INSTITUTE OF MARINE ENGINEERS
INCORPORATED.

SESSION 1904-1905.

President—The Hon. C. A. Parsons.
Local President (*B.C. Centre*)—Lord Tredegar.

Volume XVI.

ONE HUNDRED AND SEVENTEENTH PAPER
(OF TRANSACTIONS).

PROTECTION OF METALLIC SURFACES.

BY

Mr. H. BRANDON (Member).

READ AT

58 ROMFORD ROAD, STRATFORD, E.

ON

MONDAY, APRIL 18th, 1904.

Chairman:
Mr. W. LAWRIE.

PREFACE.

58 Romford Road,

Stratford.

April 18th, 1904.

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

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

Jas. Adamson,

Hon. Secretary.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

NOTICE.

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

J. A.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1904-1905.

President—Hon. C. A. Parsons, M.A.

Volume XVI.

ONE HUNDRED & SEVENTEENTH PAPER (OF TRANSACTIONS).

DISCUSSION ON

PROTECTION OF METALLIC SURFACES

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, OCTOBER 10th, 1904.

Chairman:

Mr. W. LAWRIE (Member of Council).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A vote of thanks to the Chairman terminated the meeting.