The coil clutch will stand any amount of rough usage.

The Hon. Secretary: Perhaps Mr. Shackleton would elaborate that remark he made with regard to the matter Professor Hele-Shaw referred to.

Mr. Shackleton: He said he did not believe in the reversing process, but that the steam engine should still continue to travel ahead and some other means of reversing the propellers be brought into play.

The Hon. Secretary: I believe it was the hydraulic gear he referred to.

Mr. Durtnall: When I spoke previously I was referring to Professor Hele-Shaw's system of reversing with hydraulic gear.

Mr. Shackleton: There are many advantages to be got from the electric drive that outweigh other considerations; and there are other methods of applying electricity than to the main propulsion. I think I am a pioneer in the method brought before you, although Mr. Durtnall has applied it for large powers for propulsion. There would be a saving in using one of the units for winches.

The Hon. Secretary: One of our members read a paper on that system in 1904, and there is another in preparation.

Mr. Shackleton: It would be a great advantage and the saving would be enormous. The gas engine is supposed to be hit by the reversing difficulty, but reversibility is not the thing that would, in the long run, hit it as hard as is supposed. I think, given good electrical transmission, or a first-class gear for moderate powers, there would be none of the defects which are anticipated. When the steam turbine came in there was no hue and cry about the turbine not reversing, it came in very quietly, and two turbines were put in with one for reversing. When the gas engine does come in it will not be necessary to put in an extra gas engine for reversing, or for going astern only. The fuel consumption of the turbines is not exactly all that could be desired, and I think the results are largely in favour of the gas engine. The danger is, of course, that unsuitable machines should be made and sent to sea. It has occurred in various other branches of engineering, and a freak gas engine or plant for marine work is a thing to be avoided on the introductory trials.

CHAIRMAN : I think Mr. Shackleton does not realize the fact that in the future the marine engineer will be the best friend of the gas engine, when he is satisfied with its qualities, as nothing good has ever come out but what the marine engineer has adopted and adapted himself to. The gas engines ashore have not been a perfect success, and when they have been proved to be so, Mr. Shackleton may rest assured the marine engineer will adopt them. A great amount of money was spent in laying down plant to make the compound engines when they came out, so also for turbines ; the making of turbines is a trade in itself. Our engine builders, if this is a good thing, will put down the plant to develop it, but we cannot expect them to go into it merely because it is so called. Mr. Shackleton must remember that steam engineers and builders include some very clever men who are quick to recognize a good thing and ready to adopt it if it is proved to be so to their satisfaction.

Mr. DURTNALL : I do not think there is any great trouble in this matter of reversing the gas engine, it is quite a simple matter to reverse it ; but that is not the only thing, it is really a matter of braking the propeller. In reversing the steam engine, steam is turned on, but that engine does not immediately start reversing, it holds itself against the propeller, momentarily, at the top of the power curve. As soon as the torque is reduced by the retardation of the vessel the power goes down and the propeller reverses. That is a matter minutely investigated on the Continent, and in discussing the matter I was informed that reversing the engine direct at high vessel speed is an almost impossible thing to do, or at least a very dangerous thing to do ; some medium is wanted to do that part of the work. It is my opinion, that for marine work, as Mr. Shackleton points out, the right class of engine and propeller design is wanted, and I think much more satisfactory results will be obtained when makers of engines will pay attention to the Brayton cycle, and I notice that many makers are awakening to that fact. The reversing question is not the only one to be dealt with ; in the internal combustion engine it is necessary to brake the propeller, and I explained in the last meeting a method of doing this by the electrical drive.

The meeting then closed with the usual votes of thanks.

COMMUNICATED REMARKS.

By William P. Durtnall (member).

December 14, 1908.

Mr. Chairman and Gentlemen,—

The question of the application of the gas engine in connexion with the suction gas producer for marine propulsion purposes certainly does merit our very close interest and attention, and I must congratulate Mr. Shackleton upon bringing the matter so clearly and interestingly before us. As members of the Institute we should always welcome this class of paper, especially by practical and experienced engineers, as although they may have been applying their energies in other directions of economical power, generation and application on land, there is no reason whatsoever why this advance in science and engineering should not be equally well applied for marine propulsion purposes, and tremendous economies made in the cost of operating vessels in the mercantile marine service.

The ridiculous attitude of some of the steam engine builders in the immediate past and at the present time is now beginning to tell its own story with the unfortunate owners of the white elephants that can be seen lying at anchor on the Tyne and other large shipping centres, and the progressive owner will do himself and the whole industry a large amount of good if he will invite the co-operation of engineers of experience in the application of other powers for ship propulsion and operation when having ships built, instead of giving the shipbuilder an absolutely free hand to put in what he liked to recommend, possibly to suit his own purpose or convenience.

We have now Mr. Denny's very fine piece of apparatus, "the Torsion Meter" and can now with great accuracy measure the power delivered to the propeller shafts by the various methods of power generation and transmission, and means of getting at the results of expenditure of power per ton, of displacement per mile, and there is no reason whatsoever why an owner need be bound by a shipbuilder's idea of the power to be supplied and used for the propulsion of a certain vessel: the finest thing that could take place would be for an owner to consult both naval architect and separate power engineer, and pay them by results only.

That method would soon make an alteration in the present state of British shipping, giving work for our factories, etc., and also for not only our mechanics on land but also to that large body of good men, "the sea-going engineers," and others that work ships in trade.

To those who study the work of other countries in their endeavours to compete with the British shipping firms, it cannot but be evident that if things remain as they are at present, and no progress made in the application of less expensive means of propelling ships (which is the largest item in ship operation as regards cost), that splendid connexion and trade which has been won by British shippers will fall, and foreigners with more advanced methods take their place, and then with the loss of British shipping commerce the nation will be in a terrible state.

It would be a good thing if a number of the largest and most interested owners were to form a congress to have this matter thoroughly ventilated with the co-operation of this Institute, at which all points could be thoroughly discussed in their presence. I am certain that some very great attention would be demanded by those shipping companies which own a lot of the dead shipping tonnage, and it would possibly result in a mutual arrangement in the interests of all to have an existing ship converted with gas propulsion as the substitution for steam, and put the same under the most severe tests that our friends on the opposition try to frighten us with.

I thoroughly agree with Mr. Shackleton that some of the steam-trained engineers will be astonished, and if they are not alive to the facts and details they would be left to the tender mercies of their disappointed employers, etc., so it behoves all our members to give this matter of gas propulsion the very closest attention, if only for future guidance, etc.

As regards Mr. Shackleton's remarks concerning reversing, it is perfectly possible to make a reversing gas engine, but the adjustment of the valves, timing gear, ignition, etc., to run with great accuracy in either direction, with consequent economy, is out of question, and is too troublesome and unreliable, and with the explosion type of internal combustion engine, very dangerous mechanical stresses would possibly result by such application, especially when reversing at full vessel speed "ahead," as the engine would not only have to reverse itself but also to break down the torque produced by the propeller being dragged through the water by the ship in the ahead direction. It is my opinion that the efficiency of retardation is greatest if the propeller can be braked and held still till the vessel comes down in speed before actually reversing.

Regarding unreliability in working I do not know why practical marine engineers should say that the gas engine is any more unreliable than steam engines. I am certain that they who think so are labouring under a delusion. I can assure you that both ordinary gas and oil engines have been put down not many miles from here (in fact, at Caterham) in which I was under contract to run continuously without stopping for three calendar months, and was very satisfactory in doing so, and under full load all the time, driving fans for ventilating a "mushroom mine" or disused stone quarry, and this was a few years ago, when oil engines were not made on the improved methods that they are to-day. The unreliablity argument is only a "bogey" and deserves to be treated as such by all sensible men, and I think that an engineer shows his inexperience when he raises the question in argument as against the use of the gas for almost any purpose.

In reference to the possibilities of pre-ignition and back-fires I agree with Mr. Shackleton that with well-designed gas engines this should not occur, but I may say that with the design of gas engine which I would advocate for marine propulsion pre-ignition and back-firing would be impossible, and there is no reason whatever why he should not be in a position to construct gas engines on similar lines, that is, on the improved

"Brayton" cycle, so that the starting can be made just as easy as with an ordinary steam engine, and by the fuel itself, so that there would be no necessity to provide special starting arrangements.

As regards lubricating arrangements, I would recommend some such design of mechanically driven forced lubrication similar to that which we use on high-class and successful automobiles, and which is driven by the engine itself, and is positive in action and arranged so that should it be necessary to slow the engine the lubricator automatically slows with it, and once set correctly it is reliable, economical, and gives no trouble whatever.

I am perfectly in harmony with Mr. Shackleton that generally, marine propulsion being constant work practically all the time, it is just the ideal condition for a producer plant, and some splendid and previously unrecorded results await those who will try this interesting application of gas power.

I am certain that only good results, and satisfactory both to the shipowners and the shipbuilding trades generally, would result in the mutual co-operation of specialists in such and each department of the building and power equipment of any vessel, not forgetting the electrical engineer, because it is my firm opinion (that has been the result of years of study of this power generation and transmission problem) that electro-magnetic power transmission is going to have a thumping big demand before long, with both the gas engine and the steam turbine on vessels of large size, and important conditions.

The slow speed direct coupled steam turbine makers are making a brave fight, but they will have to give in on points of lower fuel consumption and higher propulsive efficiency, that may be obtained by the "Paragon" system, which provides that an efficient power and speed may be attained from zero to maximum on the propeller, with the turbines or gas engines running at constant speed and in the same direction all the time whether the vessel is going ahead or astern.

I think that for satisfactory marine work, a much lighter type of gas engine is desirable, and that it will have to be especially designed for the purpose, and as far as I have been able to investigate the matter, and taking into consideration the low propulsive efficiency obtained by use of high speed engines, for slow cargo boats that it will pay to run the gas engine at a much higher speed than the propeller—say engine speed 400 R.P.M., and propeller speed 70 R.P.M. The motors would be right at the stern of the vessel, so that it would only be necessary to carry the copper leads to the motors from the generating plant, and the long line of shafting, which is a very effective source of power losses in rough weather, would be conspicuous by absence, and much more room to be utilized in the vessel for cargo purposes.

I can assure you that the cost of a properly-designed electrical power equipment of any class of ship is cheaper, taking things all round, in total cost than any other method, and the certainty of action and control from the bridge or other position is an enormous advantage, and why should not the engineer (operating) have the benefit of the fresh-air on the bridge, and have the plant under his immediate control from that positon, thus saving time, which is important in some cases, as you all know. It would indeed be interesting to review all the accidents that have happened through mistaken and given orders by the ordinary telegraphic apparatus to the engineer.

I hope that Mr. Shackleton's paper will come before some really progressive owner who will invite, as regards the power plant, outside assistance before coming to the conclusion as to the power for any new ships, and I am certain that our Admiralty would do the country justice if it were to look (before fitting up our battleships and new cruisers with direct coupled steam turbines, etc.) into the possibilities of other and more economical means of propelling the ships on both fighting and cruising speeds, and taking into consideration the heavier armour and larger fighting radius which would be possible, with a greatly reduced coal bunker capacity, etc.

In conclusion, I wish to add my thanks to Mr. Shackleton for mentioning my system, and for his most interesting and instructive paper.

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Vol. XX

PAPER OF TRANSACTION NO. CLI.

SOME NOTES ON THE FIRST INTERNATIONAL CONGRESS OF THE REFRIGERATING INDUSTRIES HELD AT PARIS

By Mr. JAMES ADAMSON (Hon. Secretary).

Monday, January 25, 1909.

Chairman: Mr. D. HULME (Member of Council).

SECOND DISCUSSION ON ELECTRICAL TRANSMISSION OF POWER FOR MAIN MARINE PROPULSION,

Monday, January 11*th*, 1909.

Chairman: Mr. J. McLAREN (Member of Council),

AND

Mr. Durtnall's Reply to the Discussion on the above Paper, at the London Institution, Finsbury Circus, E.C.,

Monday, March 15*th*, 1909.

Chairman: Mr. J. McLAREN, (Member of Council).

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INSTITUTE OF MARINE ENGINEERS

INCORPORATED

SESSION 1908–1909

President: JAMES DENNY, ESQ.

Some Notes by the Hon. Secretary on the First Congress of Refrigerating Industries held at Paris,

READ AT

THE INSTITUTE PREMISES, 58, ROMFORD ROAD, E.,

On Monday, January 25, 1909.

CHAIRMAN: MR. D. HULME (Member of Council).

THE Sorbonne, Paris, in which the meetings of the first International Congress of the Refrigerating Industries were held from October 5 to 12, 1908, is situated in the Quartier Latin, —famous for its traditions of scholastic records and student life. Originally founded about the year 1250 as a theological college, it gradually grew beyond its original intention, and extended its wings to embrace other studies. The history of its progress and its association with Richelieu form interesting reading, but this reference in passing is all that can be made to it here. The college building was well adapted for the purpose of holding the meetings, the class rooms being made use of to accommodate the various sections into which the Congress was divided to suit the special scope of the papers submitted, as well as to add to the convenience of the members who desired to give a more attentive study to any one particular aspect of refrigeration, whether theoretical, scientific, or practical, with the subdivisions ranged under each.

Before dealing with the actual work of the Congress, it appears fitting to preface this with a few introductory comments on the social and international value which may be derived from such congresses. The desirability of learning to listen intelligently and speak—without the aid of an interpreter—other languages than one's own, is made manifest for more reasons than one ; indeed the reproach which has often been thrown upon the insularity of Britain in respect to the narrowness of educational curriculum is brought home to one so far as languages are concerned, and it is here noted with the object of encouraging a study of languages among our junior members. The interchange of courtesies between men of different nationalities who have been brought together by a common interest helps to lessen those risks of misunderstandings and misconceptions which tend to foster animus and unfortunate political episodes. The encouragement of mutual trade and commercial relationships between different nations is made manifest, as the representatives meet and realize their different requirements with the possibilities of one set becoming the complement of another.

During the year 1851, a period which may be within the memory of some of our members, the relations between France and Britain were of a very friendly nature. The great Exhibition inaugurated by the Prince Consort had set the minds of the nations into the peaceful avenues of art, science, trade and commerce, wherein more fitting outlets could be found than in cherishing and exploiting the martial spirit or fostering selfish ambitions, regardless of the rights of others. Commenting on the splendid hospitality of France during the Exhibition fêtes at Paris, when a large number of visitors from Britain were entertained, the *Illustrated London News* (1851) remarked as to the world: "It has begun to perceive that, after all, work is the duty, and ought to be the pleasure, of great nations as well as of small individuals, and that fighting each other is not by any means the business of Christian and civilized nations." The President of the Republic, in his message to the National Assembly on November 4, 1851, said: "The English people received our people with the most welcome cordiality (at the Exhibition), and the rivalry which took place amongst the various productions of the world, so far from fomenting jealousy, only increased the reciprocal esteem of all nations." In the light of the terrible years that followed these words, during the decade then just begun, we can review the incidents and the probable causes which led to the irony of the whole situation with that calmness and unimpassioned judgment which distance in time from stirring events alone admits of, to the major part of the nations involved. During the sitting of the Congress, visits were arranged each afternoon to works in and around Paris. The Electricity Station, the Abattoirs, Refrigerating Stores and Ice Works, the Pasteur Institute, the Science and Art Museum, the Metropolitan Railway, etc., while a special day was set aside for the ladies to visit St. Cloud, and the famous pottery works at Sèvres. Those who visited St. Cloud and saw the remains of what has been described in the pages of history as a magnificent pile of buildings, adorned with tasteful works of art, and replete with all the luxury of a luxurious age, could not but feel saddened by the wreck brought about by the ravages of war. *The Illustrated London News*, already referred to, commented on St. Cloud, its buildings and surroundings, when the British guests of Paris visited them in 1851, and the difference between the description and illustrations given of what then was and what now is appeals to one very forcibly and sadly, as instancing the savagery still in the human race—latent possibly till aroused to evoke the commentary on civilization from the onlooker who can gaze from the heights.

Let us now review the proceedings of the Congress. In Section I, which was held in the Amphitheatre Turgot, the papers and discussions bore more particularly on the attainment of low temperatures in the laboratory experimentally, with brief historical references and tributes paid to eminent scientists who had devoted themselves to the study of gases and their liquefaction. The points of importance treated on were the compression of air and gases, the temperature at liquefaction and at release, in order to discover their value as refrigerating agents. There were several papers dealing with these—the initial stages, whence have sprung the enormous results we are witnesses of to-day in connexion with the refrigerating industries, and it is not only of peculiar interest to study the steps of the early investigators, each one entering the field of research armed with some data left as a legacy by predecessors, but to note and acknowledge the debt which we owe to chemists and experimentalists for their painstaking and financially unremunerative labour—the sowers of seed of which succeeding generations would alone reap the fruit. From experiments to obtain low temperatures, and a sense of the possibilities within reach of their practical application, the next point was to determine the effect which intense cold had upon bacteria and microscopic germs hurtful to man when present in food stuffs. Continuing on from their experiments, investigators presented the results of their tests in papers, and in discussions, and showed that, while such forms of life are arrested, they are not annihilated, but spring into activity when thawed; some forms may generate on frozen surfaces and develop under influencing circumstances with detrimental effects.

Following upon these, which indicate to some extent the lessons dwelt upon in this and other sections, papers were submitted illustrative of experiments and tests made to discover what changes, if any, took place in the food of man when subjected to temperatures which would preserve it for lengthened periods, and it was found out that no detrimental change of any kind was found to take place in the nutritive qualities of food, while for some kinds refrigeration was a positive benefit. The necessity of providing sound meat, untainted by disease, was obvious from the laboratory tests, and the precautions taken in Argentina were detailed in a paper which traced the course pursued by Government inspectors who rigorously examine every animal and pass or reject according to each individual case. The cattle ranches and markets are under examination, and no animal can be transported without a certificate. The abattoirs, attendants and cold stores are inspected as to their hygiene and cleanliness. Quotations from one or two papers are worth emphasizing: "When frozen meat thaws there is a tendency for the fibres to reabsorb the water frozen outside them, and if the thawing is done sufficiently slowly the fibres will reassume their normal form and appearance; if, on the other hand, the thawing is done rapidly, the fibres will not be able to absorb all the water, some juice will escape, and when examined histologically the fibres will appear distorted out of the normal, but less so than in the frozen conditions. It does not appear from the work done that any change in the muscular tissue occurs under the cold storage conditions specified which cannot be accounted for by the physical nature of the freezing and thawing process. We are able to demonstrate all the tissue elements of normal tissue in a sample of frozen beef six hundred days old as easily as in a piece frozen only twenty-four hours." Treating of chickens the same observations are made, and the following is added: "In old frozen samples (eighteen months) all the tissue elements are easily demonstrated, and are identical with the normal, providing the thawing is done slowly." Concluding, the author of this paper, Mr. W. D. Richardson (Chairman, Chicago Section American Chemical Society), states "properly conducted cold storage at temperatures below $-9°C.$ is an adequate and satisfactory means of preserving beef and poultry for periods of five hundred and fifty-four days, and probably for a longer time." Another paper bearing upon frozen chickens and laboratory tests, illustrated with lantern views, was given by Miss M. E. Pennington of the Chief Food Research laboratory, Bureau of Chemistry, U. S. Dept. of Agriculture, in the course of which it was shown that the refrigerated chicken was in no essential inferior to one freshly killed.

The treatment of milk by refrigeration was dealt with in a paper by Dr. Bordas and Mr. J. E. Lucas, where it was stated that cooked, pasteurized or sterilized milks were in many cases unfit for feeding children; the use of raw milk from healthy non-tuberculosed cows was wanted, while refrigeration carefully done had proved an excellent process for treating and preserving milk. Further papers followed, on the moulds and fungi found on refrigerated produce, the different varieties, where and under what circumstances found, with consequent losses to underwriters and merchants. Mr. C. J. Tabor (London), in concluding his paper on the subject, referred to the drastic action of the Sanitary authorities of London and Paris, and questioned if it were justifiable in view of the fact that the same moulds found on hams and considered harmless, in the case of rabbits and meat led to their condemnation as unfit for the market. S. Rideal, D.Sc. (London), in his paper pointed out that the injurious action of putrefactive organisms could be avoided by the influence of cold, cleanliness and dryness. He advocated the use of a denser material for wrapping purposes than the ordinary stockinette, and urged great care in thawing frozen produce. His investigations confirmed that of others, that frozen meat was as good as fresh. Fused calcium chloride in boxes and sulphuric acid in suitable vessels, he said, could be used with advantage to dry the air, while the surfaces of the chambers should be sterilized by spraying a preparation or combination from formic or sulphurous acid. The temperatures at which butter, milk, and various fruits can be stored with advantage were also commented on. In the course of the proceedings resolutions were passed, based upon the papers and resulting discussions, and having for their object the adoption and enforcement of such regulations as would protect the consumer from unsound food and give him the assurance that refrigerated produce was equally nutritious to fresh. On the closing day of the Congress these points and resolutions were emphasized with the further additions that the study of the questions raised in connexion with the laboratory tests should be more widely known and considered, while the regulations advocated should be enforced.

The Second Section, which met in the Amphitheatre Descartes, was opened by a paper by Mr. W. D. A. Bost (London) on "Methods and Apparatus for ascertaining the Heat Conductivities of Insulating Materials," in which it was noted that no satisfactory apparatus for testing insulators was in use. To be of any value comparative tests should be made simultaneously under working conditions, and owing to the difficulty of securing strict accuracy in all the instruments the comparisons were lacking in this important element, so as to determine the coefficient of conductivity in each of the materials. A description of the various methods of testing was given, and it was pointed out that the best points culled from some of these might be combined in an apparatus which would be more effective than any one. A long and very complete paper by Mr. D. Desvignes (Paris) followed, giving a minute description, with illustrations, of an apparatus for testing the conductivity of materials, with references to other methods, and the results obtained by various authorities compared. Appended to the paper were tables showing the coefficients found for about forty to fifty different materials. Other papers were given dealing with the subject of insulating material and methods of testing, and it appeared from the comments made, that the tests and values of insulators are not sufficiently recognized and studied. Cement floors on the insulation were advocated in place of wood, to admit of thorough cleansing by water without causing rot and damage, preserving better sanitary conditions and lessening fire risks. The efficiency of cork as a non-conductor was remarked upon in several papers, as also the value of still air. Considerable discussion took place at this stage, and a view was expressed that a study of the values of insulators should be encouraged in schools and laboratories, that uniformity in terms and methods of testing should be established, and that the desirability of forming an International Commission for dealing with this aspect of the subject should be considered.

An interesting paper by Mr. V. A. Noodt (Hamburg) dealt with a subject of great importance to shipowners—the impregnation of wood in order to effect its preservation under the trying conditions to which it is exposed in the holds of steamers. Commenting on the depletion of the forests by the constant demand for wood, it was pointed out how important it became to preserve the wood from decay as far as possible. The methods in use for its preservation were stated to be: (i) Cyanization, or impregnation with $Hg. Cl_2$, which had the objection of risk of poison on account of mercury being present; (ii) injection of $Zn. Cl_2$; (iii) impregnation with tar oil mixed with creosote, applied to dry wood only; (iv) Boucherization, or injection of $Cu. So_4$; (v) Pfister process, in which the tree, when freshly felled and cleared of side branches, is plunged into an antiseptic solution, which is drawn through the cells by capillarity. These processes all had objectionable features. A new method, free from the objections attaching to those named, consisted of impregnating wood with a mixture containing fluor, which had also the merit of being a less expensive agent. The name of the preparation is Hylinit. It was stated that the mixture used was a disinfectant, was odourless, colourless, and penetrated under the process right to the heart of the wood. It was also claimed that the wood is hardened and rendered less inflammable. The different kinds of paints or coatings for cars, chambers and abattoirs were dealt with in a paper by Mr. A. Freitag (Paris), who pointed out that the coating put on insulated cars and stores had more value than was generally supposed. Experiments had shown that a loss of heat amounting to 13 to 33 per cent. might be due to the paint.

Mr. Barrier (Vice-President of this Section) pointed out the desirability and the many advantages of having a uniform standard of power and definitions which would enable all interested in the subject to compare the various systems and machinery by different makers, as the establishment of such would be of great advantage commercially. Mr. M. Leblanc (Paris) submitted a paper on the subject, prefacing it with the question, if there was any objection to the adoption of the metric system. This question was discussed at some length, and a committee was appointed to investigate the subject from an international point of view. Mr. Leblanc, continuing, said that there were four points for special consideration: (i) Choice of convenient units to measure the different quantities used by Refrigeration Engineers; (ii) definition of the refrigerating capacity of a machine; (iii) definition of the efficiency of the machine; (iv) adoption of a uniform standard for machines. The paper proceeded to deal with these points exhaustively in detail, pointing out the conveniences of the metric system; the different quantities required in refrigeration with a table setting forth the names of the quantities, the representative signs, the dimensions of the units—fundamental, derived, and practical, with their values. Names and symbols to represent quantities and coefficients were then suggested for universal adoption with definitions to show the meanings clearly. The definition of the power of a refrigerating machine was treated at some length, the efficiency of machines, and the useful effect of a plant, and the tests for machinery. Some discussion ensued as to the exact meaning and definition of a frigorie, and the difficulties in the way of expressing in exact terms many of the quantities in general use; the result was that a resolution was proposed and adopted to remit the matter to an international commission. Another paper on the unification of measures was submitted by Mr. Hirsch (Dusseldorf) dealing with: (i) Caloric measures, under which heading the metric system was proposed as the handiest, both for scientific research and practical work; the centimetre, the gram and the second, the frigorie, the kilogram and other measures derived from the metre as international units. (ii) Building elements and the quantities and sizes of piping which if standardized would prove of great service. (iii) Test methods and the adoption of a system which will admit of the analyses of the various sections of the plant. (iv) Comparative researches and the importance of having a systematic regulation of conditions reduced to a uniform standard for comparison and intelligent guidance. After a brief discussion, a resolution was adopted advocating the general principles set forth in the paper.

Mr. Mathot, Consulting Engineer, (Brussels) gave a review of the different means and methods for driving refrigerating machinery, and after dealing with the subject generally, advocated the use of gas Power plants on account of the great economy in fuel to be realized; and, in such case, urged the necessity of having a spare motor as a stand-by. Some discussion arose on the advantages of the gas engine for small plants. A paper on air refrigerating machines by Mr. Claude (Paris) was read and discussed with the advantages of this system in military installations. A paper by the Rev. M. Audiffren (Grasse) followed, in which he pointed out the principle and the essential elements of all compressing machines, and the importance to which these had attained in the refrigerating industry. The four constituent elements in the order of the cycle, the evaporator, the compressor, the condenser, and the expander, were each considered and reviewed. The agents employed (Az, H_3, CO_2, SO_2, CH_3 Cl.) were noted and remarked upon as nearly theoretically equal for refrigerating power, on the basis that this power is represented by the amount of the vaporization heat of the liquid used, multiplied by its specific weight; in practice, however, these values are modified by other conditions which militate in favour of one or another. The revolving machine was described and commented upon as advantageous for certain classes of work, and, with fewer working parts and valves, was less liable to losses due to leakages. One of these machines was on view at work in one of the outer courts, which was devoted to the purpose of exhibiting special types of machines. The two papers which followed treated of the development of compression machinery, and the processes, with a description of an automatic regulator, by Mr. G. Döderlein (Chemnitz), and on the thermodynamics of refrigeration by Dr. Kamerlingh-Onnes (Leyden), who proposed that the celebrated French scientist Carnot should have his name fittingly associated with the unity term to which also might be fittingly added that of Kelvin. Mr. G. T. Voorhees, S.B. (New York), gave a paper comparing different methods in use for producing cold. Vapour machines were described as of two classes, compression and absorption. In these the latent heat of vaporization of a volatile liquid is depended upon for refrigeration in evaporating the liquid into its vapour; the machine reliquefying for re-use again and again. Diagrams and tables were appended to show the results of both absorption and compression machines in efficiency and horse power developed, including a comparison of tons of ice made per ton of coal by different classes of machines.

Several papers followed treating of the mechanical aspect of refrigeration, the following subjects being dealt with: descriptions of special machines of recent make ; installation of plant in public abattoirs ; different methods of driving refrigerating machines by steam, hydraulic, electric, gas, and hand power, with a note advocating that municipal authorities should supply as cheaply as possible the water, gas, or electric current to those who were inclined to instal machinery ; cold produced by vaporization of water, and notes on condensers ; description of an auto-concentrateur, the object of which is to maintain the brine solution in a normal condition, regardless of weather conditions of heat or cold. A series of questions were proposed as to the best refrigerating system from an economical point and meat storing point of view ; the best construction of condensers, straight or curved pipes, vertical or horizontal, best form of stuffing box to prevent leakage, and style of valves ; enquiry into the calcium chloride solutions ; method of determining the best, and the results of tests at densities of 1·259, 1·203, 1·140, 1·071. Then followed, after some discussion on the former named subjects, a paper for the refrigeration of powder rooms, and the insulation of these on ships of war, with references to the dangers attendant upon the storage of explosives without the employment of such preservative measures as experience has proved to be necessary. Some discussion ensued on the importance of preserving wood from decay by impregnation. Mr. Hal Williams (London) described the general arrangement of cold storage premises, the special design of which should be made to suit local conditions, whether for a central market, harbour, or railway terminus store, or smaller premises for local use. The store should be designed to obtain the greatest cubical capacity for the least wall area, to have well built air-tight doors—and to be built of well selected wood, preferably treated with some substance against bacteria. A large number of resolutions were adopted with the object of encouraging the more extended employment of refrigeration, of refrigerated produce, a wider knowledge of the whole subject, and the advantages to be derived therefrom.

Section III met in the Amphitheatre Richelieu, and was opened by a paper by Dr. D. A. de Jong (Leyden) on refrigeration in abattoirs, where this was necessary on several grounds; the cost of providing such was no objection. Attention should be paid to the rapidity with which the air is freed and cleared of foul gases, when investigating as to the best system. Mr. P. Bergès (Brazil) gave a historical sketch of the first application of cold for transport of produce. To Mr. Chas. Tellier, the French Engineer, who was present at the Congress, and received an ovation, the honour of the first application was due. The earliest trials were conducted under the auspices of the Parisian Academy of Science, and the Argentine Government. The system in use in Argentina for rigid and close inspection of ranches, abattoirs and cold stores, also all the attendants and workmen employed, was described, and emphasis was laid upon the care and attention bestowed upon the meat exported. Mr. A. Saborsky (Austria) pointed out that the slaughter of animals at the localities where they were bred was preferable in many ways to the plan of transporting them to cities to be killed under conditions which were not favourable either to them or the consumer. A resolution embodying this view was adopted to the effect that, considering the development of the trade founded on the refrigerating industry in the interests of the consumer as well as the producer, the Congress invites the Government, States' or private railway and civic authorities to favour the industry by all means, and especially by multiplying cold stores, refrigerated cars, by reducing tariffs for transport of produce and other dues.

A paper by Mr. J. de Loverdo (Secretary to the Congress) pointed out that statistics gave the consumption of meat in France to be 38 kilogrammes per inhabitant per year, or 2 kilos. less than the United States, 8·5 kilos. less than Germany, and 13 kilos. less than England. The consumption remained stationary in France, yet the price increased, due to the number of intermediaries, and to the want of a better system of distribution. The despatch of live stock from the producing ground involved loss of weight, fatigue of the animals and deterioration, increase of death-rate, enhancement of spread of disease, requirement of many intermediaries. Organized abattoirs, and an efficient system for the carriage of frozen produce, would be a great gain to the whole community. A resolution was proposed on the subject and adopted. The discussion was continued, and other papers and resolutions followed bearing upon the more general and extended use of refrigeration for various purposes, and for the general good of communities. The subjects of ice and the carriage of fish were discussed, and the desirability of the best possible means being taken to secure purity of the one, and a plentiful supply of the other, under an organized system of transport and storage.

A paper by Mr. A. Solling (Representative of the Danish Government) is worthy of special notice in connexion with the carriage of fish. It is well known that fish in contact with ice used for its preservation for lengthened periods is deteriorated and its finer flavour spoiled. Since the Congress, on discussing with an expert amateur fisherman, who has travelled widely, the flavour of various species of fish and the difference between them when fresh caught and carried to market after many handlings, the writer introduced the question of ice packing and its disadvantages from the point of view of the consumer—that is to say, the flesh is acted on detrimentally, and the consumer misses the flavour. It was agreed that a system of carriage which kept the ice and ice water from contact with the fish was worthy of consideration and experiment on a scale which would prove its advantages. The system advocated by Mr. Solling is to pack each fish separately in watertight vegetable parchment. The gutting, cleaning and washing is done before they are wrapped up, a process which entails time and labour, but it is pointed out that the greater market value amply covers the cost. Sole, turbot, brill, and halibut, even plaice and haddock, will keep fresh and sweet even in the hottest summer weather when so wrapped up and stored in ice. An experiment was carried out in the Danish steamer *Thor*, and fish were preserved for twenty-one days by the process advocated, fresh, and perfectly sweet, white and firm, while fish carried in the usual way, gutted and not gutted, were found to be soft and stale, with the skin discoloured. Other experiments had been tried with equally satisfactory results.

The carriage and treatment of horticultural products was very ably treated by Mr. G. Harold Powell (United States) in a paper which produced considerable discussion and many questions. The enormous development of the trade in horticultural produce was such that its importance had reached to high limits. There were in 1907 nearly sixty thousand refrigerated cars moved in the United States containing fruits and vegetables. The products of Texas and Florida were sold in markets from 1,000 to 2,000 miles distant. There were two important elementary conditions which demanded consideration. An improvement in the methods of handling in the fields and packing houses, in order that the quality of the products should not be impaired before shipment. An improvement in the method of shipment under refrigeration to secure a quicker refrigeration of the fruits and vegetables than is accomplished in a refrigerated car, in order to preserve and lengthen their value. The necessity of the utmost care in preventing abrasion of the skin was emphasized, also the avoidance of gathering and shipping in an over-ripe condition. The condition under which various fruits should be carried and the temperatures were discussed. The use of refrigerating plant in connexion with breweries, hospitals and wine storage was then dealt with, and a series of resolutions were submitted on the various questions arising therefrom.

Section IV met in the Amphitheatre Guizot. The use of refrigerating machinery in the iron trade was described and discussed, the advantages being that, by a uniformity of temperature in the blast during summer and winter there was a distinct gain in economy and increased production of cast iron. The extractions of paraffin from the heavy oils of petroleum, of stearine, margarine and other products were described. A paper on a new application of refrigeration for the carriage of chilled meat after being sterilized was given by Mr. H. Birkett. The meat was sterilized by blowing into the chilling rooms a vaporized solution containing 40 per cent. of paraformaldehyde for twenty minutes before and after the loading is completed. The use of refrigeration for other purposes was referred to, including the manufacture of paraffin wax, and this was followed by another paper dealing with paraffin wax, including an historical sketch of the process which had its origin in Scotland. Further papers followed on the uses of refrigeration for breweries in the process of fermentation and for bread making. Resolutions were passed with a view to encourage an extended use of refrigeration in the industries in which it had been proved to be beneficial, and also an extended use of refrigerated wagons for the carriage of produce. A paper was then submitted by Mr. G. Bullo on the working of refrigeration in connexion with Italian industries. The manufacture and the transport of ice was then considered and dealt with in several papers in which modern methods of ice making were touched upon to show the care taken to secure purity. It was urged that all taxes which interfered with this industry should be abolished. It was also urged that not only should every care be taken to place pure ice free from contamination intended for consumption on the market, but that laws should be enforced to punish those who supplied it otherwise. The use of refrigeration in horticulture was the next subject brought before the Section, and in connection with this, a number of papers were read describing what had been done in various places by treating trees and plants to retard growth and produce a pause in vegetation, thus bringing about a change in the time of flowering. A paper by Mr. C. M. Simons (London) excited great interest and appreciation, being full of details, showing what plants could be treated successfully, and the processes necessary to success. A resolution was passed expressing the view that encouragement should be given to the study of the subject by the establishment of laboratories dealing with plant life.

The meetings under Section V were held in the Amphitheatre Salle du Doctorat, and were opened by a paper by Mr. H. I. Ward (London) on the carriage of bananas, the trade in which had increased considerably during recent years. The treatment of the fruit from the time of gathering to the shipment was detailed, and several points emphasized, as, the best time for gathering, the temperature for preservation to avoid ripening, avoidance of skin abrasion, reducing handling as far as possible by the use of conveyers. The methods of sparred compartments and stowage for long distance carriage to give ample circulation of air, and arrangement of fans were described. It was stated that 4,500,000 bunches of bananas were imported into Britain in 1907. A question was then raised by Mr. de Syntenko on the subject of the importation of eggs and game from Russia into France with the high dues and taxes, and want of proper facilities for transit and storage. A brief discussion ensued, in which it was considered desirable that facilities should be given, and that a proper system of surveillance should be observed, so that the produce should be efficiently preserved for the consumer. There were other papers dealing with Russian trade in eggs, poultry and game to various countries, and the want of adequate means of transport and storage conditions.

After a paper by Mr. Bullo on the great increase in the use of refrigeration in dealing with various industries in Italy, Mr. H. C. Cameron, on behalf of Mr. J. T. Critchell (London), submitted a very complete and interesting paper on the progress made in the importations of refrigerated produce of all kinds from the colonies to Britain; also a diagram showing the amount of tonnage available for this purpose, and the extent of its value and service. The Hon. H. T. Coghlan (Australasia) pointed out that by means of the importation of refrigerated produce it was possible for the great mass of the people to obtain meat at prices within their reach. This had been the case in England, and had a material effect on her prosperity. Mr. Preedy, followed by Mr. G. Anderson (New Zealand), urged on the attention of the section the value to thickly populated districts of refrigerated produce imported from large territories, with ample facilities for breeding and grazing; pointing out also that the nutritive properties of such produce remained unimpaired, a fact which ought to be impressed upon the public to overcome prejudices. Mr. G. Harold Powell (United States), referred in a most interesting manner to the carriage of fruit; his paper on this subject was valuable to all who are in any way connected with the growth, carriage, transit or storage of fruit and vegetables. The importance of reducing the limits of handling was made clear to avoid risk of skin abrasion, whether in gathering, packing, conveying or shipping. The subject of fruit was continued by Mr. F. W. J. Moore (Tasmania), who showed that there were great possibilities within the reach of fruit growers and importers, as by the adoption of refrigerated stores, self-registering thermometers and other appliances, fruit could be preserved, unimpaired, and in good condition, for long periods, thus admitting of a constant supply throughout the year. Care required to be taken in the gathering of the fruit, carriage and storage; exposure to climatic influences likely to be detrimental should be avoided. Some discussion took place, and questions were asked and answered as to the details of fruit carriage, and the best temperatures for the several kinds. A paper dealing with the history and development of the refrigerating industry was followed by another dealing specially with the resources and fertility of the district around Lyons, and its suitability for agricultural purposes. By organization and methodical arrangements for cultivation, carriages, means of transport, and storage, great developments would result, while the encouragement of the transport and storage of all kinds of refrigerated produce —fish, game, poultry, as well as fruit and vegetables—would be a great boon to the cities. A resolution was submitted and carried in terms of the views thus expressed. It was further pointed out that the means of transport for produce from Russia might be improved with advantage to the consumer, and that the military authorities could take better advantage of the facilities afforded by the refrigerating industries to organize the supplies of food to the various centres.

The next subject under consideration was the transit arrangements and types of cars and wagons in general use for the carriage of refrigerated produce. The consensus of opinion was that there remained great room for improvement in the construction of the cars, and the time occupied in moving them. A resolution on the subject was, after considerable discussion, passed to the effect that an international committee should be appointed to consider the subject and approach the Railway Companies on the questions. Some further contributions were given as to transport wagons, service and tariffs, and other resolutions were passed with the object of obtaining better facilities for the entrance of refrigerated produce to the centres of population at reduced tariffs and taxes with fewer exactions on the frontiers. Several papers were submitted dealing with the carriage of produce, and it was pointed out that there was no difficulty in providing efficient means of transport if the subject were only taken in hand properly by the authorities.

A paper by Mr. J. T. Milton was then read dealing with the sea transport of refrigerated cargoes. The production of artificial cold by the dry air machine gave a very low temperature at the discharge, with an accumulation of snow, however, which was a detriment and an objection to its use; still, when very low temperatures were required, the dry air machine was the most suitable, reaching as low as—70° F. The production of cold with this type of machine was obtained by compressing air to 50 or 60 lb. pressure, then cooling and expanding it. The CO_2 and ammonia machines were adapted for either air cooling by means of fans passing the air over a series of refrigerated tubes on its way to the cold storage chambers, or by the cooling of brine which is pumped through a course of pipes led throughout the cold storage chambers; these pipes bearing a certain proportion to the cubic contents of the insulated space. It was pointed out that these brine pipes should not be galvanized inside on account of a wasting action which was generated. The system of brine circulation was preferable where uniformity of temperature and exact temperature were desired. The various insulating media in general use were stated, and the proportions found to be most suitable for efficiency, the depth of the chamber should be kept within the limit of 18 to 20 ft. at most. The best temperature at which to keep the different products carried over-sea was then discussed in the paper. Thus frozen meat chambers should not be allowed to rise above 20° F.; chilled meat may be carried in a temperature of 29° to 29·5° F. For butter, according to conditions, the temperatures ranged 18°, 15° and 10° F.; cheese about 40° to 45°. Each kind of fruit varied, and the degree of ripeness when gathered altered the degree at which the best results were obtained. Bananas were usually carried at 50° to 52°, and apples at 36.° Care had to be exercised when carrying fruit to change the air by circulation to prevent accumulation of carbonic acid gas. The usual practice was to provide duplex or duplicate machines where the installation was large, and the risk of a breakdown involved great amounts. Refrigerating machinery was frequently overloaded by reason of the produce not being delivered in a proper condition for shipment, owing to faulty transport arrangements. The paper concluded with a description of the methods of stowing produce in the chambers on board.

The next paper, by Mr. W. Lund, treated of the many risks involved in connexion with the over-sea transport of refrigerated cargoes, the great increase in the amount of produce carried, and the enormous dimensions to which the trade had extended. There were now 180 vessels engaged in long voyages, having a total capacity of insulated chambers amounting to 750,000 tons measurement, or 340,000 tons weight, or 12,000,000 carcases of mutton. The several risks were stated to be exposure before shipment between the breeding grounds, the slaughter houses, cold storage chambers, and the wharves. The precautions taken at the various stages were touched upon. Some of the risks were incurred before shipment, some during shipment, others during the voyage. The responsibility in connexion with a portion of the risks rested upon the ship-owner, but there were cases where it was difficult to place the responsibility of the damage, but the risk had to be borne. Examples were cited to show from experience the nature of the risks undertaken by those concerned, and of the damage sustained by refrigerated cargoes, with some of the causes leading to these. The necessity of knowledge and experience on the part of those in charge of the refrigerating plant was urged so that the various products should be carried at the most suitable temperature for each, otherwise the cargo would suffer, or the machinery, on the other hand, might be over-burdened with the increased risk of break-down. Papers and discussions followed on the details of the carriage of refrigerated cargoes; different types of machinery, with their comparative advantages for different purposes; transport of fruits, ice, fish, and other eatables.

The Sixth Section met in the Amphitheatre Quinet. The President of the Section opened the proceedings by referring to the general intentions of the Congress in respect to the advancement of the study in the theory and practice of refrigeration; spreading information on the subject; and promoting legislation in connexion with the carriage of refrigerated produce, in order to facilitate its development under conditions which would give security and confidence both to the consumer and supplier. Several resolutions were submitted, bearing on: the advisability of encouraging the introduction of refrigerating machinery into places where the community would be greatly advantaged by the installation of such plant; and the careful inspection of all produce before it is placed on the market; also the establishment of a uniform and organized system of inspection, with a view to maintain the best conditions and ensure good meat and other produce being placed before the consumer. The President supported the view thus put forward, and proposed that means be taken to formulate a series of regulations which might be universally adopted by the exporting and importing nations, as such would be of the utmost advantage in the development of the trade, giving that security which is necessary for the public in regard to what is sold in the markets for food.

Mr. G. Anderson (New Zealand), after referring to the need of an organized system of sanitary inspection from the time that animals intended for food entered the abattoirs to the arrival of the refrigerated meat at the markets, proposed the following resolution, which was adopted: "That in view of the large expansion of the trade in refrigerated meat and the wide diffusion and distribution of refrigerated products, it is desirable that an international uniform standard of meat inspection be established and agreed to by the various countries exporting and importing animal foods so as to ensure the healthy condition of the meat."

A further resolution was proposed that the regulations at present enforced by the different countries should be obtained and tabulated, with a view to adjustment to meet a wider extension of the trade in respect to all refrigerated produce.

The encouragement of the teaching of refrigeration at schools and colleges introduced in a paper by Prof. W. Anderson, of Liverpool, where the study is carried on systematically in the University, was advocated and discussed. A note of the papers published in Russia on refrigeration was submitted, and the President advocated the spread of such information as would tend to an extended knowledge of the subject. A paper on the trade in salmon introduced a discussion on the restrictions necessary for the fishing industry during the close season. The result of the discussion was that the questions arising in connexion with the salmon fisheries and preservation should be referred to the authorities regulating the industry. The Hon. T. A. Coghlan (N.S. Wales) proposed the following resolution: "The Congress expresses its opinion that in order to reduce the cost of living to the working classes and to promote international trade, regulations which hamper the introduction into any country of frozen or chilled produce, and the storage, distribution and sale of such produce in any such country, should be modified or abolished." This was supported by the President and carried. Some further discussion ensued on the restrictions and regulations in various districts with a view to an improvement in the conditions ruling, and a resolution was proposed to have an international commission formed to consider all the questions involved, and formulate regulations which would meet with, if possible, universal acceptance. The requirements of the transport service, receiving stores, and other necessary arrangements for the development of the trade in refrigerated produce, were discussed, and resolutions passed with a view to improving and adding to the present facilities for the transport of produce, including fish and game. The manufacture and transport of ice was considered, and it was urged that purity at the source of supply should be under observation. A resolution with a view to improving the transport arrangements across the Continent was passed, after several members had pointed out the disabilities under which the trade then suffered.

A paper given by Mr. P. B. Proctor (London) pointed out that by the help of refrigeration the population of Britain was supplied with produce by Australasia and the continent of America, and the markets of the Continent could be similarly supplied if the facilities were forthcoming. Statistics were given showing what had been imported during 1907, amounting to 544,723 tons of meat and a large tonnage of rabbits, butter, fruit, eggs and cheese, the value of the two latter being £14,000,000, and of fish £814,500. The consumption of meat per head of population in Australia was estimated to be 233 lb. per annum; in the United States, 143 lb.; in Britain, 122 lb.,—of which about 22 per cent. is refrigerated, resulting in a reduction of 40 per cent. in cost to the consumer. Prejudice against refrigerated produce has existed and does exist; such has to be overcome before the consumer can obtain full benefit from imported produce. The removal of tariff and other restrictions by countries where these exist to the partial closing of their markets against refrigerated produce would result in gain to the populations involved by giving them the benefits enjoyed by a country like Britain, where the poorer classes can purchase food cheaply. A series of propositions was submitted by the Argentine Republic delegates, containing a summary of the proceedings of the Congress, and expressive of the good which would accrue therefrom. A vote of thanks to the Government of France was also added, expressive of appreciation of the favour and patronage which had been extended to the members and to the Congress.

An International Conference was held at the close of the sectional meetings in order to obtain opinions on the Congress as a whole, the action to be taken with the object of carrying into effect the various recommendations and to arrange for the next Congress.

The official banquet was held in the *Grand Hotel*, Paris, presided over by M. André Lebon, President of the Congress, who was supported by the official delegates from the different nationalities represented.

A most interesting closing meeting was held in the grand hall of the Sorbonne, when votes of thanks were accorded to those who had been instrumental in organizing and contributing to the Congress, the success of which had proved so great. The intention of the executive was to publish in full the proceedings of the Congress, as up till the present only a brief summary of the papers and discussions had been printed. These it had been felt were quite inadequate to do justice to the labour expended by the members.

In concluding these notes, which have extended beyond the limits anticipated and possibly into the region of a weariness to the flesh, it may be added that on the whole the Congress has done good service all round. The papers were too numerous, and were thus necessarily crowded into time which could otherwise have been profitably employed by interpreters of salient points and by discussion. The estimated number of members was far exceeded by those who were present, and the arrangements in connexion with the probable attendance were therefore inadequate to cope with the actual requirements; still the executive did their best to meet the case, and will probably be better prepared to meet the conditions on the occasion of the next Congress which by invitation is to meet at Vienna in 1910. It appeared curious that the British Government had no representative at Paris, where so many other nations were represented at the Congress.

It has been suggested to me that as the grounds occupied by the Franco-British Exhibition during the summer of 1908 will probably be again made the focus for attracting visitors during 1909, the subject of refrigeration and refrigerating industries might well be given prominence to in whatever arrangements may be under consideration by the executive. Certainly it appears from our experience of the Exhibition which closed in October that fuller advantage might be taken of the lecture hall and co-operation with the many different societies in the Kingdom in any new venture which may be under contemplation by the promoters.

CHAIRMAN: You have heard Mr. Adamson's paper on what he calls "some notes" on the first Congress of the Refrigerating Industries, but which is really a valuable and extensive description of the work of that Congress. He has given us plenty of material for study, and if any gentleman would like to ask him any questions, I am sure he has a great deal more information stored away that might be useful to us.

Mr. W. E. Farenden (Associate): We are indebted to Mr. Adamson for this paper. Reference is made to the number of days that beef can be kept in a perfect state by refrigeration as long as the meat is in good condition when frozen and put on board. The 600 days seems to be a very long time, and it is very gratifying to hear that it can be done. In dealing with the Second Section, Mr. Adamson refers to a paper that was read treating of methods and apparatus for ascertaining the heat conductivities of insulating materials, in which it was noted that "no satisfactory apparatus for testing these materials was in use. To be of any value comparative tests should be made simultaneously, and under working conditions." I think this is a very important matter. If we could find any way of getting an apparatus at the Institute to test the different insulating materials, it would be a very valuable acquisition. A short while ago we had a paper by Mr. Dyer on the different methods put forward for the preservation of wood used for refrigeration purposes, and in the paper read by Mr. Noodt of Hamburg several methods are stated. The best one, I think, is that described as "a new method free from the objections attaching to those named, consisting of impregnating wood with a mixture containing fluor, which had also the merit of being a less expensive agent." Could Mr. Adamson tell us more about this method. The agent used is stated to be odourless, which is one good point in its favour on account of the butter, cheese, or other foodstuffs liable to be tainted.

It is very interesting to get the figures showing the comparative consumption of meat by various countries, but the authorities seem to be a little at variance. Mr. P. B. Proctor gives the consumption of meat per head per annum as 143 lb. in the United States and 122 lb. in Britain; whereas Mr. J. de Loverdo states that the consumption of meat in France is 2 kilos less than in the United States, and 13 kilos less than in England, implying that the consumption of meat in England is much greater than that of the United States. The paper read by Mr. Milton dealing with the sea transport of refrigerated produce would prove of great value to members, and it has occurred to me to ask if we could have a copy for the Institute.

Mr. Robt. Balfour (Member): On looking over this excellent paper I can assure you it astonishes me, as having been present at this Congress, I am certain that if it had been my lot to represent the Institute, although I possess some knowledge of refrigeration, I should not have been able to enlighten you to anything like this extent, and the members of Council deserve our hearty congratulations for choosing such a Representative. The organizers of this Congress were surprised at the large attendance and the number of papers submitted, so much so that they were placed in a dilemma. They did all they could, however, dividing the meetings into six sections: all the available accommodation in the Sorbonne was put to good use. No doubt some members of Congress were not quite satisfied, but they were few. There is food for discussion in the paper—it is a lecture in a sense—and I would commend it to the careful consideration of the members. At the meeting first mentioned by Mr. Adamson tributes were paid to the scientists who were the first to make researches in the field of refrigeration, and in the discussion I heard, coupled with that of Carnot, the name of our late respected scientist, Lord Kelvin. I was not able to catch all that was said, but the impression conveyed to my mind was that it was suggested that his name should be associated with the thermo-dynamic unit in standardising the refrigerating capacity of machines. I would like to call attention to the remark with regard to "the enforcement of such regulations as would protect the consumer from unsound food and give him the assurance that refrigerated produce was equally nutritious to fresh." From my own experience I find that the restrictions and regulations here are very severe with imported frozen meat as compared with the meat killed in our own country. In this country, it is easy to trace the owner of a pig suffering from tuberculosis or other disease, but in the case of one imported from the Continent this is not so easily done, in fact it is impossible. Mr. Farenden referred to the importance and value of comparative tests with the non-conducting medium. That has been gone into to a great extent by the members of the Ice and Cold Storage Association, and the representative of "Ice and Cold Storage," who I see is with us to-night, will be able to give us some information as to what has happened in years past in connexion with the value of non-conducting materials in refrigeration. We may obtain from experiment in the laboratory very valuable results, but when we consider the construction of a ship, and what it has to contend with, there is some difficulty in deciding which is the best. Reference is made to an interesting paper by Mr. V. A. Noodt, dealing with the impregnation of wood. Mr. Dyer recently brought this subject before the Institute, the importance of which and the subsequent interest taken since he ventilated the subject is a compliment to him, as I understand the question of afforestation is becoming a very serious one. There is a note of an inquiry into the calcium chloride solutions: the method of determining the best, and the results of tests at densities of 1·259 down to 1·071. In working the brine system the density of the brine is of the utmost importance and has to be carefully watched. Some engineers keep the density unnecessarily high, no doubt to prevent it freezing; but it is apt to choke the system. In an installation where there is insufficient piping or cooling surface a comparatively low temperature of brine has to be maintained, consequently a high density is necessary, say not less than 50 ozs. to the gallon; but in a well-designed plant 42 ozs. is enough. Before entering the tropics, where the sea water may be anything between 74° to 84° F., it is usual to run the brine at a low temperature to meet the tropical conditions and command the necessary low temperatures in the holds, it is on such occasions that the density of the brine requires to be watched. The handling of fruit played a very important part in this Congress, and I consider that great credit is due to some of the members of this Institute in the fact that the successful temperature for the carriage of fruit from the colonies to this country was that arrived at as a result of their long experience. Mr. Adamson mentioned another paper regarding the preservation of fish, in which the author speaks of ice being used as the cooling medium. In the north of Scotland the salmon is packed in ice for transmission to London market, but one never knows what kind of water it is made of; it may be contaminated. In making ice I think only distilled water should be used; that is a very important point. Mr. Farenden has had some experience of the freezing of fish on board ship, and, as he could tell you, the trouble is enormous.

The ice may be made from polluted water, so that it is necessary to be very careful when fish are carried in ice, and more attention should be given by the authorities to this matter of the quality of the ice ; it should be insisted upon that the ice be made from distilled water.

The HON. SECRETARY : I may mention incidentally that I have seen ice gathered in the winter time from polluted ditches by ice-cream vendors.

Mr. BALFOUR : With regard to Mr. Milton's paper, I am sorry he is not present, but I am sure he will be only too pleased to supply this Institute with a copy of his paper. There is one item which ought to be recorded. I do not want to touch upon politics, but I regret very much that there was no official representative or support from the British Government at this Congress and I think it is a thing much to be regretted.

Mr. B. H. SPRINGETT (Manager, "Ice and Cold Storage") : I certainly did not intend to say anything to-night—I came here as a humble listener—but as Mr. Balfour has made one or two references to me I might venture to say a few words. First of all, I should like to say that had I had in my possession during that memorable week in Paris this very careful precis of the proceedings as a whole, I should have been very much more comfortable than I was, because only those who were present can realize the immense importance of the Congress, the great desire of everybody to be in six different sections at the same time, and the feeling of utter incapacity at the moment to get a clear idea of what was going on. My difficulty was a little worse than that of other people, because I was under contract to send to America, on the fourth day, an up-to-date epitome of everything that had transpired. I did my very best, and while I do not want to lay myself open to the charge of self-conceit, I may say the publication did manage to come out on October 17 with a digest of the proceedings, while the paper represented at the Congress deferred its account till December. It might also interest some of the marine members to know that I had to inform the French Post Office, at one of its head offices, of the dates and the names of the steamers by which a letter could be sent to America. The three points which appealed to me most were these. First of all, as Mr. Adamson said, the necessity of being a linguist, because not only were many handicapped from fully appreciating the intensely interesting matter put before them by being unable to understand French, but also those who could understand were not a little handicapped by those who could not speaking every language of the world behind one's back. The second point that impressed me was that referred to by Mr. Balfour, and perhaps one of the most strange things to us Britishers over there was the eagerness with which the greatest protectionist countries in the world approved the resolutions, which seemed to show the absolute need in these protectionist countries for the free trade which is said to be doomed in this country. The third point that pleased me most of all was the tour through the industrial centres of France which we were afterwards permitted to take part in. They showed us the wine industry and the way in which refrigeration was used there, and also a large steelworks, where, it is said, the use of refrigeration advocated in America was not really an economical advantage. In that steel works in Eastern France, however, one of the largest in the country, turning out railway material of all kinds for many countries, there were fifteen steam cranes moving about the yard, all manufactured in Bedford, and they depended for their principal supply of motive power on two very large steam engines manufactured in Glasgow. It pleased me, as the only Englishman in the party I travelled with, to place on record that fact, that, notwithstanding the so-called advances in engineering in France and Germany we hear so much about, British engines were still the main source of power in those very large works. I am certainly not prepared to go into the question raised as to the conductivity of material, but I think one great result of the Congress will be to produce more of these papers in our own country than has hitherto been the case, and no longer to leave us dependent upon what has been brought out in America or translated from the German. In connexion with our own paper, we have had, up till now, the greatest possible difficulty in getting an English engineer to write an article for us on any subject connected with refrigeration. Our leading men could write, but they say they have no time or they wish to postpone it, and in the end the article is not written. But now there seems to be a feeling in many quarters that, as so many papers were read and prepared by engineers of other countries at the Congress, the time has arrived when we shall have to get a few more from our own men, who, I feel, as an Englishman, are much more competent to deal with the subject. I think the various engineering institutions in this country should impress upon their members how anxious other people are to hear the views of really good technical men, and I think, also, if a man has views on an important subject like refrigeration, he ought, as a natural duty to his fellow-men, to put them on paper at the earliest moment. I think we offer a suitable medium, and if any of our marine friends can give us details of any of the points raised to-night, or any other point connected with refrigeration such as the point Mr. Balfour raised as to how one cannot go entirely by theory in fixing temperatures, all these points might be the basis of valuable papers for the benefit of the refrigerating industry at large. We have had to depend on America hitherto, and that brings me to another point Mr. Balfour has called attention to, and which was also raised by Mr. Adamson—that the British Government did not take a leading part in the Congress. Everybody in the English section, it seemed to me, wanted, as I did myself, to try and hear every paper, and as they were mixed up very much indeed—the natural consequence of the overcrowding of papers and people—perhaps a paper on an important subject, say, for example, the handling of fruit, would be read in one section and a paper on the same subject would be given at the same time in another section under a different heading, yet in whatever section you went, you found part of the American delegation listening to everything that was going on by an organized arrangement lacking in the British contingent. They had a man posted in every section, who was able to answer a few questions on the spot, while they sent out all round the other halls to find the exact man who could best answer the different questions that arose, and not only give a denial to certain statements, but also go at full length into subjects that otherwise would be left an unknown quantity. With regard to the last point in the paper, for many weeks past we have been in communication with Mr. Imre Kiralfy, and I think there will be something interesting in connexion with refrigeration at the Exhibition to be held at the White City in 1909. There was some idea of trying to arrange this last year in connexion with the Congress, but it was decided to let the matter remain in abeyance, as it might possibly tend to lessen the importance of the Congress.

CHAIRMAN: There is a gentleman with us to-night who has an intimate knowledge of a process of impregnating wood to prevent decay, perhaps he would give us some information on the subject.

Mr. LIONEL CASTLE (Visitor): I have to thank your Hon. Secretary for inviting me to attend this meeting, but I feel rather diffident about addressing you, as I have been much disappointed, not being able to procure certain valuable data with regard to burnettized timber employed for refrigerator installations. As Managing Director of a firm of Timber Preservers, who have been established over seventy years, Sir Wm. Burnett & Co., I am keenly interested in the preservation of timber, and Mr. Dyer's paper on "Timber used in Marine Installation for the Carriage of Refrigerated Cargoes," interested me very much. There are several methods of preserving timber, some of which were alluded to at your meeting in October last. For refrigerator installations it is essential that the preservative employed should be odourless, and as far as possible uninflammable, so that for this purpose, for obvious reasons, creosote is out of the question. Of the chemical preservatives mentioned in Mr. Dyer's paper, we have found from careful observation that they have a tendency to wash out, and when this occurs the wood becomes an easy victim to the germs of animal and vegetable life, which are the beginning of decay. The difficulty therefore to be overcome, when employing chemicals as a preservative, is to fix the preservative insolubly in the wood; that is to say, the preservative must form a permanent chemical combination with the ligneous fibre, like ironmold, which will not wash out.

Mr. Adamson just now mentioned the *entente cordiale* with France, at the time of the Exhibition of All Nations held in London in 1851. Burnettizing for the preservation of timber was invented in 1838, and it was at this exhibition that Sir Wm. Burnett was awarded a medal and certificate for burnettized wood. Since then, different members of my firm have spent a great deal of time experimenting, to perfect and ensure permanent chemical combination taking place between the preservative employed and the fibre of the wood, with success.

I have a few samples of burnettized wood with me, which I should like you to examine : you will notice that the wood is rendered considerably harder, and the pores are closed up, also that it is clean, odourless and not inflammable, and when desired could be painted or varnished.

The preservative employed in burnettizing is a powerful odourless and colourless antiseptic, and when forced into timber under pressure, it thoroughly permeates it, and enters into permanent chemical combination with the ligneous fibre. And I should like to here point out that there is no reason why burnettizing should not equally effectively be employed for preserving wood employed in confined spaces as for wood employed in the open, which is subject to the elements. Perhaps it may interest you if I tell you a few places where burnettized timber is in use at this moment.

In 1901, we burnettized about 250 loads of timber for the War Office, for cold-storage work in Gibraltar, and in view of attending this meeting, I asked for a report on this burnettized timber, which would have been valuable data; but to my disappointment I was informed "it is against the practice of the Department to furnish reports." This is quite on a par with having no Government delegate at the Congress recently held at Paris. However, it may be safely assumed, that as burnettizing was specified to preserve this timber, and, as we have received no complaint, that this method of preserving has proved effective for the purpose for which it was required. When burnettized timber is specified by engineers, we seldom know for what purpose it will be employed, as the timber is usually sent to us by some timber merchant, who is unwilling to furnish us with any information regarding his customer. We burnettized last year some twenty loads of timber for a timber merchant, for refrigerator installation on a ship; this must have been specified by some engineer who knows the process. As recently as last week, we received an inquiry from a timber merchant, to whom we had submitted a sample of burnettized timber in the early part of last year, for burnettizing about fifty loads of timber for refrigerator installation in a ship. With regard to other work for which burnettized timber has been used, about eleven years ago we burnettized the timber of a jetty in the Victoria Docks after it had been burned down, this jetty had previously been built with creosoted timber. This burnettized timber was reported on after it had been erected over nine years, and it was owing to its extremely sound condition at that time that the order was placed with us to burnettize about 1,250 loads of timber used in building the West Pier Extension in the Tilbury Docks. We supplied several thousand sleepers to the C. & S.E. London Railway, and after they had been in use about twelve years they were reported to be in good condition. My company has at various times burnettized timber for the different Government departments, dock companies, private companies, railways, etc., and the results have always proved effective. I need only add that we burnettized several thousand sleepers for the Metropolitan District Railway last year, and that all the telegraph poles employed by the G.P.O., other than those creosoted, are burnettized by us, and we always hold a stock of ready burnettized poles for this department, to be drawn on as required. From all which it may be seen that burnettized timber is employed for all sorts of purposes, and it is to be especially recommended where no smell, uninflammability and cleanliness are required. I am very strongly of the opinion that burnettized timber might be effectively employed by marine engineers for refrigerator installations, and my only regret is, that I am unable to produce a report from the War Office on the condition of the timber supplied to them eight years ago for this purpose, as it would have been interesting to us all here to-night.

Mr. C. M. B. Dyer (Member): I should like to ask Mr. Castle to what conditions the timber at the Victoria and Albert Docks is subjected. Is it in a confined condition, or is it exposed to the action of the atmosphere and really under good conditions for seasoning?

Mr. Castle: It is on a platform fully exposed, and is near No. 9 shed I am given to understand.

Mr. Dyer: We want to know of some process that will preserve timber more or less confined, and not exposed to the atmosphere or with free access of ventilation.

The Hon. Secretary : The remark made by Mr. Farenden as to the meat being kept for 600 days is correct. The meat was actually kept for that length of time, and was then found to be equally good, so far as the tissues and the nutritious qualities were concerned, as meat frozen for twenty-four hours only ; that was a point emphasized in several papers at the Congress. We had the enlarged view of a section of a chicken shown upon the screen by an American lady demonstrator with a view to show that the fibre of the frozen chicken was a facsimile of that of a chicken freshly killed. With regard to the testing of insulating materials, one of the papers contained an interesting table showing the insulating capacities of about fifty different materials, and although in one paper it was stated that there was no perfect instrument, the paper immediately following proved there was a perfect instrument —from the writer's standpoint. I think it was Mr. Desvignes who described an instrument which he was satisfied gave perfect results. We have often thought of having in connexion with our experimental department not only the coal-testing apparatus, but also the means of testing insulating materials ; we have talked about it for years, but have not got it yet; but if the means were forthcoming we should be glad to extend our laboratory in this and in other directions. In reference to hylinit, as Mr. Balfour as mentioned, there are two copies of Mr. V. A. Noodt's paper in the reading-room, printed in French, German and English, describing the process. In the burnettizing process I believe the timber is placed in a cylinder which is then closed by jointed doors, and an exhaust pump is used to draw the moisture and air out of the wood. After the air and moisture are exhausted the substance, which is stated to be a disinfectant, is pumped in under pressure, the process being called "burnettizing." I looked at some of the timber at the Victoria Dock since I knew it was done by that process, and it seems sound and good. With regard to the figures for meat consumption given in kilogrammes, I think it is possible a different basis has been worked upon in each instance. Mr. Proctor does not give the consumption for Germany, he gives it for Australia and Britain, and the difference is about 11 or 12 lb. per head from the French writer. It may be that the figures are for different years or on a different basis. With regard to Mr. Milton's paper, we hope to have both it and Mr. Lund's paper in full for our reading-room table, if not for more extensive use. In connexion with the first section the names of a good many scientists were mentioned, among them that of Lord Kelvin; but I did not hear the reference where it was stated that his name should be perpetuated in our memories by having it applied as one of the standard terms, but it would be very fitting to have it so.

Mr. BALFOUR: I think you came into this section just after the proposal was made. I just caught the name of "Kelvin" mentioned in connexion with the thermo-dynamic theory.

The HON. SECRETARY: It might be a good thing for us to take action, and if nothing has been done, to see that it should be done, that Kelvin should stand alongside of Carnot and others. We all know how much we are indebted both to Carnot and Lord Kelvin. With regard to the Government new regulations for killing animals, I see these are now published, and I was rather astonished at the complete details. Every animal is to be killed separately, and every animal when brought to slaughter must be prevented from seeing the blood of the animal slaughtered immediately before it. These regulations are to be enforced in the public abattoirs of this country, and were evidently drawn up from a humanitarian point of view. Many have expressed the opinion that, say, Canterbury lamb—which is held out by our New Zealand friends to be the best—brought into this country, cannot be traced where it goes to, and I have heard a good many express the view that some steps should be taken to trace the meat from the ship right up to the market. There have been articles in some of the technical papers bearing on that point, and it not only applies to meat, but to butter and cheese. I am told that beautiful consignments of Colonial butter come to this country and are transported elsewhere, returning to market under a different name.

With reference to the use of timber, there was a paper read at the Edinburgh Exhibition last year on the subject of afforestation, and several of the Arboricultural Societies in the Kingdom have been going into the matter and urging upon the Government the necessity of something being done. Several landed proprietors are dealing with the subject, but also, as Mr. Balfour pointed out, a Royal

Commission, appointed for another purpose, have taken this question up, and now propose that millions of pounds should be spent for planting forest trees by the unemployed. I think we are all agreed that a step such as this is in the right direction ; whether we should go into it to the large extent and in the manner proposed is another matter. I am glad Mr. Balfour referred to the question of the density of the brine, as the statement is too bald in the paper without the qualification as to conditions. In connexion with fish, the flavour seems to suffer when brought into contact with ice, and the object of the advocated process is to seal the fish from contact with the ice. I had a discussion on the subject with a gentleman whom I knew as a keen fisherman, he quite agreed that ice was detrimental, especially to fish of a delicate flavour. I prefaced the notes read to-night with quotations from the *Illustrated London News*, as I thought it emphasized the fact that the British Government were not represented at this Congress. It was quite a treat for me to read over the accounts given in that journal of the fêtes in London and Paris in 1851, and the receptions given both on English and French ground. It only came to my notice at the committee meeting before the Congress took place that there was no official British representative. It was deplored, but it was too late to remedy it, and I hope the hint given to-night will prove effective, and that in the event of the British engineers going over to the next Congress at Vienna, the isolation of members will be avoided by a united organized and systematized arrangement, although I personally did not feel the want of such. I think there is room for a number of papers from these notes, and I am sorry the Convener of the Papers Committee is not here to-night to emphasize that point ; I now do so in his absence.

Mr. F. M. Timpson (Member) : I beg to propose a very hearty vote of thanks to Mr. Adamson for his very able paper. A lot of subjects have been dealt with of very great interest, and I have no doubt they will be even more so to the many members who are more intimately connected with this class of work.

Mr. Dyer : I have very much pleasure in seconding the proposal; the Institute is indebted to Mr. Adamson for the masterly way in which he has brought all these facts together.

The meeting closed with a vote of thanks to the Chairman on the proposal of Mr. Balfour, seconded by Mr. Farenden.

SESSION 1908-1909

President : JAMES DENNY, ESQ.

Adjourned Discussion on "Electrical Transmission of Power for Main Marine Propulsion."

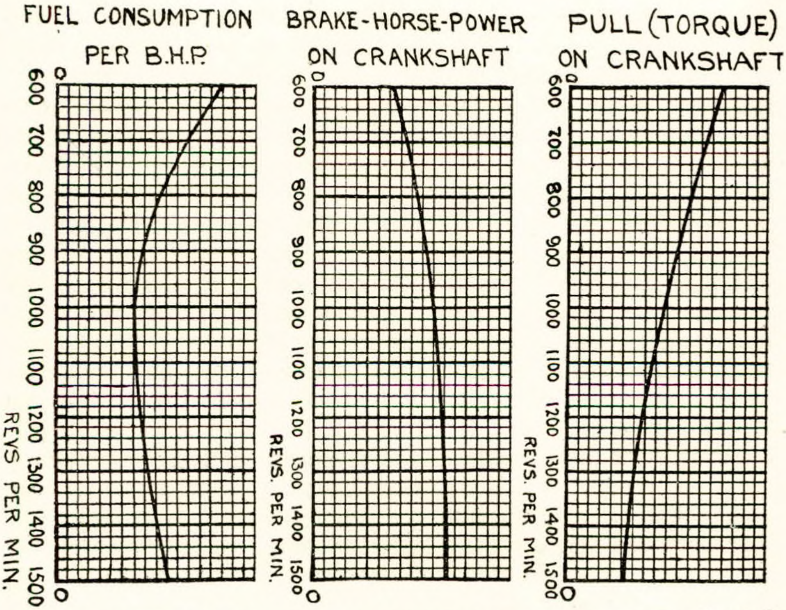
Monday, January 11, 1909.

CHAIRMAN: MR. J. McLAREN (MEMBER OF COUNCIL).

CHAIRMAN : We are met again to-night to take part in the adjourned discussion on Mr. W. P. Durtnall's paper on "The Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulation." I think Mr. Durtnall has some fresh matter which he will be pleased to put before us, and I will now call upon him to open the discussion.

Mr. DURTNALL : As most of you are aware, the object of the proposed electrical transmission of power is to ensure a high speed of the steam turbine in conjunction with a slow speed of the propeller in order to obtain the highest economy in steam and propulsive efficiency. In the existing turbine-driven ships, where the turbines are direct-coupled to the propellers, the speed of the turbines is very low indeed, comparatively, as they have to be run at a speed to suit the propeller efficiency, and I therefore put this forward as an electro-magnetic gear, if I may so call it, between the propeller and the turbine. The principle may also be applied with non-reversible gas engines and oil engines. For instance, we can get the slow vessel speeds and the reversing electrically, and then, by means of a magnetic clutch, clutch the engine direct through to the propeller ; in cases where engines do not run more than, say, 200 r.p.m., therefore, the greater part of the time we get the mechanical power transmission as well as being able to keep the engine at a constant speed. In existing vessels fitted with internal combustion engines, the matter of fuel consumption at low vessel speeds is an important one. The reversibility of internal combustion engines is practicable, and engines have been reversed with some satisfaction, especially the Diesel engines, and some gas engines made for that purpose, but for the slow vessel speeds often necessary, some difficulty is experienced with the high compression required in the explosion engine—although the Diesel engine is better in that respect, as it is a constant combustion type of engine —and to obviate that difficulty I advocate the adoption of some medium such as I have described, either by electrical power or by hydraulic power. Gears are very suitable for small powers; in motor boats of 50, 60 or 100 horse power, they are fairly satisfactory. But when thousands of horse power are in question it is a different matter altogether, and then comes in the necessity of adopting electrical driving for slow propeller speeds, using an electric motor for coupling direct to the propeller to suit the propeller efficiency. A good method of driving vessels electrically is what I call the all-electric "Paragon" method, thus allowing of an increase in the speed of the engine to a much higher pace than would be possible by coupling the engine direct to the propeller. For instance, in a twin-screw ship, where the engines are proposed for 200 revs. per minute, direct coupled, the lower speeds might be obtained electrically, but with the "all-electric" method it would be possible to keep the engines running at a higher speed, at, say, 400 r.p.m. and say 500 horse power. There would be no necessity for the long shaft tunnels; polyphase induction motors could be placed at the stern of the vessel as near as the build of the vessel will allow, and for this reason naval architects are inclined to be favourable to the "all-electric" method, because it enables them to dispose of the engines in more suitable positions. By this method also full power can be got for reversing, whereas only half power could be obtained on the electrical method, using electricity for reversing and slow speeds only. The engine speed would be higher, it would be a lighter engine, and there would be a better thermal and mechanical efficiency. The motor is not dependent on the engine speed, and instead of running at

200 r.p.m. it may be run at (say) 100 r.p.m. ; the consequence is a larger propeller could be used, and a propeller with a higher propulsive efficiency. Taking everything into consideration, it is the most satisfactory method, and although the direct drive method is fairly satisfactory, there are disadvantages which make it not quite so suitable.



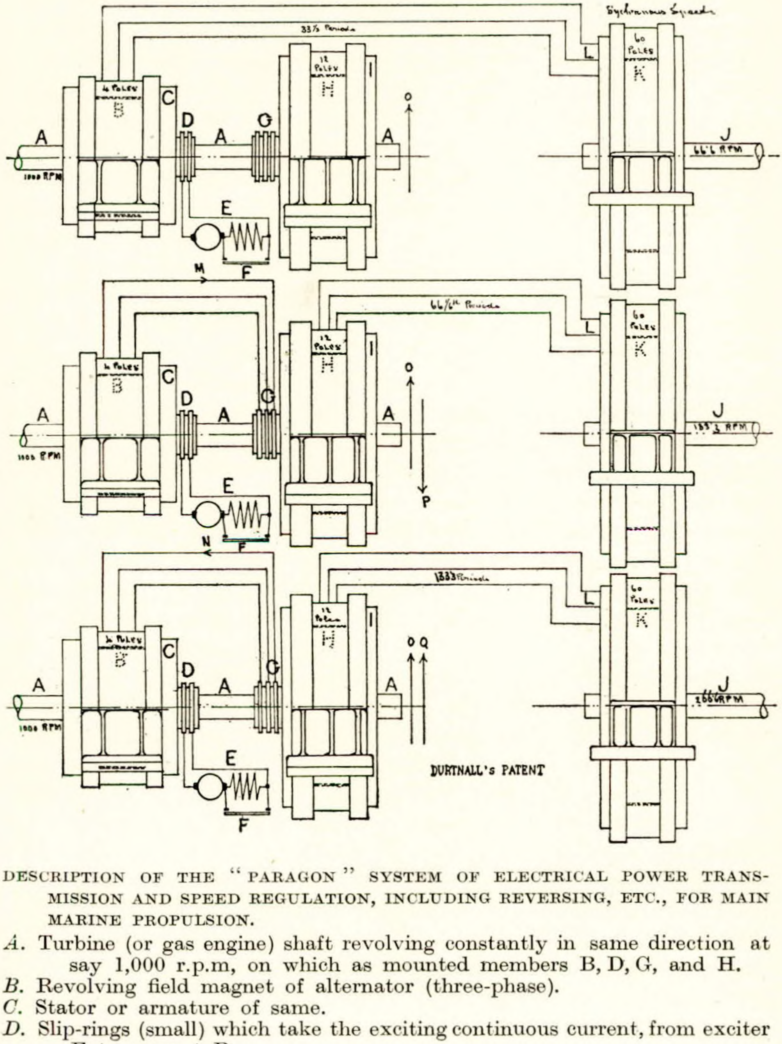
TYPICAL CURVES INDICATING THE APPROXIMATE MANNER IN WHICH THE "PULL" THE "HORSE-POWER" AND THE "FUEL" EFFICIENCIES OF AN ORDINARY PETROL ENGINE VARY AT DIFFERENT SPEEDS.

Speeds from 600 to 1,500 revs. per minute are represented in these graphs.

That represents a petrol engine of, say, 40 h.p., with which I have had some two years' experience, in connexion with the road vehicle, the petrol-electric motor omnibus. Now you are all aware that when the question of climbing a hill is under consideration, the point chiefly studied is how to get more power, but the subject of fuel consumption is not so much studied as it might be, the cost per passenger, or per ton per mile. "Commercially" is a serious consideration in the bottom sketch, which is the curve of fuel consumption and the curve of fuel per horse power. 1,000 r.p.m. is the critical speed of the engine, owing to the fact that it is at that speed, that has the lowest fuel consumption per horse power, that the engine will do ; therefore it is best to run it always at that speed, say, 1,000 r.p.m. in this case. Not ten days since, on Muswell Hill, with a gradient of about 1 in 7 or 1 in 8, that vehicle did surprisingly well ; in fact, we carried out some tactics there that had never been done with a motor bus before. I allowed it to go at full speed as if the brake had given way, and then put on the electrical reversing gear, which pulled it up instantly, but without concussion, similar to pulling out a strong piece of elastic, and caused it to back up the hill at the rate of about three miles per hour. The same thing in principle applies to marine work. When the engine is accelerated in speed above the critical one, by about 50 per cent., say 1,500 r.p.m., a fuel consumption is obtained equal to about 43 per cent. more fuel per horse power. If we decrease the speed, say 40 per cent., equal to 600 r.p.m., by retarding the sparking and adjusting, we then drop the speed by one-half, the fuel consumption goes up to 114 per cent. per horse power. Of course the power is less, but for every horse power developed at that speed the fuel consumption is 114 per cent. more. So that it is best to keep the internal combustion engine, especially if it be an explosive type, at a constant speed. I mention that because it applies to the use of gas engines and suction gas plant for marine work. The question was asked at the last discussion, in reference to my advocacy of the use of polyphase alternating-current squirrel-cage rotors—which, in my opinion, is the only way of dealing with big powers—as to how I intended to vary the speed, because with the constant periodicity the speed would be practically constant, and there would be no variation at all ; it would be like a pinion driving a spur wheel. But if we change the pinion driving that spur wheel so that there would be a smaller number of teeth, of course there would be a variable speed on the spur wheel. It is in that way I propose to get a variable speed on these motors, and I will now explain roughly the manner in which I propose to do that.

Working conditions.—Say alternator B is 4-pole, and transformer-generator H 12-pole. Assuming that contact F is on and bridging the field of exciter E, start prime-mover A through suitable switch-gear, couple armature C to motor stator L, then by lifting contact F voltage will gradually rise in the system,

THE "PARAGON" SYSTEM



DESCRIPTION OF THE "PARAGON" SYSTEM OF ELECTRICAL POWER TRANSMISSION AND SPEED REGULATION, INCLUDING REVERSING, ETC., FOR MAIN MARINE PROPULSION.

A. Turbine (or gas engine) shaft revolving constantly in same direction at say 1,000 r.p.m, on which as mounted members B, D, G, and H.

B. Revolving field magnet of alternator (three-phase).

C. Stator or armature of same.

D. Slip-rings (small) which take the exciting continuous current, from exciter E to magnet B.

E. Series wound exciter, for revolving magnet B.

F. Contact which can short-circuit the field of exciter E, therefore making a no-voltage condition throughout the whole system.

G. Slip-rings (small) that take the three-phase current from armature C to primary of transformer-generator H, for the two top speeds of rotor K.

H. Revolving primary of transformer-generator, in use on two top speeds.

I. Stator of transformer-generator, from which three-phase current is taken to motor stator L, on the two top speeds.
J. Propeller shaft that requires to be under variable speed, torque conditions, either ahead or astern.
K. Short-circuited squirrel-cage rotor of induction motor, which is coupled to propeller shaft J.
L. Single-winding stator of induction motor as above, say for 60 poles.
M. Direction of current (three-phase) between armature C and slip-rings G, as arranged for middle speed of rotor K.
N. Direction of above three-phase current at top speed of rotor K.
O. Direction of rotation of prime-mover A at all times.
P. Direction of revolving magnetic flux in revolving primary H when supplying current at the middle speed of rotor K.
Q. Direction of revolving magnetic flux in revolving primary H when stator, or secondary I, is supplying current to the motor stator L, when rotor K is running at top speed.

and the rotor K and propeller shaft J will rise to a synchronous speed of 66·6 r.p.m. (speed of A 1,000 r.p.m.).

Second speed.—Bridge over the contact F, and voltage will immediately fall to zero in the whole system, then change the connexions as follows : instead of going to the motor stator L, take the three-phase current from C to slip-rings G, and connect in such a way that current is in the direction marked M, at the same time connect the motor stator L, to the transformer secondary I ; now by lifting contact F the voltage and periodicity from I to L will rise, and the rotor K will increase to a synchronous speed of 133·3 r.p.m.

Top speed.—Bridge over the contact F, when a no-voltage condition will take place in the whole system, then just reverse two of the three phases at N, then by lifting contact F the voltage and periodicity will rise, and the rotor K will increase to a synchronous speed of 266·6 r.p.m.

Reversing at either of the above speeds.—Bridge over the contact F, and voltage will fall into a zero condition, then reverse two of the three phases at L, and the same speeds will be obtained, but in the opposite direction, prime-mover remaining in the same direction.

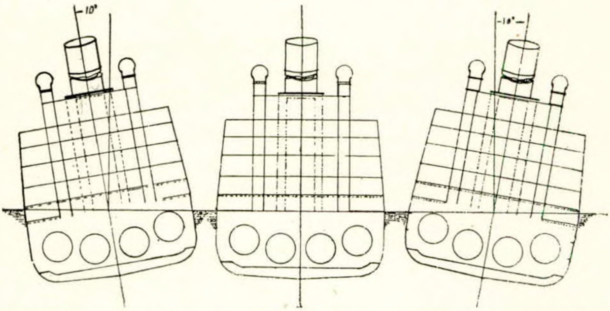
Particulars.—When in the first speed condition, the periodicity at L is as follows : Prime mover speed, 1,000, plus 4 generator poles, equal 4,000 alternations per minute, therefore 33·3 periods per second.

When on the second speed condition, the periodicity at L is as follows : Prime-mover speed, 1,000 r.p.m., plus 4 poles, equal 4,000 alternations per minute, then, prime-mover speed, 1,000 r.p.m., plus 12 transformer-generator poles, equals 12,000 alternations, minus 4,000 alternations, equals 8,000 alternations per minute, therefore 66·65 periods per second.

When in the top speed condition, the periodicity at L is as follows: Prime-mover speed, 1,000 r.p.m., plus 4 poles, equal 4,000 alternations per minute, then, prime-mover speed, 1,000 r.p.m., plus 12 poles, equals 12,000 alternations, plus 4,000 alternations equals 16,000 alternations per minute, therefore 133·3 periods per second.

It will be observed that if the armature C is mounted on bearings, and a brake attached to same, that by letting the brake slip the armature will endeavour to follow the magnet B, and should the brake be free the armature C will equal the speed of B and the periodicity of the whole system will then be zero, and consequently the rotor K speed. It will thus be seen that a speed may be obtained on rotor K from zero to 66·6, the turbine running at constant speed, or bring it up to 133·3 by the main revolving field, or bring it up to 266·6, as may be desired, by varying this small brake. That is the method by which I propose to vary the periodicity of the whole system by means of these connexions, and "floating fields," as I term them, in the generator. This is the right place to do it, because by close investigation it has been found that in dealing with big powers, the disposal of the heat given off by these large motors is a thing the dimensions of which few people are aware of. For instance, there would be considerable trouble to get the heat away from a motor fitted with slip-rings, and in fact even on motors for 4,000 total horse power with windings in tandem, suggested in the paper, one behind the other, although it acts very well on the small powers, I find on investigation that it is not so satisfactory when applied to big powers. Therefore, by using a motor with a single winding on the stator and a squirrel-cage rotor, you get the best machine you possibly can have for efficiency, you have a highly efficient motor, small amount of heat to dispose of, a motor which has a minimum of diameter, so that it may easily be placed in the stern of the vessel, a motor small in cost, which is not an inconsiderable matter in applying the scheme to ship propulsion, and it means a motor that has a maximum of strength and utility, as regards electric motors of any description. I refer to the polyphase induction motor with squirrel-cage rotor. That is the object of developing the "Paragon," system in this manner, and I think I have made it clear how it is possible to get a variable speed with the squirrel-cage motor. In the paper you will observe there is a diagram of a ship rolling. When the paper was read, there was not time to point out every detail, but it was one of the most interesting things in the paper, and one which will appeal to you, I am sure, as practical men.

Take a vessel on even keel, we will say with reciprocating engines, and the same thing applies to all mechanically driven vessels. The case I am about to describe is from actual results of a run from Southampton to Jersey last Easter, when the experiments were carried out. In rolling severely, there is a roll of about 10°, one propeller is deeply immersed, while the other is almost out of the water. What takes place is this.



A Vessel heeled over 10 degrees, and also the unequal immersion of Propellers and consequent extra resistance to Propeller Rotation. Speed can be synchronized, thus saving Power, with improved Propulsion.

One rises in speed to about 130 r.p.m., while the other one slows down to about 78 r.p.m. That is the result of the decreased resistance in the one case, and increased resistance in the other. Now they are both wasting steam while the vessel is rolling. Assuming these propellers are designed for 100 r.p.m., of course the efficiency is much less in the case of this lightly immersed propeller ; because of cavitation effect, it is being run at a higher speed than normal, and if there is a lighter immersion the engine consequently races and wastes steam. The other propeller slows in speed, and possibly takes a full steam, instead of an expansive stroke at a lower speed ; the blade pitch being the same, there was not much effect owing to the constant steam pressure. If the steam pressure could be momentarily increased, it would still keep to 100 turns a minute. We will assume the propellers to be driven by electric motors. Say our turbine and our alternator are running at a constant speed, independent of the speed of motors or propeller shafts ; because of this fact, the propellers do not race, because of the fact that if a motor, a squirrel-cage motor, endeavours to get above synchronism, that is to say, at the speed that represents the whole speed of the generator, it becomes an asynchronous generator, so that when the generator is running at 1,000 a minute, these motors cannot exceed the 266·6 turns a minute. Owing to the less resistance, the power is less, and it therefore draws less current from the generator. Now the other one cannot slow down, except to the extent of about $1\frac{1}{2}$ per cent. to 2 per cent. It may also have an overload momentarily, anything up to 100 per cent., which a squirrel-cage motor will easily stand. So you will observe that as one keeps its speed at the deeper immersion, the propulsive efficiency is therefore higher, the lightly immersed one does not take so much current from the generator, and so there is a kind of differential couple between these motors. The load on the generator remains constant, and there is a current on these couples to and from as the ship rolls. The consequence is that the propulsion in heavy weather will be found to be increased. The amount I am not in a position to say, but that will be appreciated when the thing comes to be further investigated. I think, gentlemen, I will not detain you any longer. I thank you for following my remarks so closely, and will be pleased to answer any questions.

Chairman : I am sure we are all deeply indebted to Mr, Durtnall for the information he has given in such detail. My own opinion of things of this kind is that they very often look better on the blackboard than in actual work ; as described it seems to be simplicity itself, but whether it will work well in practice is another question. Mr. Durtnall, however, has not put before us any castles in the air : he has brought actual facts, particulars of what has taken place ; most of his figures are from actual tests. When I read the paper first I thought the whole scheme was an impossible suggestion, but on going through it again I found they were hard facts that were put forward, and the results of practical experiments, and I have come to the conclusion that there is a good deal in it ; it is a thing we shall have to face in the near future. There is no doubt it will give shipowners something to think about: they have to face the bill for these new ideas. The paper was read on July 18—that is a good while ago, and I am sure some of you will have something to say on the matter. Marine engineers as a rule do not get the opportunity of studying electricity applied on such a scale as this, and I am sure Mr. Durtnall will be pleased to answer any questions.

Mr. H. H. B. Deane (Visitor): This subject has interested me very much indeed as an electrical engineer. The diagram Mr. Durtnall has given you is, from an electrical engineer's point of view, very interesting, and I can safely say that it is the first time such a proposal as that given in the diagram has come before any public institution; I do not know of anything of the same nature having been done previously, so that marine engineers can congratulate themselves on having elicited something new from the electrical aspect. I am quite convinced that the proposal is perfectly practicable, and that it is theoretically quite right. I am not quite in line with Mr. Durtnall on the point that he is going to increase the efficiency of his motor very much, but certainly he gets a very good speed regulator with the polyphase system, the difficulty with which has always been the bugbear of polyphase current. I think the reason is that electrical engineers are most familiar with the central station work. All our work has been in the way of distributing power at one steady potential and periodicity, and for a steady purpose; therefore it has not brought us to the necessity of requiring quite so much variation. I may say that I have felt the lack of variation in polyphase work owing to having had considerable experience in mining work where we certainly should have adopted the polyphase system if we could have adapted it to that work. This also gives us the opportunity of having the polyphase current for rolling mill work, on which, up till now, continuous current only has been used for the sake of reversing. There have been alternating current motors, but all on the uni-directional system with particularly heavy flywheels. This system, therefore, will give us, as electrical engineers, food for thought in other directions than marine work. With regard to the question of turbine propulsion, which seems to be a point causing some controversy among marine engineers at the present time, there seems to be a general consensus of opinion on one aspect of the subject as far as I can see by reading and coming in contact with various marine engineers and naval architects. While waiting in your reading room for this meeting to begin, I came across a very interesting article on *Warship Engineering* by Mr. C. de Grave Sells, which is, I believe an extract from the 1908 edition of "Fighting Ships." A statement is there quoted from the words of one of our leading naval architects, Dr. Elgar, who stated in his paper read before the Institution of Civil Engineers in June last, that the problem is to secure a combination of the turbine and propeller such as will give an efficient speed of the turbine without unduly reducing the diameter of the propeller. I feel inclined to add, although an outsider, "and also to keep the speed of the propeller at its economical limit." That is a condition which it may be presumptuous for me to make, but it seems to me that one notices in reading of the tests of racing ships that have been turbine driven, that the propulsive efficiency certainly falls as the propeller speed rises. Now, unless the propeller expert can give us a propeller that is going to increase in speed to keep pace with the increased speed the turbine has to run at for economical work, I really do not see anything else for it but to adopt some such system as is proposed by Mr. Durtnall. As an electrical engineer I must say I think the electrical solution of the problem is the right one, and I am quite convinced that, of electrical systems, the polyphase system is the only one that should be applied, for several reasons. The outstanding advantages of the polyphase machine is that it can be much more "hammered," that is, it can be subject to very much more severe strains and stresses than continuous current machines, because the trouble of commutation is got over. I think that is probably the point that has driven Mr. Durtnall into using the short-circuited rotor, as it does away with the difficulty of commutating the current by rubbing surfaces, and that is very serious trouble with all electrical work. We get more trouble with commutators than with any other part. Another advantage of the short-circuited rotor is that the potential can be kept down to a very, very low figure. That is extremely useful, because, naturally, to have a rotating machine with a high pressure is to court trouble. The higher you go the more insulation is required. There is a certain amount of vibration, one cannot call it shaking, but slight differences of speed, which causes stresses on the insulation owing to the centrifugal action, and the tendency to throw out against the edge of the machine, which tends to deteriorate the engine to some extent. The polyphase system with the short-circuited rotor does away with the necessity of insulating the rotor ; in fact, the Westinghouse Company practically drive a copper bar into the iron of the rotor and short-circuit it by rings.

Mr. DURTNALL : We are doing that in this case ; there is no insulation whatever.

Mr. DEANE : That is so, you can do without it. I cannot see how the continuous current is going to be a success. We have it in rolling mills, but in that case it is necessary to brake the motor by using it as a dynamo. That is what is done with colliery winding gear ; we reverse the direction of the current in the motor and turn it into a dynamo, using current from that to accelerate the prime mover which is supplying the power. I think that was brought out by Dr. Ilgner and it is probably the biggest advance made in bringing electricity into use for mining work. I think Mr. Durtnall is to be congratulated in having introduced this alternating current system for main propulsion.

Mr. T. R. STUART (Assoc. Mem.) : I think it is quite possible to drive a ship by electrical transmission, and I think it would be a most economical way, because with the turbine with high superheat, high revolutions and a high vacuum are necessary conditions ; but one cannot put a high tension dynamo into an engine-room. There are a good many water pipes about and I do not think you would get through the trial without a joint giving way, which would be disastrous for the dynamo. I admit it would be possible to have insulated compartments, but that would mean more engineers to look after them. At the present time in many ships it is possible to put one white man in charge, but I do not think one white man only would be required for this installation.

Mr. DURTNALL : I might say the voltage of a 1,000 horse power vessel would be 200 volts. It is very low.

Mr. STUART : Another point is this : if you have a heavy turbine running at a very high speed, under the conditions proposed a serious difficulty would be raised by reason of the gyroscopic action which would be set up, and a good many broken shafts would be the result.

Mr. DURTNALL : That depends upon the shaft entirely.

Mr. STUART : I do not know whether I quite understood the blackboard drawing, but for reversing I believe you introduced slip rings on the shaft to connect the current to the transformer. Would there not be the objection of rubbing surfaces which was emphasized by the last speaker ?

Mr. DURTNALL : It is only a matter of 200 kilo-watts out of a total of 5,000 kilo-watts.

Mr. STUART : Yes, but the rubbing surfaces are there, and I do not think it would be a reliable system with them. It would not be possible to run three weeks without having to attend to those rings.

Mr. DURTNALL : It is quite possible, many do run for months.

Mr. STUART : Then with regard to the question of the dynamo revolving ; I think you said you release by a brake. I do not see how you are going to get the connexion between the fields. Would you require to have revolving connexions also ?

Mr. DURTNALL : Yes, there would be another set of slip rings in that case.

Mr. STUART : That seems to me to be a point of considerable difficulty, and probably the crux of the whole thing. I do not think you will get the revolving connexions into action very satisfactorily ; I think you will have great difficulty in getting them.

Mr. F. M. TIMPSON (Member) : The last speaker referred to rubbing surfaces. Is the shaft shown on the diagram a direct shaft right through with the pieces rubbing together ?

Mr. DURTNALL : Yes.

Mr. TIMPSON : I suppose you will have to keep the armature stationary.

Mr. DURTNALL : It will be mounted on bearings, in normal conditions with the brake on.

Mr. Timpson : Will it not require to be finely adjusted ?

Mr. Durtnall : The rubbing surfaces only involve a matter of 200 kilo-watts and 500 ampères altogether, in a 1,000 H.P. vessel.

Mr. Timpson : But are those fixed points on the shaft ?

Mr. Durtnall : No, the slip rings carry the contact from the revolving part. If I had slip rings on the motors I should require to have them capable of carrying thousands of kilo-watts instead of 200.

Mr. Timpson : Of course there is no doubt that turbines at the present time are not applicable to low speed vessels, and some means of gearing will have to come between so as to get the conditions claimed to have been obtained in central stations. There is a good deal in what has been put forward in this scheme. It needs to be carefully thought over before one puts money into it, but I hope it will go further and that we will hear more of it in the practical stage.

Mr. C. M. B. Dyer (Member) : With regard to motor-buses and cars, Mr. Durtnall held out hope that we might some day do away with the troublesome gear boxes, etc., and if so what would be the saving effected ? We lose 50 per cent. efficiency in transmitting to the wheels, sometimes more, never less. What would be the saving if this were applied to an ordinary motor of say 30 to 40 horse power ?

Chairman : I think this is a paper that should be criticised very severely, and I think Mr. Durtnall really delights in criticism. Things that look very well on paper often work out very differently when put on board ship. We know the trouble there is in keeping up even the most efficient steam engine—we have heard nothing about the breakdowns likely to result in this system. One question I would like to ask is, what is, approximately, the largest power for which this system could be applied to a ship with four propellers. I must say I admire Mr. Durtnall's courage in advocating alternating current, because it is shunned even ashore. I think there is a good deal in the adoption of alternating current, and I have long thought of alternators as a means of driving auxiliaries, but Mr. Durtnall goes much further in advocating it as the prime mover on board ship.

I do not know whether he has been to sea or not, but it is well known to all of us that under the best conditions, with the best engines, there are big drawbacks unknown on shore, and it is hard work to keep even the finest engine in repair.

Mr. J. Howie (Member) : We have some idea of the overload put on machines ashore, but this polyphase system might be a new system altogether if it is overloaded on board ship, and the whole thing might be destroyed. Is not that a possibility ?

Mr. Durtnall : There is no possibility; the absence of commutators and brush gear is sufficient to ensure that.

Mr. Stuart : The other day on a certain ship a pipe burst sending a 3 in. jet of water across the engine room. If that occurred with an electrical installation, the ship would be stopped until it was towed into port.

Mr. Durtnall : I do not think so. There would be no damage in a case like that. Of course necessary and reasonable precautions would have to be taken.

Mr. Stuart : If it were covered with water, it would mean the absolute break-up of the whole system.

Mr. Durtnall : When I give my reply I will probably show a motor working under water ; however it can be done with polyphase induction motors.

Mr. Timpson : There are numbers of motors working on board ship : could Mr. Durtnall give us some idea of the percentage of breakdowns, comparatively, between motors and steam engines. Motors are yet only used for small powers to what is proposed here, but it would lead up to the same point. I think the motor would have to be thoroughly closed in, because in all electrical installations there is considerable trouble from time to time. I have seen a great many electric lamps out after being in bad weather for a few days, and in a main engine the results would be much more serious. But no doubt precautions would be taken to cover that possibility.

Chairman : I think this proposed system is entirely different to the system used at the present moment. This system does away with rubbing surfaces. The greatest trouble is caused with brush gear and commutators, and this system does away with them. The squirrel-cage motors will run for years with scarcely any attention.

Mr. DEANE: I have under my observation a motor which was used for driving a pump for pumping out an old flooded mine. We had several motors and were supposed to get assistance from the steam pumps up above us, but unfortunately the steam pumps failed on four occasions and let the whole volume of water down on us. These pumps in three cases had been under water, and in fact actually stopped through the current being cut off by the water, causing the fuses to be pulled out at the station. We hauled the motors up that same night and managed to get them out of the water, and in a very short time they were at work again. One of those machines, about four months before, had exactly the experience Mr. Stuart mentioned, of a water pipe bursting and flooding the motor. That machine was on a stand at an Exhibition at the Agricultural Hall, and while it was being brought away, a cart that was passing knocked off the top of a water hydrant and the machine got the benefit of the full pressure supply. Nothing was done to that machine to my knowledge, and I had the handling of the job right through. Of course we did not leave the water on very long, but that machine was almost immediately afterwards set to work driving centrifugal pumps and did the work perfectly well. Marine engineers are quite right: there is a tremendous lot of trouble on board ship with electric light, and for this there are many reasons. Firstly, I think that electricians have been too much electricians and not enough engineers, and they have brought a lot of trouble upon themselves by putting in materials of a finical kind. These small electric lighting installations have been put in without consideration being taken of the circumstances under which they had to work. Wires were placed in position without any previous experience of the action of salt on the insulation, and in many cases I have seen them on ships in wood casing. That is sure to result in moisture being absorbed, and I think it is certainly a source of trouble. I thought the concentric wiring system of Mr. Mavor of Glasgow had killed that practice, but it is still done. The Admiralty, I understand, are using vulcanized bitumen for their insulation, and are putting in heavy vulcanized armouring for their wires. That is exactly the practice in mining work where there is moisture worse than heavy flooding. I know of cables which have been under water eighteen months or more and have not been deteriorated. The wires have been laid at the bottom of the drift where there is a constant flow of water. It is bad practice, of course, but the roof was in such a bad state and was coming down so often that the bottom of the drift was probably the best place for the cables. On the other hand, in one case there was a certain amount of acid in the water, a thing we very often encounter in mining work, and in that case the cable had gone wrong in a very short time. I have seen bitumen cables go down to one volt in the junction box, never from bad insulating qualities as far as the substance itself was concerned, but generally due to faulty handling or faulty fixing in the junction boxes. From the standpoint of insulation generally, it does sound rather impracticable to put a heavy machine like this on a ship, but I think with the polyphase system one reduces that liability to breakdown to the minimum, practically to the irreducible minimum. The moisture or water is the thing which is probably its greatest enemy, but I think that will be got over quite well. It will need a certain amount of experience, but I have heard of even reciprocating engines breaking down, and the marine turbine also. I can only say, from my experience in steel works and mines, I would never think of putting in continuous current machines for that class of work if possible to avoid it ; if given a free hand I would put in a short-circuited rotor, polyphase alternating current induction motor. In one job I am interested in there are fourteen pumps for underground working and each one is a short-circuited rotor machine, and there are numbers of machines of that type running now. Certainly they are not started against a heavy load, but the overload goes up to 70, 80, or 100 per cent.; in fact, a guarantee is given for 70 per cent. overload. I do not think immersion would cause such a heavy overload as that. I am very pleased to assist with the little experience I have had.

Mr. J. S. Gander (Assoc. Mem.) : I should like to ask what would be the effect of this current on the ship's compass. It is a very important thing, and one on which the suitability of the system will stand or fall. I presume, however, the compass will only be affected by direct current. I should also like to ask if the author prefers the oil engine to turbines, and if so which make would be the most economical.

Mr. Durtnall: That depends on the power of the ship. The alternating current would have no effect on the compass.

Mr. Gander: I was referring to turbines for high powers. Another question that occurred to me was how would this system stand with regard to the Board of Trade regulations as to voltage?

Mr. Durtnall: The voltage can be made to suit circumstances; for instance, in a scheme which I have in hand, for one ship of 1,000 horse power, the voltage is 260.

Mr. Gander: Is that allowed?

Mr. Durtnall: Yes, for main marine propulsion, not for lighting.

Mr. Gander: The Board of Trade has a limit.

Mr. Durtnall: It is constantly being raised: it is now at 210 volts, it used to be 80, and it was raised to 100, then to 210.

Mr. Gander; I think that in ships with the single wire system armouring should be avoided altogether. In a ship I was in we had a new cable without armouring, and it lasted much longer than the others. They were mechanically as strong and the absence of armouring did away with a good deal of the short-circuiting.

Chairman: I cannot see what objection there can be to high voltages on board ship if the machine is properly installed, even up to 2,000 volts provided it is properly coupled, properly insulated and properly protected. If a system of this kind proves successful the Board of Trade would bring their regulations up to it; I do not consider the Board of Trade rules will stand in the way of progress. I think the time will come when we will need to recognize the use of alternating current on board ship. In shore work there are not so many accidents, there are more cases with continuous current, yet even in those cases the simple reason is that they are not taken care of. Take the case of a ship with continuous current, you see flexible wire here and there, perhaps a bunch of wires hanging with the woodwork torn away. That kind of thing must not be allowed with alternating current, everything must be watertight and properly protected. As far as motors are concerned I have seen motors working while buried in snow for three days, and I have had experience of working motors under the worst possible conditions, working in vapour, steam, and if it survived that it will soon get over the effect of having a stream of water over it. We must not think only of the continuous-current installations all exposed as we see them at present on board ship, we must remember that a system of this high voltage would need to be installed on board ship under very different conditions. As far as the Board of Trade is concerned, if it is found necessary to apply 2,000 volts they will make their regulation to suit the new conditions.

Mr. J. H. REDMAN (Member) : I think it would be interesting if Mr. Durtnall would make it clear whether he intends to feed into a bus bar from one or more generators and then distribute the current to twin and triple screws as would be required in order to allow twin screws to balance one another when rolling, or to fit each propeller with its own generator in order that reversing and speed regulation of the screws may be accomplished independently. It appears to me from the sketch on the blackboard that the polarity of the exciter must be reversed in order to reverse the propeller. This appears so complicated that the electrical connexions and even changing the phases of 200 kilo-watts at 260 volts as mentioned by Mr. Durtnall would be liable to give trouble.

Mr. A. ROBERTSON (Member) : I think it would be advisable if Mr. Durtnall included in his paper a full description of the type of motor he is proposing to fit. I think he might go into a little more detail, as the members of the Institute may not be so conversant with the subject as electrical engineers. Another point occurred to me in connexion with the men who are to be in charge of the engine-room. Will there be two separate classes of men in control, electricians for the electrical part and men accustomed to steam turbines for that part, or do you expect the marine engineer of the future to combine an expert marine education with an expert electrical education ?

Mr. DURTNALL : As you will no doubt have seen the invitation card, the evening set apart for my reply is March 15, when I intend to answer every single piece of criticism in connexion with this paper, or any written question which any member wishes to communicate to the Secretary from now till within a fortnight of that date. I welcome all criticism, and I will have pleasure in illustrating the whole thing, giving the fullest particulars. Mr. Stuart was good enough to mention the effect of water upon the machine. I have had it pointed out several times, it is often cropping up among people interested in this matter as to how these motors stand immersion. That is one of the things which led me forward to adopt this method, the Paragon electrical power transmission system, which in ordinary language means superior to anything else. There is a minimum amount of insulation. On the latest motor 'buses where this rotor is used, the rotor itself is simply a plain copper bar $\frac{3}{8}$ in. square, driven right through the slots and at the end simply short-circuited with a ring around. The rotor of the alternating current motor, although of simple mechanical construction, is one of the most ideal. The only remaining part is the stator, of which the insulation wants some protection. The distance the power has to be transmitted is simply from the engine-room to the stern of the ship, practically a few feet, and the voltage is decided on in each condition to suit the transmission efficiency. I can give you an instance of a cargo boat of 1,000 horse-power ; the working voltage in that case is 260 volts ; in a bigger boat it may go up to 500, it depends on the amount of power to be transmitted and the distance through which it is to be transmitted. I will make a much more detailed reply later, and my reply, as I conceive it, will be a full supplement to the paper itself. The paper was written for criticism, and I am here to answer any question that may be put. I can tell you in the meantime, that this Institute is looked upon at the present time from the owners' point of view in a very interesting manner. I can tell you there are many owners waiting the results of the publication of this discussion to-night. I should have liked to have seen one or two others support the scheme. I have done my best, I have made it public, and asked for criticism. If there were time I should have been pleased to read extracts from the journals of foreign countries repeating the words spoken at this Institute, and when foreigners discuss things in a friendly light, as the majority of them do, you may take it for granted there is something in it. I make a big statement when I claim 40 per cent. saving in steam against any turbine ship afloat working with direct-coupled turbines, as compared with high speed turbines and slow speed motor, and notwithstanding the losses electrically, there is a nett saving in steam, consequently there is less fuel required, less boilers, less steam-pipes, less exhaust pipes, condensing plant, air pumps, circulating water, less water for the boilers and a reduction in many other things. I think I can make that quite clear when I make my reply, and I will ask you to be good enough to make any written communications by March 1, so that it may be embodied in the proceedings with my reply. All I ask of you is to support the scheme if, in your opinion, it is correct; if not, then condemn it. I think I cannot do anything fairer. It is a British idea, covered by British patents, and I will make bold to say it will be backed up with British pluck. I thank you very much for the very interesting and kindly way in which you have received and discussed this paper.

CHAIRMAN: We have listened to Mr. Durtnall with much interest, and I can only say he is a true sportsman. He has thrown out a challenge, and on March 15 he will give us a reply to all the questions raised.

The HON. SECRETARY: I would like to propose that we accord to Mr. Durtnall a very hearty vote of thanks for coming here to-night, and I should like to include in that vote our appreciation of the clear enunciation made by Mr. Deane in support of Mr. Durtnall's view. I think he has made several things a little more clear than they were before he spoke. With regard to the remarks made as to breakdowns at electric light stations I do not know that we have often been put in darkness or that we have been stopped in going to and from business by the cars owing to the current being cut off. There have been such experiences, but I do not think they have been very frequent. Speaking of pumps working under water, we saw a steam pump at the Municipal Technical Institution which had worked under water very effectively to clear away the flooded basement around it, so that experience is not altogether confined to the class of motor referred to. I should also like Mr. Durtnall to give us one or two ideas as to the system advocated by Mr. Mavor before the Institution of Engineers and Shipbuilders in Scotland. I think it would add to the enlightenment of our members if Mr. Durtnall would give a brief criticism of that paper and the remarks made upon it. Also of the vessels propelled by electrical transmission which have been placed on the Continent, I believe, for ferry service.

Mr. W. E. Farenden seconded the resolution, which was carried with acclamation.

A vote of thanks was also accorded to the Chairman on the proposal of Mr. Gander, and the proceedings were brought to a close.

Mr. H. A. Mavor (Glasgow) writes as follows :—

The case for electric propulsion as stated by Mr. Durtnall is fairly substantiated. He passes somewhat lightly over the difficulty which has hitherto operated against the application of what he rightly says is the only known method with immediate promise of success.

The difficulty is to get a three-phase alternating current induction motor which shall run at three or more speeds and be reasonably efficient and practical at any of the three speeds.

The method of providing the motors with windings for 12, 24, and 48 poles which he proposes on page 38 has been put forward from time to time as a solution of the problem, but when the designer attempts to apply this apparently simple proposition to the design of an actual machine, the impracticability of it becomes evident.

The case chosen by Mr. Durtnall is not by any means an extreme one, but even in such a case the resulting design is not one which commends itself.

The top speed proposed, 250 revolutions, is far above the speed which would give good results on the propeller, which at this speed would not be much better than if it were coupled to the marine turbine direct.

The *King Edward* has about the horse power in question, and her propeller shafts coupled direct to the turbines run at only 500 revolutions per minute.

The normal revolutions for high propeller efficiency for this power, if the speed of revolution be fixed so as to give the best results on the propeller without reference to the engine, would probably be of the order of 100 revolutions per minute. Mr. Durtnall does not state the speed assumed for the vessel in question. If the speed were low the revolutions asked for might be as low as 70 revolutions per minute for full speed. It will be seen that the difficulty of winding a three-speed motor for a maximum of 250 revolutions becomes much greater for the slower maximum speeds.

It will be seen also that for slower speed vessels there is on an electrically driven ship as on a direct driven a call for slower speed on the turbo generator, otherwise the number of motor-poles and consequently the diameter of the motor becomes excessive.

On high speed vessels a high speed propeller is possible, and the direct steam turbine is a more efficient appliance because of the possibility of using high rate of revolution.

The results of trial trips of marine steam turbines do not bear out Mr. Durtnall's estimates of economy. The claim is made by the shipbuilders that at full speed the steam consumption per torque-horse-power actually delivered to the propeller shaft has been reduced to 15 lbs. without superheat. It will be seen that this figure somewhat alters Mr. Durtnall's figures and emphasizes the fact that we have here to deal with a problem which has already received the most highly skilled attention, and any improvement will be attained not easily but at the expense of very careful and prolonged attack on the problem.

A comparison with reciprocating engines shows results more conspicuously favourable to electric propulsion, and the speed change problem is soluble on lines fully described in a paper by the present writer in the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland, February 18, 1908.

It is there shown that such a claim of economy as is made by Mr. Durtnall is in certain cases by no means an exaggeration, but it is not safe to make the statement so general as he has made it.

Mr. Durtnall's proposal to parallel the generators is open to some objection, especially if the control is to be effected as suggested on page 30, under no voltage conditions.

With the compound spinner motor described in the *Transactions* above referred to, all necessary combinations can be made without paralleling the generators, which is a delicate operation at all times, and in a seaway when the ship is turning on her heel is not to be contemplated with perfect equanimity by the people who actually have to do it. By the use of the spinner motors it is possible to keep the generators entirely independent electrically, and put them in and out of circuit at any speed of revolution whether synchronous with the other sets or not. It is well known that the propellers on a ship where there are more than one rarely run at the same speed. This indicates that at full speed of the ship there would be very unequal loading of the motors were they compelled as they would be in a paralleled system to run at or near the same speed.

These are matters which are perhaps outside of the scope of Mr. Durtnall's paper in the form in which it is presented, professing as it does to sketch the outlines of the question, but as the paper has been put before the Institute of Marine Engineers it may interest them to know that this subject has been for some time and is now occupying the attention of the leading builders of steam vessels all over the Kingdom, that the problems are being dealt with on the most rigid practical lines and that the prospects of electric propulsion are very hopeful indeed.

Mr. T. R. Stuart writes as follows :—

Since the discussion on January 11, through the courtesy of Mr. Deane, I have been afforded permission to visit the works of the General Electric Co., Witton, where I saw several large induction dynamos and motors in various stages of construction. I should like this opportunity of expressing a modification of my opinion of the effect of occasional splashes of water, etc., on these machines. The rotor would be absolutely unaffected, and the perfect insulation of the windings of stator would enable them to stand considerable wetness without deterioration; and I can quite believe Mr. Durtnall when he says that such motors have worked in water. The slip rings, however, would *not* stand such treatment. The space between the live part and the shaft is very small, and if anything should start an arc it would probably continue until there was considerable damage done. Owing to the high voltage it would not be possible to clean these parts when under weigh to prevent oil creeping on to them and so causing trouble. In short I think it absolutely essential that the electrical part of the plant should be isolated in a clean room free from water pipes, etc., or that all naked parts be enclosed in water-tight boxes. If this is done I do not see any other serious objection to the system; on the other hand there is the great advantage of reduced coal consumption. For this reason I should be very glad to see an electrical transmission system installed in an ordinary passenger ship to obtain data of working results.

REPLY TO DISCUSSION ON ELECTRICAL TRANSMISSION OF POWER FOR MARINE PROPULSION

By Mr. W. P. Durtnall (Member)

at the London Institution

on Monday, March 15, 1909.

Chairman: Mr. J. McLAREN (Member of Council).

Chairman: We are met here to-night to hear Mr. Durtnall reply to the discussion on his paper on "The Electrical Transmission of Power for Marine Propulsion." The paper was read some time ago. There have been two discussions on it since, and I understand Mr. Durtnall has come prepared with some further information on the subject.

Mr. Durtnall: Mr. Mavor, of Glasgow, who has paid considerable attention to this problem, has contributed by correspondence some very interesting remarks, and during the evening some slides will be put on the screen, showing Mr. Mavor's system and illustrating his paper as read at the Institution of Engineers and Shipbuilders in Scotland. Mr. Stuart since our last meeting has visited some large works and has come to a different opinion as to the liability of the polyphase induction motors to be damaged by water. If electrical power transmission is possible, it is most decidedly so with the polyphase induction motors and squirrel-cage rotors, which is the lightest and most efficient method of power transmission. As there are several gentlemen here to-night who were not present when the paper was read I will take the opportunity of explaining further some of my previous remarks.

"The Paragon Electrical Power Transmission System for main marine propulsion and speed regulation, for steam turbine, oil, or suction gas engine driven ships" (Durtnall's Patent).

The above system has been designed for the purpose of providing a means that in driving ships by steam turbines the turbine may be run at a high speed (say), 1,000 r.p.m., and that for the propellers a speed, say 120 r.p.m., most suitable in order to attain the most satisfactory propulsive efficiency for the amount of horse power delivered to the shafts, thus in many cases making a very considerable saving in coal required for a given passenger or freight ton per mile.

It is well within the range of possibility to make a saving as compared with existing steam turbine-driven ships, of no less than from 35 to 40 per cent., and as compared with existing reciprocating-engined ships, of quite 20 to 30 per cent., which, taking the present state of the shipping industry into consideration, is no mean attainment. The above figures can be substantiated by guarantees from some of the very largest manufacturers in this and other countries, who are prepared to manufacture the above system in very large sizes, and the steam consumption per shaft horse-power at given propeller speeds will come under same, together with the workmanship and material, making for absolute reliability and safe working at sea.

The whole of the plant is "alive," whether the vessel is going full speed astern or ahead, as the electric motors used, coupled direct to the propellers, run with equally high efficiency in either direction, the steam turbines always running in the (say) ahead direction; therefore it becomes not necessary to carry, or to go to the expense of reversing turbines, together with all the reversing valve gear, steam-pipe connexions, etc., and the cost of running the reverse turbine rotor while the vessel is going in the ahead direction, or to run the ahead turbine rotors while the vessel is going astern.

The turbines running at (say) 1,000 r.p.m., instead of (say) 200 r.p.m., they are consequently smaller in diameter, for the power developed, and the radiation and tip clearance losses are very low comparatively, with the existing slow-running turbines as used on some of the largest liners, battleships, and cross-Channel steamships, etc.

Further, the direct-coupled steam turbine is not suitable for the practical application to the great majority of steam vessels (by reason of its high speed or its inefficiency at low propeller speeds that are absolutely necessary for cargo boats, etc.). The application of the Paragon system brings the economical high-speed steam turbine into order for the driving of cargo steamers, tramps and the like, with great economies in coal, boiler-power, steam pipes, condenser plant, coal bunkers, and valuable space in the most important part of the ship. Owing to the great economy in steam per shaft horse power developed, the saving in the stoke-hold equipment, including boilers, and the dead water in the boilers, smaller turbines, etc., together with the above items worked out in weight, more than compensates for the weight of the alternators, motors, etc., and the effect on draught is very noticeable, and for the same horse-power developed at the propellers the vessel speed is higher, or more passengers or tons of freight may be carried for the same draught and power and vessel speed, or less power is required for driving ships, of a given passenger or cargo tonnage, than is required with a given vessel speed (owing to the lighter draught, etc.) with the ordinary direct coupled turbines or reciprocating-engined vessels, if this system is adopted for propulsion purposes.

A few of the reasons as to why the direct coupled steam turbine is not considered satisfactory for ship propulsion are as follows :—

Tip clearance, in steam turbines.—To allow of rotor and blade expansion under heat, a certain working clearance has to be allowed between the tips of the rotor blades and the inside surface of the casing, also between the tips of the casing blades and the outer surface of the rotor drum. This, of course, works out as a certain per cent. of loss by leakage over blade tips, no useful work being done by the steam in passing through. It is calculated that if the loss is 3 per cent. when the revolutions are 600 r.p.m., then the loss at 200 r.p.m., will be 27 per cent., as the percentage loss varies as the square of the revolutions, or, which is the same thing, as the square of the rotor diameter.

So that, allowing for the increased expansion due to larger drums, the loss increases by the square of the diameter, or in other words by the area open to leakage.

Steam turbine efficiency.—The theoretical best efficiency of the steam turbine is attained when the linear velocity of the rotating blades is equal to one-half the velocity of the steam impinging upon those blades, and as this figure is very high, there remain but two alternatives to obtain the results which the best efficiency would require.

The first of these two is to arrange the revolution speed so high as to enable the vanes to receive the steam under the conditions stated above.

The other alternative is to reduce the speed of rotation of the turbine by increasing its diameter, in equal ratio to the reduction of rotative speed, which, of course, has the disadvantage of increasing the weight of the turbines required, also the above steam leakage.

Turbine and propeller efficiency.—It is often found advisable in turbine steamers to sacrifice propeller efficiency so as to obtain a high turbine efficiency. This accounts for the high slip ratio noticeable in many turbine steamers, as it is found better to drop some of the propeller efficiency to gain more turbine steam efficiency by raising the speed of same. Hence with high revolutions the turbine efficiency will be good, but the propeller efficiency would be better with less revolutions per minute. A compromise is thus effected to produce the highest possible combined efficiency of the turbines and the propellers, and that accounts for the statements that are often made as regards the steam used per shaft horse-power. In some cases it appears very low; but if the speed of the shaft is given, it will become very evident that the propulsive efficiency of the power that is delivered by the turbine to the shaft is very low, and the cost in coal per passenger or cargo ton mile is high.

Propeller efficiency.—Above a certain revolution speed a propeller of a given diameter, pitch ratio, and area ratio rapidly loses in efficiency as cavitation sets in and reduces the effective thrust. The slip ratio therefore increases, which produces a correspondingly reduced propeller efficiency; it is thus impossible to obtain a maximum propeller efficiency in combination with a maximum turbine steam efficiency. Propellers of comparatively small diameter also possess the disadvantage of losing in efficiency against head seas and head winds, which again results in slip ratio increase. The problem has been, and always will be to combine both propeller and turbine speeds, so as to give the highest possible combined efficiency. It will have been observed, possibly, how turbine steamers with high-speed propellers fall away from the trial speeds when at sea. The above is a possible explanation.

Cavitation.—Cavitation is formed by the ineffectiveness of the atmospheric pressure to press up the water at the back of the blades of the propeller fast enough to allow of effective thrust, and usually occurs at high revolution speeds and at high blade pressures per square inch.

Reversing turbines.—Turbine steamers are not very efficient in the matter of quick stopping and reversing, which is a very important thing to have, especially in vessels similar to cross Channel boats and the like, and it has been stated that, owing to the lack of reversing power, it is necessary to turn off steam some considerable time before reaching the landing-stage, and that the time that is gained, to a great extent, in quick-vessel speed, is somewhat taken up at landing, and that the average time of the trip is longer than it would have been had the turbine ships had the same power on reverse that reciprocating engines have. It should be borne in mind that the sudden reversal of the steam turbine is very severe on the turbine, as excessive vibrations are said to be set up by the change of rotation, and this is especially so, when the reversing has to be carried out (say to avoid possible collision) when the vessel speed is high, and the positive torque at the propeller is almost at the maximum.

Slow vessel speeds, manœuvring etc.—When turbine steamers are slowed owing to fog, etc. or are proceeding at slow-vessel speed for other reasons, such as manœuvring in and out of harbour,etc., the steam consumption is very high per shaft horse-power, which is a very serious matter to contend with, especially in the case of cargo boats that travel to all parts of the world, meeting with all conditions of weather, etc. A case in point is very interesting, such as that given by Mr. Thomas Bell in his paper on the steam trials of the *Lusitania*. He stated that at 25·4 knots the steam consumption in the main turbines only was 12·77 lb. per shaft horse-power hour, and that when the vessel speed was dropped to 15·77 knots the steam consumption was 21·23 lb., showing conclusively that by slowing the vessel speed 38 per cent. the steam consumption per shaft horse-power rose to 65 per cent. more than that which was required by the turbines when running at a higher speed (without auxiliaries).

The Paragon system.—A few of the advantages to be gained by the adoption of this system are :—

1. Either steam turbines, suction or pressure gas engines, Diesel or other oil engines may be satisfactorily applied for the purpose of economical marine propulsion and transportation, the prime movers always running in the same direction, whether the vessel is going ahead or astern.

2. Increased vessel speed for the same boiler power, due to the better utilization of the steam, and producing more power, and by reason of the slow-speed propeller, and the absence of cavitation, therefore producing more thrust per horse-power given to the propeller shaft.

3. Or the same vessel speed may be attained, with reduced boiler power, as above, together with considerable reduced coal consumption.

4. Absence of vibration, giving greater comfort to passengers, partly due to the absence of racing of the propeller under

heavy pitching or rolling conditions, and constant rotary torque given by the electric motor, or motors.

5. Increased cabin or cargo accommodation, due to the smaller machinery and absence of shaft tunnels, etc.

6. Better trim can be given to vessels, tending to lighten the hull structure (if necessary), owing to the easy disposal of the machinery; as, for instance, the turbo-alternators may be placed forward of the boilers, or aft over the electric motors, as may be desired; and to suit the ever-varying conditions met with on various classes of vessels, the high-speed turbo-alternators may be situated close down to the bottom of the ship.

7. Less up-keep in machinery and smaller engine-room and stoke-hold staff required.

At the first discussion Mr. Farenden said he could not see how the system advocated could effect a saving in coal, as the propelling plant in the ordinary ship was made up in three parts—the boilers, engines and propellers—whereas with the electrical transmission, of course, there are five parts—the boilers, the turbines, alternators, motors and propellers. The saving is made by running the steam turbine at, say, in a small cargo boat of 1,000 or 1,500 H.P., from 1,200 to 1,500 revolutions per minute. If the turbine were direct-coupled to the propeller it would run at about 400 to 500 r.p.m. and at that high propeller speed. In that same boat you would get a propulsive efficiency per shaft horse-power of probably 30 per cent.; the slip ratio is very high indeed in a slow boat. As regards brake horse-power, taking the two turbines together, there would be a saving of about 50 per cent. in steam between the turbine running at 1,200 to 1,500 r.p.m. and the one running only at 400 or 500 r.p.m. Consequently it allows us to more than cover the losses in a ship of that size which would be about 14 or 15 per cent. between the brake horse-power on the turbine and a slow-speed motor driving the propeller. The saving in steam, of course, means a reduction in the boilers and further reductions in other directions. In a cargo vessel I recently had to get out, the following are the figures :—

Particulars of an existing cargo boat 339′ × 46′2″ × 22′5″

Displacement, 8,010 tons. Dead-weight carrying capacity, 5,700 tons. Block co-efficiency ·796. Speed, 9·2 knots. Indicated horse-power, 1,250 (single-screw). Consumption of coal, 20 tons per day. Hull and equipment, 2,000 tons. Machinery, including boilers, etc., 300 tons. Boilers, 15′6″ × 10′6″, 180 lb. working pressure. Engines (triple expansion), 24″, 39″, 65″ by 45″ stroke. Shaft speed, 62 r.p.m. Diameter of propeller, 17′0″. Present cost, complete vessel, £33,000. Present cost of machinery only, £9,500.

The reciprocating machinery and boilers cost £9,500, and on working out the particulars for electrical transmission not only is the cost approximately the same, but the weight of the total machinery, including boilers, etc., in both cases is, I believe, about 45 tons less. The saving in steam is 24 per cent. for the same shaft horse-power at the same shaft speed. That goes to show there would be a saving of 24 per cent. in a cargo boat if fitted with high-speed turbines instead of slow-speed reciprocating engines. Mr. Timpson remarked on the possibilities of electrical gear, owing to the saving made in electrically driven factories on land, a saving obtained by concentrating the generating plant, and to some extent we have that already in the marine engine. The steam loss is partly compensated, but it is really because of the higher speeds and economies made in the turbine, making a saving in steam for the same power. I do not know of any electric launches other than those using accumulators, except in Russia, where the Diesel oil engine is at work driving dynamo and motor for propulsion. In that case I was informed by the authorities there had been trouble, owing to the difficulty with reversing and speed regulation at the low-vessel speeds. Ultimately they direct-coupled the Diesel engine to the propeller shaft by means of a magnetic clutch ; but that was not efficient, as in order to get the weight of the engine down to a reasonable degree, they had to raise the speed of the engine to about 200 r.p.m. The engine was about 800 H.P., and the propulsive efficiency at slow speed of 10 to 11 knots was low. I would rather raise the engine speed to possibly 350 to 400 r.p.m. and use a lower speed for the propeller, say 100 revs. In two cases I have now in hand the electrical design of an installation of 1,000 H.P. with Diesel oil engines using the "all-electric" drive. Mr. J. H. Redman asked for particulars of a motor required for a vessel of 3,000 H.P. with a 15 ft. propeller. I cannot show a 3,000 H.P. motor, but will show an illustration of a 2,000 H.P. motor running at 100 revs., and the total weight is 94 tons, the mechanical efficiency being 95 per cent., taking the electrical input to brake horse-power on the shaft. Mr. Frank Broadbent, an engineer of no mean qualification and well able to speak on this subject, when I first suggested this system ridiculed the idea, but on going closer into it found it quite practicable. He confirmed my statements about steam consumption and, in fact, wound up his contribution to the discussion by saying he was "of opinion that the adoption of the system will effect very large economies in coal, space and weight." He has done a large amount of important work in this country, and I think I can ask you to take what he says as correct. I referred almost entirely to the steam turbine in my paper, and Mr. Deane drew attention to the possibilities of the reciprocating internal combustion engines; to this I agree also. We use the Diesel oil or suction gas engine, and it is quite possible to run it at high speed, as in a case I am now quoting for, the engine the speed of which is 400 r.p.m., or 315 B.H.P. The engine to be coupled together to an alternator of 290 electrical H.P. at 400 revs. Like Mr. Deane I do not see any other motor more suitable than the polyphase for the purpose, and certainly it is the right thing for control on no-voltage conditions. It would be a very impracticable thing to reverse a motor of 5,000 to 6,000 H.P. under live conditions, with an ordinary controller, without special means, I prefer to bring everything down to no-voltage conditions, then change the connexions and control the whole by the exciting current. I have not tried it at sea, but on road vehicles it is very satisfactory; there is no trouble with it whatever.

Mr. W. McLaren considered that superintendent engineers would be averse to adopting this system without some surety of it working well in practice. I fully anticipated that, and the object of reading the paper was to bring the possibilities out with a view to discussion and I think that was the right course to adopt. We have had two discussions, and the subject has been fairly gone into.

I agree with Mr. Robertson that marine engineers are at a disadvantage in discussing the electrical side, as few can follow the subject in its more technical aspects and grasp every portion of it, but as members of this Institute we should endeavour to enlighten ourselves more on this subject. I have learnt a lot since attending the meetings, and the more

I know of marine engineering the more enthusiastic I am, and marine engineers will be enthusiastic also the more they know of the possibilities of electrical engineering. My claim of 10 per cent. loss is low, yet it is possible to obtain. Mr. Robertson referred to sets of 1,000 or 1,500 kilowatts, while I was considering a ship of 4,000 to 5,000 brake horse-power.

Mr. R. H. Willis mentioned, among other methods, the combination set,—the vessel with reciprocating engines and the slow-speed low-pressure exhaust steam turbines. That is an interesting proposal now being tried with some measure of success in at least two vessels, but presently I will show you a slide which will explain how the steam may be more usefully employed. The losses incurred in the low-speed low-pressure turbine will be more than compensated by running the exhaust steam into a high-speed steam turbine direct-coupled to the dynamo and having a motor on the engine shaft. I think more steam economy would be got in that way and a higher combined propulsive efficiency obtained.

Mr. Austin remarks about the fine-speed regulation for marine work. He asks how I propose to obtain a fine-speed variation with squirrel-cage motors. I showed on the blackboard at the last meeting the method in which you can get a variable speed from zero to maximum with an induction motor, and that is illustrated and explained in the report of the last discussion.

Mr. Timpson referred to a tramp steamer, going to the West Indies, and, to avoid taking coal, slow-vessel speeds between the islands was the rule, and he asks if there would be the same elasticity with the electrically driven ship. That is the difficulty with the direct-coupled turbine engine, there must be maximum rotation speed for maximum efficiency. It is possible to keep all the turbines running at half load or less, but would not be very advantageous; it would be as inefficient as slowing the turbine down. But with three turbo-generators at half speed we could close down two and run the other at high speed and probably full load. There would be economy in a turbine-driven vessel by running one turbine with the power transmitted to three propeller shafts, which would be driven by the induction motors at the reduced speed.

Mr. E. P. Hollis is right in saying that in ordinary electric lighting stations the load factor may be 30 or 40 per cent., taking the 24 hours through, but it would be as much as 80 or 90 per cent. at sea. For many days it would remain at its highest maximum, so that there is every reason to believe that the economy would be high.

As to the effect of racing, being an alternating current system, the motors would usually run fully loaded at probably 3 or 4 per cent. behind the synchronous speed of the current or the generators. Immediately the propellers attempted to rise to the surface by heavy pitching conditions, the motors would run closer into synchronism, perhaps to ·5 per cent., and there would be no racing, because with the generators it would be well governed. On land, meeting normal conditions, it is at 3 per cent, but from very full load to empty load it is within 6 per cent, so that there is not much risk with these motors.

As the Chairman said, at the first discussion, the matter of a "guarantee" is a thing that has to be met, and he questions whether the system would ever be adopted without proper guarantees. Several electrical firms in this country are at present tendering for ships' machinery up to 3,000 H.P. on this system and under the most stringent guarantees that I can draw up. They are now quite willing to construct machinery on these lines and to give the necessary guarantees.

Mr. Adamson raised the question of reversing and said, "When it is remembered that there may be as many as fifty to sixty reversals in thirty and a half minutes coming into or leaving port, it will be seen what strains and stresses the marine engine, and the marine engineer, have to be able to withstand." Of course I do not know what conditions such a number of reversals would be necessary under; they are most severe conditions, but with electric motors it is quite possible to do every bit of reversing that is necessary. I do not quite see, however, why 50 or 60 reversals should be needed in such a short space of time. Mr. Adamson is quite right in saying this system is intended to get the highest possible results from the turbine machinery and yet run the propeller shaft at efficient speed. That is the whole thing. He further says, "Our difficulty just now, I apprehend, is to get data." That is quite right. A more difficult thing I have never had in all my experience than to get the necessary data, not only from marine engineers but also electrical engineers, in order to make true and proper comparisons. I went before writing this paper to a firm that has built large machines with a view to obtain the weights, efficiencies, steam consumptions and various particulars necessary for calculation in order to make a true comparison. I was told that such information was private. It remains so, I suppose, and I was driven outside this country for information. I was received with every respect, attention and courtesy, while designs were put at my disposal in Berlin, where three of the large firms gave me the data to deal with in this case, also at Zurich, Paris, New York, etc. There are firms in this country who build turbine machinery quite as well, as good, as efficient, and as cheap as those in Berlin, but being there on business I took the opportunity of getting particulars for comparison. Since then I have been in touch with marine engineers, shipbuilders and turbine builders in this country, and the technical journals have given the subject some prominence, and now the electrical engineer is more enlightened as to the qualifications necessary for marine practice, and I believe I can say marine engineers have been enlightened as to the possibilities of electrical engineering. I should like to see our members pay more attention not only to the possibilities of electricity for marine propulsion, but for ordinary auxiliary machinery. We were all greatly impressed with the paper read at the last meeting of the Institute on "Alternating Currents of Electricity for Auxiliary Machinery," where some advantages were pointed out which must have appealed to most of you.

I gave the cost per kilowatt, including turbine, generators, motors and controlling gear, at about £4 10*s*. per kilowatt. Of course, that is not definite, as the price will vary a great deal. In a very small boat it would be greater, anything up to £8 or £9 per kilowatt, but you may take it the cost of power plant need not be much more, if any, than under the existing circumstances with properly designed apparatus.

Mr. Deane opened the discussion on January 11 and, as an electrical engineer, he was favourably inclined towards the system, while he also passed some very interesting remarks, and in his experience of mining work, which lies in line with marine work for heavy work and damp atmospheres, he has plenty of evidence of the value of this method. We have had many conversations and discussions on the subject, and as a result he is in possession of facts about this system known to very few. He quotes the late Dr. Elgar, who stated that the problem was to secure "a combination of the turbine and propeller such as will give an efficient speed of the turbine without unduly reducing the diameter of the propeller." You will observe that by adopting this method there is practically an electric gear reduction between the high-speed machine and the slow-speed machine, we get high-speed turbine efficiency and high propulsive efficiency in the large diameter slow-speed propeller. It has been suggested from time to time to use the continuous-current method. About four years ago, before I had gone much into the alternating current method for heavy work for want of the data, I got out a continuous-current method, but on going further into the question, and in view of the possibilities of breakdowns, I came to the same conclusion as others, that the continuous current will never be practicable for marine propulsion. We have only tried it on small boats of 300 to 400 H.P. in Russia, but in big jobs it is not possible to make it work satisfactorily. Of course it is an interesting system. You can get a variable speed from zero to maximum, and that is what I have shown I can get with my method, with polyphase alternating current machinery. As Mr. Deane mentions, the scheme brought out by Dr. Ilgner " is probably the biggest advance made in bringing electricity into use for mining work." In that case they reverse by reversing the motor, making it into a dynamo for the acceleration in the speed of the prime mover by the kinetic energy of the mill that is driving it.

Mr. Stuart raised the question of high tension machines. There is certainly a limit to what amount of pressure can be carried on very large boats, but I think the voltage can be kept as low as possible ; it would be more a matter of the amount of current. Take the case of the *Lusitania* of 60,000 H.P., at 1,000 voltage pressure the current would be 47,000 amperes. It is more the carrying capacity, the weight of the conductors, that would be the controlling factor in that case. I was in hopes of having a model showing this " Paragon " method at work, and I will, at a future date, have a set down to show you the motor working under water. I do not say it is continually under water, but it will work under water and show no harmful effect. As to the voltage, I might say that in a cargo boat with a Diesel engine, where there are two motors of 420 H.P., the voltage is 260. That is all that is necessary for that given power ; the distance is only a few feet and the voltage necessary is reasonably low.

Mr. Timpson referred to the rubbing surfaces, but as I showed there are only three slip rings taking the current into the transformer, the slip rings carry very little current and are not liable to get out of order. It is quite different to the use of commutators; in a continuous current system it is only rubbing contact.

Mr. Howie says, "We have some idea of the overload put on machines ashore, but this polyphase system might be a new system altogether. If it is overloaded on board ship, might it not be destroyed?" Well, I think you will have some difficulty in destroying a polyphase current motor of a certain output that is being driven by a generator only capable of supplying that output. On road vehicles of 40 H.P. you can work it at the full power and it will not burn any rotors out; there is no question of that. There is no fear of having trouble in that respect at sea, where it has practically a soft medium to work against—water—as compared with macadamized road.

Mr. Timpson asked as to the percentage of breakdowns comparatively between motors and steam engines. My experience is this: that with polyphase alternating-current motors, under proper management and attention, which, of course, they would get under properly trained engineers, I do not see why there should be any more unreliability in these motors than in reciprocating engines—possibly less, because there is a less number of working parts. The machine I showed at a former meeting was composed of the stator, rotor and two bearings, and that was all in the machine. To give an idea of the attention required, I had a motor 'bus equipment on for two years—certainly, it has ball bearings running in grease—but during that time it has never been touched, although it has been in constant use in London, Hertfordshire, Bedfordshire and other parts of the country. The Chairman, at the last meeting, said that squirrel-cage motors would run for years with scarcely any attention, a remark which is quite true. I visited at Newcastle the Carville power station, where the engineer told me that they have a whole set of machines, squirrel-cage rotor machines, running for six months continuously without stopping. I think the output of those machines is 800 or 900 H.P. each. To see them running one could easily see there was not much possibility of having any trouble from lubrication, heating effect, dangerous overloads or breakdowns.

Mr. Gander referred to the ship's compass. As you all know, there was trouble with the ship's compass until Lord Kelvin investigated the subject and a remedy was found. In this case the main current would not be circulating—that is to say, it would not get the compass in a circuit of unequal power—moreover, the compass has proper armature protection, so that the current would have no effect whatever in this direction. As to voltage, I quite agree that if it were found necessary to have electrically propelled vessels the Board of Trade would not stand in the way of progress. They would adapt their rules to circumstances within the possibility of the new conditions being successfully applied.

Mr. Redman remarks as to " feeding into a bus bar, and then distributing the current to twin and triple screws, as would be required in order to allow twin screws to balance one another." My ideas are that when manœuvring or starting a voyage, especially going in and out of harbour or among congested traffic, to run starboard and port sets independently, but as soon as the vessel has a clear headway and can go for a run continuously for several days or some considerable time, to parallel the machines and put them, practically speaking, on like a set of bus bars by means of a cross-connexion. Then that effect will be obtained as seen in the illustration of the rolling vessel in the paper, giving increased propulsion with the rolling vessel, non-racing of the propellers and further economy. Mr. Mavor remarks upon the difficulty of parallel running. Of course it all depends upon the man, practically speaking ; a man would not be in charge of an electrical equipment for a big vessel unless he thoroughly understood his position. The paralleling of the alternators with high-speed turbines is quite a simple thing. At Newcastle, there were young fellows of 22 to 25 years of age in charge of the great 6,000 kilowatt machines, and regulating them at the switchboards, which it would be quite easy to use at sea. Of course the marine engineer would be equally trained and equally able to carry out these operations. Mr. Robertson questioned on this point, " Will there be two separate classes of men in control, electricians for the electrical part, and men accustomed to steam turbines for that part ? " I do not think so, as there are hundreds of marine engineers in our leading electric lighting stations handling plant of tremendous power. Of course they have had some training, but that is all that is necessary, the first instructions for working. Certainly, also, it would not be right to send to sea a man in charge quite ignorant of such plant. My opinion is that there would be an electrical expert on the first vessel until the marine engineer was suitably trained. It is the usual practice on land when a plant is put down, and there is no reason why it should not be just as satisfactory with marine engineers.

DESCRIPTION OF MR. MAVOR'S ELECTRICAL POWER TRANSMISSION SYSTEM FOR MAIN MARINE PROPULSION

in connection with the Paper that he read before The Institution of Engineers and Ship-builders in Scotland, on February 18, 1908, the illustrations of which are reproduced with the kind permission of the above institution.

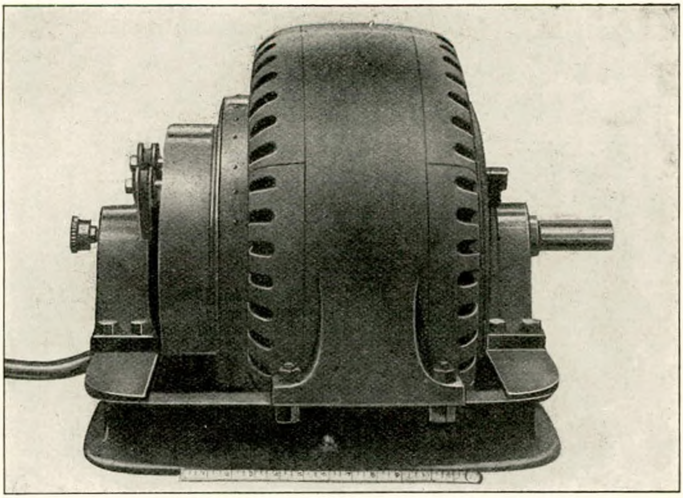


FIG. 1 is an outside view of the model machine that he showed (observe the brake-drum, etc.)

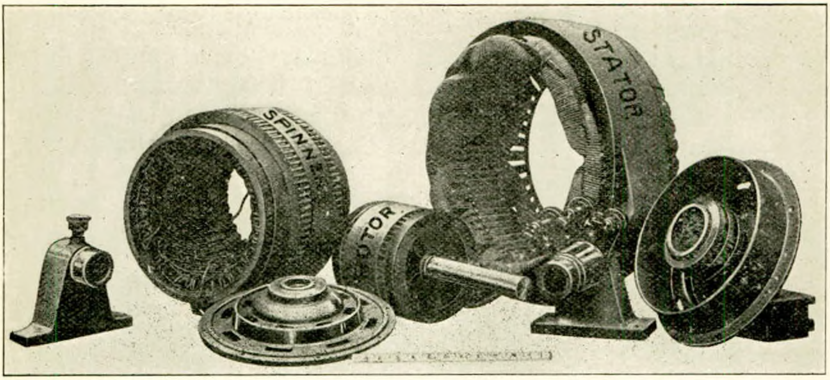
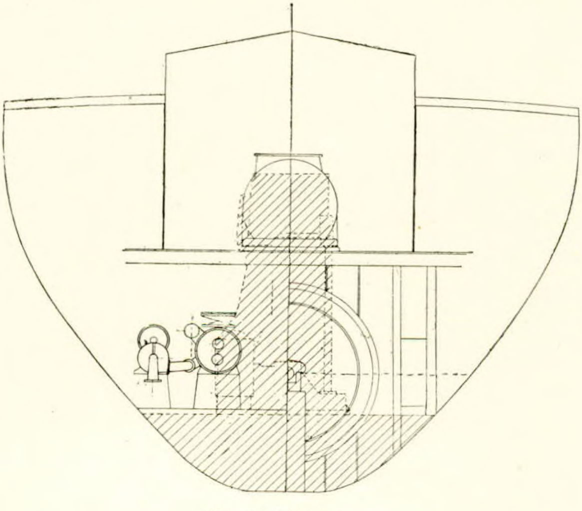
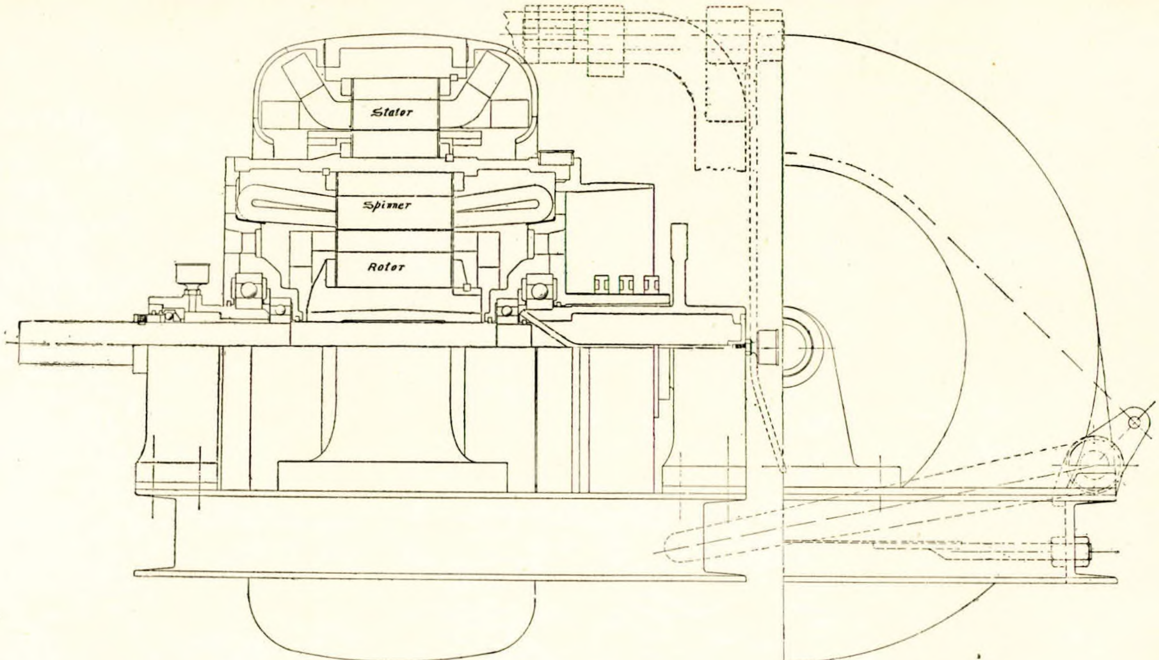


FIG. 2 shows the above machine taken to pieces, the stator, spinner, rotor, and brake-drum may be seen together with their relative dimensions; the rotor, which is to do the total work of propulsion, it will be observed, is the smallest member as regards diameter (it is most essential to keep the diameter of the members of the motor small in order to get them in the narrow after lines of certain vessels); there being no less than four windings in the motor, the mechanical efficiency of the motor cannot be high, which is most necessary for main marine propulsion.



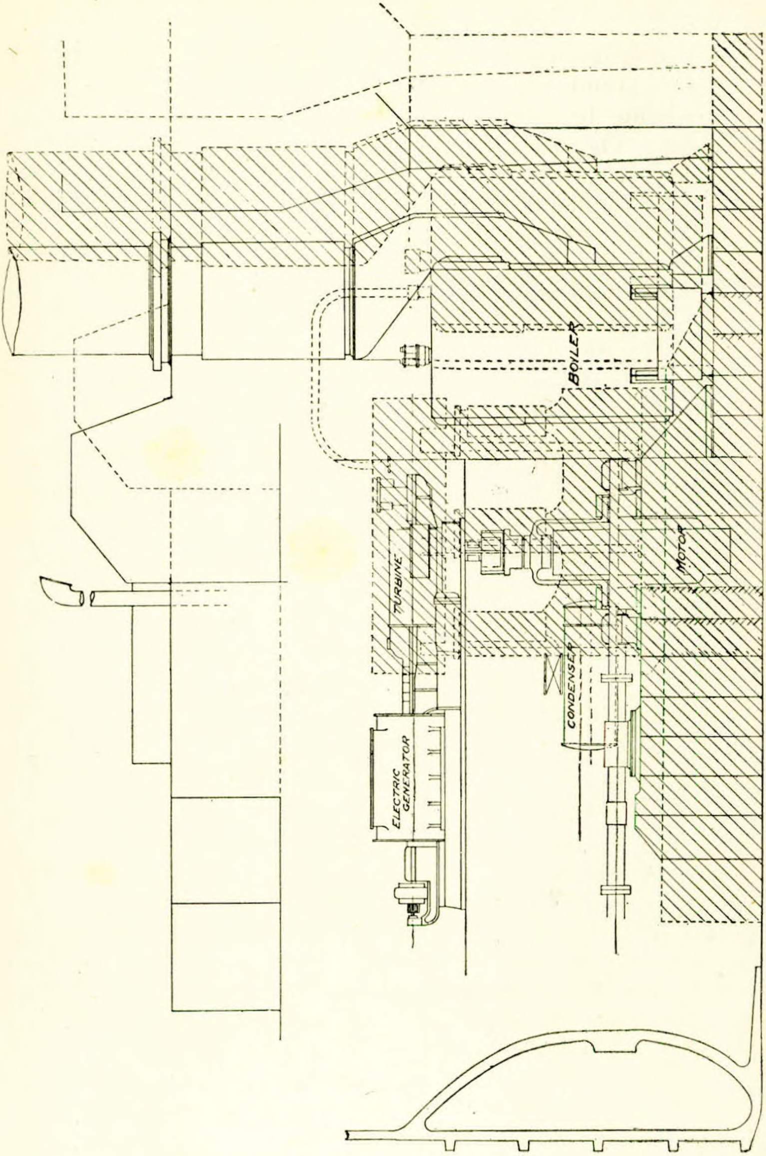
CROSS SECTION.

FIG. 3 shows a cross section of the above. It will be observed that the motor goes well down in the bottom of the boat, and that the turbine alternator does not reach much higher than the reciprocating set.



ELEVATION. SECTION.

FIG. 4 shows an elevation and section of the proposed machine. It will be noticed that there is an ordinary three-phase winding on the stator, a squirrel cage winding on the outside of the spinner, a three-phase winding on the inside of the spinner, and a squirrel cage winding on the outside of the rotor connected to the propeller shaft. Three speeds may be obtained, with this method of construction, by sending the main current into the inside winding of the spinner, and by sending the main current into the stator; it will be observed that the spinner revolves by the influence of the stator, and the rotor by the influence of the inside winding of the spinner.



LONGITUDINAL SECTION.

FIG. 5 shows a longitudinal section of a lay-out on Mr. Mavor's system. It will be noticed that the turbo-generator is placed over the motor. It is a very good lay-out as it allows the steam from the boiler to rise to the turbine, and to well drain the exhaust to the condenser. A shaded part shows the relative position of an ordinary reciprocating set of equal power (approx.). It will be observed that the electrical plant with boiler, etc., takes up less room than the reciprocating set.

It is a very interesting study, and I criticized it purely from a technical standpoint; I do not believe in pulling another man's scheme to pieces merely because it is different from one's own. The diameter for a given horse-power I consider to be excessive, for the simple reasons explained. Say you design an equipment for a vessel; the first thing to design is the diameter and length of the rotor, and everything above that has to be designed from that, including losses. So that for the total equipment you have the spinner and losses and also of the stator outside that. It is a very ingenious idea and he gets variable speed, but with such a diameter I do not believe it is possible to get it into working conditions on the large scale that is necessary for main marine propulsion.

Mr. Durtnall then exhibited a large number of slides illustrating various aspects of the subject.

A hearty vote of thanks was accorded to Mr. Durtnall on the proposal of Mr. W. Britton, seconded by Mr. W. E. Farenden, and to the Chairman on the proposal of Mr. W. McLaren.

The meeting then adjourned.

CONTRIBUTION FROM MR. A. E. SHARP (MEMBER).

In perusing this paper, and also the discussion that has taken place since it was read, I am convinced that the case put forward by Mr. Durtnall should be subjected to further investigation, and I gather he is anxious for marine engineers to express themselves freely upon it. At the present time I am afraid he will have some difficulty in inducing shipowners—and especially those who go in for the cargo type—to entertain his proposals. In almost every ship having a speed of 10 knots and over, and where the mileage run is answerable for 80 per cent. or thereabouts of the coal expenditure, as distinguished from ships making short runs where banked fires, auxiliaries and harbour consumption play an important part in the total consumed, the coal bill is the most serious item of expenditure the owner has to contend with, and it is under this head we have to consider this proposal, viz., the coal used for the speed obtained. The weakness of the proposal here put forward is in making the comparisons on the basis of what can be achieved in the steam consumption from turbine engines. I have had the actual performances of many of the turbine driven ships during a fairly long run before me for investigation, and I find that when they are running at their one and best speed, they have not given the economical results that are obtained in the mercantile marine from reciprocating engines; warships we know are always more costly in fuel. In the special ship-building number of *Cassier's Magazine* Dr. Caird has there shown that the fuel consumption of these latest big turbine ships is 33 per cent. more than it would be with reciprocating engines; I entirely concur with his comparisons, as I am certain he has not overstated the case. Now to turn to the figures put before us by Mr. Durtnall; the whole proposal is based on the assumption that the propelling machinery is going to be so efficient that the steam consumption is only going to be 16 lbs. per K.W. hour. The steamship owner is not concerned with 16 lbs., his concern is a minimum of fuel for a maximum of speed with a standard ship, and I maintain he will not obtain these with this scheme. I do not think we are justified in accepting 16 lbs. per K.W. hour. From the published records I find the best that can be obtained under special—what we would call a run on the measured mile—conditions is $18\frac{1}{2}$ to 19 lbs. per K.W. hour, and actual voyage conditions will be between 15 and 25 per cent. increase according to circumstances. On the *Saxonia* during the voyage the steam consumption was under $13\frac{1}{2}$ lbs. per I.H.P. hour, and the coal 1·29 lbs., and these results can be taken as normal at sea for ships of her class. I am confident the same speed could not be obtained with electrical motors driven by turbo-generators for this expenditure of fuel. Then again has the author investigated what these four propellers are going to be like that are driven by 1,000 B.H.P. at 250 r.p.m., and how the four motors are to be placed in the ship? There will be some difficulty in arranging the wing screws to dispense with the long length of shafting, and how is this arrangement with regard to breaking up the space in the ship for cargo purposes? Assume a ship 450 ft. × 54 ft. (I have allowed a good beam to get in the wing screws) on a mean draft of 21 ft. 6 in. the displacement would be 10,000 tons, and 4,700 I.H.P. would give a speed of 14·3 knots with reciprocating engines. The propeller would return 52 per cent. of the I.H.P. giving 2,440 effective H.P. Now with four propellers on this same ship they would require to be 7 ft. 9 in. diameter and 7 ft. 3 in. pitch to enable the 1,000 shaft

H.P. to get the revs. up to 250. The slip of these propellers would be 26·2 per cent., and their efficiency would not exceed 45 per cent., giving a total effective H.P. of 1,800, and this would only drive the ship at a speed of 13·2 knots. Stated in another way the reciprocating engines give 35 per cent. more H.P. than the electrical scheme, if applied at the tow rope. I had to go into the details of a proposal of a similar nature to this some time ago, but with twin screws only, and a different scheme for the generators. The plant was larger comparatively for the same power and slower running, consequently the efficiency was higher and the weights likewise.

Reply by Mr. Durtnall.

I agree with Mr. Sharp that the case for electrical propulsion of ships on the method I have indicated should be subjected to further investigation, as the more the matter is gone into the more will the important points be evident concerning the possibilities of this advance in marine engineering for reducing the cost of propulsion. Let me take the figures given as an example. The *Saxonia* is a twin screw steamer, having a boiler capacity of 132,600 lbs. of steam per hour (according to the report of the committee on naval boilers) with a boiler room equipment of a 1,000 tons weight, giving an output of steam per hour, per ton, of boiler-room weight of 132·6 lbs., the evaporation of the boilers equalling 11·3 lbs. of water per lb. of coal burnt (actual). Now taking the weight of the engines, shafting and propellers at 15 lbs. per I.H.P. developed, the total weight of the propelling machinery is therefore 658 tons, making the total weight of the boiler-room and engine-room equipment equal to 1,658 tons. Now taking the consumption figures of 13·5 lbs. of steam per I.H.P. hour, the total I.H.P. would therefore be 9,822, and allowing a mechanical efficiency of the engines of 85 per cent. the total shaft H.P. developed would be 8,350, or equal to each shaft H.P. of 4,175 ; the coal consumption was therefore at 11·3 lbs. of water evaporated per lb. of coal used, 11,734 lbs. per hour, or equal to 5,125 tons.

The coal bill is the principal thing for progressive owners to think about, and I made it clear in the paper that there is a considerable saving to be made in that direction. Let us also look into the comparative weights of machinery and coal consumption per shaft H.P. developed, in an electrically driven *Saxonia* which would be as follows :—

Two motors capable of developing 4,175 S.H.P., including shafts and propellers at 90 lbs. per S.H.P. would weigh 336 tons.

Two turbo-generators, each developing 3,265 kilowatts (capable of supplying the above motors) at 60 lbs. per kilowatt output, would weigh 175 tons.

Condensers and pipes for the above at 30 lbs. per kilowatt output would weigh 87 tons.

The above turbo-generators would consume 14 lbs. per kilowatt hour, therefore the total steam used would be 91,420 lbs. per hour, taking the same evaporation per ton of boiler-room weight, namely, 132·6 lbs., makes the boiler-room equipment weight, in this case only, 690 tons. The total weight of an electrically driven *Saxonia's* boiler and engine-room weights would thus be 1,288 tons, as compared with the present total of 1,658 tons, or a saving in the total weight of boilers and propelling machinery of no less than 22·3 per cent.

The steam consumption per kilowatt hour is 14 lbs. (which can be guaranteed), therefore for the 6,530 kilowatts generated, the total steam required will be 91,420 lbs. per hour, as against 132,600 lbs. as at present ; the consequent saving in steam is, therefore, no less than 31·5 per cent. Taking the same evaporation of water per lb. of coal consumed, namely, 11·3 lbs., the total coal consumed per hour would be 8,091, or also a saving of fuel per hour of no less than 31·5 per cent. The figures quoted are those of actual land practice, and may be absolutely relied on to be easily obtained at sea.

The present system of turbine-driven (direct coupled to propellers) ships are not to be compared with those fitted with efficient and well-tried reciprocating engines. But either of these methods are not to be compared with the high speed turbine and electrical power transmission method, as the figures cited are absolutely correct and are taken from quotations received from several quarters on very stringent specifications, in connexion with some propulsion schemes now under contemplation, in some cases of large power. The conditions are as follows :—

The turbines run at 1,300 r.p.m., with 200 lbs. steam pressure at a superheat of 150° F., and a vacuum of 28 in. at sea (the trial run will show better results). The motors run at 96 r.p.m., at full vessel speed of about 15 knots.

One of the most interesting points in the above design is that in case of meeting fog or through other causes, the vessel would be able to drop to half-speed, and in that condition one of the two turbine alternators would be closed down, and the other run at its normal speed of 1,300 r.p.m., but the motors would only run at about 55 to 60 r.p.m., so it will be observed that approximately the same high efficiency in steam that is to be got at full vessel speed, would be obtained at half speed, which is not an inconsiderable thing to be able to attain as practice goes to-day.

As the *Saxonia* takes about eight days to go from Liverpool to Boston, she therefore takes approximately 1,008 tons of coal, while if fitted with the electrical system of propulsion, she would require only 696 tons. The saving weight of boiler-room and propelling machinery, namely, 370 tons, added to that on coal gives a total dead-weight saving of 682 tons. To this may be added a reduction of stokers and attendants. It would be interesting on the basis of the data given to work out the increase of speed the vessel would attain, and also how many hours would be saved during the voyage by the electrical method over the reciprocating method of propulsion, considering that we are providing the same shaft H.P.

Dr. Caird quoted to the Institution of Engineers and Shipbuilders of Scotland in the discussion on Mr. Mavor's paper last year, the report of the tests of the steam turbo-generators at the Newcastle "Carville" Station, that a 4,096 kilowatt turbo-generator running at 1,200 r.p.m., consumed 13·8 lbs. of steam per kilowatt hour (showing that the amount I have allowed is well within the range of every-day practice) when supplied with steam at 200 lbs. pressure, superheated by 108° F., and with 29 in. of vacuum.

Despite the fact that Mr. Sharp has taken the *Saxonia*, which is one of the finest examples he could take in the reciprocating engined ships, it being well known that this vessel is very easy to drive, it seems quite clear that the case has been proved in favour of the electrical method of propulsion.

As evidence to a remark made in the Annual Report read at the Annual Meeting regarding the increasing ratio of membership, it may be interesting to note that the following have been elected since January 31, 1909 :—

MEMBERS.

Name.	Proposer.	Seconder.
John C. Black, Glasgow	A. Beldam . .	J. Adamson
Lewis C. Calcaterra, Malta	J. G. Hawthorn .	J. Adamson
John P. Cheney, Hull .	J. H. Silley . .	J. G. Hawthorn
E. W. Giles, Hay, Herts.	J. Adamson . .	E. W. Ross
P. J. N. Hogan, Westminster	J. Adamson . .	E. W. Ross
G. A. Laing, Dundee .	T. A. Crompton .	J. Adamson
P. Lawrie, Edinburgh .	Wm. Birkett .	Jas. Smith
A. G. McDougall, Greenock	R. Elliott, B.Sc..	J. Adamson
J. McNaught, R.N.R., Birkenhead	J. H. Silley . .	F. E. Sheppard
M. M. Murray, Shanghai.	F. W. James, R.N.R.	J. S. McGavin
M. D. Neil, Burma . .	A. M. McAllister	D. J. Munro
Ernest Pull, R.N.R., London, S.E.	J. G. Hawthorn .	J. E. Elmslie
A. E. Ridley, London, N.	J. H. Silley . .	C. A. Flower
J. Robertson, Glasgow .	R. Elliott, B.Sc..	J. McLaren
W. T. Seaton, London, E.C.	A. Boyle . . .	J. Adamson
John Stewart, Durban .	R. Elliott, B.Sc..	J. E. Elmslie
F. G. Taphouse, London, E.	J. G. Hawthorn .	J. Adamson
Louis Tessier, Glasgow .	J. H. Silley . .	F. E. Sheppard

AS COMPANION.

Name.	Proposer.	Seconder.
F. M. Garnham, London.	P. C. Garnham .	J. Adamson

AS ASSOCIATE MEMBERS.

Name.	Proposer.	Seconder.
Robt. Allan, Paisley . .	J. Adamson . .	A. H. Mather
P. Zographos, Piraeus .	J. G. Hawthorn .	J. Adamson

As Associate.

Name.	Proposer.	Seconder.
Wm. Gosling, Portsmouth	J. T. Milton . .	J. G. Hawthorn

As Graduates.

Name.	Proposer.	Seconder.
R. H. Bridson, Douglas, I. of M.	R. Elliott, B.Sc..	J. Adamson
J. E. Hawthorn, London, N.E.	J. G. Hawthorn .	D. Hulme .
Wm. J. Holmes, Barrow	J. Adamson . .	A. H. Mather
J. H. Ormsby, Glasgow .	Jas. Stark . .	J. Adamson
E. L. Taphouse, London, E.	P. K. Robertson.	J. E. McGibbon