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Corrosion of Marine Boilers. Its Causes and Prevention.

BY THE LATE MR. D. E. REES (Member).

READ

Tuesday, December 18th, at 6 p.m.

CHAIRMAN: MR. B. P. FIELDEN (Vice-President).

The CHAIRMAN: We are met to-night to hear a paper read which was written by Mr. D. E. Rees. Unfortunately, he lost his life through warfare. The Council considered whether the paper he had written previous to his death should be read publicly now, and it was decided that his opinions should be published in the "Transactions." I think that Mr. Rees was a good member of the Institute of Marine Engineers, and that it is a great loss to us that he should be taken away, because he was one of our sea-going members who has written a paper for the Institute. It is very much more difficult for a sea-going man to do so than it is for some person occupied in shore employment. I now have pleasure in calling upon Mr. Adamson to read the paper.

The HON. SECRETARY: A very pathetic interest attaches to the paper we have before us to-night. The manuscript was found amongst Mr. Rees' effects after they were forwarded to his uncle, who had been a foster-father to him from his early years. As it was found amongst his effects, dedicated to the Institute, his uncle sent it on. I thought it was fitting, when we had the paper before us to-night, we should have the photograph of the author and the notice of his death as a frontispiece.

The life of a marine boiler depends to a certain extent on the care and attention bestowed on it during the first few months of its existence, provided that the plates have been properly treated at the building of the boiler—that is, all mill scale removed and the plates kept dry and free from atmospheric corrosion. The mill scale, if not removed, has a very irritant action on the clean metal of the boiler, and is most hurtful to the plates if allowed to remain on them. When new boilers are put under the varying conditions and temperatures found on ship board, the greatest care and attention is needed for the first period of working if the boilers are to be kept free from corrosion; the new metal of the boiler at this stage being most open to attack from all sources of corrosive agencies. It is advisable on the first voyage to put into the boilers before closing them up 5 lbs. of lime per 1,000 I.H.P., and afterwards for a period of about six days 2 lbs. of lime per day per 1,000 I.H.P. should be passed through the hotwell as milk of lime, and 1 lb. of lime per day per 1,000 I.H.P. during the remainder of the voyage. At the first opportunity the boilers should be opened up, and if a thin coating of lime is found on the internal surfaces the use of lime with the feed water may be gradually reduced, but if such is not the case and the boiler water shows any signs of black or red oxides, then the use of lime with the feed water should be continued. Daily tests of the boiler water with a chlorine testing bottle should also be made, and should the water contain a greater amount than 100 grs. per gallon the lime should be increased in quantity. If, on testing, the water was found to be acid, carbonate of soda should be added to the feed water until the water becomes a safe alkaline again.

Having thus given the boilers a good start in life, constant attention on the part of those in charge is required if the boilers are to be kept in anything like a good condition. As the conditions under which different sets of boilers work vary so considerably, and the management of them so often changes hands, it is a matter of great difficulty to make any fixed laws or rules governing their treatment; and it is also a well-known fact that seldom do two different sets of boilers require the same treatment. However, if the following methods of dealing with the corrosive agencies are attended to they will help to prolong the life of any marine boiler considerably.

One of the principal causes of corrosion is sea water, it being practically impossible to entirely exclude it from the boilers even under the most favourable conditions. One of the constituents of sea water is chloride of magnesium ($Mg\ Cl_2$), and under certain conditions sea water in contact with heated copper, brass, iron or steel surfaces becomes acid by the conversion of the chloride of magnesium into hydrochloric acid ($H\ Cl$) and magnesia (Mg). The action is as follows:—Where cloride of magnesium is present it attacks the iron, and when water containing it is used as the boiler feed serious corrosion is produced, this being due to the high temperature, and under high pressure this salt is decomposed, as shown by the following equation:—$Mg\ Cl_2 + 2H_2O = Mg\ (OH) + 2HCl$.

The magnesium hydrate is precipitated and the HCl dissolves in the water. This acid dissolves a certain quantity of iron from the boiler furnaces, forming chloride of iron ($Fe\ Cl_2$); as soon as the latter is formed it is decomposed by the magnesia already liberated, precipitating oxide of iron and re-forming chloride of magnesium, as will be seen from the equations $H\ Cl_2 + Fe = Fe\ Cl_2 + H$, and $Fe\ Cl_2 - Mg_2 = Mg\ Cl_2 + Fe_2$, the H in the first equation being given off into the water. This oxide of iron deposited is ferrous oxide, and is black in colour, and remains so unless air is allowed to get into the boiler, when it becomes ferric oxide and changes in colour from black to red or brown. Thus, if corrosion is to be prevented, sea water must be kept out of the boilers; and this can only be done by keeping condensers tight, evaporators free from priming, and a supply of fresh water carried in engine-room tanks for use in case of any emergency. The carrying of fresh water is, unfortunately, a condition which seldom exists on the majority of steamers to-day, as by keeping the fresh water in engine-room tanks the cargo-carrying capacity is diminished, so that, from the shipowners' point of view, the boilers must be sacrificed to cargo.

For the rendering of sea water non-corrosive about 8 lbs. of quicklime, or 45 lbs. of soda crystals per ton would be required, and such quantities are, of course, prohibitive when there is any considerable leakage of sea water with the boiler feed. The use of lime has the further disadvantage that out of the 8 lbs. mentioned above about $5\frac{3}{4}$ lbs. would be deposited as scale. Sea water in itself has sufficient sulphate of lime to produce $3\frac{1}{4}$ lbs. of scale for every ton of water, so that if the proper proportion of lime be added the total quantity of scale which will be deposited is 9 lbs. Although this scale, when evenly coated over the surfaces of the boiler, may form a protection against the corrosive action of the chloride of magnesium, it is, at the best, only an expensive and unsatisfactory remedy, as it increases the consumption of fuel and may also damage the boiler by overheating when accumulated.

Another point which demands careful attention, and is not sufficiently recognised by Marine Engineers, is the working of evaporators for the production of the make-up feed water. Evaporators are, of course, very essential for making up the loss of feed water due to leakages at glands and joints, but they should be blown down before the brine becomes too concentrated, otherwise the magnesium chloride will be decomposed and give off hydrochloric acid, which will pass over into the boilers with the distilled water, thus producing acidity in the fresh feed water. The action of the acid formed in this way differs from that formed in the boiler by the decomposition of sea water, inasmuch as it is not destroyed immediately afterwards by re-uniting with the magnesia, but is carried in with the feed water and held in solution throughout the entire volume of the boiler water. It is thus in a position to attack all parts which are not protected, also the parts where circulation is poor. As this action goes on, the acid is becoming more concentrated, and will continue in its harmful action until prevented from entering the boiler. It is, therefore, essential that all evaporators should be fitted with baffle plates, have their vapour pipes led well above the dome, salinometer cocks fitted, and the density taken at frequent intervals. The density should not be allowed to exceed $\frac{3\frac{1}{2}}{32}$, and when this point is reached the evaporator should be blown down and re-filled.

As will be seen from the above, the use of soda and lime should receive careful consideration, and the quantities added to the feed water should be governed by the condition of working in each case such as the density of the water, the rate of working and the time which must elapse before the next cleaning of the boilers. Experience points out that the use of lime is more generally satisfactory on a voyage, soda being used in cases where the boiler water is acid through the density of the brine in the evaporator being excessive, and where no vegetable oil has been allowed to enter the boiler.

As before stated, sea water cannot absolutely be prevented from getting into the boilers, therefore it is an excellent plan to continually use a small quantity of milk of lime to neutralise this sea water. One lb. of lime per day per 1,000 I.H.P., dissolved in fresh water in the following way may suffice, and the lime thus used should be ordinary unslaked lime. It should be finely powdered and kept in a dry place, the milk of lime being made by mixing 1 lb. of this lime in a gallon of fresh water, the solution to be strained through gauze wire before use in order to get rid of any lumps or solid impurities.

Carbonate of soda is effective in changing the sulphate of lime found in the sea water into sulphate of soda, which is soluble, therefore harmless. Carbonate of lime is also formed and is easily got rid of by blowing out. Formerly practically all corrosion in boilers was attributed to galvanic action, and a certain amount of corrosion is still attributed to this cause. If two separate plates of metal, one more corrodible than the other, are taken and partially immersed in a corrosive liquid and connected in the atmosphere by a wire, a current of electricity is generated which originates from the more corrodible plate and passes by way of the liquid to the less corrodible plate, then through the wire and back to the more corrodible plate. If the wire be removed and the plates placed so that they complete their own circuit, the current will still exist. Therefore, if in one construction there be two metals of different electrical potential exposed to corrosive influence, the electro-positive metal will be attacked and a current will pass between the component metals. Now, in boilers containing sea water this action takes place between the different metals used in the construction of the boiler. To counteract the galvanic action zinc plates placed in perfect metallic contact with the plates of the boiler should be used, as the position of zinc in the list of electro-positives causes the zinc to be attacked before the iron, and, therefore, the boiler plates would be left in good condition. This action, of course, only takes place when sea water is allowed to enter the boilers, and zinc plates are only fitted to minimise the action of the objectionable sea water. Therefore, if sea water is kept out of the boilers the zinc will not readily act, and there will be little need of its use in such large quantities, thus lessening a very expensive item in the working of marine boilers. To afford an efficient protection by the use of zinc there must be perfect metallic contact between the zinc slabs and the iron or steel plates of the boiler. The practice of hanging the zinc slabs by wire or hooks from stays or tubes is an absolutely useless one, as the zinc is not serving the purpose for which it is intended; and although the zinc may show signs of deterioration, yet in such a case this would be from attack by the sea water, and not through any electric couple. Another cause of corrosion is the presence of animal or vegetable oil in the feed water. By using compounds containing such oils as lubricants in steam cylinders the exhaust steam carries them over to the condensers, and the fatty acids liberated from these oils by decomposition will cause pitting wherever the sludgy deposit can find a resting place in the boiler. Only a minimum quantity of the highest grade of hydro-carbon oil should be used in steam cylinders, and in lubricating piston and valve rods the same precaution should be observed. Apart from the evil effects of acidity, the hydro-carbon deposited upon the heating surfaces of a boiler is most harmful, as a thin film of this deposit forms a very bad conductor, thus preventing the heat passing through to the water and so causing the heating surfaces to burn, blister and crack.

Under the care of careful and competent engineers a marine engine can be operated without a particle of internal lubrication, only a very small amount of oil being used for the purpose of swabbing the rods. Should it, however, be necessary to resort to internal lubrication, various samples of oils should be thoroughly analysed by vaporising a small quantity of the oil over a Bunsen burner and carefully noting the temperatures at which vaporisation takes place, the remaining deposits being tested for grit, acids and other impurities. Thus by taking this deposit at various temperatures before the point of vaporisation is reached and testing same, a good resulting oil could be found, for it is in this remaining deposit that the evil effects of cheaper oils lie. Feed water containing oil should be purified on its way to the boiler by passing it through some efficient filter, of which there are several types of varying degrees of efficiency on the market. By the use of a filter a good deal of oil is prevented from entering the boilers and carrying on its corrosive action. Where vegetable oils have been allowed to enter the feed water the use of soda to neutralise the acids is sometimes attended with trouble in the form of a soapy scum on the surface of the water in the boiler, and this is frequently carried into the H.P. cylinder by priming. In such cases lime alone should be used to neutralise the acids from the oil. Air has been a well-known cause of corrosion for many years, and many instances of rapid corrosion have been proved to have been caused by the feed pumps drawing air from the hotwell and the feed being delivered to the boiler at a level considerably below the water line. Corrosion arising from the presence of air takes place in the following manner:—Small beads or bubbles of air are expelled from the water on boiling and attach themselves tenaciously to the heating surfaces. The oxygen at once attacks the plates, and the action results in iron rust, and produces a thin crust or excrescence. This, when washed away by the circulation or dislodged by expansion and contraction, leaves beneath it a small hole or pit. Pitting when once started progresses very rapidly, as the indentations form ideal resting places for the bubbles of air and at the same time present fresh surfaces for attack. Fresh water at 32° F. absorbs oxygen to the extent of 4·9% of its own weight, at 50° F. it absorbs 3·8%, and at 68° it absorbs 3·1%, whilst salt water absorbs more air than fresh water. It will thus be seen that, as far as possible, air must be prevented from entering the boiler with the feed water, and the best method of doing this is to have an automatically-controlled independent feed pump working in conjunction with a direct-contact feed heater of the "Weir" or other approved type, where the air is liberated from the water in its passage through the heater. Care should also be taken to ensure that the feed pump glands are kept tight, to guard against air entering in this way. In the majority of cases it is impossible to entirely prevent air from entering the boilers, at the same time a good deal of the air can be kept from attacking the plates if the internal feed pipes are led into the steam space and slots cut in them so that the water can spray out of the pipe; most of the air will then be given out to the steam, thus preventing it going down with the water to the heating surfaces and having a chance of attacking the plates.

The design of a boiler also enters into the prevention of corrosion by air, for if a boiler is designed to give as good a circulation as possible, then the air bubbles would have a lesser chance of finding resting places. Another practice which is very detrimental to boilers is that of filling them up from dock or river waters, and especially from rivers that have their courses leading through coal-mining districts, as water that is pumped out of coal mines contains, among other constituents, iron sulphate ($Fe\ S0_4$), and this oxidises the iron when brought into contact with the atmosphere, the action forming iron oxide (FeO_2) and leaving sulphuric acid, this being brought about by the hydrogen amalgamating with the SO_4 and producing H_2SO_4, which, of course, is anything but a desirable constituent of boiler feed water.

The CHAIRMAN: I think you will agree with me that, having heard the paper read, the loss of Mr. Rees is a decided loss to the Institute, for he was evidently a very thoughtful man, and the paper he has written should certainly be of great assistance to our sea-going members. Mr. Rees, of course, cannot reply to any criticisms which are made by the members, so what has to be done is to have a more or less debating class amongst ourselves, and for you to offer your opinions. I know there are other gentlemen present who will take exception to anything you say, and by doing so we shall get a discussion.

Mr. F. M. TIMPSON: I thoroughly agree with the Chairman's remarks as to the loss of Mr. Rees. He has certainly shown himself to have been an engineer who has studied his profession very closely, and he has given in his paper a good many items, some of which are perhaps new to us. At any rate, they are of very great general value. The class of paper which Mr. Rees has put before us is looked forward to by our members. To the paper we cannot offer a criticism; we can only concur as to what has been said as regards the style of it. I may say, in respect of some remarks, especially in regard to evaporators, that the working of this apparatus is not always given the attention that it needs. In one part of the paper Mr. Rees speaks of not being able to get the ballast tanks full of fresh water. As a matter of fact, that is believed to be undesirable, as the water supply from various rivers is worse than salt water. The question of keeping the density of evaporators down is very important. It is recognised as such by some of the eminent makers. Some have introduced apparatus which keeps the evaporator from an undesirable density. The various formulæ given for the chemical solutions are very useful, and I regret that the writer was not spared to be with us.

Mr. JOHN B. HARVEY: The late Mr. Rees was the author of a very valuable paper on "Corrosion of Marine Boilers," and I quite agree with that gentleman that new boilers, if not thoroughly well attended to and treated in a proper manner when first placed in commission, will be productive of endless trouble before they are very old. Lime or soda, when placed in a boiler, should be thoroughly dissolved, and not put in all at once; it should be allowed to drip into the feed water continuously from a tank. There is no doubt that evaporators do not receive the attention they require, often being allowed to prime through not being blown down at the necessary intervals. A very little priming will be the cause of a great deal of harm, and will soon be the means of creating much scale on the heating surfaces of the boilers as well as causing corrosion. The author, in his paper, mentions internal feed pipes. In quite a number of marine boilers these are led across the tops of the tubes with a branch leading down between each nest of tubes, with the result that the feed water is forced down towards the furnace, and as it is not possible to get rid of all the air from the feed water before it enters the boiler the remaining air is carried down on to the top and sides of the furnace, which will be the means of starting corrosion sooner than anything. In my opinion, the internal feed pipes should be led across the tops of the tubes with pipes slotted on the side facing the combustion chamber, so that the feed will meet the water as it is circulating away from the combustion chamber in the direction of the front end of the boiler. If all internal feed pipes were fitted in this manner it would prevent a great deal of the corrosion which occurs on the furnace, as the air would then have a better chance of being liberated into the steam space before being carried down on to the heating surfaces.

Mr. S. G. MARTLEW: I beg to thank the late member for his paper, which no doubt will be thought over a great deal by many engineers and lead to discussion in mess-rooms and other places where they congregate, as most of us are unable to get to the Institute in these stirring days. He speaks of the use of lime to treat the boiler water, but does not refer to putting the lime into a tank and passing the feed through it. By circulating the water *via* a lime-tank and suitable filters prior to entering the boiler, objectionable influences are greatly reduced in potency; in fact, the whole of these, including globular and emulsified oil, may be caught externally if electrolytic action is arranged to take place in addition to the mechanical and chemical safeguards. Removal of corrosive or scale-forming matter in the feed should preferably be effected *outside*, and not within the boiler, otherwise the steam generator is turned into a chemical works, with injurious results arising mainly from the reactions and the settlements of impurities upon the heating surfaces. An old and inexpensive method in starting up new boilers is to first limewash the inside, and/or use a little sea-water for a very short time as feed, and by using the surfacing cock, a thin scale, say $\frac{1}{32}$ inch thick, will adhere to the interior structure. This dispenses with the considerable amount of lime referred to in the author's opening paragraph, thus minimising deposit and loss of efficiency. I notice that there seems lack of balance in two of the equations employed to represent chemical reactions, due possibly to inadvertent errors in the MSS. The first one should, I think, read :—$MgCl_2 + 2H_2O = Mg(OH)_2 + 2HCl$; and the third one :—$2FeCl_2 + Mg_2 = 2MgCl_2 + Fe_2$, or else $FeCl_2 + MgO = FeO + MgCl_2$. At the end of the paper may be added :—$FeSO_4 + 2H_2O = H_2SO_4 + FeO_2 + \widehat{H}_2$, the nascent hydrogen, $\widehat{H}$, being a corrosive factor as well as the sulphuric acid. The presence of oil obviously being detrimental to boilers, for internal lubrication when working engines in or out of port and manœuvring generally, I have often succeeded in preventing slide-valves, etc., from squeaking or grunting by pouring a little water in by the grease-cups, the only addition throughout entire voyages being a small quantity of best cylinder-oil for rod-swabbing. Where zinc-plates and their supporting iron studs or hangers touch, both metals should be scraped bright at the surfaces of contact to ensure good results. I have found that by enclosing the lower part of each plate with a perforated guard-tray, as the zinc disintegrates, any large pieces are thereby stopped from falling upon the heating surfaces, thus obviating corrosion, over-heating and waste of an expensive metal. By emptying, cleaning, drying and closing up steam generators which are to be out of service, they may be kept from wasting, and in the case of water-tube types, when in and out of service, special measures against corrosion are sometimes necessary. The author does not refer to methods taken to repair damage done by corrosion. Upon surveying the boilers of one vessel I found deep pits and scars on the combustion chamber tops and sides, and, having scraped these down to the bare metal, filled one lot with Portland cement and the other with zinc powder-paste. Care was observed when steaming to prevent the entry of air or other injurious fluids or solids, and upon subsequent examination the old defects were barely perceptible, and no new ones arose while I remained as chief. Seeing no mention of *external* corrosion in this paper, but having met with some serious instances, I feel bound to state that this must particularly be guarded against. Leaky joints, either above or on the shell, causing insidious percolation beneath the lagging; deposit and cooling of ashes next to unprotected front plates; wash of impure bilge water against the bottom; and steam or water leaking at tube or stay ends—all these are responsible for wastage on the outsides of marine boilers.

Mr. A. J. McLeod: The paper written by the late Mr. Rees touches upon a subject which is of vital importance to the marine engineer, and it is to be regretted he was not spared to read the paper himself before us.

The author appears to have followed the practice advocated in a pamphlet published some years ago and quoted verbatim in several text books, notably Jamieson's "Steam and Steam Engines." The conclusions given represent good practice and have long been accepted by marine engineers.

In establishing new boilers, almost always a considerable amount of "bleeding" takes place, or, in other words, porous oxide is formed excessively, and the most rapid method of dealing with this is to follow the directions given in the paper supplemented by judicious "blowing down." The writer speaks from actual experience with new boilers, and first tried these methods some ten years ago at the time the above-mentioned pamphlet was published; the results fully confirming the efficacy of the methods advocated.

Ten years, however, represents a long stride in engineering progress, and after a boiler has become established with a protective coat it is doubtless better practice to introduce lime to the extra-feed water on the principle of concentration up to the point of deposition in the manner used by various water softening processes now on the market, and thus pass into the boiler softened water. It doesn't seem quite right to introduce lime into a boiler and afterwards laboriously chip it off again; the external application of lime while being equally effective has not this objection.

The danger of hydrochloric acid given off by the evaporator is rather overstated, this would only occur when the density reached saturation point. Twenty-five ounces per gallon, or $\frac{5}{32}$, and most engineers know how hopeless it would be to attempt to make up feed with the evaporator at such high densities. However, should any (H. Cl.) hydrochloric acid be formed it would be an aquarius vapour, which when diluted with the boiler water, would form an extremely weak solution, which could readily be neutralised by soda.

Galvanic action is really a weak aciduous solution setting up an electrolytic action between the dissimilar metals used in the boiler's construction, *e.g.*, ferrous and non-ferrous. A boiler in this condition closely resembles a "plating bath," the zinc plates which we introduce being the anodes and the boiler itself the cathode. As in the plating bath unless a good metallic contact is established between the anode or electro-positive element and the cathode or electro-negative element, no deposition from the anode to the cathode would take place but both would become corroded in proportion to their electro-chemical equivalents; similarly both boiler plates and zinc plates would be corroded unless proper metallic contact be established between the zinc and iron.

Corrosion in the very nature of things will occur in and about boilers, and undoubtedly the greatest enemy of all is free oxygen. Oxygen will attack every known element except fluorform in greater or less degree so therefore no steamship should be without adequate air extracting devices attached to the feed-water systems so as to de-aciate the water before it enters the boiler. Only constant care and vigilance will keep in hand and restrict the many corrosive influences met with in marine boilers.

Mr. Wm. McLaren: We all regret that our member, Mr. Rees, has passed away as a victim of the submarine, and at the moment we can only say that he died for his country. It is difficult to criticise a paper written by one who has passed away. It is left to us to make the best of the means at our disposal. The author has evidently given some study to the care of boilers. There is no one amongst us but has his own particular way of treating boilers, and, as Mr. Rees admits, no two boilers can be run alike. I came out of a boiler last night; it was a boiler of the Lancashire type. It has been giving trouble, the feed water having been passed through a water softener, and when the furnace rings were examined one would think that either they had been scoured or some acid had been acting on the plates. They were cleaned and painted with Portland cement wash. The boiler has been at work for the past seven months; there has been some sign of pitting showing ever since the water softener was put into use about eight years ago. The other parts of the boiler where pitting is has been in patches, "not regular," all on the heating surface, changing about; first one place and then another has been attacked. There is not any signs to be seen about the shell plates. The boiler was left to cool from steam. Scale was there, but it was not difficult to get rid of it. The boiler water had been drawn from an artesian well 370 ft. deep and run in a water softener; also town's water on occasion when either the softener was being cleaned or well pump under repair. Mr. Martlew remarked upon the use of cement. If you wash the heating surfaces as well as the shell surfaces of a boiler which is coated with Portland cement you will find, after the boiler has been run for a time, that this acts as a preventative to pitting. Would it not be an advantage to test marine boilers on land, in the boiler works, before they are fitted into the ship? Would it not be an advantage for the life of the boiler, and also for the life of the engines, to supply steam to it in the boiler works, to keep it going for a few weeks on end, with all the conditions that it would be put to when it was fitted into the ship? That, I think, is a question for the metallurgist. Some boiler tubes go for the life of the ship and boiler, say 10 or 20 years. Some only go for a few months. There is nothing harder on the Marine Engineer, and it is always a cry of "lubricator"—that is, the engine slide valves grunting—when it is the blessed boiler giving off some sort of scale or deposit that goes pumping into your engine slide valve casings. You hear of this grunting, and that is from the boiler tubes and plates 'at it,' hence the poor engine has had to suffer under this scale. I say, give the boiler some work to do, at least before it is fitted into the ship. Whether, when under such test, the boiler supplies steam to an engine, or whether it is merely under test for blowing off, it should be supplied either with normal town water or you can put it under water such as would be used in seafaring conditions. It is like starting from the sea water to the evaporator. I quite agree with the author that the boiler should be *treated early* with sea water. Certainly we have the different rivers from which we have to take water. Until you are trading with these particular places you never have the chance of finding out the conditions under which your boiler is working. One point I have neglected to mention. Why we should stick to these calculations or quantities of I.H.P. when we ought to take as a basis the amount of water evaporated.

Mr. J. Shanks: In reading Mr. Rees' paper, I have been very much impressed with its excellence; it is one of very great value to sea-going engineers, and shows that Mr. Rees had given diligent thought to the management of marine boilers, and if everyone applied themselves to the recommendations made in the paper, I feel sure we should hear little or nothing about corrosion. Mr. Rees emphasises the importance of giving boilers a good start in life, and all Marine Engineers know that this is the great consideration. Too often, however, this is neglected. In the leading lines of steamers I think I may say that all the precautions recommended are adopted in regard to the cleaning of the boilers, washing the heating surfaces with cement wash, filling them with fresh water and fitting zinc plates in metallic contact with the vital surfaces before the vessel starts on her first voyage. When these precautions are taken, there is little fear, provided the boilers are in the care of an intelligent engineer with an up-to-date plant on board, of trouble accruing from corrosion. I would like, however, to emphasise to sea-going engineers the importance of keeping sea water out of the boiler from the first day of its life. Many still believe that the introduction of sea water into a new boiler creates a protective scale on the heating surfaces; nothing could be more deceptive. In regard to the management, or rather arrangement, of evaporators, Mr. Rees recommends that the vapour pipe should be led well above the dome; this, in my opinion, is important. I know of one well-known line of steamers where the vapour pipe is led to such a height as to prevent the possibility of water being carried on to the condenser, and the evaporator is practically being worked under the pressure in the condenser, and the results are most satisfactory. The judicious introduction of soda or lime with the feed water is to be recommended, but first of all the engineer must know the character of the water in the boilers and the feed water he is putting in. In regard to lubricating oils, this opens out a wide question; but there is no reason, with our present knowledge on the subject, why oils should be used for internal lubrication of cylinders which may leave a residuum which is detrimental to the boilers. In any case, a modern ship should be fitted with an efficient feed water fitter. Our Hon. Secretary, I think, should be thanked for bringing this paper before us, and the Institute will treasure the memory of Mr. Rees, who has given his life for his country, and leaves behind him such a valuable contribution to the Transactions. I feel sure that the members who have read it will benefit.

The Hon. Secretary: The presence of mill scale is a feature in connection with the care and treatment of boilers which it is well to have emphasised, as has been done in the paper submitted for our consideration. The mill scale if left on the plates has a very injurious effect, fortunately it is comparatively seldom that this scale survives the various operations involved in the building of a boiler, still, it is sometimes found, and ought to be removed immediately it is noticed. All boilers ought to be examined periodically, preferably every voyage, if of three or four months' duration, so that any changes taking place in the internal parts may be carefully observed and noted for guidance in regard to treatment from voyage to voyage. The periodical examination of boilers should start as soon as the trial trip is finished, as the beginning of their working days requires to be watched and safeguarded from the possible presence of germs, which may develop into troubles later on.

The worst case of mill scale corrosion that came within my experience was in the boilers of a new steamer that had made one voyage. In this instance circumstances prevented an examination of the boilers prior to sailing from the home port. The scale was on the inside shell plates and the corrosive action had so developed that in places, when the scale was removed, the depth of the pitting was quite a quarter of an inch. The whole of the inside shell plates were scaled and rubbed clean, a good deal of time being expended on the job, the plates were then coated with a protective solution. These boilers on examination afterwards voyage by voyage showed no further deterioration, the cause had been removed.

The Chairman: The greatest cause of corrosion in boilers is air, and in modern steamers there is very much less corrosion than in the older type of vessel's boilers, owing, I think, to the fitting of independent feed pumps. Where single acting pumps are worked from the main engines it is very common to have an air valve on the pumps which is used to keep the pumps more or less quiet. The air thus admitted is a remedy for one trouble, but causes another. Independent feed pumps removed this cause very largely, and feed heaters and filters are also assistants in the preservation of boilers. Some builders also fit special devices for extracting the air from the feed water, and I think there is no doubt but that the proper installation is one which removes the cause of the trouble rather than one where special remedies have to be applied to cure the trouble. I agree with the author that the addition of lime water is good, and for corrosion due to galvanic action I think zinc, with thorough contact, is one cure and the Cumberland System another. The principal duty of all Marine Engineers, however, is to look after the water before it goes to the boilers. In closing the meeting, I suggest that we ask our Hon. Secretary to convey to the relatives of Mr. Rees our sympathy and regrets that he has lost his life. He, like many of the members of our profession, has faced his duty to the end, and whilst we deplore the loss of many, we are proud that the British Marine Engineer is standing up to his dangerous work and is an asset to this Empire and her Allies. The British Marine Engineer was largely responsible for the growth of the Mercantile Marine before the War, and since then had it not been for the engineers the War would have been much more difficult to this Empire, so that it is a personal matter for the whole of us that we must also face our duty to the end—to use a military term, we must "carry on."

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H.M.S. ———,
G.P.O.,
London.
Nov. 26th, 1917.
(Received Jan. 11th, 1918.)

JAS. ADAMSON, Esq.,
Hon. Secretary.

DEAR SIR,

I very much regret that, having been without our mails for seven weeks, I have only just received the Transactions containing Mr. W. V. Lang's most interesting and instructive paper on "Standardisation of Marine Engines for Cargo Steamers."

One would have thought that the case for standardisation hardly needed debating now, and that we could have got down to business in earnest to build our standard engine. Instead of which the foggiest ideas seem to prevail as to what standardisation is, and several members would appear to have missed the meaning as outlined in the author's prefatory remarks. There is no mention or hint in Mr. Lang's paper that standardisation stands for stagnation or finality and a clog in the wheels of progress, but rather the reverse.

The great case for standardisation for such a large number of ships of a certain kind as Mr. Lang has in view, is the fact that our leading engineering firms, for various reasons, still continue to turn out anything but a satisfactory or ideal job.

It may be ignorance of what is the best practice; it may be the manufacturer's idea of economy to use old drawings and patterns and antiquated methods of manufacture. Or it may be, as several members suggest, that the shipowner is not always as flush of money as he would like to be, so that that greatest of all sinners, "Initial Expense," does not permit of his having the best.

But whatever the reason for it, the fact still remains that we have a big lot of engineering science and experience that we are not making use of. It is for this reason many of us hope that the Government will retain its control over shipping and shipbuilding for many years to come after the war. Not that we have anything against the kindly and well-disposed shipowner, or think him to be "the villain of the piece" that a section of the Yellow Press would have us believe. But simply because the Government work on the principle that "the best is plenty good enough for us, no matter who has the second best," and they do the same with the expense as Lord Milner did with the consequences. And that represents the whole case for standardisation as arrived at by a competent body of all the different interests concerned. It enables you to put to sea with the best practice that the profession is acquainted with, and by turning out the work in large quantities it enables us to produce the best almost as cheap, if not quite as cheap, as a lot of individual inferior stuff.

For after all, although as one member pointed out, the shipowner gets what he pays for, yet it is rather degrading to our characters as engineers to have to turn out what we know to be inferior work. The manufacturer takes no pleasure in turning it out; the superintendent engineer does not like having to keep it in repair; and as for Marine Engineers—well! how many poor thirds have lost all hopes of ever getting aloft just because someone thought how nice it would be to have a nice cheap lead-base alloy for the bearing metals.

So whether we can compel the owner to buy the best or not, it should, nevertheless, be the business of our Institution to keep before him what, in its collective judgment, is absolutely the best practice obtainable. To me it appears to be the acme of stupidity to use one's own brains as against the considered and reasoned judgment of the whole engineering profession. That is individualism of the worst kind—we usually call it "obstinacy." On the other hand, I am unable to follow Mr. Fielden's argument that by standardising the best practice we shall kill individualism of the right sort and so lose one of the country's greatest assets. For who would be able to look at a standard engine or step into one of Mr. Lang's engine-rooms without seeing our old friends Newcomen, Watt, Stephenson, Weir, Gywnne, Whitworth, and a host of others too numerous to mention. And I fail to see why any member of this Institute should not have the impress of his individualism stamped there, if even in no other way than by lending the weight of his own sound argument.

As regards auxiliaries, doubtless, as Mr. Fielden remarks, the leading firms who specialise in these things will not lead us far wrong. But I think even these and the minor details of other parts should receive consideration. It is frequently the small details that make all the difference between a first-class job and a mediocre one. How often does one see the very best of work ruined for the sake of fitting an oil cup that has a sporting chance of catching at least 50 per cent. of the oil fed to it? Whereas a well-designed cup made to touch a worsted drip every time the engine turned its top centre would give the bearings every drop of the oil supplied. Also, we still see oil boxes bolted on to the cylinders. I have myself found the temperature of the oil as high as 148 deg. F., which, compared with a temperature of about 75 deg. F., would have a reduced viscosity of over 50 per cent. Yet it would be just as easy to bolt the oil-box to an insulated bracket, keeping it a couple of inches away from the cylinder.

Then we still see on modern jobs turning engines with the worm shaft at the bottom, close to the tank top, which takes anything up to a couple of hours to get in and out, instead of a few minutes. And this runs away with a lot of valuable time for overhauling, besides further reducing the third's chances of ever playing on a golden harp. And we still go away to sea in brand new jobs where you have to disconnect two or three pipes before you can get at a leaky bilge pipe, just because some inexperienced draughtsman, who had never heard of a place called the sea, and consequently he did not know that his bilge pipe would ever have to come out again on account of their having a very bad habit of "going in the neck." He simply went to the drawer and fished out an old engine arrangement, and congratulated himself because he had been able to save 6 ft. of copper pipe, which, nevertheless, would have to be paid for over and over again in "time lost." Mr. Lang's suggested £50 prize would prove of inestimable value to the profession. Again, a great deal of time is lost over badly designed top and bottom ends. The simple device of having a tapped hole in the top end bolt for an eye bolt saves much time in rigging up gear for lowering the bottom end brasses; yet you do not often find the tapped holes there.

I have seen a whole day wasted trying to get a top end adrift because the pinching pin had broken off short. Had the pin been screwed into the side where it could have been drilled out, instead of into the end of the keep, a lot of valuable time would have been saved.

I have been on a first-class passenger ship, not yet eight years old, where the top end crown brass was part and parcel of the crosshead, and could not be taken down without lifting the cylinder cover and slinging the piston. This ought never to be, and yet the job was designed by one of our leading firms who turn out first-class battleships. A standardised engine would save us from a lot of this stuff.

Then we still go to sea in brand new ships with main check valves and other boiler mountings and valves, where you have to tighten up the gland nuts with a hammer and caulking tool. This is cheese-paring with a vengeance and wants standardising out of existence.

One member, speaking of piston rods and glands, says different jobs require different treatment. But surely that is the result either of faulty workmanship or want of specification as to the composition of the material.

There is a lot of sloppy engineering about those sort of things, and a lot of thinking and guessing, when it is possible, by taking a little more trouble, to prove. Take, for example, this case of piston-rod gland packing. Why cannot a competent body of engineers, such as this Institute can furnish, pass the leading "makes" through the mill of their criticism and pronounce a verdict that would be worth having? What are the things we require to know? Roughly, they are:

(1) Amount of friction on rods.
(2) Steam tightness.
(3) Amount of abuse they will stand.
(4) Time taken in fitting and overhauling.
(5) Life of packing.
(6) Facilities for renewals.
(7) Initial cost.
(8) Cost of repairs.

Most of these points can be settled with almost mathematical accuracy. Any engineering professor at one of our laboratories could work out experimentally the amount of friction on the rod for any desired steam pressure and the coal consumption thereby represented. The loss of water through leaky glands most of our superintendents would be able to tell us who have had years of experience with many kinds of packing. The initial cost can be found exactly; the repairs or renewals almost exactly. The remaining points can be found with a good degree of accuracy.

The importance of deciding which is the best article from the above points of view is very important. It means that instead of packing, say, 1,000 glands with one type and another, 1,000 with about 50 different types, we pack 2,000 with the best and which would incidentally have the beneficial effect of reducing the initial expense. Similarly with other things; each part or system should be examined and receive the verdict of the profession. If the owner wants a round condenser let him have one, but let him have no doubt about what Marine Engineers think of pear-shaped ones, or the contra-flow system of condensation.

It would be with many tender regrets if we had to lay aside our Edwards air pump for the Mirrless Watson multi-ejector air pumps, but it might have to be done in the interests of standardisation and scientific progress. Most of us would be very sorry to part with our Weir groan, but we might conceivably have to get rid of our old love to take on a motor or turbine driven centrifugal feed pump. A 1 per cent. saving of steam in a feed pump that is always at work is worth a considerable addition to the initial expense. I am conscious of having gone beyond the author's own idea of standardisation, but after all a marine engine is far from complete without its auxiliaries just as without the author's pipe arrangement. At least, I think the auxiliary machinery should have to conform to the best known practice as regards steam consumption, simplicity of design, space taken up, weight and reliability.

Mr. Lang does not make good his point on non-standardisation. The "cornering" of Parson's turbine has not kept every other works in the country idle except the Wallsend Slipway; nor has it had any adverse effect on "producing in plenty" and economy. Neither will it spell national disaster if we have to do away with the old familiar thrust block and "corner" the Mitchell thrust, until someone else can design a better one.

In conclusion, I would suggest that a standard engine should not be considered complete without being able to feel its pulse. Yet it is seldom you see a ship sent away to sea with anything better than a Richards' indicator. There has been a lot in the Press lately about the ignorance of Marine Engineers (which obviously accounts for our not being able to obtain any advancement in rank as in the deck department); yet it is not altogether our own fault. We can scarcely imagine our American cousins putting to sea in their new merchant fleet without CO_2 recorders, differential draught gauges, steam and water meters, pyrometers, recording gauges, etc.

It is not enough to know that we can get 8,000 tons along at 10 knots for 33 tons of coal per day. We want to know how it is that we are not doing it on 32. Guessing is no use. We must have the proper instruments and make sure that our own ideas and assumptions are the correct ones.

Mr. Lang has done us a great kindness to find time these busy days for such a paper, and has done the profession a valuable service, for which he has our best thanks.

I am,

Yours faithfully,

HAROLD BULLEN.

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*Notes on Prepared Paints for Metal Surfaces.

* *The Canadian Engineer*, Sept. 13th, 1917.

Bulletin of the Affiliated Engineering Societies of Miners, by Henry A. Gardner, Assistant Director the Institution of Internal Research, Inc., Washington, D.C.

In designing protective coatings for metal the modern practice has been to apply the results available from researches into the cause of corrosion. These results have shown that materials of a basic nature or substances which contain soluble chromates prevent the rusting of iron. For this reason pigments of a basic nature or pigments containing the chromate radical have come into wide use in the manufacture of protective paints. That they are the best pigments for this purpose has been proved not only in practice, but also in the Atlantic

City tests, which were made upon a series of three hundred large steel panels, using nearly one hundred different pigment paints. Applying the results of these tests to the practical manufacture of protective coatings, the writer will discuss the use of the various pigments under separate headings, taking up the composition of the most widely used colours for metal painting, namely, red, gray, black and green. Most of the paints outlined herewith are suitable for the painting of structural steel, bridges, steel railroad cars and equipment, ornamental ironwork, poles, posts and for general work on metal surfaces.

RED LEAD PRIMING PAINTS.

Red lead may be purchased in the market ground to a heavy paste in linseed oil, ready to thin with oil for use. Such red lead is usually produced by the thorough oxidation or overburning of lead, the dry pigment generally containing

PIGMENT PAINTS OF TEN HIGHEST AVERAGE RATINGS, 1910-1914.

	1910.	1911.	1912.	1913.	1914.
Basic chromate of lead	9·1	10·0	9·9	9·8	7·5
Sublimed blue lead	9·6	8·8	9·0	7 2	6·0
Carbon black and barytes	—	—	—	6.8	5·0
Chrome green	9·8	9 8	8·6	7·6	5·0
Willow charcoal	—	8·8	8·6	7·9	4·5
Red Lead .. :	—	—	8·1	—	4·0
Natural graphite, containing clay, etc. ..	—	—	—	—	4·0
Zinc chromate	9·4	9·5	8·8	8·0	4·0
Zinc-and-lead chromate	9·5	9·7	9·2	8·3	4·0
Magnetic black oxide	9·5	9·5	8 6	7·8	4·0
Zinc-and-barium chromate	9.7	9·5	8·5	7·8.	—
Sublimed white lead	9·5	9·0	8·1	—	—
Bright red oxide	9.3	—	—	—	—
Prussian blue (water stim.)	9·2	—	—	6·7	—
Prussian blue (water inhib)	—	8·5	—	—	—

approximately 98 per cent. of lead tetroxide. This pigment, being practically free from litharge, does not react to any great extent upon the linseed oil in which it is ground, and. therefore, remains soft for a considerable period of time. It is well understood, however, that one of the most valuable properties of red lead is its ability to set up to a hard, elastic film that shuts out moisture and gases which are apt to cause corrosion. This cementing action is due to the presence of unburnt litharge, a pigment which rapidly reacts upon linseed oil to form a lead linoleate compound. It will readily be seen, therefore, that red lead free from litharge has no cementing action, and should not be considered more protective than iron oxide or any other similar neutral pigment. It is thoroughly essential that red lead should be highly basic and should contain a considerable percentage of litharge if the red lead is to protect iron from corrosion. Although such red lead is often purchased in the dry form and mixed with linseed oil on the job at the time of application, it is a growing custom to use prepared red-lead paints made from finely divided red lead ground to a fluid condition in linseed oil. Such paints remain in excellent condition for a long period of time. They have a high protective value and are well suited for general purposes. They are used extensively for priming steel vessels. The Navy Department has found that inert pigments, such as silica and asbestine, give good results when used in ready mixed red-lead paints, their action being to prevent settling of the red lead upon storage.

A specification which may be used by the grinder when purchasing dry red lead for the manufacture of prepared paints is given herewith:—

Specification.

1. The dry pigment to be of the best quality, free from all adulterants, and to contain not less than 85 per cent. nor more than 90 per cent. Pb_3O_4, the remainder being practically pure lead monoxide (PbO).

2. It shall contain not more than 0.1 per cent. of metallic lead nor more than 0.1 per cent. of alkali figured as Na_2O.

3. It shall be of such fineness that not more than 0.5 per cent. remains after washing with water through a No. 21 silk bolting-cloth sieve.

Note.—If desired, the gram weight of the red lead may be specified. Extremely light, fluffy red lead should run from 10 to 13 grams per cubic inch. Medium red lead will run from 13 to 16 grams per cubic inch. Heavy red lead will run from 17 to 19 grams per cubic inch.

Composition of Red-Lead Priming Paints.

The cost of red-lead paints is a subject of vital importance to the large user. Red lead may be produced in different physical states. Ordinarily the grade that has been overburned is extremely heavy, one cubic inch weighing from 18 to 20 grams. For the production of a paint from such red lead, according to the formula used by one large consumer, the following quantities would be required: —

Red lead	26 lbs.
Linseed oil	26 gills
Petroleum spirits	3 gills
Drier	3 gills

This would produce approximately 1 2/5 gals. of paint. Each gallon would contain about 20 lbs. of red lead, the actual cost of the red lead itself being in the neighbourhood of $1.60. A red lead of a much better protective value, containing from 10 per cent. to 12 per cent. of free litharge and produced in an extremely fine physical state of comminution, so that one cubic inch would not weigh over 12 to 15 grams, would produce a paint of exactly the same body on the following formula: —

Red lead	20 lbs.
Raw linseed oil	26 gills
Turpentine	3 gills
Drier	3 gills

This would produce approximately $1\frac{1}{3}$ gals. of paint, each gallon of which would contain about 15 lbs. of red lead, the actual cost of the dry pigment per gallon being in the neighbourhood of $1.20. Red lead of still lighter gram weight could be used, so that a still smaller quantity of pigment would be required per gallon of oil. The durability of such paints should compare favourably with those containing very high percentages of red lead of high gram weight. Pigments of an extremely light nature, such as lampblack, grind in very large quantities of oil, yet their films are more elastic and durable than many paints which are composed of much pigment and little oil.

Red Paints.

Iron oxide has always been one of the most widely used pigments for the manufacture of protective coatings. Oxides that are free from acid or soluble substances give the best results. There are many grades, from the brilliant Indian reds, containing 98 per cent., down to the natural mined brown shale oxides, containing from 30 to 60 per cent. of ferric oxide, the balance being silica, clay, etc. Venetian reds, consisting of about equal parts of ferric oxide and calcium sulphate, are also quite widely used. It is customary to add to iron oxides from 10 to 20 per cent. of zinc chromate, zinc oxide, or red lead, in order to make them rust inhibitive. Such red paints are widely used for application to tin roofs, metal siding and general structural steel. Red paints made from basic lead chromate (American vermilion), the pigment which gave the best results in the Atlantic City tests, would doubtless be the most economical in the long run, but the high cost will probably prevent their use to any great extent. The use of a percentage of basic chromate of lead in iron-oxide paints is to be approved.

Gray Paints.

Mixtures of white lead (basic carbonate or basic sulphate) and zinc oxide, tinted gray with carbon black, are widely used for this purpose, and give excellent results in every climate.

A valuable rust-inhibitive coating for general priming or finishing work may be prepared from sublimed blue lead. The use of two parts of blue lead and one part of linseed oil containing about 5 per cent. of turpentine drier makes a paint of the right consistency. This may be purchased in prepared form. When this paint is used for top-coat work in marine exposures (battleship gray), the addition of 1 per cent. of carbon black to the blue lead aids in the maintenance of the colour. The rust inhibitive value of this pigment is due to the high percentage of lead oxide (litharge). This pigment, however, is so combined with the lead sulphide that it does not have any great hardening action upon the linseed oil and stays in an excellent condition in paste form for a long period of time without hardening. When purchased ground to a paste in 10 parts of oil, there should be added approximately 5 gallons of linseed oil and one pint of drier for use. A specification for the purchase of blue lead for use in metallic paints is given herewith:—

	Minimum.	Maximum.
Lead sulphate	44%	52%
Lead oxide	33%	40%
Lead sulphide		0.5%
Lead sulphite		3.5%
Zinc oxide		3.0%

Black Paints.

Black paints are often preferred for the finishing coat on steel work, carbonaceous paints being unsuited for application direct to the metal on account of their rust-stimulative action. Carbon pigments, such as gas carbon black, oil black, artificial and natural graphite (flake and amorphous) are usually the base pigments used in black paints. Silica and other earth pigments may be combined with the carbon. The slow-drying nature of such paints is lessened by the addition of litharge. The use of boiled linseed oil as a vehicle is advisable.

Magnetic black oxide of iron (precipitated) forms an excellent black protective paint when ground in linseed oil. The slightly basic character of this pigment accounts for its inhibitive value. The natural variety of black magnetic oxide of iron is also suitable for this purpose, but should be tested for freedom from soluble acid impurities before use. Willow charcoal is not made in commercial quantity; its use, therefore, will be restricted. Its inhibitive value depends upon the basic nature of the impurities present.

Green Paints.

Mixtures of zinc chromate and Prussian blue in oil are highly inhibitive, and have proved satisfactory in long service tests. Chrome yellow tinted with black oxide of iron to an olive shade is very permanent and protective. Chrome green made from lead chromate and Prussian blue is generally used when precipitated upon a barytes base.

Marine Paints.

Steel vessels traversing bodies of salt water are rapidly acted upon, corrosion and incrustation by marine growths being shown. The bottoms of boats are usually protected by applying over the red-lead priming paint a coat of anti-corrosive paint containing iron and zinc pigments ground in a shellac-alcohol vehicle. There is subsequently applied a coat of anti-fouling paint, usually made of iron oxide, zinc oxide and metallic zinc powder, admixed with a poisonous compound such as red oxide of mercury or bichloride of mercury. The upper portions of vessels are usually painted with a linseed-oil paint, the standard slate colour of the Navy Department consisting of a mixture of white lead and zinc oxide tinted gray and ground in linseed oil. This is, of course, applied over a prime coating of prepared red lead. The boot topping or water-line paint is generally of a bituminous nature, the exposure at this point being extremely severe. Chinese wood-oil varnish improves the bitumen base.

Bituminous Paints.

Bituminous coatings have a wide use for special purposes. They are often made by blending refined coal-tar pitch, asphalt, linseed oil and oleo-resinous varnishes, subsequently thinning down with turpentine or light mineral thinner. During recent years a heavy-bodied blown petroleum residual pitch has come into wide use in the manufacture of water-proofing bituminous paints. This pitch usually has a light melting point (150° C.). It is soluble in turpentine, benzol and some mineral distillates. When in solution it may be admixed with oils for the production of rapid-drying elastic paints. The pitch has high resistance to acids, and is not acted upon by the sun to the extent that coal tar is.

When coal tar is used in the manufacture of paints it should be refined. Ammonia and water in the tar are the active causes of saponification or non-adherence to metal. The presence of large quantities of free carbon or naphthalene in the tar will cause disintegration and checking. For refining, the crude tar may be heated to approximately 115° C., holding it at that temperature until the water is evaporated. From 5 to 10 per cent. of lime may be stirred in in order to neutralise the free acids. The tar may then be thinned with benzol or mineral spirits. If a rapid-drying paint is desired, a quantity of resinous varnish may be added. The addition of Chinese wood oil and asbestine in a coal-tar paint made along the above lines will aid in producing a film that is not so subject to alligatoring when exposed to the sun.

Bituminous paints of the above composition are used as coatings upon pipe-lines in acid factories, tanks containing dilute acids, metal submerged in water, and for other similar work. For such purposes it is generally advisable to first coat the metal with a thoroughly hard drying prime coating made by adding 2 lbs. of litharge to a prepared red lead or other rust-inhibitive paint. The bituminous paint may then be applied. Steel mine timbers subjected to sulphur water and gas, reservoir tanks containing water, submerged lock gates, tunnel metal, etc., may be efficiently preserved from corrosion by this method.

Painting Galvanized Iron.

Roofing, siding, railing, drain pipes, cornice work, etc., constructed of galvanized iron require painting if they are to be kept in a good state of preservation. Paints are apt to peel from galvanized iron on account of the smooth spangled surface. This condition, however, is obviated by first treating the metal before painting with a solution of copper salts. Such a solution may be prepared by dissolving 4 ozs. of copper acetate, copper chloride, or copper sulphate in one gallon of water. By brushing on this solution the galvanized iron is roughened, a thin deposit of copper being plated out over the surface. After an hour or so, the surface may be lightly brushed and then painted with a thoroughly inhibitive oil paint. Firmly adhering films are thus produced.*

Painting Tinned Surfaces.

Tin plate, such as is used for roofing and siding, will rapidly corrode unless protected by paint. The pin-holes present in the tin-coating on the steel base metal act as pockets to catch moisture, which causes rust spots and pit-holes. Before applying paint to the sheets it is advisable to rub the surface of the tin with a cotton rag saturated with benzine or turpentine. This will remove the palm oil that is present upon the surface and allow the paint to firmly adhere. Iron-oxide paints containing an inhibitive pigment are widely used for preserving tin. The use of 15 to 20 per cent. of zinc oxide, red lead, or zinc chromate with a neutral bright iron oxide produces an excellent paint. The partial use of boiled linseed oil or kauri gum mixing varnish will add to the gloss and water resistance. Such paints are also suited for use on metal shingles and pressed-steel siding—plain black, galvanized or tinned. For dipping purposes, turpentine or high boiling point mineral spirits should be used for thinning. Cheap driers containing a low boiling point benzine should be avoided.

* The writer has recently experimented with solutions of metallic salts of arsenic, antimony, tin, lead, mercury, cobalt, iron and manganese to replace copper solutions for the above purpose. Arsenic and tin were most satisfactory, but not as economical or desirable as copper.

Notes.

The following instructions were drawn up and issued (see the *Employees' Magazine* in connection with the Lehigh Coal Co.), and were reprinted in *The Power User* for October.

There are several points in these instructions which may be of service to our members:—

1.—Two men shall always work together when cleaning boilers. One man should remain outside of the boiler all of the time in a position to see the man working in the boiler, and give assistance in case it is needed.

2.—Never go into a boiler until you have locked the steam valve and closed all other valves.

3.—Before entering a boiler put a candle or torch inside to determine the presence of gas or bad air.

4.—In cutting a boiler in or out, use the non-return valves exclusively, to make sure they are working properly. Should the non-return valve fail to work in any instance, notify the foreman immediately.

5.—The automatic valves should be examined often enough to ensure their prompt action in emergencies, such as the bursting of tubes, etc.

6.—When boilers are taken off for cleaning, the main stop-valve in the steam connections should be shut off. Do not depend on the automatic quick-closing valves alone.

7.—A sign, "Danger: do not Move," should be hung on the steam valve of any boiler when it is shut down.

8.—Never open a slide or valve when a danger sign is attached and until you have seen that no one is in the boiler.

9.—Safety valves should be tested by every shift.

10.—When opening up any steam line take the following precautions:—

(*a*) Open all available drips.

(*b*) Warm the line by opening the by-pass when possible, or by opening the stop-valve sufficiently to warm it slowly.

(*c*) Unless accompanied by the foreman, never allow an inexperienced man to turn steam into the cold line.

(*d*) Never open the main valve until you are certain that the line is thoroughly heated.

11.—When starting up a boiler that has been dead, raise steam slowly, drop the pressure a few pounds on remaining boilers in the battery, and do not open the stop-valve until the gauge on the dead boiler shows the same pressure as the other boilers. Then open the stop-valve slowly.

12.—All steam traps in large lines should be kept clean and in working order, as this is the only safe way to remove water from the line. Should a trap get out of order, and it is impossible to repair it at once, the by-pass should be opened enough to eliminate all water that might collect. Blow off boilers every shift.

13.—Leaks in pipes, flanges and gas jets should be repaired at the earliest possible moment, as they may be caused by defective material.

14.—Keep the water glasses clean and tops and bottoms open by frequently blowing out every shift.

15.—In carrying water, try-cocks should be frequently used, and dependence not wholly placed on gauge glasses.

16.—Never tighten any bolts or nipples or do any caulking while steam pressure is on the boiler.

17.—Take great care in cooling and handling flue dust, as it is liable to fly, slide and explode, causing bad burns. Never step on it.

The following papers will be found of interest to members who desire to study the subjects which have been brought before us for consideration recently:—

"The Training and Work of the Chemical Engineer." Faraday Society, March, 1917. Introductory Address by Sir George Beilby, LL.D., F.R.S.

"Making Manganese Steel Castings." By Mr. W. S. McKee (American Foundrymen's Association).

Abstracts of these papers will be found in *The Mechanical Engineer*, March 23rd, 1917.

Election of Members.

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Associate-Members.

George King Baguley, 9, Colmar Road, Yeovil, Somerset.
William John Robertson, 140, Southwark Park Road, Bermondsey, S.E.

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