INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1901-1902.

President—JOHN CORRY, Esq.

BRISTOL CHANNEL CENTRE.

Local President—SIR THOS. MOREL.

VOLUME XII.

NINETY-FOURTH PAPER

(OF TRANSACTIONS)

TREATMENT OF BOILERS

UNDER

FORCED OR INDUCED DRAUGHT,

BY

Mr. JOHN H. SILLEY (*Member*).

READ AT

THE INSTITUTE PREMISES, 58 ROMFORD RD., STRATFORD,

ON MONDAY, FEBRUARY 11TH, 1901.

AND AT

3 PARK PLACE, CARDIFF,

ON WEDNESDAY, MARCH 6TH, 1901.

PREFACE.

58 Romford Road, Stratford,

February 11th, 1901.

A meeting of the Institute of Marine Engineers was held here this evening, when a paper on "The Treatment of Boilers under Forced or Induced Draught," by Mr. John H. Silley (Member), was read, and in part discussed.

The Chair was occupied by Mr. T. F. Aukland (Companion). The discussion was adjourned till next meeting, Monday, February 25th.

JAS. ADAMSON,

Hon. Secretary.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1901-1902.

President—JOHN CORRY, Esq.

NINETY-FOURTH PAPER OF TRANSACTIONS.

THE TREATMENT OF BOILERS UNDER FORCED OR INDUCED DRAUGHT.

BY MR. JOHN H. SILLEY (*Member*).

READ AT

58 ROMFORD ROAD, STRATFORD,

ON MONDAY, FEBRUARY 11TH, 1901.

Chairman—Mr. T. F. AUKLAND (*Companion*).

As forced and induced draught boilers are now being largely adopted by shipowners, the number of ships which arrive in port with boilers out of order is sufficient excuse for the title of this paper, and for bringing the subject before the members of the Institute. I feel sure that a discussion on the part of those who have had experience with this class of boilers would produce much valuable information, whereby plans could be devised to prevent accidents that are continually occurring in the use of forced and induced draught, and I daresay many will agree with me that while the inside treatment of ordinary or forced draught boilers may be similar, both forced and induced draught boilers require special precautions to be taken in their treatment from the stokehole.

I consider many of the accidents to boilers are due to the following causes:

(1) By the carrying of excessive air pressure.

(2) By allowing the fire bars to become bare, and allowing a rush of cold air to strike the heated plates—this often occurs with a light fire and high air pressure.

(3) The bulging of combustion chamber backs through the bridges getting knocked down and allowing the fierce heat to strike the back of the combustion chamber, and having no means to baffle it.

(4) By the wedging in of the fire bars, the bars expanding more than the furnace, and thereby forcing the sides of the furnace out.

Undoubtedly one of the first questions that arise when any ship arrives into port with forced draught boilers damaged is that of air pressure. In several of the boilers that I have heard of, this appeared to be due to excessive air pressures. What air pressure then shall we say should be carried with safety under different conditions? I think that, whereas a light scale $\frac{1}{16}$ in. thick would do no damage in an ordinary draught boiler other than impair its efficiency, it is quite possible that the same boiler would be easily damaged under forced draught by excessive air pressure, and as boilers in many cases have to work continually from two to three months without any inside examination, there is always the possibility of a certain amount of scale forming, due to unavoidable causes. It therefore behoves every engineer in charge of this class of boiler to pay very careful attention to air pressure, as any excessive pressure, though only temporary, may do serious damage. Different methods have been adopted to prevent damage occurring: some of these in my opinion only assist the evil. In some cases, the practice of locking the stop valve is adopted. One engineer informed me that he set the air pressure at 3 in. leaving London and took the wheel off the stop valve to prevent anyone tampering with it, the fan not being touched for weeks together. I consider this a great mistake, for immediately it is required to check the draught the firemen have to rely on shutting, say, half the number of air valves, thus setting up an air pressure of possibly 5 in. to 6 in. in the other furnaces, which is the very thing that should be avoided. I consider that, to get satisfactory and economical results, the fan must be under the perfect control of the engineer on watch so as to ensure the air pressure being kept perfectly steady.

I think I am right in saying that a less quantity of air is required when working with forced draught than with ordinary draught, owing to the air being properly distributed. The air being heated not only saves so much heat that would be otherwise lost, but also allows a more facile and rapid union of the oxygen of the air with the gaseous products and carbon of the fuel.

Taking the theoretical quantity of air required to burn 1lb. of coal at 12 lb.; in ordinary practice with natural draught, 24 lb.; I don't think we shall be far out if we assume 18 lb. of air to each pound of coal with forced draught.

The following rule will give us an idea of the waste of coal if excessive air pressure is carried.

Taking the mean specific heat of the products at

·237 Rankine, we have, assuming 2 in. air pressure to mean 18 lb. of air:

$$\text{Total heat of combustion } \frac{14500}{(18 + 1) \times \cdot 237} = 3220^\circ$$

If we increase our air pressure to 3 in., we have:

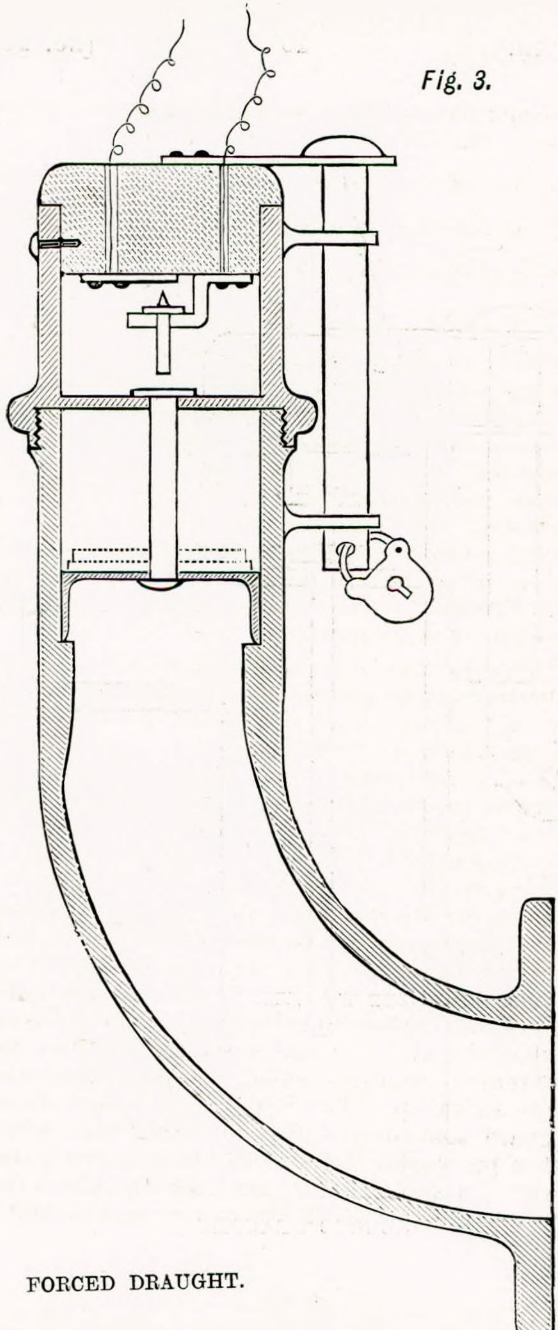
$$\text{Total heat of combustion } \frac{14500}{(27 + 1) \times \cdot 237} = 2218^\circ$$

which shows a difference of 1002 degrees.

From the above it is readily understood the great loss that must necessarily arise from any excess of air pressure. The supply should be restricted to the minimum amount which is consistent with perfect combustion. Any excess of air in the first place reduces the temperature within the furnace and diminishes the rate of conduction through the heating surface, and also augments the bulk of the gaseous products of combustion, and thus makes it more difficult for the heating surface to reduce the temperature of the products.

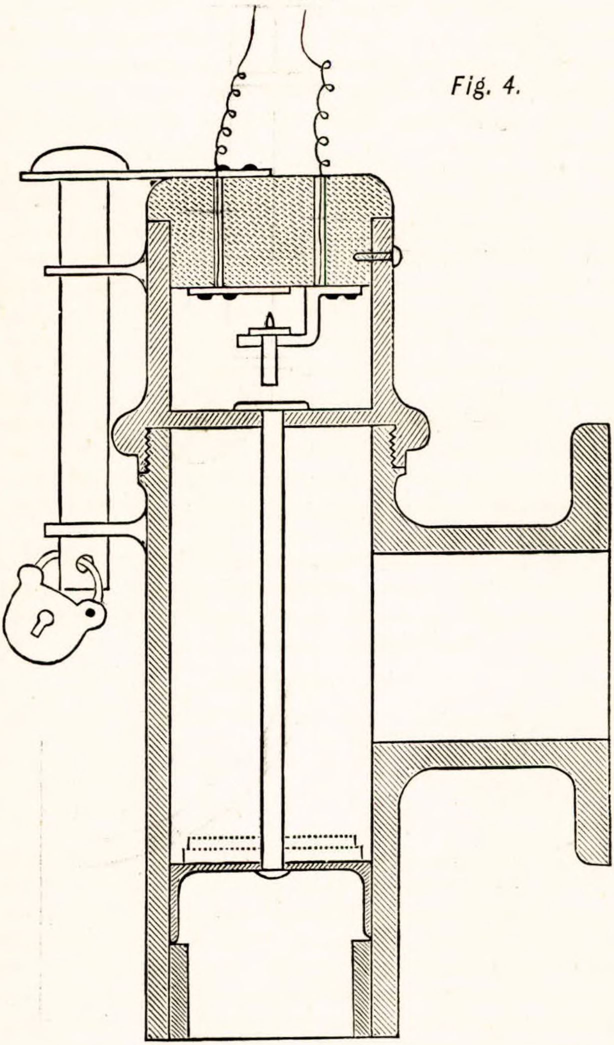
When we take into consideration that, in addition to the risk of damage to boilers, possibly 10 to 15 per cent. of coal may be wasted owing to want of attention on watch, you will agree that some means are required to prevent this occurring. To ensure careful attention to the air pressure at all times, I fitted to the ss. *Star of New Zealand* an automatic air pressure alarm, which can be regulated to suit any desired pressure and will give warning by electric bell immediately the required air pressure is exceeded. This arrangement can be fitted to the side of the fan or other desired position, and can be locked up to prevent tampering with it. It not only prevents the engineer on watch from carrying more pressure of air than you wish, but also warns the engineer should the firemen check the steam by shutting a number of the air valves. This is a practice I have often had to guard against, the firemen doing this with the idea of preventing the engineer from slowing the fan down. I may say that I have used this alarm for the last twelve months with satisfactory results, and have

Fig. 3.



FORCED DRAUGHT.

Fig. 4.



INDUCED DRAUGHT

always found it reliable. My experience has proved that this fitting is entirely agreeable to the engineers, as it prevents one watch getting an unfair advantage over another. Of course the bell can be so arranged to either warn the chief engineer or the engineer on watch, or both (see Figs. 3 and 4).

John Liversidge, R.N. (*Engine Room Practice*, page 81), states:

"The fans supplying the air to the furnaces must be run at a regular speed. It often happens that the fans are used to cloak faulty stoking; the fires having been heavily fired, the speed of the fan is temporarily increased to force the air through the fuel, whilst when the fires are subsequently burnt, then the speed is diminished. This practice should be corrected, and the system of quick regular stoking established."

I also found the watch that properly works the fires can keep steam on from $\frac{3}{4}$ in. to 1 in. less air pressure than a careless watch, whose fires you will often find too solid in one part of the bars, and full of holes in other parts which are getting the full force of the air.

I have copied the following table from Hutton's *Practical Engineering*, which will confirm my statement as to the quantity of air used at the different pressures. The table is headed:

WIND PRESSURES.

1	in.	Water pressure =	$5\frac{1}{2}$	lb. per	sq. ft.	Velocity,	57	ft. per sec.
$1\frac{1}{2}$	,,	,,	$7\frac{3}{4}$	,,	,,	,,	68	,,
2	,,	,,	$10\frac{1}{2}$	,,	,,	,,	78	,,
$2\frac{1}{2}$	,,	,,	13	,,	,,	,,	88	,,
3	,,	,,	16	,,	,,	,,	97	,,
$3\frac{1}{2}$	,,	,,	$18\frac{1}{4}$	,,	,,	,,	104	,,

And while dealing with this question of air pressure, I would suggest that the temperature of the funnel should occasionally be tested with a pyrometer, and if frequently compared with the air pressure carried this would show the most economical air pressure to carry, and would give an idea of the loss which occurs when using too much air. According to some Admiralty tests, with severe forcing of boilers the temperature of funnel has been recorded as high as 1,444° Fahr. Any temperature approaching anything like that must be produced at a considerable waste of fuel.

As a protection against excessive air pressure, some steamers are being fitted with an automatic relief valve, which works similar to a flap valve. I consider there are several reasons against its adoption. In the first place, it will require to be very large, which means a difficulty in keeping it tight, besides the possibility of the fan running faster to make up loss caused by leakage. If fitted in the engine room, it means a cloud of dust every time the valve opens, and if fitted in the stokehole it is practically useless, as it cannot possibly have proper supervision. I have been able to keep the air pressure with a part of the air casing open by running the fan so much faster. It is therefore questionable if a relief valve is of much advantage.

It has been suggested to me that a governor should be fitted to the fan engine, to regulate the speed of the fan, or to slow it down if the required air pressure is exceeded. This may appear all right in theory, but I am afraid it would not work very well in practice. In the first place, the fan has to run at so many different speeds, especially when cleaning fires. It would also be a very difficult matter to fit any arrangement that could control the fan by the air pressure, when the mere tightening of a gland would possibly affect it and prevent it working.

The late Mr. R. Sennett and Mr. H. J. Oram, in their latest book on boilers, say on page 35 :

"By experience in actual cases, it is found that where the draught is produced by artificial means such as a fan, the theoretical quantity of air must be increased by one half. In cases of natural draught it must be doubled in order to ensure perfect mingling. In practice, it is not necessary to calculate with exactness the quantity of air required, and it is sufficient for all practical purposes to take 12 lb. of air as the quantity chemically necessary for the combustion of each pound of coal. With natural draught, therefore, 24 lb. of air is required; with artificial draught 18 lb. of air would be required for each pound of coal. This forms, therefore, one advantage of accelerated draught, the temperature of the fire being thereby less decreased, so that the radiation of the heat from the burning fuel is greater, and the loss from the heat carried off by the nitrogen in the air less."

It also states, apropos of excessive forcing of boilers, that experience has shown the desirability of reducing the amount to which boilers are forced, and the last Admiralty specification for water tank boilers provides for a total heating surface of not less than 2·5 sq. ft. per I. H. P. at natural draught power, and 12 to 12½ I. H. P. per sq. ft. of grate; while the forced draught power is limited to 20% beyond the natural draught power.

In reference to the damage to boilers due to cold air striking the heated plates, I don't think this is liable to do much damage in Howden's system owing to the air being heated to a temperature of about 240° Fahr. before entering the furnaces, but it is undoubtedly very dangerous in some systems of forced and induced draught. One ship that I know of has had a great deal of trouble owing to this cause, and in this case the regulating of the fan was not under the control of the engineer on watch, so that during the whole of the time occupied in cleaning the fires, there is a rush of cold air through the bars at a temperature of less than 60° Fahr. at certain periods of the voyage, owing to the atmospheric temperature being low.

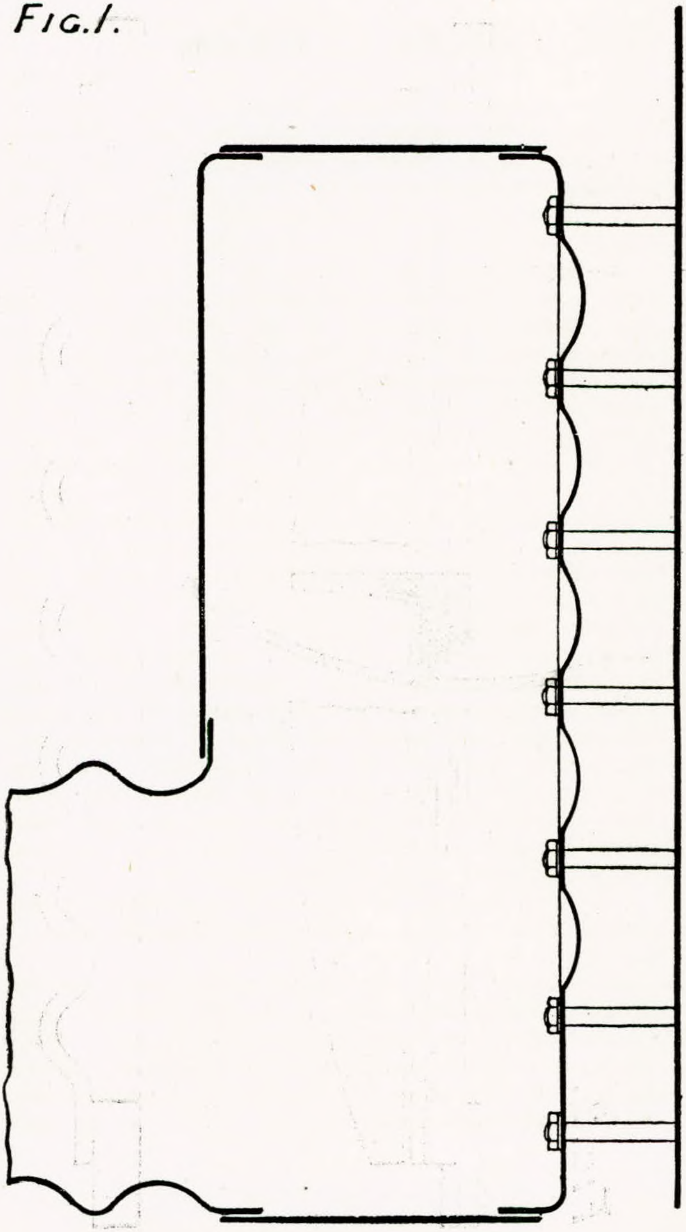
I understand that some furnaces have shown cracks in the front end of the furnace owing to the air on passing the valve striking the plate. I have not had any personal experience of such, but to prevent this damage some ships are fitted with a brick moulded the shape of the furnace and fitted closely against the cheek plates on the furnace front, the brick being bevelled off so as to prevent the air impinging the plate. I think this tends to prevent any damage occurring in this particular place.

I think I am right in saying that one of the first places in forced draught boilers to show signs of damage is the combustion chamber back, where it becomes bulged more or less by the intense heat striking the plate, especially if the bridges are out of order. In a number of ships, large brick blocks are fitted instead of the usual built bridges, the bridges often remaining intact from six to nine months. This kind of bridge is not adopted to anything like the extent it deserves. In the first place, it is cheaper than ordinary bricks. The bridges can also be built in less than half the time, and as is often the case with the usual built bridge, the top rows of bricks are knocked off during the first few watches. These blocks are made the depth of the bridge, two blocks fitted side by side forming the bridge. I think this style of bridge may prevent damage at the back ends; but I think if also a brick were fitted to the whole width of the combustion chamber and about 18 in. deep over the stay nuts, it would protect both the stay nuts and the plate. When in a repair shop some little time ago, I saw the back plate of a combustion chamber from a forced draught boiler, which showed a series of curves caused by the pressure forcing it out between the stays. I have thought since that the back of the combustion chamber might be made with slight curves against the pressure. This must necessarily be much stronger than a flat surface: an objection to this form of plate might be the difficulty of cleaning it.

Mr. Stromeyer, in his book on boilers, when referring to bulged combustion chamber backs, states:

"Another part of a boiler where scale deposits produce visible deformation is the flat plates of combustion chambers with narrow water spaces. The pressure of much steam assists in causing the plates to get hot and bulge by keeping the scale partially dry. If this treatment did not tend to make and

FIG. 1.



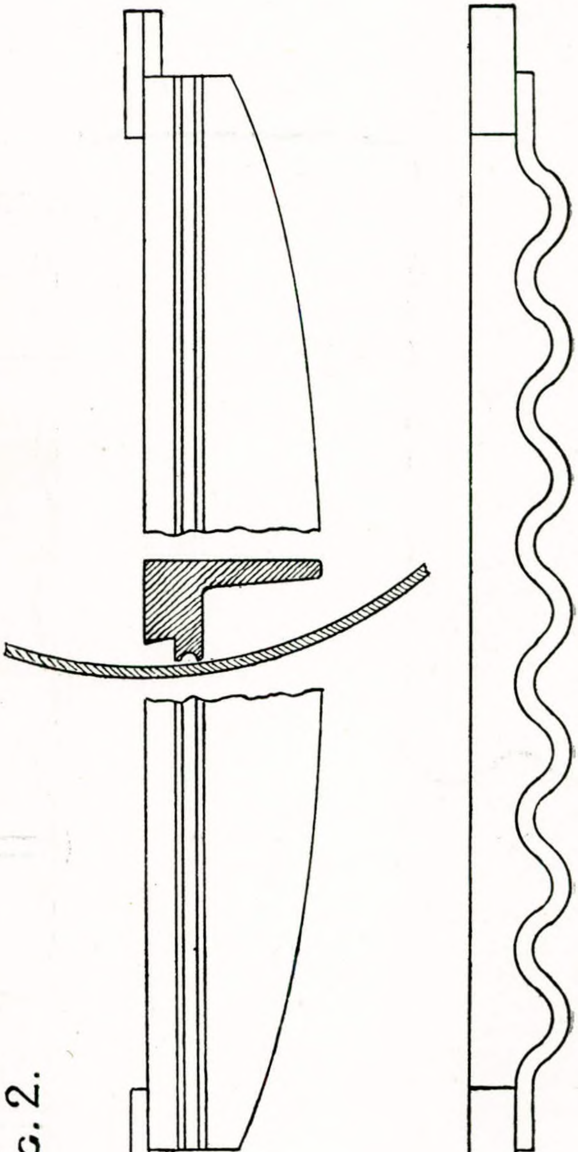


FIG. 2.

cause them to crack between the stays little harm would be done, because in a bulged shape plates are stronger than when flat."

Mr. Stromeyer also states that corrugated plates have been adopted for combustion chamber tops in some cases.

I think a plate made similar to Fig. 1 would be much stronger than a flat plate, it having a compression instead of a tension strain in the weakest part of the plate.

A difference of opinion exists as to the advisability of wedging fire bars into the furnace, although advised by Messrs. James Howden & Co. in their instructions to do so. Some furnaces have of late got out of shape, and the cause is attributed to this—owing to the firebars expanding in width more than the furnace; and I think this is feasible when we take into consideration that from three to four feet of practically solid metal has to expand some way.

I have seen several patterns of side bars, all made with the idea of making an air tight joint between the bar and the furnace, but with no allowance for expansion. To overcome this, Messrs. J. P. Corry and Co. have adopted a wing fire bar similar to pattern shown in Fig. 2. As you will note, this style prevents the bar being forced against the furnace. It also makes a perfect air tight joint. We fit a piece of ⅝ in. pure asbestos packing into a groove, supported on top by a layer of gannister about 1½ in. deep, the bar being so recessed that once the gannister becomes set it cannot blow out. Both the front and back dead plates have a recess in them for a part of the bar to fit into. This allows the bar to expand lengthways. I have often found, on examination of furnace, the round packing, oval in shape, in the centre of the bar, which shows that a certain amount of expansion takes place. I have tested this bar thoroughly, and have found, after a five months' voyage, the packing intact, and no leakage between the bar and the furnace. I maintain that this speaks greatly in its favour.

In conclusion, I may say that after several years with Howden's forced draught, I am a strong advocate of the system (in preference to natural draught), and feel sure that with careful management the greatest economy is assured, besides greater comfort for all concerned. I have never known the temperature of stokehole at any time to exceed 94° Fahr., against 130° Fahr. in natural draught.

DISCUSSION.

58 ROMFORD ROAD, STRATFORD.

MONDAY, FEBRUARY 11th, 1901.

CHAIRMAN:
MR. T. F. AUKLAND (COMPANION).

Mr. G. HALLIDAY said there was just one point to which he desired to call attention, and that was as to the amount of air allowed to go into the furnace under different systems of draught. Mr. Silley, the writer of the paper, quoted certain things from a theoretical point of view, and worked out certain theories laid down by Rankine. But since Rankine, a very great deal had been done. Professor Kennedy and others had conducted an enormous number of experiments on this question to determine the proper amount of air to be admitted to the furnace under different conditions, and so far as he could remember the best results were obtained when 22 lb. of air were allowed per pound of coal. It was said in the paper that about 18 lb. of air might be taken as the quantity required per pound of coal with forced draught; but the quantity necessary was more than that, and speaking as nearly as possible, was probably between 21 and 22 lb. The question did not seem to be a theoretical one. There was no one who could explain why more than 12 lb. of air was required per pound of coal, but, as a matter of practice, they had to allow into the furnace some 22 lb. instead of only 12 lb., which should suffice theoretically. It would be very interesting if they could get the proper quantity as ascertained by the experiments of Professor Kennedy and others, because the author of this paper treated it as a mere matter of calculation theoretically, whereas it was nothing of the kind.

Mr. J. R. RUTHVEN said the author told them in the paper that in some Admiralty tests the temperature of the funnel had been as high as 1,444° Fahr., but Mr. Silley had omitted to tell them the temperature he would expect to find, and the lowness of the funnel temperature was one of the chief things to be noted. Mr. Silley should be asked to give them some more data about funnel temperatures. He (Mr. Ruthven) thought he was right in saying that less than 700° had been carried with satisfactory results. There were many points that Mr. Silley had brought forward in his paper, and no doubt before the subject was disposed of they would be considerably discussed.

After a few remarks from Mr. W. MCLAREN,

Mr. J. T. SMITH proposed a vote of thanks to the author of the paper, whom he thought deserved their thanks for having contributed a paper which presented so many points for discussion.

Mr, J. R. RUTHVEN seconded the motion, and observed that if the sea-going members of the Institute would only take the trouble to write more papers of this character he was sure that the members generally would feel deeply indebted to them.

The motion was carried unanimously, and a vote of thanks to the Chairman concluded the meeting; the discussion upon Mr. Silley's paper being adjourned until Monday, February 25th.

DISCUSSION CONTINUED.

58 ROMFORD ROAD, STRATFORD.

MONDAY, FEBRUARY 25th, 1901.

CHAIRMAN :

Mr. J. R. RUTHVEN (MEMBER OF COUNCIL).

The CHAIRMAN : The subject before us to-night is the adjourned discussion upon Mr. Silley's paper on "The Treatment of Boilers under Forced or Induced Draught." The paper was read at our last meeting and briefly discussed, and there are a great many points in it well worth our notice. The coal consumption is perhaps the biggest item to be considered in the working of a steamer, and there are many important points raised in this paper for us to discuss.

Mr. F. COOPER (Member) I believe there are gentlemen here who have sailed with both systems of mechanical draught, and it would be very interesting if they would give us their experiences.

Mr. W. McLAREN (Member of Council) said they would all be agreed that the subject dealt with in the paper was one of considerable importance to marine engineers, for in these days it was certainly essential to get the best possible results out of their boilers. He agreed with the author in thinking that accidents to boilers were frequently due to the carrying of excessive air pressure, and also to the fire-bars being allowed to become bare, so that a rush of cold air struck the heated plates. But he was not in agreement with the suggestion in the paper that accidents were also frequently due to the wedging in of the fire-bars so that the bars expanding more than the furnace forced out the sides of the furnace. He had never experienced this excessive expansion of the fire-bars; indeed, he thought that the forced draught would have the effect of keeping the bars at such a low temperature that there would be no chance of their expansion. Induced or any other kind of mechanical draught would, he believed, have much the same effect, and this view was proved by the very thin class of fire-bars usually put into the furnaces. He was very much surprised to read the suggestion in the paper about locking the stop-valve as a means of preventing excessive air pressure; and he had thought that practices of this kind were done away with long ago. On this point the author said: "It therefore behoves every engineer in charge of this class of boiler to pay very careful attention to air pressure, as any excessive pressure, though only temporary, may do serious damage. Different methods have been adopted to prevent damage occurring; some of these in my opinion only assist the evil. In some cases, the practice of locking the stop valve is adopted. One engineer informed me that he set the air pressure at 3 in., leaving London, and took the wheel off the stop valve to prevent anyone tampering with it, the fan not being touched for weeks together." He (Mr. McLaren) took it for granted that the author was here referring to the main stop valve.

Mr. JAMES ADAMSON: I take it he is referring to the fan stop valve.

Mr. McLAREN said he understood the reference to be to the main stop valve. Then again he could not see how it could be either desirable or economical that the fans should always be kept running at the same speed. A certain speed might answer very well when the fires were first started, but as soon as the fires began to get dirty they must increase the speed of the fan to get the same result. There was also the difficulty of different classes of coal, and different classes of coal were found even in the same bunkering. He quite agreed with the author as to the great waste of coal with excessive air pressure, and they sometimes saw half the coal that should have been burnt, on deck.

Mr. P. SMITH (Member): The author of the paper in his opening remarks leads one to infer that he must have been very unfortunate in his experience with forced draught boilers, The number of ships which arrive in port with boilers out of order, as stated in the first paragraph, is sufficient to almost frighten an inexperienced engineer from having anything to do with forced draught. I have seen a few accidents, or rather the results of accidents, to boilers worked under some of the forced draught systems. My experience of forced draught has been confined to Howden's system, which is simplicity itself. A well-built boiler properly constructed, with sufficient heating and steam spaces, and fitted with good expansive furnaces—such as Morrison's suspension furnace, with what is termed the Gourlay neck or back end—is about the best and safest arrangement to fit for the application of any system of forced draught. A boiler so fitted ought to give no trouble, and if properly looked after should see the ship out; at all events there is no reason why it should not last for twenty years, and that is a good average life for a vessel. The class of boiler built twenty years ago was worn out in about ten years, and it took two sets to see a vessel broken up. The life of an up-to-date boiler has not been determined yet, but it ought to be quite equal to the life of the modern steel-built vessel. A set of new boilers put under the care of an inexperienced or careless engineer might sustain more internal injury during the first twelve months than another set, properly looked after, would sustain in the first ten years. I don't think that excessive air pressure is such a source of danger as the author makes out, neither ought the air pressure to fluctuate to any dangerous extent, if the firemen are giving proper attention to their duties. Although it is often necessary for the firemen to check the draught by shutting off half the number of air valves, as stated by the author, it does not follow that the boilers would be under any temporary excessive air pressure. The result of shutting the valves under the control of the firemen would give a greater pressure of air at the fans and in the air trunks leading to the furnaces, but by the time it is wire drawn through the decreased openings and diffused in the furnaces the pressure would be actually less than before. Good fans for forced draught require very little attention. Of course the speed would vary considerably if a constant pressure of steam is not steadily maintained. The automatic air pressure alarm referred to is a very good idea, but I fail to see what harm would result from the firemen shutting off the air valves.

If the leading fireman or whoever is in charge of the stokehole gives the order to check the draught, it ought to be done at every furnace. No man qualified to take charge of a set of boilers would allow any indiscriminate tampering with the valves. Where boilers come to grief it seems mainly due either to internal incrustation or grease on the water side of the furnaces. The imprudent use of the fans to cloak faulty stoking is a practice amounting to criminal carelessness. A set of boilers exposed to such treatment might be damaged in a few minutes. I would consider an air pressure equal to a column of 3 in. of water an excessive and dangerous pressure to carry. Very good results can be obtained by carrying from $1\frac{1}{2}$ in. to 2 in. of air pressure, and even at that, about double the indicated horse-power can be obtained per square foot of fire-grate over natural draught, with a corresponding degree of economy, equal to a saving of about 3 to 4-tenths of a pound of coal per indicated horse-power. To fill up the furnaces with coal and attempt to force the air through it, is absurd, and is a practice that no stoker who understands the science of stoking would be guilty of. A chief engineer in charge of a set of forced draught boilers should occasionally keep his eye on the funnel, and if he found the smoke rather black or dense would endeavour to regulate the air valves above and below the furnace bars to give the correct amount of oxygen in the right place to consume the smoke, as each quality of coal requires special treatment to give the best result. I agree with the author that Howden's system of forced draught is not liable to do much damage to furnaces as the air is heated considerably, but in my experience 240° Fahr. is rather high an estimate of the air entering the furnaces. No doubt Mr. Howden would tell you and even prove theoretically that it ought to be so, but the difference between theory and practice is often misleading. In my experience I never found an increase of more than 100°—that is to say, if the air entering the fans was 80° it would be 180° entering the furnaces, and under those conditions the funnel temperature would be about 640° Fahr.

Mr. W. LAWRIE (Member of Council) said he certainly thought that the author had some reason for his statement about the number of vessels working under forced draught that arrived in port with defective boilers, and an engineer with considerable experience in dealing with steamers when they came into port had recently told him that in his opinion the disadvantages of forced draught were greater than its advantages. This engineer's opinion was that natural draught was preferable, but he (Mr. Lawrie) did not take the same view, because it stood to reason that if they could put into a furnace the proper amount of air for combustion it must be a better system than that which permitted the variation of draught that must occur with natural draught when there was a change from half a gale of wind to a dead calm. The paper seemed to have been written more particularly for those who had had practical experience on the subject. In dealing with the waste of coal due to excessive air pressure the author gave a table from which it appeared that with two inches of air pressure the total heat of combustion was 3,220°, but if they increased the air pressure to 3 in. the total heat was 2,218°, showing a difference in favour of the 2 in. of over 1,000°. But if the plates were going to buckle through excessive heat he (Mr. Lawrie) should think the buckling much more likely to occur in the first case than in the last. The author seemed to deal with the subject entirely by the regulation of the fans, and that, no doubt, was an important matter, but even in vessels that were not fitted with mechanical draught the furnace crowns would come down unless they were reasonably careful about the cleanliness of the furnaces. He was afraid, therefore, that although the paper dealt very clearly with the regulation of the fans it did not give sufficient attention to the condition of the internal parts of the boiler. He agreed with Mr. McLaren that the removal of the wheel from the stop valve was an expedient that should be a thing of the past. Surely the engineer on watch should be able to so arrange matters that the proper pressure was maintained in the furnace. Certainly when the chief engineer did not keep a watch there should be no difficulty in keeping the air pressure regular. On the question of the excessive forcing of boilers the author mentioned the Admiralty practice of limiting the forced draught power to 20 per cent. beyond the natural draught power. This was a point as to which a lot of trouble often arose, and he knew of one case in which the fans were driven at such a high rate that it had the effect of bringing the whole of the furnaces down. This result was due to a reckless use of forced draught, and if shipbuilders and engineers would bear in mind, when fitting forced draught or any form of mechanical draught, that too much should not be expected from it, there should be no difficulty in working it.

Mr. MURRAY (Member) said he was not then prepared to criticise the paper, but there was one remark by the author with which he agreed, and that was that fans were sometimes used so as to involve not only loss but also risk of damage to the boilers. Some three years ago he was on board a large passenger excursion steamer that was being brought round from the builders when it was noticed that on one watch the speed was faster than on others, and that at certain times the fans were being driven very much faster. On making investigation it was found that one watch of stokers was driving the fans at the rate of $3\frac{1}{2}$ in. of air pressure, while the next watch worked with an air pressure of only $1\frac{1}{4}$ in. and yet there were more revolutions of the paddle engines with the lighter pressure. He did not agree with the suggestion that the wheel should be taken off the stop valve. If the coal was bad, for instance, it stood to reason that a little more air pressure would be required, while with good coal they could ease down the fan engines a little and so get economy. The regulation of the air pressure ought to be left to the intelligence of the engineer on watch,

Mr. J. Howie (Member) said that in the early part of his paper the author spoke of an air pressure equal to 3 in. of water, which was rather high, but later on he spoke of 5 or 6 in. which seemed tremendous. He (Mr. Howie) would like to be the founder who supplied the fire bars where such a pressure was used ; he would soon make his fortune. He had found 1 in. of pressure to give very good working.

Mr. Lawrie said that the boiler which he had referred to as having been driven too much was, he was told, worked with an air pressure equal to 5 in. of water.

Mr. D. Greer (Member) said that some years ago he was chief engineer of a steamer which was fitted with Howden's forced draught, and so far as any damage to the boiler was concerned they found the results no different from those of ordinary draught. When they wanted to get more steam they turned on the fans quicker. The usual pressure was about 3 in., and they allowed the men in each watch to work the fans according to their requirements. But the boilers themselves showed no more deterioration with forced draught than with ordinary draught.

Mr. PETER SMITH said he quite agreed with Mr. Lawrie that damage to boilers was often due to excessive air pressure. He considered a pressure equal to 3 in. of water a very excessive pressure with Howden's forced draught, and that very good results could be obtained by carrying an air pressure of 1½ in., or at the most 2 in. The chief engineer should keep his eye on the funnel occasionally. If only reasonable care was exercised there was no reason why boilers should come to grief at all. A boiler properly constructed and fitted with forced draught, properly fitted and well looked after, should last almost as long as the ship. At the present day a good boiler ought to last at least twenty years.

Mr. McLAREN said he should like to ask some of those gentlemen who had worked with an air pressure up to 4 or 5 in., what was their coal consumption compared with the consumption with an air pressure of 1 in. or 1½ in. His impression was that with a pressure of 4 or 5 in. they would find most of the coal on deck.

After some remarks from Mr. HULME.

Mr. HENRY J. VOSE (Member) stated that the superintendent engineer of a line of steamers with which he was connected made a very careful comparison between the results shown by two steamers fitted with Howden's forced draught and two running with natural draught. The various particulars were carefully recorded for a period of twelve months, and in the result the natural draught ships came out better than the forced draught ships. The forced draught ships showed a greater consumption per I.H.P. Every element that should be considered in connection with such a comparison was taken into account. The result came out at 1·7 with forced draught and 1·5 with natural draught.

Mr. LAWRIE: I should like to get hold of the builder whose steamer gave 1·5 with natural draught.

Mr. BASIL JOY said from the title given by the author to his paper they were justified in expecting something in the nature of a comparison of the relative merits of different systems of working boilers, but the author scarcely mentioned induced draught, and he certainly did not deal with the treatment of boilers under induced draught. He (Mr. Joy) imagined that no engineer would treat boilers in exactly the same way with forced draught as with induced draught. The title of the paper was certainly somewhat misleading, and he thought the council should consider whether the title of a paper was really borne out by the contents of the paper itself. They had heard a good deal about excessive air pressure, and they had had different opinions as to what was excessive pressure. It would, however, be very interesting to know what was the excessive pressure that was harmful. So far as one could learn, it seemed that 2 in. was about the limit of safe running. It might interest some of the members to know that a test with a locomotive boiler had shown an actual pressure in the fire-box of 8 in. An air pressure of 8 in. in a marine boiler would soon bring trouble. In making a comparison between steamers with forced and natural draught there were many points to be considered besides the question of consumption, and one year would hardly be a sufficiently long period to give a reliable series of figures. Three years was the shortest period that should be taken for a comparison of the two systems.

Mr. HULME said that no speaker had yet given them the amount of air pressure to be carried in the furnace under different conditions. His advice on this point was that the amount of air pressure to be carried in the furnace was that which the chief engineer considered the best pressure to ensure perfect combustion.

The CHAIRMAN: Can Mr. Vose say if the same class of coal was used in all the steamers to which he referred?

Mr. VOSE: Yes, it was the same class of coal in all the steamers.

The CHAIRMAN observed that complaint had been made that this paper was not a complete treatise on forced and induced draught in all its phases, and as he had something to do with the passing of papers before they were read he might perhaps explain shortly the principle on which he acted. He had a great preference for a paper, even if it was only a short one, in which a member told them something that he knew or had ascertained himself, and which had not been taken from books or from the experiences of others. He was not too critical with regard to the title of a paper, provided it recorded the results of the member's own experiences and investigations, for the whole matter came out in the discussion, and very often the discussion was the best part of the paper. He hoped that this explanation would be accepted to cover the title which had apparently led one or two members astray. They could not expect a sea-going member to write a regular treatise on a subject of this kind such as one who was always ashore would have an opportunity of doing. With regard to one point that had been referred to, he thought the term "natural draught" ought to be done away with, because it all depended upon the length of the funnel. Where there was a funnel 150 ft. long they had induced draught, and the term "natural draught" was misleading.

Mr. H. C. WILSON (Member) said he had a very lively recollection of the discussion upon a somewhat similar paper that was read at this Institute some years ago, and one of the most important points threshed out at that time was induced draught against forced draught. There was no mention of induced draught in the present paper, but, according to the statements that were made in the course of the previous discussion, the effect of induced draught upon ordinary cylindrical boilers was very different from that of Howden's forced draught. With regard to air pressure, the amount of air necessary in a furnace to ensure proper combustion was more or less a moot point, but one of the speakers that evening had put the question in a nutshell when he said that the air pressure necessary was the amount which the engineer required to get proper combustion. That appeared to be the best answer to the query as to the proper pressure to work at in a boiler. In his sea experience he found that too little attention was given to the matter of bridges, and his attention was more particularly drawn to this point by a little incident that occurred in a steamer in which they were suffering from bad coal. He had a fireman in his watch who always managed to keep better steam than was kept in the other watches, and going below rather earlier than usual on this occasion he found this particular fireman fetching out two fire-bricks from a corner of the stokehole. When his watch commenced the fireman carefully placed these two bricks on the top of the bridge, and when his watch was over he as carefully hooked the bricks out again, and stowed them away in readiness for his next turn of duty. Certainly the fireman who employed these bricks was able to do better in keeping steam than the other firemen.

The discussion was adjourned until Monday, March 11th, and a vote of thanks to the Chairman concluded the meeting.

DISCUSSION CONTINUED.

MONDAY, MARCH 11th, 1901.

CHAIRMAN:

MR. J. E. ELMSLIE (MEMBER OF COUNCIL).

Mr. J. R. RUTHVEN: I regret that the Hon. Secretary is unable to be with us to-night, but he has sent us the following contribution to the discussion on Mr. Silley's paper:

Mr. JAS. ADAMSON (Hon. Secretary): In former sessions we have had papers on forced and induced draught, and this comes from our young member, Mr. Silley, as a fit corollary to them. That there is justification for the opening paragraph is patent to all who are visiting the various dock centres. Exception has been taken to the title adopted by the author, and in his absence at sea I should say that the title exactly represents the intention and scope of the paper, namely, the treatment of boilers under forced and induced—or, in one word, mechanical draught. We may agree with the author in saying that while it is of importance to keep the heating surfaces of all boilers perfectly clean and free from deposit, it is of two-fold importance in the case of boilers under forced and induced draught, in that the heat to be transmitted through from the fire to the water is greater per square foot of surface per minute, hence the danger of collapse or overheating is so much greater. Illustrations of this have been by no means infrequent of late years, and one lesson to be drawn is that evaporators of greater capacity, or tank accommodation, for carrying fresh water should be provided in order to lessen or entirely stop the supplementing of boilers from the sea; this is always desirable, but especially so in cases of mechanical draught.

The question of air pressure has been discussed and the danger of a high blast pressure urged so frequently that one is surprised to hear there is so much diversity in practice. Considering the warnings that have been given it seems strange that troubles arise from such a cause, after all the experience that has been gained. It is possible, however, that when 6 in. of air pressure is mentioned, the gauge has been taken at the fan; the ash-pit pressure should not be more than from 1 in. to 2 in., and in my opinion this should be nearer the 1 in. than the 2 in. in order to obtain the most satisfactory results in the treatment of the boilers. A hard and fast line can hardly be drawn to cover all cases; the quality of coal and speed required are two factors which have to be considered in determing the air pressure.

Where mechanical draught is used one object aimed at in its adoption is to obtain as much as possible out of the boiler, which with natural draught would be inadequate for the requirements; such being the case, the limits of safety in regulating the least possible size of boiler is a very important element and helps really to fix the normal air pressure for those who have to work out the results in actual practice. It is a great mistake to reduce the size of a boiler to such an extent that it becomes a constant source of anxiety and worry to keep steam at full power; frequently this is the cause of some of the troubles referred to by the author, who has been himself very successful in dealing with the machinery under his charge, and the care and attention he advocates in dealing with the air pressure are thus justified in the results he has obtained.

The instrument illustrated and referred to in the paper is a simple arrangement for indicating at once when the air pressure rises above the normal and calls the attention of the engineer on watch to any irregularity which may be taking place in the stokehold. It has been adopted in several steamers with advantage, I understand, from inquiries I have made with regard to it.

Some of the evil results specified in the paper have come under my observation from time to time, and I can bear witness to the several hints given, and those who have charge of boilers fitted with mechanical draught will doubtless appreciate their value. Such papers as the one before us should be encouraged from our sea-going members, and as a first essay towards committing his thoughts to paper on a subject of great interest to the members, the author, as well as the paper, should be commended as an inducement for others to follow on similar lines.

Reference was made at last meeting to the air pressure used in locomotive boilers, which is well known to be much higher than we have in marine boilers, but the conditions are entirely different in respect to the material of the fire-box—copper *v.* steel or iron—to the construction and staying, to the time under continuous service, to the plentiful supply of fresh water, to the steady quality of the fuel and to the frequency of examination.

The modest way in which the author has brought before us his opinions, while expressing his desire for further light from more experienced members, induces the hope that his desire will be gratified, and that when the paper is issued, those who have considerable experience in mechanical draught will communicate their views by correspondence to be incorporated in the transactions for the benefit of all.

The discussion upon Mr. Silley's paper was then declared closed.

BRISTOL CHANNEL CENTRE.

DISCUSSION.

3 PARK PLACE, CARDIFF.

WEDNESDAY, MARCH 6th, 1901.

CHAIRMAN:

MR. T. W. WAILES (VICE-PRESIDENT B.C. CENTRE).

Mr. T. A. REED said he should have liked more details as to the treatment of boilers under forced and induced draught.

Mr. EVAN JONES agreed with the author that a great deal of damage was done by wedging in the firebars too tight to the furnaces.

Mr. HENDERSON said the paper failed to give them information about the size of the boilers and the size and speed of the fans. He believed in forced draught if it was applied properly. If Howden's forced draught was applied to natural draught sized boilers, with big fans, and a good bulkhead, thoroughly dust-tight at the back of the boilers, he thought it would be a perfect success. He had seen good results got from it, in fact, consumption brought down as low as 1·1 or 1·2 lb. per I.H.P. per hour. He did not, however, believe that forced draught would ever be a great success in the mercantile marine until they had better firemen. It was a terrible thing to instruct these foreigners. "Forced draught" was not a correct term; it should be "assisted" or "mechanical" draught.

Mr. T. A. REED thought the whole question resolved itself into one of capitalised cost, up-keep, and space occupied. In the Navy forced draught was essential, every kind of weight being minimised in view of the monster armaments in order to reduce displacement. Forced draught was also necessary for fast mail boats, but in the case of "tramps" the question needed careful calculation.

Mr. CADOGAN and Mr. HAUSEN both referred to the absence of points of interest from the paper, the latter observing that the author said nothing about induced draught, which was quite as important as forced draught. With induced draught, he added, they had no fear of injury to back plates.

Mr. F. MASON claimed that there was no greater economy with forced draught than with the ordinary machinery. The saving with forced draught resolved itself into carrying about 15 tons more cargo in a 6,000-ton ship. After the forced draught had got three or four years old, the up-keep was much greater than the ordinary set of machinery, and from what he heard the up-keep of the furnaces was pretty heavy too. He knew of very few cargo-boat owners going in for forced draught, and knew of more who were taking it out and going back to the old plain boilers and engines. The induced draught system was far and away better than that of the forced draught.

The CHAIRMAN said that some years ago he tried an experiment, which turned out a perfect success. An iron box was put round the base of the funnel, and from that box was taken about sixteen pipes round the diameter of the funnel pointing to a common centre. On the box was fitted a fan worked from the engines with a rope. As soon as this started, the effect upon the furnaces was marvellous. The air was drawn from the engine-room and forced up the chimney.

The discussion then closed, and a vote of thanks was passed to the author.

The Author's reply, dated Las Palmas, June 5th:

I regret that I have not had an opportunity of being present at the discussion of my paper, but will endeavour to reply to the criticisms on same as clearly as possible.

I have not had an opportunity of measuring the amount of air per lb. of coal, but the amount stated, viz., 18 lb., was taken from some Admiralty experiments; it is the amount allowed by Hutton, Sennet, Stromeyer, and other important engineering authorities.

The following pressures and temperatures were taken by me during the past voyage ending May, 1901.

The funnel temperatures were taken with a pyrometer manufactured and tested by Messrs. Dollond, of Ludgate Hill.

	Pressure, Starb. Boiler.	Pressure, Cent. Boiler.	Pressure, Port Boiler.
Air Pressure at Fan, $2\frac{1}{8}$ in.	Ashpit, $\frac{13}{16}$ in. Furnace, $\frac{7}{16}$ in.	Ashpit, $\frac{3}{4}$ in. Furnace, $\frac{3}{8}$ in.	Ashpit, $\frac{3}{4}$ in. Furnace, $\frac{3}{8}$ in.
Temp. Air in Fan Casing..	217°	229°	221°

Funnel Temperature, 400°.

	Starb. Boiler.	Centre Boiler.	Port Boiler.
Air Pressure at Fan, $2\frac{3}{8}$ in.	Ashpit, $\frac{7}{8}$ in. Furnace, $\frac{3}{8}$ in. full.	Ashpit, 1 in. Furnace, $\frac{3}{8}$ in. full.	Ashpit, 1 in. Furnace, $\frac{7}{16}$ in.
Temp. Air in Fan Casing..	229°	242°	224°

Funnel Temperature, 440°. (The above with Welsh Coal.)

	Starb. Boiler.	Centre Boiler.	Port Boiler.
Air Pressure, $2\frac{1}{4}$ in.	Ashpit, $\frac{5}{8}$ in. Furnace, $\frac{1}{4}$ in.	Ashpit, $\frac{9}{16}$ in. Furnace, $\frac{1}{4}$ in.	Ashpit, $\frac{5}{8}$ in. Furnace, $\frac{5}{16}$ in.

Funnel, 440° to 460°. (New Zealand, Westport Coal.)

	Starb. Boiler.	Centre Boiler.	Port Boiler.
Air Pressure at Fan, 3 in.	Ashpit, $1\frac{1}{4}$ in. Furnace, $\frac{5}{8}$ in.	Ashpit, $1\frac{1}{8}$ in. and $\frac{1}{2}$ in.	Ashpit, $1\frac{1}{8}$ in. Furnace, $\frac{5}{8}$ in.
Temp. Air ..	211°	227°	220°

Funnel Temperature, 440°. (Bulli Coal.)

The stop valve referred to should read "the fan stop valve." As to the danger of checking the draught by shutting half the number of air valves, I find it increases the pressure in the fires with valves open in fan casing from $2\frac{1}{8}$ in. to $3\frac{1}{4}$ in., ashpit from $\frac{3}{4}$ in. to $1\frac{1}{8}$ in., furnace from $\frac{3}{8}$ in. to $\frac{5}{8}$ in. I have tested above with Welsh coal.

Referring to the statement that according to my remark the buckling of combustion chambers was more likely to occur at 2-in. than 3-in. air pressure, my answer to that is, when working with excessive air pressure you get a very uneven temperature in your combustion chamber, and part of the time after your fires have burnt through you get a very high temperature, which is obtained by burning considerably more coal without getting any beneficial results. An additional ½-in. air pressure means at least two tons of coal per day, often with decreased speed.

From the remarks made by Mr. Joy he appears to be dissatisfied with the scope of my paper, which he is pleased to term misleading, and goes on to say that he would imagine that no engineer would treat induced and forced draught boilers similarly. I have had several opportunities of examining both systems and conversing with those in charge, and I may inform him—as I presume he is not a sea-going engineer—that the outside treatment of both systems is very similar. I certainly did not go into the inside treatment of boilers very minutely, as I consider that every chief engineer is fully aware of the absolute necessity of keeping the inside of his boilers free from oil or dirt, and adopting other precautions necessary in any class of boiler. I am aware of, and could enumerate several instances of accidents to induced draught boilers, including the collapsing of furnaces, cracking of tube plates, leaky tubes, etc., but would prefer to leave such to those having had charge of that system.

In conclusion, I maintain that a large percentage of the collapsed furnaces, etc., in forced and induced draught boilers have been caused by abuse of air pressure (possibly only temporary). This was my reason for devising a means to prevent this occurring. During the last few weeks I have seen several collapsed furnaces, covered with only a moderate scale, which, if there had been a limit in the amount of forcing (in my opinion), would have been avoided, as I have known scale heavier in ordinary draught high-pressure boilers without doing any damage. I entirely agree that it is a great mistake to reduce the size of boilers to such an extent as to become a constant source of anxiety to keep steam at full power, and no doubt many of the accidents are to be attributed to this cause. I will conclude by thanking the members for the manner in which they have received my paper, and must admit of its many shortcomings.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1901-1902.

President: JOHN CORRY, ESQ.

Volume XIII.

CONTRIBUTION TO DISCUSSION

ON THE

NINETY-FOURTH PAPER

(OF TRANSACTIONS)

Treatment of Boilers under Forced or Induced Draught.

BY

Mr. ROBT. T. RULE, R.N.R.

(MEMBER).

READ

AT 58, ROMFORD ROAD, STRATFORD, E.

ON MONDAY, NOVEMBER 11TH, 1901.

PREFACE.

58, Romford Road,
Stratford,
Nov. 11*th*, 1901.

A Meeting of the Institute of Marine Engineers was held here this evening, when a Paper, contributed by Mr. R. Rule (Member), on "Some Experiences in Forced Draught," suggested by the Paper on the "Treatment of Boilers under Forced or Induced Draught," by Mr. Silley (Member), was read. The chair was occupied by Mr. W. Lawrie (Member of Council).

JAS. ADAMSON,
Hon. Sec.

INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1901-1902.

President: JOHN CORRY, ESQ.

CONTRIBUTION TO DISCUSSION

ON

TREATMENT OF BOILERS UNDER FORCED OR INDUCED DRAUGHT,

BY

ROBT. T. RULE, R.N.R. (Member).

READ AT

58, ROMFORD ROAD, STRATFORD, E.,

ON MONDAY, NOV. 11TH, 1901.

CHAIRMAN:

MR. W. LAWRIE (Member of Council).

I have read with great interest the papers by Mr. John H. Silley and the discussion following, anent the "Treatment of Boilers under Forced Draught," and it appears that the views of Members who have had experience with either of these mechanical aids to combustion will be welcomed; that is, therefore, my excuse for writing at this late date on the matter, for I have no opportunities of attending discussions, and the paper has only just reached me.

I agree with the author of the paper entirely in regard to what he says concerning the regulation of air to the furnaces, and I consider that the means he adopted to secure that an excess pressure of air was not carried is ingenious and efficient, as it practically forms a safety device, and at once control can be exercised in cases of inadvertence or carelessness, or even wilful acceleration of Fan Engines.

My personal experience with Forced Draught has been gained solely from Messrs. James Howden & Co.'s system, and I propose to confine my remarks entirely to it, although I have seen the Closed Stokehold system in operation also.

Some six years ago I was appointed to take charge of the machinery of a steamer fitted with the above system. She was the sister ship of another vessel exactly similar in size of hull, size and style of engines and auxiliary machinery, and differed only in not being fitted with mechanical draught, her boilers being worked under natural draught. I append some particulars of both ships, for the sake of comparison, as I believe the points I will refer to later will be of interest to Members, as I see from the discussions that some are in favour of Natural Draught, and others ascribe certain ill effects to boilers as the result of Forced Draught, as well as deny any beneficial results in economical consumption of coals.

	Gross Tonnage.	N.H.P.	I.H.P.	Total No. of Furnaces.	No. of Boilers.	Style of Engines.	Steam Pressure.	No. of Stoke-holds.	Pitch of Propeller	Type of Steamer.	Sea speed Loaded.
Nat. Draught Ship	3333	290	1500	8	2 Double ended	Tandem Inv'rt'd quad'pl. Exps'on with 4 Cyl'd'rs	lbs. 182	2	22 ft.	Cargo	9 knots.
Forced Draught Ship	3333	290	1500	4	2 Single ended		lbs. 182	1	22 ft.	Cargo	9 knots.

It will be seen from the above that the steamer with Forced Draught had just half the boiler power and half the grate surface of the other, but was expected to burn per square foot of grate about double the quantity of coal to produce similar speed results. Both ships were on services entailing long distance steaming periods at sea, usually such as 3,000 to 4,000, and on some occasions as much as 7,000 nautical miles, without touching at intermediate ports. I was in the Forced Draught ship for 18 months when she was about three years old. In addition to the Fan Engine in the Forced Draught ship, there was fitted a steam hose or jet for purposes of cleaning tubes. The Fan Engine itself was on the engine-room lower platform under the direct control of the engineer of the watch, and could not be interfered with by firemen. The fan was on the level of the 'tween decks and above the boilers, access to it was obtained from the engine-room only, a door and windows being cut in the forward bulkhead of engine-room casing allowing the fan to draw its air from that surrounding the main engine cylinders. The fan was an ordinary centrifugal one, 6 feet in diameter, and was driven by an 8 inch wide cotton belt with suitable guide rollers. The engine or fan gave no trouble whatever, the belt only once carrying away when we had been about 31 days under weigh without a stop. There were heating tubes on fronts of boilers, above smoke boxes, the boiler tubes were 2 ins. in diameter each fitted with spiral retarders. The furnaces were of the Adamson's ring pattern, 3 ft. 6 ins. in diameter by 6 ft. 6 ins. long, and tapering at combustion chamber section to a smaller dia. forming what I believe is called the Gourlay neck. The bridges were built in such a manner as to leave a space of 10 inches between their backs and the back plate of the combustion chamber, from which space any soot collecting could be raked out through a small door under the bridges and into ash pits when required. There were three air valves to each furnace, two to admit air above the fire-bars, and one to admit air to ash pits. The furnace and ash pit doors were recess-jointed with asbestos, and I found it essential to keep these joints in good order. The whole of the fittings, therefore, of the boilers were under the control of the engineer of the watch, viz. :—Fan engine, steam and water gauges, feed check valves, stop valves (main) all being in the engine-room, and the only valves the firemen handled were those to admit or shut off air above firebars at furnaces, when firing. An iron bulkhead separated the stokehold from engine-room, being built round the back ends of boilers (on which steam and water fittings were placed), with an air-tight door (which was ordinarily kept shut), to exclude dirt, etc., from stokehold to engine-room.

In the working of the draught and fan, I found that the most beneficial results were obtained by regulating the speed of fan engine to suit the steam required or the quality of the coal. The air pressure carried therefore ranged from $\frac{1}{2}$ in. to $1\frac{3}{4}$ in. above the bars to $\frac{3}{4}$ in. and 2 ins. in ashpit. I never allowed the air pressure to exceed 2 ins. by gauges on boiler fronts, and this pressure was ample to supply perfect combustion with very inferior coal—viz., Indian. When fires were being cleaned, the fan engine was slowed down (in order to reduce large volumes of comparatively cool air passing over heating surfaces), and the speed was increased again gradually, to suit, when fires were again spread and bars coaled. On firing a furnace, the two valves admitting air above the fires were shut, leaving the ashpit air valve open (this latter was duly shut when cleaning fires or opening ashpit doors), and I found that the best results were obtained by having a thicker fire near the bridge, and tapering gradually down in thickness to the furnace door, as it allowed the air forced in above the bars to strike the coal, and meet that coming up from below, acting, in short, as two blow-pipes at different angles, and deflected to meet where combustion was most required. With an ordinary more or less flat fire I found that the air admitted over the bars seemed to have a tendency, to some extent, to glide over its surface, and so escape, and combustion also was not so rapid or complete.

The temperature of the air used was never over 200° Fahr. At the intake to the fan the temperature was usually 100°, and it was heated under ordinary conditions in the heater tubes before entering the furnaces to 190° and 200° Fahr. At sea the four fires were cleaned every watch (some times oftener if the coal was very bad), and the tubes were cleaned every 48 hours. As regards this latter operation, I have already mentioned that a steam jet was fitted. I found it necessary to discontinue its use, for several reasons. In using the jet, the nozzle was played into the tubes, blowing the soot back into the combustion chambers, and choking up the back ends, and also, in some cases, blowing the retarders back too at the same time, when the steam happened to be wet, caking the soot in the tubes themselves. Further, the loss of high pressure steam (180 lbs.) wasted in this operation was serious, involving a large consumption of fresh water to supplement and to make up feed by evaporator. The stokehold, which was a small one, was almost unbearable, in consequence of escaping steam during the operation, also it was impossible to get the men to stand up to the tube-plate and use the jet efficiently, and I decided to substitute instead of steam the air pressure itself, as a means of cleansing the tubes, and the method I adopted was this. The smoke-box door was opened (after all air pressure had been shut off from that furnace), the tube-plate was then swept down and the soot swept out from bottom of smoke-box with a broom. The heater tubes were brushed through. The smoke-box door was then closed, and the air valves on that furnace and nest of tubes opened, and the air valves on all the other three furnaces closed for about two seconds to allow the full blast to pass for the moment through the one nest of tubes requiring it; the fires at the time being bright. There was a fireman or coal trimmer at each of the furnaces to open and close the valves smartly, and the engineer of the watch (usually the 2nd) supervised the operation, which took about 15 minutes for the whole four fires. I never found it necessary that this operation need be performed oftener than every 48 hours, with even the worst kind of coal, and also I found that the scour of the soot through tubes (which in a forced draught ship is gritty and coarse) tended to keep them clean internally, and obviated all need for the use of scrapers at any time.

In port the retarders were drawn and scraped, and the tubes swept in the usual manner with wire brushes, and I never found any choked or any trouble with them after the use of the steam hose was discontinued. Not one ever leaked or needed an expander, the furnaces were perfectly tight, and I had no trouble with buckled combustion chamber plates, furnace crowns coming down, or altering shape, neither any burnt stay nuts,or cracked plates. In fact, no repairs of any kind were needed or carried out on those boilers for the 18 months I was in the ship. Curiously enough such was not the case in the sister ship, which was troubled from the first with leaky rivets at saddle plate in two of her furnaces, in spite of her natural draught.

The furnace-bars had to be kept in good order and renewals were more frequent than I have ever found to be the case with boilers under natural draught, that could only be expected however, considering that double the quantity of coal was burnt upon them in less time, and occasionally with some qualities of coal they showed a tendency to burn. This could always be checked in time, however, with care, as each of the ashpit doors was fitted with mica windows, and it was a small matter to occasionally glance through to see if sparks were falling from the bars at any place, and if so, then to slice up the fire. The firemen could be depended upon to see to this themselves, for their own comfort, as when a bar failed it meant that another had to be put in at once. I never found it necessary to wedge the fire-bars, and do not at all approve of the practice.

Both the engine-room and stokehold were certainly the coolest of any I have ever been in, and I attribute the cause, in the first place, to the fan drawing heated air from top of engine-room, and as regards the stokehold, the air trunks had double casings and were carried down in the usual manner on fronts of boilers. The ashpit doors also being airtight and closed, cut off the radiation of heat from ashpits into the stokehold. The funnel temperatures ranged from 550° to 650°

Fahr. I have no actual tabulated results, but no doubt they could be obtained if desired.

Now as regards the internal treatment of these boilers. No salt water was ever used in the feed make up, neither were the boilers ever filled at the commencement of a voyage with salt water. The only salt water getting in, came from any very slight leaks of condenser tubes, or from the priming of the evaporators. I never saw the density of the boilers reach 5 ozs. of salt to the gallon in the whole period of my charge. When reaching about 3 or 4 ozs. I had it changed and we usually ran about 2 to 3 months without opening up. The feed was supplemented from tanks (as well as evaporators), one of the ballast tanks in double-bottom being set aside for that purpose. When at sea the temperature of feed was usually 210° Fahr. and in port, if it was necessary to pump up boilers under steam, one direct acting steam pump circulated the hot water in the boilers and feed pipe connections, whilst a similar pump drew the water from tank and pumped slowly into feed pipe. Thus, the cold water was heated on its passage to the boilers, and at the same time mixed in the boilers themselves, the temperature falling certainly, but kept constant throughout the whole structures. On raising steam from cold water, the first mentioned pump was started from the time fires were lit, drawing water from the bottom of boilers and pumping it back at the top or water line level, until the steam pressure reached 60 lbs. This is a much more efficient circulating method than any hydrokineters ever fitted. To raise the steam gradually to 140 lbs., 12 or 18 hours were invariably allowed, and fires were always lighted under natural draught, the fan not being started until the engines were getting under weigh. No doubt even 4 to 6 hours or less might have sufficed, but I never allowed any forcing to be done.

Internally the boilers were fitted with studs having large square shoulders to take zinc tiles. I increased the number and therefore the weight of zinc carried in the boilers, which was about 11 lbs. to the square foot of fire-grate area. I was always particular in securing a metallic connection between stud and zinc. The studs and nuts being polished on shoulders and faces with files before tiles were put on and the tiles themselves faced up and right round stud holes with a pin drill on both sides. No cast zinc was used on studs, only rolled plate. Old tiles when taken off studs were well scaled and then cast into blocks, which were placed in bottoms of boilers in contact with the shell. The steam spaces of boilers were painted with a mixture of white zinc and kerosine oil. I never found any signs of pitting or corrosion. Further, as no oil was ever used to lubricate main engine pistons, or piston and slide valves, or in fact any auxiliary engine pistons or valves, the only oil possibly able to enter boilers was that used to swab the piston rods, and that was infinitessimal, the second Inter. piston rod being swabbed once lightly every half-hour and the L.P. rod once every hour. Naturally, there was never any indication of any grease or oil in those boilers and neither was there any scale. The upkeep expenses were therefore confined to the cost of fresh water, zinc tiles, and firebars, fire bricks, and cement, and I hear that her expenses still are very low, for with the exception of firebars, everything can be said to be halved to what a steamer of the same I.H.P. under natural draught would need, the only other extra being fan and engine.

In consumption of coal per I.H.P. the results were most favourable, even with Bengal coal, and I daresay a good number of members are familiar with it. The range of consumption was from 1·8 lbs. to 2·3 lbs. per I.H.P. per hour, and the way this was computed was for the total consumption for voyage in relation to average I.H.P. to be calculated, and not the mere measurement of the weight of coal for an hour or two. The deduction made on total coal consumption was for steering engine and ash hoist. The way I arrived at the latter quantity was as follows: the auxiliary or donkey boiler being also worked at 180 lbs. pressure, it was kept working at sea for two days and nights, and the steam used only by steering engine and ash hoist, and exhausted into condenser (main). The coal used was carefully measured and weighed, and 5 per cent. was deducted from total, and it formed a constant value to subtract for every 48 hours steaming from total consumption. The extras of fan engine and direct-acting steam feed pump (Weir's System) were included as belonging to consumption of main engines.

In actual running the coal consumption in this ship was always marked by much greater economy from the time she commenced running, as compared with her sister with natural draught, in spite of there being an actually greater demand for steam on account of an extra auxiliary engine running constantly, viz., the fan engine.

On one particular voyage of about 14,000 miles (outwards and inwards), both ships doing exactly similar work, commencing voyage within a few days of each other, draught of ships the same and both freshly docked before voyage, the ship with the forced draught kept up ½ a knot greater speed and had a less consumption of similar coal (Bengal) than her sister by about 500 tons. Both ships as regards internal treatment of boilers were worked in an exactly similar manner to what I have fully detailed.

In my experience also in charge of machinery of exactly similar style to these, but with boilers under natural draught, the lowest consumption of coal (Bengal) that I could obtain was from 2·0 lbs to 2·4 lbs. per I.H.P. per hour, and in good triple engines with natural draught I have found it the same,—calculations being made on the same basis, and boilers worked in all respects under similar conditions internally as already detailed.

My opinion, therefore, from direct personal experience and supervision of both systems is, that for economy and comfort, forced draught is greatly superior to natural draught. At the same time I do not deny that in individual cases it often happens, even in ships exactly similar, results do not agree. Forced draught may require more care in manipulation, and I am prepared to say that it *does*, but I cannot agree with some speakers at the discussion that marine engineering practice should revert to natural draught because in some cases leaky tubes and furnaces have occurred in steamers. I do not undertake to say what will effectually prevent such things occurring, and I merely give an instance in which they did not occur, also I might remark the fact that we all know that leaky tubes and furnaces are not confined wholly to ships with forced or induced draught, and can generally be traced to feeding or pumping up boilers with cold water while under steam, the injudicious forcing of fires when cold, or partly so, and through ills attendant on deposits of scale or oil on internal heating surfaces.

To my mind the suggestion of reverting to natural draught for any modern steamer seems on a par with the idea of reverting again to natural means for propulsion also, viz., sails and wind for sea-going vessels. Mechanical draught seems to me a natural means to attain mechanical propulsion. It will cross the mind of members with sea-going experience in the Tropics, how at times on a hot calm night, or days, or a following wind, the stokehold and engine-rooms are as furnaces, and steam hard to get, ventilators trimmed to catch every "cat's-paw," and men dripping with perspiration. I see in the mechanical means of producing draught for the fires, a method by which the engineer himself is independent (as well as the steamer herself, as surely all steamers ought to be) of atmospheric conditions for obtaining proper and efficient combustion which can be (or ought to be) controlled by him to suit any given conditions or requirements, such as speed, the varying conditions of good and bad coal, and the facility by which the latter can be burnt, and more got out of both than is possible under natural draught.

To my view, a system of mechanical draught, to be successful, should be capable of having its air heated (the hotter the better) for feeding the fires, on the same principle as feed water is heated to feed the boilers. It tends to minimise strains and stresses owing to fluctuations of temperature while working, as well as shows an economy in coal. If possible, the fan or fans should be placed above the boilers in the hottest position, and air trunks provided to draw air from hot and confined spaces; it should have a compartment to itself. All the fan bearings should be dust-tight, and of ample strength, and have automatic lubrication. The engine should drive it direct, coupled by an intermediate shaft through the fan room bulkhead, being itself in the engine room, where it could be kept in good order, and at the same time be under efficient supervision and control. I do not believe in any machinery being placed in a stokehold, not even pumps, of whatever nature or use, far less quick running fan engines. The engine-room is the place for engines; they can be kept in condition for good work, and wear longer, which object can never be attained by having any sort of machines in a dusty stokehold.