INSTITUTE OF MARINE ENGINEERS

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President—D. J. DUNLOP, ESQ.

Volume XIV.

ONE HUNDRED AND FIRST PAPER.

BOILER DEFECTS AND THEIR SUGGESTED CAUSES.

BY

MR. C. W. W. HANSEN (MEMBER).

READ AT 3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, JANUARY 29th, 1902.

AND AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, FEBRUARY 10th, 1902.

PREFACE.

58 Romford Road,
Stratford,
February 10th, 1902.

A meeting of the Institute of Marine Engineers was held here this evening, when a paper on "Some Boiler Defects and their Suggested Remedies," by Mr. C. W. W. Hansen (Member), was read. The meeting was presided over by Mr. T. F. Aukland (Companion). The discussion was adjourned.

The paper was read on Wednesday, January 29th, at 3 Park Place, Cardiff, by the author before the members resident in the Bristol Channel Centre, when Mr. M. W. Aisbitt presided. The discussion was adjourned.

JAS. ADAMSON,
Hon. Secretary.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1902-3.

President—D. J. Dunlop, Esq.
Local President (B.C. Centre)—Sir Thos. Morel.

BOILER DEFECTS AND THEIR SUGGESTED CAUSES.

BY

Mr. C. W. W. HANSEN (Member).

READ AT 3 PARK PLACE, CARDIFF,

WEDNESDAY, JANUARY 29th, 1902.

Chairman: Mr. M. W. AISBITT.

58 ROMFORD ROAD, STRATFORD,

MONDAY, FEBRUARY 10th, 1902.

Chairman: Mr. T. F. AUKLAND (Companion).

In preparing this paper for the Institute it is not my intention to place before the members a learned disquisition upon boiler defects and their causes, as I am thoroughly convinced that I am addressing many far more able than myself to undertake such a weighty task, but my desire is to comment upon a few instances of boiler defects with the object of raising a discussion on that very important subject, and to open up an opportunity for members to give us some of their experiences and the causes to which they attribute the defects.

About ten years ago a very peculiar accident occurred to the boilers of a large cargo and passenger steamer lying in Cardiff docks. She was, as far as I remember, ready to proceed to sea and was raising steam when it was noticed that a great number of her furnaces were fractured round the back end. At the time, the desired information as to the cause of these fractures was not to be obtained; but some years later, when in New Orleans, whilst in conversation with the chief engineer of another steamer, which was the same age and belonged to the same owners as the one referred to, this matter cropped up, and he told me that it was the fault of the people who flanged the ends of the furnaces. As it happened that the firm who rolled and supplied the furnaces had too many orders to attend to and could not proceed with the flanging process, they sublet that portion of their contract to another firm, who had not had as much experience as themselves, and this second firm, instead of flanging in two or three heats, required a great many more heats, and thus probably altered the nature of and fatigued the material, which finally caused the fracture. It is surprising that the furnaces did not go the first voyage, but held on to the second. At the time of the accident the ship was not more than three months old.

The next accident is one with which I came into more personal contact. The boiler in this instance was over eleven years old, and the front plate of the boiler cracked above all three furnaces. My opinion is that the boiler was too rigidly stayed. The furnaces were of the corrugated type, the plate being stayed in close proximity to the furnace. From the two foregoing facts I drew the conclusion that when the boiler was warming up during the raising of steam the furnaces would expand longitudinally in a greater proportion than the stays, and so gradually force the rounding of the flanged portion of the plate in a hinge-like action between the furnace and the stays, and in a reverse way this action would take place when cooling down. Thus for years a bending forward and backward had been going on, which resulted in a fracture due to fatigue of material.

This boiler was patched first of all in a French port, where they placed thin internal and external patches on the two wing furnaces and one thick external, $\frac{9}{16}$ in. thick, on the centre one. These patches leaked badly on the ship's arrival at Cardiff, and particularly the centre one, where the fracture was found to have extended about 5 in. below the ends of the patch, but on the inside of the plate only. This patch was taken off and a new patch of same thickness made to cover the whole of the fracture, riveted on and caulked; $\frac{1}{2}$ in. holes were also drilled at each end of the fracture and tapped and pegs fitted in. When the job was finished and being surveyed it was found that the fracture had extended again below the ends of the patch, and the only way I account for this is that when the patch was being riveted on, the boiler-makers, to ensure it getting quite close to the boiler plate, hammered the patch very considerably, and so enlarged it between the two rows of rivets, which simply helped to tear the plate asunder, such I do not think would have occurred had a piece been cut out of the plate; but this was objected to by the owner's representative owing to the extra time it would have taken and so delayed the ship.

I will now turn to another and I think equally interesting and far more perplexing style of boiler, namely, the water-tube boiler. The great perplexity in water-tube boilers as compared with the marine type or Scotch boiler is that with the latter you can have them large or small, single or double-ended, yet they remain practically the same; but with the former there are so many different kinds that an engineer may become expert in the handling of one class, whereas if he should be placed in charge of another class he would at first scarcely know how to treat it.

Apart from the various patents, water-tube boilers may be divided into two classes, viz., straight-tubed boilers and curved-tubed boilers ; amongst the latter there are some very fanciful-looking designs—what their advantages are I regret to have been unable to learn. It is my intention, however, to place before the Institute a few observations which I have been able to gather concerning the former.

I will not mention the name of the boiler I propose to deal with. There is one very peculiar phenomenon I have noticed, and that is that in a certain class or make of straight-tubed boiler, the tubes in the lowest row, or that next to the fire, after some time at work take an upward curve in the centre of the tube ; why this should be so I cannot conceive, as it seems to me the reverse of what one would naturally expect, viz., that an unevenly heated surface would bend towards that side which has the most heat. This bending action has been illustrated in a very peculiar manner in the twin-screw steamer *Kherson*, of the Russian Volunteer Fleet. Mr. G. Gretchin, in a paper sent by him to the Institute of Engineers and Shipbuilders of Scotland, February 22nd, 1898, and partly published in the *Engineer* of April 1st, 1898, describes some very interesting phenomena in connection with the Belleville boilers as fitted in the *Kherson*. In this ship there are twenty-four boilers placed back to back, with furnaces athwartship ; they are divided into three groups, of eight in each group. The tubes are iron, lap welded, 4½ in. outside diameter, the two lower tubes are ⅜ in. thick, the two next $\frac{5}{16}$ in., and the remainder ¼ in. During the trials at moorings the ship had at the first trial a list of 10½° to starboard, and during this trial, although the boilers were worked under equal conditions, those on the port side gave an amount of trouble ; it was noticed, on examining the boilers the following day, that the tubes in the starboard boilers were all straight whilst in the port boilers they were nearly all bent downwards, thirteen of them from 1 in. to 1½ in. At the next mooring trial the ship was listed 5° to port, when the same thing occurred as before, but instead of the port boilers giving trouble it was this time the starboard side. During her maiden voyage from Newcastle to St. Petersburg, and thence to Vladivostock and back to Odessa, the same condition of things held throughout. One trouble which accompanied the bending of the tubes was leakages, which Mr. Gretchin explains thus: that suppose the ship listing to starboard, all the uneven tubes in the port boilers will have their back ends higher than their front ends, if the list be more than $2\frac{1}{2}°$; in consequence of this the steam bubbles will flow back to the feed collectors instead of onward to the steam drum; when this takes place the tubes will become overheated. There is another very interesting thing which occurred, viz., that when those boilers which had been previously on the high side owing to the ship's list and had their tubes bent downward, were in their turn reversed as it were, by the ship taking a list to the side on which these boilers were, then the tubes had a tendency to straighten and in some cases actually bent upward. This brings me back to the type of boilers I first mentioned and their position in the ship; they were not placed, as in the case of the *Kherson*, athwartship, but fore and aft; and another thing, for the back ends of those tubes to get into a higher position than the front end, the ship would be in such a position that I should say it was time for all hands to clear out. One peculiar occurrence with water-tubes I would draw your attention to is the blisters or steam pockets on the tubes; several of these have been taken in hand by the makers of the boilers and cut longitudinally through the blister to see if there might be any flaw in that part of the tube, but a minute examination failed to reveal anything deficient in the material. I think that there might be two reasons for these blisters: one is that it is very probable that there might have been a hole in the fire under that place where the blister showed, and so caused a fierce Bunsen flame to play on that part of the tube for a sufficient period to cause the mischief; the second reason is that it might have been a steam bubble which, unable to get up owing to the tube not having a sufficient angle, has caused the tube to be overheated in that spot and so formed a steam pocket.

Two things appear to me to cause failures in water-tube boilers: the diameter and length of tube and also the angle of rise. I think that in referring to reports of recent failures, burst tubes, etc., it will be noticed that the majority have occurred in boilers with tubes of large diameter and long length with an easy angle. It is possible that in tubes of large diameter the generation of steam is such as to leave a large amount of broken water in the tube, and owing to the slight angle and great length of tube the steam does not obtain as free a passage to the steam drum as it ought to have; and it is also possible that owing to this retarding of the steam the water may be divided in the centre of the tube by a steam bubble, which may keep the water off that portion of the tube, and so cause it to be injured locally.

On the other hand, in most boilers with small diameter of tube, the tube is shorter and placed at a much larger angle to the horizontal, thus allowing a more free discharge of steam into the steam drum; and provided that the circulation arrangements are such as to allow the lower drums to be always full of water, then I think that distortions and blistering of tubes are to a great extent minimised. In comparing the ability of water-tube boilers and fire-tube boilers to be forced, we have very recently learnt some very sad truths from the trials carried out by the Admiralty between the *Hyacinth* and *Minerva*, where the water-tubes gave so much trouble with leakages that 50 tons of water per diem was not sufficient to make up losses, whereas with the Scotch boilers the only trouble recorded was what I believe is only common to most fire-tubes when pressed by heavy fires, viz., "bird-nesting" at the ends of the tubes.

I would like also to draw attention to the amount of water carried and shown in the gauge glass. Of course we are well aware of the grave consequences attending shortage of water in a Scotch boiler, but I have spoken with engineers who have been with water-tube boilers, and they have told me that it is with the greatest difficulty that they can maintain a practically constant level; some of them are satisfied if they get the water to blow through the gauge drain-cock, and some do not appear to be much concerned even if they do not get it that way. Can it be that the steam drums are too small to carry a sufficient amount of water without being carried over into the engines? This is most important and deserves serious attention.

Referring to the feed arrangements in water-tube boilers, there are several makers of water-tube boilers who fit an automatic feed regulator, which gives very good results, but do they continue the same satisfactory operation beyond a certain point? Do they act regularly and satisfactorily when the boiler is being forced, or do they only act in such a manner when being worked under ordinary conditions?

Before closing I may refer to the economy of a water-tube boiler over that of the Scotch boiler as claimed by makers. The efficiency or deficiency of any boiler depends in a great measure upon fuel and more upon firemen. In the case of a Scotch boiler a man may be a first-class fireman, whereas with a water-tube boiler he may be no good at all. This points to the necessity—as shown in the Royal Navy—of training men specially for this class of boiler. On the question of economy, it is argued that the first cost of the water-tube boiler is less than a Scotch boiler, in respect to the water and fuel consumption, also space occupied, while in case of renewal it is not necessary to pull the ship to pieces. Against this we have cost of upkeep, constant renewal of tubes, the loss of water from leakage, when cleaning in port, the enormous amount of stores consumed to make joints for each door opposite each tube, and I think the consumption of fuel is not as economical as the Scotch boiler. This last fact was vividly illustrated in the race from Gibraltar to Portsmouth between the *Hyacinth* and *Minerva*, where the water-tube boilers consumed over 100 tons more coal in a four days' run, although at one short period their engines indicated 2,000 horse-power more, but even that did not win the race, which ended so disastrously for the water-tubes.

Mr. W. S. Hide, superintendent engineer for Messrs. T. Wilson, Son & Co., Ltd., of Hull, has very kindly sent me the following particulars in reply to my inquiry regarding their experience with water-tube boilers. The *Ohio* was fitted with Belleville boilers in 1895, but finding that they proved unsatisfactory they were removed, and cylindrical double-ended boilers fitted in 1898. Their steamers which are fitted with Babcock-Wilcox boilers are: *Nero*, 1893; *Otto*, 1898; *Tasso*, 1899; *Hero*, 1895; *Truro*, 1898; *Martello*, 1900; *Cameo*, 1896; *Rollo*, 1898.

It would be interesting to learn what it has cost to keep these boilers in repair during the various periods. As will be noticed, the oldest boiler is now eight years old. How many tubes have been replaced in that period? What length of time will fire-tubes last with proper care without requiring any renewal?

My thanks are due to Mr. Hide and other gentlemen who have very kindly assisted me with the information which I have been able to gather for this paper.

I have endeavoured to treat of a few failures and defects, with the causes which have led to such defects, in two types of boilers with equal impartiality, and as the water-tube boiler is gradually forcing itself upon us we must be prepared to look the matter squarely in the face, and tackle it with determination, making at once as thorough a preparation for it as possible.

DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, FEBRUARY 5th, 1902.

CHAIRMAN:

MR. G. F. MASON (MEMBER).

Mr. W. EVANS said he was called upon to survey, a few years ago, a ship with quadruple engines of 240 lb. pressure. Here water-tubes had come out from one end, and swinging round had knocked out other tubes. The result was that ordinary boilers had to be put in, and the engine was reduced to a triple-expansion. The size of the tubes was about 2¼ in., not big enough to easily clean, and they knew what a fireman was under such circumstances.

The CHAIRMAN said that if they got a good boiler it should last the life of the ship if properly looked after. He had however seen a good deal of trouble with the ordinary corrugated furnace at the back ends. In the cases he had in his mind the tube plates were flanged down to the furnaces instead of being flanged up, and he attributed the trouble to neglected cracks which had developed in the back seams and, of course, commenced to leak, salting up the back ends. On the other hand, he had known boilers which developed cracks the first six months that had run without trouble of any sort for eight or nine years. He thought the cause of these cracks was the bad fitting of the furnaces in the first instance, rather than to any overheating. He always considered it the best plan to have the tube plate and front ends flanged by the makers of the furnaces, so as to secure a really good fit. If that was not done they were almost sure to have some contraction set up between the furnaces and the plates owing to the former being drawn out or the latter drawn in to make a tight joint. This was the only cause of trouble he had had with his own boilers for many years.

Mr. LEWIS said the author had referred to a case which had come under his own notice. After the furnaces had been cut out and placed on railway trucks he noticed a difference in the thickness of the tubes, varying 1-16th in places.

The CHAIRMAN thought that was due to the unusually long flange at the back end. In flanging the furnaces up, the plate had been drawn so much that it was barely 30 per cent. of the original thickness of the furnaces in places.

Mr. LEWIS asked if that would be done in rolling the plates.

The CHAIRMAN replied in the negative, adding, that the flanges were set up afterwards in the case referred to. Another cause of complaint was that the plates were not annealed after being worked.

Mr. W. EVANS said no doubt forced draught got more power out of the coal than ordinary draught; but no matter how a boiler was constructed, as long as it kept steam the firemen did not trouble about covering the bars while the blast was still on, and the cold air going through struck the furnace and cracked the plate.

Mr. GEO. WALLIKER recalled the case of the *Port Caroline*, belonging to the Milburn Line, on a homeward voyage from Australia. They coaled at Perim, and up to that time the boilers had given no trouble whatever. But after leaving Perim about 75 per cent. of the tubes leaked at the back ends, and from Perim to Suez they were engaged expanding the tubes. When at Perim they were under banked fires, and as soon as the ship left, the tubes started. The water gauge fittings were all right, and the ship was a new one. They had Henderson's fire-bars, Weir's feed-pumps, an evaporator, the boilers were beautifully clean—no sediment—and used good coal, although in the course of the voyage from Australia to Batavia, Japan and China, they had changed the fuel. The strange thing was no defect in the tubes showed itself afterwards. In another case the trouble arose from defective water gauge and fittings. It was one of the first ships fitted with the patent ball fitting, and somehow it stopped up, and the vessel had been but a few hours on its trial trip when three furnaces of the six in the centre boiler gave out.

Mr. HANSEN said he was reminded of a similar experience. It was on a voyage from Cardiff to Bombay, the ship six months old, and all the tubes began to leak in the back end without any apparent cause. When they were all expanded there was no more trouble. They attributed it to insufficient expansion.

Mr. EVANS : That was not the defect of the boiler, but of the workmanship.

The CHAIRMAN said he had known a lot of trouble to arise from the use of the native coal referred to. The Labuan coal, for example, would burn like a piece of wax—it was very nice-looking coal, round cobbles —burning very fast and giving out a terrific local heat for a few minutes, quickly dying away to a dull red. At its short-lived maximum, the intensity of the heat was enough to melt the fire-bars.

Mr. TOD thought great credit was due to the author of the paper, which, however, might have had its value enhanced if it had referred to defects arising from corrosion and incrustation and their causes. With regard to the second case referred to by the author, it took eleven years for that flaw to show itself—a period which was sometimes the life of a boiler. As to water-tube boilers, he did not think there was a water-tube boiler in the market yet (at least in its present form) which was going to replace the old fire tube or Scotch boiler in the mercantile marine. Nevertheless, they might look forward to seeing a water-tube boiler carrying at least double the pressure now being carried, which would replace the old cylindrical marine boiler. This would enable them to reduce the piston area and run at a higher velocity, even if the old vertical type of engine was not replaced by the turbine. As to feed arrangements, there were various methods of automatically feeding boilers. One consisted of fitting a tank in the engine room which always showed the same water-level as the level in the boiler. It had a float arrangement which controlled a valve in the feed-pipe. Another feed arrangement was an independent pump altogether, which received steam from an internal pipe, the end of which terminated at the water level. When the water got below the pipe the steam passed to the pump and forced more water into the boiler, and when the water rises above the pipe water will pass and the pump works hydraulically, and so a constant water level is maintained.

Mr. WALLIKER said there was no doubt the life of a boiler, assuming it to be originally well constructed, depended upon the chief engineer. If the boiler was badly used the first six months, it was going to be a bad boiler. He instanced the case of two vessels, both with a well-known maker's boilers, both of the same age: in one vessel the boilers caused no trouble, the same chief engineer being in the ship from the first; in the other, a poorly paid ship, where the chief was changed almost every voyage, there was always trouble with the boilers.

Mr. EVAN JONES agreed that a good chief engineer had a great deal to do with the prevention of boiler defects, but he could not be held responsible for defects arising from inherent defects in design and material. As to general defects, his experience was that it was the double-ended boiler which needed the most repair. Why this was so had puzzled a great many people. His opinion coincided with that of the author of the paper—boilers were too rigidly stayed. Then in the majority of cases they were badly designed. The Board of Trade and Lloyd's allowed a very great latitude in the design of boilers so far as the staying was concerned. He agreed with Mr. Walliker as to the vastly different results accruing from two boilers built about the same time, by the same firm, and from the same drawings. The explanation probably lay in inherent differences in material and in the methods of manipulating the boiler. The care of the engine and that of the boiler were arranged for very differently. If there was anything wrong with an engine it was renewed; if there was anything wrong with a boiler it was patched up.

On the motion of Mr. TOD, seconded by Mr. MORGAN, the discussion was adjourned for a week.

A vote of thanks to the Chairman concluded the proceedings.

ADJOURNED DISCUSSION

AT

3 PARK PLACE, CARDIFF,

ON

WEDNESDAY, FEBRUARY 12th, 1902.

CHAIRMAN:

MR. M. W. AISBITT (MEMBER).

The CHAIRMAN said the first case of fracture referred to by the author was probably due to the flanging process carried out by the firm other than that which had rolled and supplied the furnaces. Instead of the end of the furnace being staved up so as to thicken the metal in way of where it had to be flanged to allow for stretching, it had evidently been flanged off the ordinary thickness thus allowing the material to become much thinner in way of the flanged parts. With regard to the second case, he agreed with the author as to the probability of too rigid staying causing the front plate of the boiler to crack above the furnaces, which expanded more than the stays. He also concurred with Mr. Hansen that water tubes with only a low angle and of large diameter and length were likely to give trouble.

Mr. W. EVANS quoted the case of a boiler built in Cardiff. The back plate was put in in two halves riveted together. It was always giving trouble when the steam went down. The rivets were taken out, when the plate was found to be cracked from side to side, right through the rivet holes in the combustion chamber. Pieces were cut out in three or four different places, and it was found that there was no deterioration whatever in the plate, which was of the original thickness.

Mr. T. W. WAILES said he believed he was the builder of that boiler. At that time he was full of hope of Cardiff becoming a boiler-making port. He had not the record by him, but he was almost sure that the plates mentioned by Mr. Evans were of steel. At that time they could better deal with steel than with iron—unless it was the expensive Low Moor iron. But steel was a very precarious material to deal with; and he recalled how a workman threw his coffee on to a tube plate lying on the ground, being flanged, when the plate split three-parts through. That plate was afterwards cut in two and made into two top plates, and those plates were still in service. They had better material to work with now, but greater liberties were taken with it. They were reducing their proportions and sizes, etc., but it should be remembered that just as lifting gear became fatigued so did their boiler material lose its vitality. The great thing was to have their boilers thoroughly annealed. Then it was a question whether too many rivets were not put in. Much incrustation, due to sweating, etc., took place at the rivets. They must avoid a multiplication of different materials, and also too rigid staying fore and aft. To design a boiler without stays would be the ideal. Then great mischief was done by hurrying up steam and hastening cooling.

Mr. ROBERTS said, with regard to Mr. Hansen's observation about the length of the water tubes, that he believed the tendency was to increase the length.

Mr. H. BRANDON thought all cracking trouble with the Scotch boiler would be obviated by the proper annealing of the plates—heating them to a continued cherry-red and allowing sufficient time in which to cool uniformly from end to end, covering them with sawdust or hot ashes. The best way to keep boilers from deteriorating was to gradually cool down, and as the water was running off put the hose in at the side and wash the boiler free of sediment along the tubes and at the backs. Incrustation was a great cause of plate-splitting and burning. Dealing with water of temporary hardness, all they had to do was to re-heat the water sufficiently to allow it to get rid of its carbonic acid gas, when the carbonate of lime sinks to the bottom. This was the "fur" in the domestic kettle. But sulphate of lime, the bugbear of the boiler, was a different thing altogether. It was a hard, crystallised mass, produced by water of permanent hardness. To turn this into carbonate of lime was why they put soda into the boiler. He calculated that to do this they required about 2½ lb. of soda for every ton of water used in the boiler. Common soda contained only about 30 per cent. of carbonate of soda, the rest being water, so that in paying 7s. 6d. per cwt. for carbonate of soda they would get as three to one, and it would act very much better in getting rid of scale. As to pitting or wasting, it was originally produced by foreign matter in the material of which the boiler was made. The best remedy, if the place was bad, was to cut out the piece of plate and put another in its place, or thoroughly cleanse with gold size cement, or white or red lead, so as to prevent the strongly exciting action of the chloride of sodium. He had not much faith in the zinc plate. Within a comparatively few days there was formed a thick coating of oxide of zinc. He had seen zinc put in with conical studs, and within four days there had been a cover of oxide of zinc between the two which no galvanism could pass.

Mr. A. S. JACKSON said the shell plates of single-ended boilers rapidly deteriorated owing to accumulation of soot, etc., in the up-take above the water line. As to zinc plates, he used to have faith in them, but of late years he had come to the conclusion they were no good at all. With regard to pitting, he had found the use of wire brooms beneficial. He did not believe in closing up the pittings with any cement; the best way was to attend to them at the start, and scrape and clean them thoroughly and regularly. One serious cause of corrosion was the use of certain lubricants. Other material got into a boiler besides water.

Mr. T. A. REED had great faith in the small type water-tube boiler for the class of vessel for which it was designed; it enabled steam to be raised in a very short time without any bad results common to the ordinary marine type. He cited a case of a torpedo-boat destroyer on the China station during the recent troubles there which was hit by a shell from one of the forts, the same penetrating through the side bunkers and into a nest of tubes. Nothing serious happened. The shell, fortunately, did not explode, neither did the boiler. The fire was then immediately extinguished in that boiler and she steamed with the others. A large tube-boiler would in a similar case probably have caused considerable trouble and loss of life instead of only a few tubes being simply bent into a bunch. He had also seen a small tube which after a few years' use was sawn up the middle to ascertain if any scale was deposited; there was no scale, however, and he attributed this to the rapid circulation through the tubes.

The author of the paper had mentioned the want of a satisfactory automatic feed regulator. He considered this want had been filled, and he recalled the case of a destroyer while on the run round from the builders to the dockyard had to depend entirely upon the automatic feed regulator the whole way round, as all hands were sea-sick owing to the rough weather. This regulator has always given most satisfactory results. As to the use of zinc in boilers he did not agree with Mr. Brandon's remarks, and considered the use of zinc and soda, either as plates or otherwise, was most beneficial. The only satisfactory way to use zinc plates was to fit them on studs, which method was adopted by the Admiralty, thereby bringing the plates into metallic contact.

He had not yet found a case where corrosion in a boiler could not be practically stopped, if accessible. There was no reason why a boiler should not last nearly as long as the ship if properly constructed and intelligently cared for. Improper raising steam and blowing down same at the end of a voyage was a common cause of trouble. In raising and lowering steam care should be taken to secure a uniform expansion. Boilers should never be blown down but allowed to cool down. The great difficulty in these days of rapid loading and discharging was to get sufficient time to properly work a boiler.

Mr. FRASER said defects in boilers were by no means all caused by defective design. Much, for example, depended upon the care and intelligent treatment meted out to them by the engineer. In this matter "cleanliness was next to godliness." With common soda and ordinary treatment most boilers could be kept well. He admitted, however, that evil arose from different metals coming in contact with the feed water. As to pitting, it took place mostly towards the bridge. Fire-clay and bricks were very injurious. They did not allow sweating, and it was in the parts where the plate could not bead freely that the damage was done. Then, furnaces and combustion chambers should be so fitted as to be allowed to breathe a bit. If the expansion did not give on the furnaces it would give on the rivets.

Mr. EVAN JONES was of opinion that trouble with boilers arose from defective design, defective material, and defective workmanship.

Briefly replying on the discussion, Mr. HANSEN said he agreed with Mr. Evan Jones that, granted good design, material, and workmanship, plus careful tending, there was no reason to expect trouble with boilers for many years. A well-designed and well-constructed boiler depended upon the first six months of its use. With what had been said as to the importance of proper annealing he was in hearty agreement, as he was also with the necessity of exercising discretion in the raising of steam and the cooling down of the boiler. If a boiler was allowed to cool itself down for 24 hours, and the water then pumped out, it would go far to keep it in good order. There was much, too, in what had been said as to evil arising from the feed-water coming in contact with various metals and causing chemical action to be set up in the boiler.

On the proposition of Mr. E. NICHOLL, seconded by Mr. BRANDON, a vote of thanks to the author of the paper was carried by acclamation.

Before the proceedings concluded,

Mr. T. W. WAILES intimated that it was the intention of the directors of the Mount Stuart Dry Dock to invite the Bristol Channel Centre to inspect their new dry dock upon its completion. He promised that they would see something to interest them.

Mr. HANSEN'S reply: In reply to Mr. Lawrie's remarks,* I must agree with him that remarkable things are done in Cardiff and that it is a fortunate thing for owners that their superintendents tell the ship repairer how things are to be done; otherwise, if the repairer could work out his own sweet will he would not be satisfied with, in fact would not "tolerate," patching a boiler, but would build and supply a new one instead, and then in all probability send in a good stiff bill for same.

The other remarks were very interesting and simply illustrate the diversity of opinions on water-tube boilers. I desire to take this opportunity of expressing my sincerest thanks for the honour done to me by the manner in which my paper has been received.

DISCUSSION

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, FEBRUARY 10th, 1902.

CHAIRMAN:

MR. T. F. AUKLAND (COMPANION).

MR. W. McLAREN (Member of Council) said he must congratulate the author on having brought forward a paper of this character, for the boiler question was one that they could always argue about. At the same time, he was not prepared to accept all the statements that the author had made. In the third paragraph of the paper, for instance, the author spoke about a boiler being too rigidly stayed; but, if this was the cause of the accident, what force must

* Cf. Discussion at 58 Romford Road.

there have been to crack this plate? From his experience of tight-stayed boilers, he believed that this crack must have existed from the first. Referring to another case, the author said: "I will not mention the name of the boiler I propose to deal with," but he thought that they ought to have the name of this particular boiler. If it was one of the Belleville boilers he could not say that he had had any experience with them, and he was not very partial to boilers of the water-tube type, although he had a Babcock and Wilcox boiler under his charge at the present time, and it was doing very well. With regard to the question of the tubes rising instead of falling, he had to do, some years ago, with an elephant boiler, and some of the tubes going through the fire space were arched. He attributed this to the fact that the top sides of the tubes were comparatively free from the flames, and the heat being nearly all on the under sides caused them to rise. It would be very interesting if Mr. Hansen could give them more information about the experiences at sea with the Babcock and Wilcox boilers that had been fitted in several of the Wilson liners.

The HON. SECRETARY stated that this paper was read before the members at the Bristol Channel Centre, in Cardiff, and had been in part discussed there. Mr. Peter Smith (Member) had sent the following contribution, having been unable to attend in person.

Mr. P. SMITH (Member): "I do not agree with the theory that the furnaces cracking at the back ends was due to the firm that flanged them, neither do I think it would matter, if the material is good, how many heats it required to complete the flanging process, providing the precaution was taken to have the plates annealed after all local heating was finished. This applies very forcibly to steel plates. The author does not state whether these furnaces were iron or steel, or what type they were. I have seen in a first-class boiler shop various cases of combustion chamber plates cracking, even when made of the best of steel, through want of ordinary care. I observed on one occasion a combustion chamber back plate badly cracked while being flanged; the work was about half completed when knocking off time came, and the plate was left lying exposed in the shop. The next morning a fracture about 18 in. long and considerably open was discovered. This took place about the junction between the cold part of the plate and where it was black hot. The weather was cold at the time, and if the workmen had taken the precaution to cover it with hot ashes before leaving the works it would not have happened probably. A survey was called and the material was blamed, the steelmakers replacing the plate at their own cost. In the course of building a boiler enormous strains are set up by local heating, but most boilermakers now take the precaution to anneal all plates exposed to high temperatures just previous to riveting. I have not had any experience of water-tube boilers. I understand, however, it is always advisable to have them fixed fore and aft to avoid the danger of having the tubes bent and leaking through overheating as in the case quoted by the author."

Mr. G. SHEARER (Member) said that when speaking of cracks in the plates of furnaces the author did not mention what class of steel the plates were composed of. Of course we were now getting very superior steel for this purpose compared with that formerly obtainable. The first disaster with steel plates occurred in the case of the *Livadia*, which was a special kind of vessel built for the Russians from the designs of Admiral Popoff. Her boilers were made of either Bessemer or Siemens steel, but the material was far from what it ought to have been for boiler plates. Instead of the holes in the plates being bored they were punched and reamed out, and when the boilers were tested the hydraulic pressure had only reached about half the test pressure when the boilers gave way at all the longitudinal seams. Nearly the whole of them were, he thought, split across, and of course the boilers were useless. New boilers made of a different steel were afterwards supplied, and they caused no trouble. The author spoke of cracks in a boiler front, but he (Mr. Shearer) had never had any experience of them. He had had cracks in the combustion chamber at different times and also in the furnace, although this was a number of years ago when steel was not of the same quality that it was now. He supposed it was too rich in carbon, and local heating was no doubt the cause of the cracks. The author did not tell them what kind of furnaces they had in that ship where the boiler fronts gave way, because if they were corrugated furnaces he (Mr. Shearer) should say it would be impossible for what was described to have taken place.

The HON. SECRETARY: It is stated they were corrugated furnaces, but not of what type.

Mr. SHEARER: If they were corrugated furnaces it is impossible that that would take place from the rigidity of the furnaces, because it is one of the principal points of a corrugated furnace that expansion and contraction will take place in the furnace. Mr. Shearer, continuing, said he had had experience with Belleville and other water-tube boilers, and it certainly was a rather curious circumstance related by Mr. Gretchin in the case of the *Kherson*, that while some of the tubes rose, other tubes fell. He (Mr. Shearer) had often had falling tubes but never rising tubes, but his experience had been with furnaces placed fore and aft, while in the case of the *Kherson* they were athwartship. The only explanation he could suggest for the tubes bending upwards was that at the bottom of the tube there was probably a certain amount of water, while at the top there was only steam, and, with the intense fire burning with forced draught, it was quite possible that the upper portion of the lower row of tubes would be heated, while the lower parts would be kept cooler. There being more heating, therefore, on the top side, the tube bent upwards. Referring to blisters or steam pockets on the tubes of water-tube boilers, the author suggested that the hole in the fire possibly caused a fierce Bunsen flame to play on that part of the tube for a sufficient period to cause the mischief, but if he had had experience with Belleville boilers he would have found that the very reverse of what he suggested took place. It was absolutely necessary, in order to carry steam on these boilers, to have very light fires —from 3½ to 4 in. thick—and if they got holes in the fires, such as the author described, they would find that they were raising steam with one part of the fire and condensing it with another. Mr. Shearer also alluded to the circulation in small tube boilers, such as were used for torpedo boats and destroyers, and pointed out the wide difference between the angles of the tubes in these boilers and those fitted in boilers of the Belleville type. It was, he said, a case of 60 or 65 degrees compared with 2½ or 3 degrees, and of course the steam bubbles would ascend much more quickly where the angle was 65 degrees than where it was only 2½.

Mr. H. BALES (Member) said that in the second paragraph of the paper the author dealt with what he called a peculiar accident, and it certainly was a peculiar case. It was remarkable that the initial fracture was not noticed by the inspectors, if there were any, when the furnaces were inspected before they were put in the boilers, and it was still more remarkable that this defect was not noticed at the examination on the arrival of the ship in port after the first voyage. The author might be right in his suggestion as to the cause, but it was rather curious that if the defect was due to fatigue of material through repeated heats in flanging the defect did not develop itself when first raising steam. The author might be right in his suggestion, but he (Mr. Bales) thought the cause was to be looked for elsewhere.

Again, fatigued material was remedied by annealing, and the Board of Trade required a plate, after it had been worked, to be annealed. He believed that the defect was brought about by the way the boiler was treated after being put to work—by the method of firing, for instance—not by defective material at all. In the case of another accident to which he referred, the author suggested as the cause that it was too rigid. The plans were subject to the inspection of the Board of Trade, and if the staying was too rigid why did not the Board of Trade, who had such a wide experience, point it out? And if the accident was through too rigid staying what was the value of corrugated furnaces? He understood that one of the most important advantages of the corrugated furnace was its effect in absorbing the expansion in itself and not passing it on to the plates. He believed that there was very little in either suggestion put forward by the author as to the causes of the defects in these two cases.

Mr. W. E. FARENDEN (Member): Regarding the fracturing of the furnaces round the back end, mentioned in the first paragraph, page 4, of the paper, I think you will agree, gentlemen, that it was a bad principle for one firm to sublet the work of flanging the furnaces to another, and who were, as stated, not experienced in this class of work. Using a number of heats in flanging no doubt altered the nature of the material, and the uniform thickness of the plate may not have been maintained but slightly reduced. The author has omitted to give the material the furnaces were made of. I should like to know whether the furnaces were carefully annealed after being so treated in flanging.

I cannot agree with the author, in third paragraph of the paper (page 4), that the front plate of the boiler cracked above the furnaces owing to the boiler being too rigidly stayed at this part, as I find it is the common practice to stay this plate in close proximity to the round of the plate with corrugated furnaces. It is rather the rule than otherwise that boilers are stayed at this part, as mentioned by the author; if the staying, as suggested, was the cause of the plate fracturing, then I think this would have shown up in many more boilers stayed in a similar manner and brought prominently to our notice, and boilers built to the Board of Trade or Lloyd's requirements would have been altered at this part.

The discussion on the paper was adjourned until Monday, February 24th.

A vote of thanks to the chairman, proposed by Mr. MATHER and seconded by Mr. ELMSLIE, concluded the meeting.

DISCUSSION CONTINUED

AT

58 ROMFORD ROAD, STRATFORD,

ON

MONDAY, FEBRUARY 24th, 1902.

CHAIRMAN:

MR. WM. McLAREN (MEMBER OF COUNCIL).

THE HON. SECRETARY: The following communication has been received from Mr. Hansen in reply to the discussion which took place here at our last meeting.

"Mr. McLaren remarked that it would be interesting to hear any further information about the experience of the Babcock and Wilcox boilers as fitted in several of the Wilson liners. Here I regret that no more information was forthcoming other than what I mentioned in my paper. In reply to Mr. Peter Smith, I think that the firm which flanged the furnaces was to a great extent responsible, though not in the manner that I suggested. It transpired during the discussion at Cardiff what was in a large measure the cause of those furnaces giving way as they did. Mr. Aisbitt drew attention to the fact that when the furnaces had been drawn out of the boilers it was seen that the end of the furnace plate, instead of being set up somewhat thicker than the body of the furnace, was actually a full sixteenth less in thickness. Mr. Lewis, who was also on that piece of work, noticed when the furnaces were in the railway trucks that the ends where the fracture had taken place appeared to be thinner on one side, and to make sure of it he measured them with callipers and rule, and found that there was a difference of over a sixteenth. The furnaces were of steel, and I believe of the Purves type. Mr. Shearer asked what class of steel the furnaces were made of. I can only say the information I obtained was that they were rolled at Messrs. John Brown & Co.'s works, at Sheffield, and that, in my opinion, is a recommendation of its own, but they did not do flanging. Mr. Shearer's theory as to the cause of large tubes bending up goes a long way, I think, to explain the reason why they do take an upward direction, and I frankly admit that it never entered my mind as being a cause to reckon with. His remarks upon the state of the fires, I think, go far to corroborate my assertions that to fire a water-tube boiler properly we must get men specially trained for that class of firing. As regards Mr. Bales's remarks about the Board of Trade requiring a plate which had been worked to be annealed, I would ask how many plates are annealed properly? I have seen a furnace plate annealed by having a wood fire lit around it, and then left to cool in the open air. My idea of annealing is to bring the plate to a dull red heat and cover it over with sawdust or dry sand and leave it to cool in a place where there are as few draughts as possible. As to the plans for the construction of a boiler being submitted to the Board of Trade, I don't think that the Board of Trade finds fault with a boiler for being too strong, but the Board of Trade allows a considerable amount of latitude in the staying of boilers. The advantage claimed for a corrugated furnace is to take up its own expansion, but I am afraid that I must disagree here, as I have noticed in the corrugation of a Purves tube that there is in one portion of it a section of 1¼ in. to 1⅜ in. of metal vertical to the axis of the tube. Now I fail to see how such a section can absorb its own expansion, and not being able to do so, either the furnace collapses if the pressure be high enough or the front end of the boiler is forced out."

The CHAIRMAN, having called attention to several points which seemed to invite discussion, Mr. W. LAWRIE (Member of Council): The second accident referred to in the paper occurred, in the opinion of the author, because the boiler was too rigidly stayed, but it was not at all clear how the extra staying caused these fractures. There the cracks were, however, after eleven years working, and at places where they were not usually looked for. The boiler repairing carried out at Cardiff in this particular instance was of a very elementary character. It would seem that, instead of having the work done properly, the superintendent said, "No, you must do it in a certain time, and efficiency must take a second place." Of course if that kind of system was carried out there would be plenty of trouble with boilers. They heard of remarkable things being done at Cardiff, but he should not have thought that they would have tolerated things of this sort. Mr. Lawrie also referred in some detail to the *Hyacinth* and *Minerva* trials, and said the results, so far as reported, presented some rather remarkable features. One point brought out very clearly was the large loss of water that occurred with the water-tube boilers on the *Hyacinth*. One could not help smiling, however, at the list of defects that had been presented with regard to the cylindrical boilers. The great defect that was found on this particular run between Spithead and Gibraltar was bird-nesting, but this was a defect in the treatment and not in the boilers, and it was put forward by one of the engineering papers as a defect that could not be remedied. To say that bird-nesting could not be prevented was saying that which was not the case. It seemed to him that in these particular trials the cylindrical boilers stood the test very well, especially if they considered what happened on the other boat, which had to come to a dead standstill for want of fresh water after running some 1,800 miles.

Mr. METCALF said he entirely agreed with an observation that fell from a previous speaker as to the difficulty of discussing a paper of this sort until they had all the material facts before them, and he therefore proposed to limit his remarks to the defects, and to the methods for meeting those defects, in the Babcock and Wilcox boilers, of which he had had some six years' experience. But first he might state, in reply to a question that had been asked, that the cost of the up-keep of the Babcock and Wilcox boilers fitted in the Wilson liners compared very favourably with that of the ordinary cylindrical boilers running in similar trades under similar conditions. Practically the only defects in these boilers were blistered and bent tubes, and these defects, so far as they had been able to ascertain, had generally been due to the excessive accumulation of scale, or to oil deposit. The chief difficulty they had experienced up to the present had been the leakage of seawater into the feed, and that still remained a very difficult problem. The only possible way in which they could prevent salt getting into the boiler was to see that the condenser was quite tight. With reference to the author's remarks that the majority of failures occurred in boilers having tubes of large diameter and long length with an easy angle, he would say that in their type of boiler for land use they had tubes 4 in. in diameter running up to 18 ft. in length, and many of these boilers had been working for a number of years without showing any defects by tubes giving out owing to their bending or blistering. In their marine boilers the most recent development was the adoption of $3\frac{1}{4}$-in. tubes throughout, instead of $1\frac{7}{8}$-in. tubes as in former designs, the smaller size now only being used in special cases where either the space was limited or light weight of great consideration. The chief advantage of the larger tubes was in the fact that they could be examined and cleaned more quickly. The adoption of a new system of baffling, by which the gases of combustion were made to travel three times over the surface of the tubes, had also resulted in increased economy of coal consumption, especially with poorer classes of coal, and when the boilers

Martello, said he thought it a very bad sign when firemen left a steamer every voyage. When firemen found a good job they generally stuck to it. From his experience of water-tube boilers generally he thought the design of the Babcock and Wilcox boiler was good, but he did not think that it could be an economical boiler. He did not believe that any water-tube boiler could be an economical boiler, so far as he could judge from the designs at present available.

Mr. RUTHVEN, Mr. BALES, and other members, having spoken on the subject, the discussion was declared closed.

The CHAIRMAN reminded members that on Monday, March 3rd, Mr. J. T. Milton, the chief engineer surveyor to Lloyd's Register, would deliver Part I of his lecture on the "Microscopic Structure of Metals," illustrated by lantern views, and Part II of the lecture would be delivered on the following Monday, March 10th. The annual meeting of the Institute would be held on March 14th, and on March 24th Mr. H. M. Rounthwaite would read a paper on "The Balancing of Engines.'"

A vote of thanks to the Chairman concluded the meeting.