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President: JAMES DENNY, ESQ.

PAPER OF TRANSACTIONS No. CXLVIII.

Improved Force Draught Arrangement.

BY MR. J. MACDONALD STRATTON (MEMBER).

READ AT

58, ROMFORD ROAD, STRATFORD,

On Monday, March 30, 1908.

CHAIRMAN: Mr. F. M. TIMPSON (MEMBER).

The HON. SECRETARY: I am sorry Mr. Stratton is not able to be with us to-night. He informed me the other evening that he was expecting to be called North and was afraid he would not be with us to-night, and I will therefore read this paper on his behalf.

As a number of engineers have rather a vague idea of the obstacles which combustion of the fuel has to encounter in the ordinary return tube boiler, I think a short paper on the subject, and on the best means of increasing the efficiency of a furnace, might profitably be discussed at this meeting.

The first and principal obstacle to combustion is the small space between the fire and the shell of the boiler.

Second: The air required for combustion not being sufficiently heated before passing over the fire.

Third: Admitting either too much or too little air into the furnace.

The space between the fire and the front of the furnace is not sufficient for the air required for combustion to mingle freely with the hot gases rising from the body of the fire; the consequence is that the air does not receive the full benefit of the heat from the hot gases when passing over the fire.

When the air is forced into the front of the fire it passes along this confined space at a high velocity, cooling, and carrying along with it some of the burning and unburned gases of the fire.

As a considerable amount of these gases pass along in contact with the water-cooled plate of the furnace crown they do not obtain sufficient heat, and are, in some cases, even reduced in temperature by coming in contact with either the colder air supplied for combustion, or with the water-cooled plate of the furnace crown, that they fail to ignite before passing out of the combustion chamber, thus a great loss of the economical furnace efficiency occurs.

To increase the economical efficiency of a furnace I think the following points should be attended to :—

(1) A refractory lined space should be made at the bridge end of the furnace, and in the lower part of the combustion chamber, for the furnace gases to mingle freely without hindrance from water-cooled plates.

(2) Admitting only a sufficient amount of hot air into the furnace above the fire-grate, and into the refractory lined space of the combustion chamber, as will ensure proper combustion of the fuel.

(3) Working with two air pressures under the fire-grate— a strong air pressure along the centre, and a light air pressure along the sides and back.

(4) The furnace gases must be of a sufficiently high temperature at the bridge end of the furnace as will ensure their ignition before passing out of the combustion chamber.

A suitable refractory space can easily be got by lining the lower part of the combustion chamber with brick or other refractory material, and by forming openings fitted with regulating grids, and perforated plates on the plate, at the back of the ash-pit for admitting air from the ash-pit into the refractory space.

To deflect the furnace gases down towards the refractory space of the combustion chamber a brick arch should be built at the combustion end of the furnace, a short distance off the bridge.

In some cases where the bridge is at the end of the furnace tube, the fire-grate would have to be shortened, and the bridge brought forward, so as to leave a space between it and the arch for the gases to pass from the fire into the combustion chamber.

One of the most important, and I may also say the most neglected, points in effecting combustion is the regulating and admission of air into the furnace. I think if a little more care and thought were given to this important subject, a much greater economical efficiency would be got out of the furnace.

As a general rule, in forced draught arrangements very little attention is paid to it ; the tendency, however, seems to be to work with a large excess of air, and the heat losses are much more largely due to the heat mechanically carried away by the waste gases than to imperfect combustion. The heat losses due to these causes are often very much greater than is generally recognized by engineers, and there is no doubt that in many cases these losses rise to over 30 per cent. of the total heating value of the fuel.

In some cases I have noticed when the fires were being replenished with slack coal that a considerable amount was carried by the draught directly into the combustion chamber, without it even resting or falling on the fire.

Owing to the varying conditions of the fire it is not possible to state the exact amount of air that should be admitted into the furnace, but an approximate amount can easily be given. The best way to test the efficiency of a furnace is by examining the waste gases. The examination should cover the following points :—

(1) Chemical composition.
(2) Draught and temperature.
(3) Colour.

The composition of the waste gases passing from the furnace may be ascertained by examining a sample taken from the smoke-box. The form of sampling apparatus employed depends upon the character of the test. The most suitable for marine purposes appears to be either the Fischer, or the Orsat-Lunge gas testing apparatus. By either of these apparatus the percentages of CO_2 can easily be found. For practical purposes it is usually sufficient to ascertain the percentage of carbon dioxide (CO_2) in the waste gases. Perfect combustion yields a gas containing 21 per cent. CO_2 and 79 per cent. nitrogen.

The maximum percentage of CO_2 in the waste gases when bituminous coal is burned is 19 per cent., but in working practice this percentage cannot be got, the average under the best working conditions being about 15. In a great majority of cases, however, the percentage will be much below this figure.

Percentages of CO_2 below 19 per cent. indicates that more air is being passed through the furnace than is required for the combustion process, and the diminished CO_2 percentage is the measure of this excess of air.

Thus 15 per cent. of CO_2 represents $\frac{19}{25} = 1{\cdot}27$ times the requisite amount of air, or a 27 per cent. excess.

As it is not practicable under ordinary working conditions to reach a higher percentage of CO_2 than 15, there must always be some waste of fuel which will not be less than 12 per cent., should the percentage of CO_2 drop to 9 the loss of fuel would be about 20 per cent.

Another important point is the draught. The air pressure should be taken at the fan, furnace, and ash-pit. There is a great difference of opinion among engineers as to the amount of air pressure that should be carried in forced draught arrangements. A number advise an air pressure at the fan of at least 3 inches, others say $1\frac{1}{2}$ or 2 inches is quite strong enough.

If a high air pressure is carried, the heat losses must be very great, unless means are adapted to retard the velocity of the gases in the furnace above the fire-grate.

The colour and appearance of the waste gases should also be examined. When perfect combustion takes place, the gases—while still in a flaming state—are transparent. It is not possible to inspect a furnace properly without a coloured glass. The best glass to use is a violet blue ; flames looked at through such a glass will, if in a state of imperfect combustion, be resolved into streams of a dark coloured gas, but when the combustion is perfect, the interior of the furnace and the fuel assume a lavender-grey colour, all rays of a lower intensity being cut off by the glass.

The absence of smoke is no absolute guarantee that perfect combustion and the highest economy are being obtained; this absence of smoke may be the result of using a large excess of air in the combustion process.

I HAVE been asked by Mr. Adamson to give a description of my forced draught arrangement, and to state the advantages to be derived from it. This I have pleasure in complying with in the following short paper. Having had a number of years' experience with Mr. Howden's forced draught system, I have noticed three points which I think could be improved upon :—

(1) Insufficient heating of the air required for combustion when the fires are being cleaned, or when the air-heating tubes are dirty.

(2) The liability of the air in the ash-pit escaping through weak or uncovered parts of the fire-grate into the furnace above the fire-grate, without doing any useful work along the centre of the fire.

(3) The difficulty of preventing an excessive amount of air getting into the furnace above the fire-grate, which would reduce the evaporative economy of the furnace.

In Mr. Howden's air-heating chamber the air enters at the centre in two separate volumes, each volume being divided into three or more currents passes along the chamber to its respective end. Thus each volume comes in contact with only half the number of the air-heating tubes that are in the chamber ; consequently when a fire—especially a wing fire—is being cleaned, or when the air-heating tubes are dirty, the air passes through the chamber without getting the full benefit of the waste gases from the other fire or fires.

The principal defect in the system most generally in use is the liability of the air escaping from the ash-pit into the furnace along the outer wing bars of the fire-grate. Mr. Howden noticed this, and put broad-side bars in the wings of the furnace, but these are not broad enough to do much good, and if they are made any broader they would impair the efficiency of the furnace. The air in the ash-pit tends to cling to, or rush up, the walls of the ash-pit, causing the coal along the sides and back of the fire to burn more quickly than the coal along the centre, so that holes and weak spots are soon formed along the sides and back of the fire, through which the air escapes from the ash-pit into the furnace above the fire-grate. I think the best way to prevent, or at least check, this escape of air from the ash-pit would be to form a separate chamber along and underneath the fire-grate ;

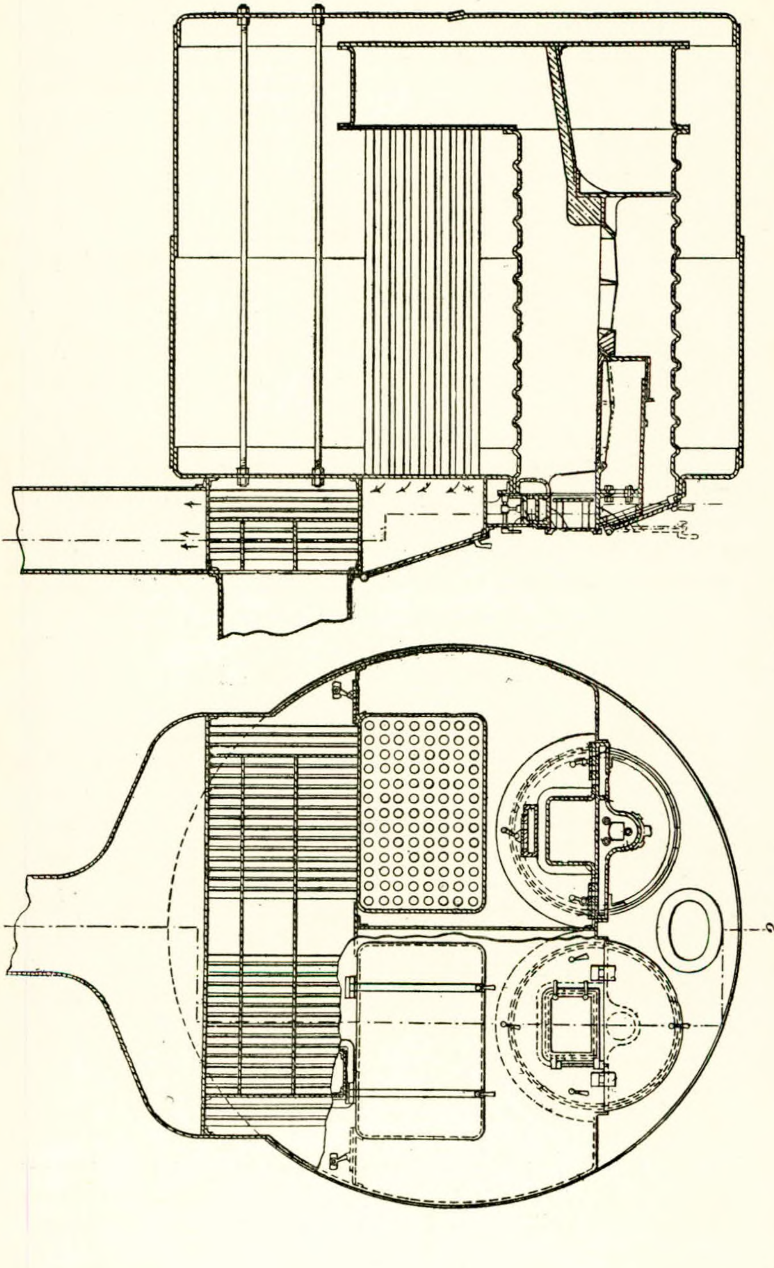


FIG. 1.

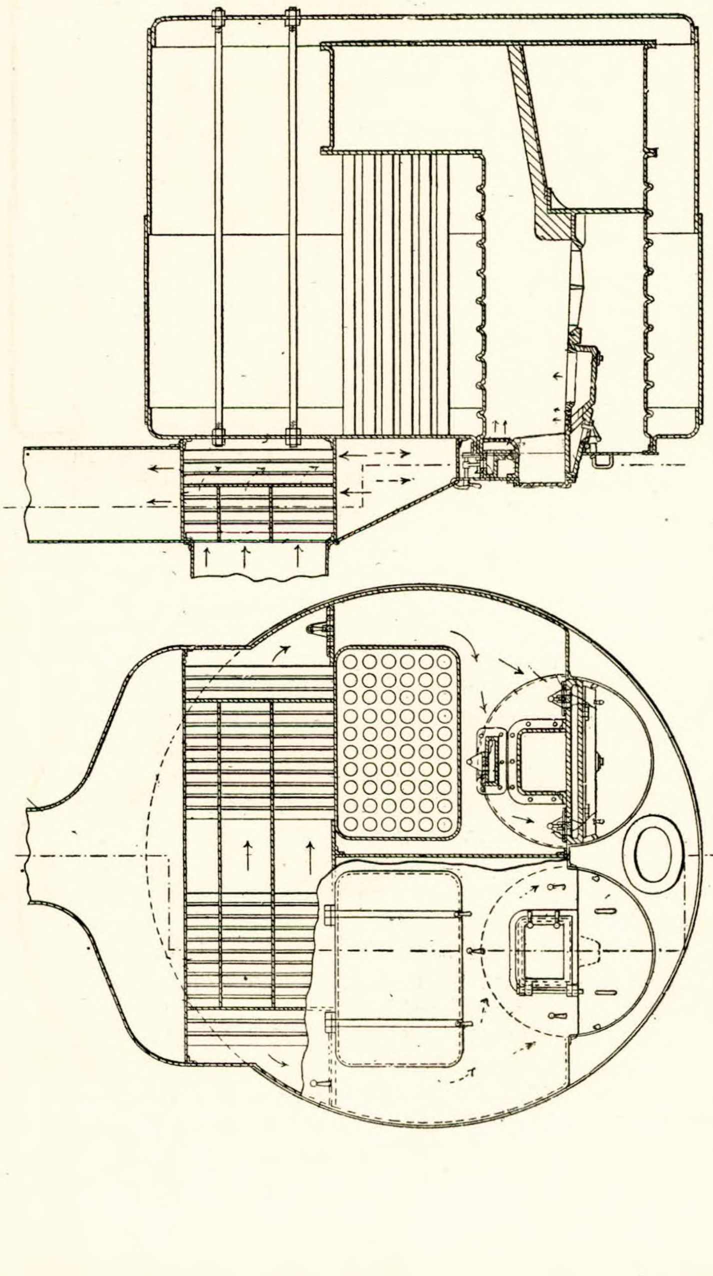


FIG. 2.

by doing so, two air pressures can be used under the fire-grate—a strong pressure along the centre, and a light pressure along the sides and back. The part of the fire that requires a strong air pressure is along the centre of the grate for a length of about 18 inches from the front end. If that part is kept in good burning condition there should be no trouble in getting the remaining part of the fire to burn freely with a light air pressure under it. I have been told that the flames might be forced into the sides of the ash-pit on account of the small air pressure used there, but I think this could only occur if the bridge and tubes were choked; the strong air pressure along the centre would be greatly reduced in strength in its passage through the thick part of the fire.

I will now give a short description of the several improvements which have suggested themselves to me in my experience of forced draught, and which I have embodied in specifications and drawings setting forth the arrangements in detail. The air enters the heating chamber through an opening adjacent to one end of the chamber, and passing through it in the direction indicated by the arrows, is heated by coming in contact with the tubes through which the waste gases pass. By this arrangement the air is made to traverse the whole length of the heating chamber; consequently it gets the benefit of the waste gases from all the furnaces in the boiler or section before passing out of the chamber.

From the air-heating chamber the air passes through openings at the ends into the air casing fixed in front of the boiler; from this air casing the air passes through valve-controlled openings into the front of the furnace, whence it is distributed through perforated baffle boxes over the front of the fire. From the air casing air also passes through valve-controlled openings into a chamber fixed across the furnace. From this chamber the air passes through an opening into a trough-shaped chamber fixed along the centre of and underneath the fire-grate. From this trough-shaped chamber the air passes through the perforated plate or firebars fixed on the top into the bottom of the fire. The front end of the trough-shaped chamber rests upon the chamber, and its inner end rests on the middle or back bearer bar. The advantages of this arrangement over the present system of forced draught are:—

(1) The air required for combustion would be more effi-

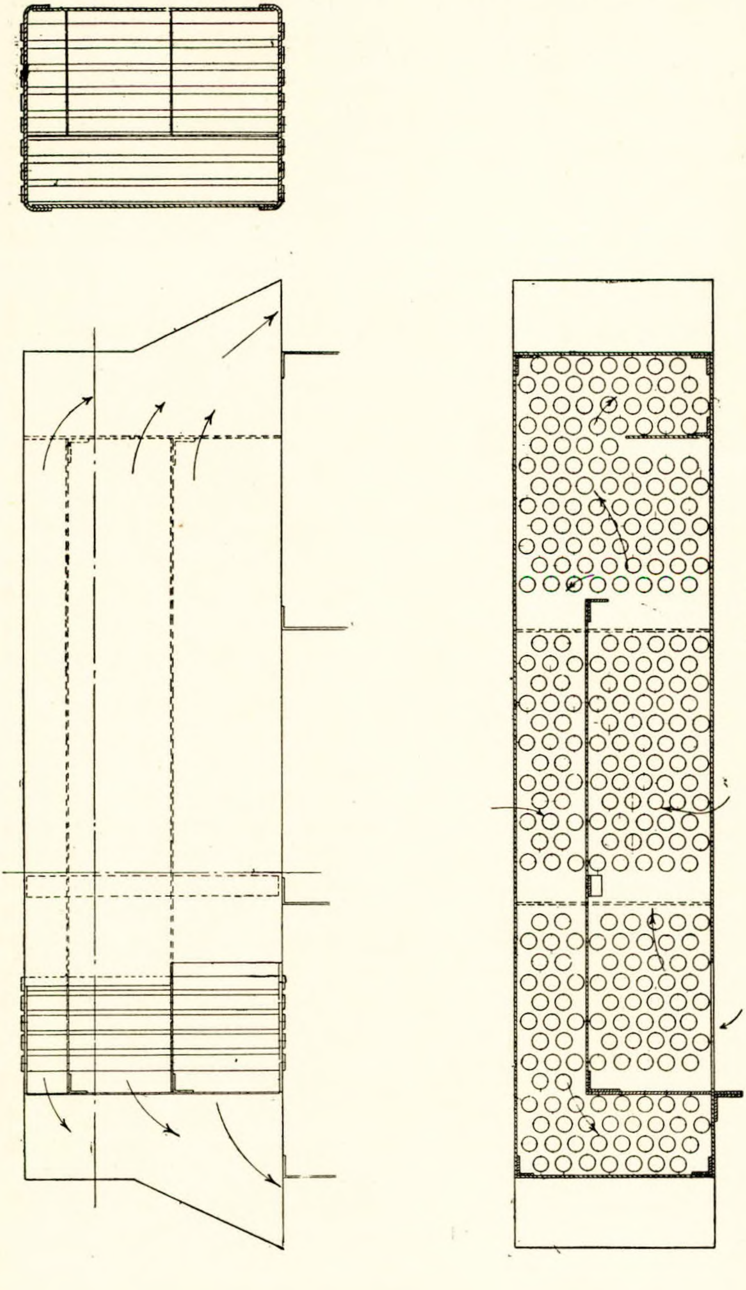


Fig. 3.

ciently heated in the air-heating chamber. Mr. Howden stated in one of his lectures that the heating of the air required for combustion by the waste gases is an element of the first importance in effecting a high economy of fuel in forced combustion.

(2) The area of the valve-controlled openings being designed to give a low air pressure in the sides and back of the ash-pit, there is less liability of the air in the ash-pit forcing an opening through the sides and back of the fire, and so escaping into the furnace above the fire-grate.

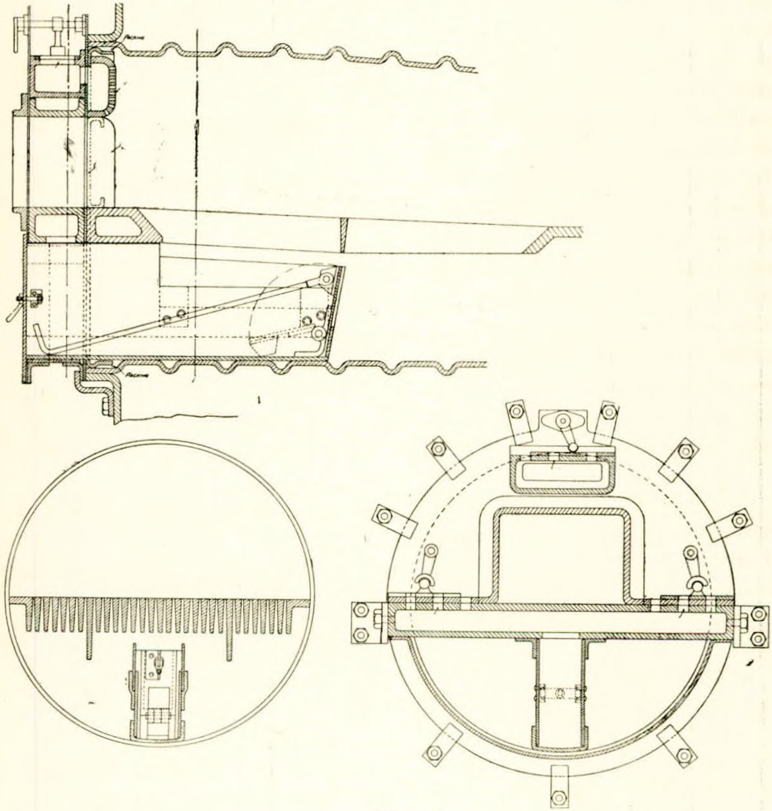


FIG. 4.

(3) Less damage to furnace, furnace fronts, and tube box doors.

(4) Greater evaporative economy of the boiler.

In lieu of the chamber along the fire-grate a narrow chamber may be fixed along the ash-pit. This chamber is open at the top, and is of a depth to extend from the floor of the ash-pit to, or nearly to, the under side of the firebars, and extends from the door of the ash-pit longitudinally along the whole or part of the length of the ash-pit. The front end is closed by the door of the ash-pit, and the inner end is preferably provided with a hinged shutter adapted to be regulated, or opened and closed by a rod. An extra deep firebar is preferably arranged at a suitable distance from each side of the chamber, along the whole or part of the length of the ash-pit, with the object of baffling the air and diffusing it to the wings. The air from the chamber enters into the front end of the ash-pit chamber. Rising, some of it enters directly into the bottom of the fire, and some of it passes over the walls of the chamber into the sides and back of the ash-pit. In this arrangement only one air pressure can be used under the fire-grate ; the air being forced to rise along the centre of ash-pit causes a greater draught along the centre of the fire-grate than along the sides. I will now conclude, in the hope that this somewhat brief description may result in provoking a discussion on the details of forced draught to which your attention has been directed, and with the desire that those of my fellow-members who have had experience in the use of mechanical draught will relate their experience, that the advantages and disadvantages of the different systems may be considered in the light of the aggregate experience.

CHAIRMAN : I am sure we must thank Mr. Stratton for bringing up this very important subject, a subject which is of interest to every marine engineer, as forced draught is used so universally. It is a pity he has not explained details more minutely, but as he desires the opinions of the members, no doubt those who have experience of the system will express your opinions freely. There is no doubt forced draught causes anxiety in some cases, one source being in the class of coal supplied. Some have the opinion that any coal will do, but there are other opinions on that point. I think the great object in forced draught is in cutting down the number of boilers, a reduction which makes a great difference in the earning capacity of the ship. The subject is now open for discussion.

Mr. J. H. Silley (Member) : As I feel a little in the dark as to what Mr. Stratton's proposed arrangements are, it would have been better had he been here to answer any questions. I do not see there is any difference between his principle and that in general use on the great majority of steamers except in detail. The air heating chamber is practically the same, but I understand the vertical baffles have been tested against horizontal baffles and found less efficient. Another part that strikes me as being objectionable is the cast-iron trough arrangement in the ash-pit. This would restrict the capacity of the ash-pits considerably ; even now with some classes of coal, great care has to be exercised in keeping the ash-pits clear. I think there might be some advantage if we could get some air up through the front of the fire, but this has been done before in natural draught jobs by means of a sliding baffle in the ash-pit, which could be regulated according to the rate of combustion required. Then again if I understand his sketch, he allows an amount of air to pass from the ash-pit into the combustion chamber without passing through the fire. Is that as the sketch shows ? If the cold air is allowed to go into the combustion chamber, without passing through the fire, I think it would not do. Some years ago we had a paper on forced draught in which it was made very clear that any quantity of air over that required to complete combustion, admitted to the combustion chamber actually reduced its temperature and consequently the steaming abilities of the boiler.

Mr. J. H. Redman (Assoc. Mem.) : I should like to ask Mr. Stratton by what arrangement he proposes to remove ashes from the central chamber. There appears to be a little half-round door in the front, possibly 4½ in. diameter and 3 in. up from the bottom. I do not see how it is possible to get the ashes out of this, unless the sliding door in the bottom, along the centre of the furnace, is for that purpose. There does not seem to be very much room to remove the ashes. In the front of the furnace there is a space about half the length of the furnace. In a very short time that will be filled with ashes, and how are they to be withdrawn ?

Chairman : With regard to Mr. Redman's remarks, I think the arrangement is to draw the ashes either from the side or from the centre. The opening at the bottom will be for raking the ashes through, and I suppose a special rake will be required for the purpose. These sketches are just to show the various conditions and how he proposes to adapt his system to them.

Mr. SILLEY : My difficulty has generally been to get the ash-pit large enough, this arrangement reduces it.

CHAIRMAN : I understand the point you emphasize is that if the central combustion chamber is closed in with some kinds of coal, the bars would come down ?

Mr. SILLEY : With some coal it would be absolutely impossible to work with this arrangement.

Mr. W. H. HOWELL (Member) : With Australian coal it would take them all their time to work with the arrangement shown.

CHAIRMAN : Yes, even under the present system some kinds of coal are very bad with forced draught, and the same coal, under natural draught, gives excellent results. Nesting appears to be very common with some coal under forced draught, and I have seen pieces about 6 to 8 in. long choking up the tubes.

Mr. SILLEY : It may be there is a certain amount of vapour from the coal which naturally varies with the quantity of moisture contained in it. With Welsh, Australian or New Zealand coal nesting very seldom occurs. Some ships use steam jets for cleaning tubes, and these are sometimes blamed for causing nesting.

Mr. R. S. KENNEDY (Member) : I saw a curious steam turbine the other day for cleaning out tubes. It was for electrical work and was rather a novelty. It was used to clean out any hard scale that had formed, by means of centrifugal force.

CHAIRMAN : I think there are retarder arrangements nowadays that help very greatly in keeping the tubes clean. Henderson's automatic firebar arrangement seems to be on similar lines. They clean the fire from the back with a long scoop. I presume this would be worked on a similar plan.

Mr. J. G. RENDALL (Member) : We use Henderson's bars on the arrangement Mr. Timpson mentioned. We have done away with the shovel and simply let the back fill up, pulling the ashes out over the top. It does not affect the fires, or the heat in the combustion chamber at all. We keep the door underneath always shut, in fact it is blocked up with the ashes.

The Hon. Secretary: Practically the back is filled up to the back bridge.

Mr. Rendall: There is no bridge at all with Henderson's bars. His arrangement comes down something like that shown on the sketch where the brick arch is, but there is no brick arrangement. At first we used the door underneath and shovelled it out, but now we find it answers better to leave the door shut and pull it out over the top. When we have finished cleaning the boilers, we fill the back end up with ashes, stopping all draughts from getting in.

Chairman: In that case you may just as well have the bridge built across.

Mr. Silley: Mr. Stratton says there will be less trouble with the back plates, but I am doubtful about the smoke-box doors and the furnace fronts. The difficulty now is quite serious enough, although the greatest combustion takes place at the back of the furnace, if it is to be increased towards the front, I do not know how the baffle plates will stand.

Chairman: There are no baffle plates shown.

Mr. Silley: There must be baffle plates, or the furnace fronts would be destroyed.

Chairman: It is not usual to leave the air space exposed, it is bound to be baffled somewhere. Mr. Stratton says that, having had a number of years' experience with Mr. Howden's forced draught system, he has noticed three points which he thinks could be improved upon. The points are: (1) Insufficient heating of the air required for combustion when the fires are being cleaned out, or when the air-heating tubes are dirty. (2) The liability of the air in the ash-pit escaping through weak or uncovered parts of the fire-grate into the furnace above the fire-grate, without doing any useful work along the centre of the fire. (3) The difficulty of preventing an excessive amount of air getting into the furnace above the fire-grate, which would reduce the evaporative economy of the furnace. Is that the experience with the ordinary types, generally?

Mr. Silley : The air supply above or below the bars can be easily controlled. With certain classes of fuel it is necessary to work with the top valve full open and with a reduced supply to the ash-pits, but under ordinary conditions as to coal, the air supply above the bars is about one third of that in the ash-pits. When the quantity of the air above the fire is greater than it should be, the efficiency of the boiler is lowered.

Chairman : It will greatly depend upon the class of coal being burned. The regulating at present seems to me to be pretty well in hand. Mr. Stratton claims as an advantage of his system over the present arrangement that "the air required for combustion would be more efficiently heated in the air-heating chamber." I do not think he clearly shows what that system of heating the air is. I do not know whether there is any objection to the present system.

Mr. Redman : There is the objection he made in stating his first point : "Insufficient heating of the air required for combustion when the fires are being cleaned." In this case he makes the air travel the whole width more than once. Mr. Stratton refers to Mr. Howden's arrangement and says : "In the air-heating chamber the air enters at the centre in two separate volumes, each volume being divided into three or more currents passing along the chamber to its respective end." Apparently in that system it only passes right and left.

Chairman : Of course it would be a mistake if the air were driven too quickly through the furnace. A recording instrument would be a great advantage, but I do not think there is an instrument that can be applied to marine work.

Mr. Redman : I inquired into that point at the recent Engineering Exhibition at Olympia, and was told that the makers had not paid particular attention to marine work.

Chairman : It was tried on two ships that I know of. The trouble was that it would not register properly on account of the vibration. With regard to this question of air pressure, he appears to provide two different pressures, strong in the centre and light in the wings. That would possibly be an advantage if it worked out all right. Of course that is a thing that has to be proved in practice, the idea is good enough.

I presume with the ordinary Howden's system the pressure is the same all over.

Mr. Silley: One point he raises is about the wing firebars. This was gone into years ago. I believe that several of the troubles with furnaces, apart altogether from the question of economy, were supposed to be caused by air passing up between the wing firebars and furnace sides, but since then great improvements have been made. That is, I presume, what he means when he speaks about the wing firebars not being satisfactory. They are very different from what they were when forced draught first came out for marine purposes. Mr. Howell could give us some experience on that point.

Mr. W. H. Howell (Member): We have a ship fitted with Howden's forced draught system. It has been fitted six years and we have had no trouble with the wing bars. They are made with a groove which is fitted well into the corrugations, and thin asbestos is fitted inside so that there is no escape of air at all.

Chairman: There is another point that Mr. Stratton raises in relation to the draught. He says: "There is a great difference of opinion among engineers as to the amount of air pressure that should be carried in forced draught arrangements. A number advise an air pressure at the fan of at least 3 in., others say $1\frac{1}{2}$ or 2 in. is quite strong enough." Well, I think that depends upon the coal and the conditions under which it is worked; but, on an average, perhaps some of the members might say what is their experience.

Mr. Howell: With Welsh coal I should say $1\frac{1}{2}$ to $1\frac{3}{4}$ in., Australian coal, $2\frac{3}{4}$ to 3 in., and about the same with American coal, $2\frac{1}{2}$ to 3 in., New York coal is generally about 3 in. I have never been over that, and have had very good results with those pressures, that is at the fan.

Chairman: What would it be at the ash-pit.

Mr. Howell: About 1 in. at the ash-pit and a little less at the furnace.

Mr. A. Robertson (Member): I think the average is about $\frac{5}{8}$ to $\frac{7}{8}$ in. as a general rule. I have had the pressure tested watch after watch for a fortnight and seldom got more than $\frac{7}{8}$ in. We were not supposed to exceed $2\frac{1}{2}$ in. at the fan.

CHAIRMAN: Another point that might be useful to know is the poundage of coal per sq. ft. of grate surface.

Mr. ROBERTSON: It depends upon the size of the boilers and the amount of steam they have to generate. If you are rushing the boilers you will naturally burn more per sq. ft. of grate surface. Our average was about 25, but the boilers were forced to some extent.

Mr. SILLEY: I should not say that was very economical running; 20–22 lb. would be most economical. Of course, as Mr. Stratton says, if there is not sufficient air there is no economy.

Mr. REDMAN: I should like to ask on what grounds he claims there will be "less damage to furnace, furnace fronts, and tube box doors." I do not see how it will affect the tube box doors in any way.

Mr. SILLEY: The highest temperature at which the air would be admitted under this arrangement would be about 240 degrees. If that air is allowed to mix with the gases in the combustion chamber at a temperature of 3,000 degrees it is going to bring down the temperature to a great extent. I worked out some years ago that an increase of 1 in. air pressure reduces the temperature in the combustion chamber 1,000 degrees. If the temperature is reduced to that degree it must result in low efficiency. The question seems to be whether proper combustion can be maintained in the furnace itself or whether air should be admitted direct to the combustion chamber. According to Mr. Howden's experiments, I understand he got the adverse of satisfactory results when he allowed air to pass direct from the ash-pits to the combustion chamber, as the temperature in the former was thereby much reduced. I believe that Mr. Stratton is right in theory, that if it is possible to get the air right up into the front of the fire there might be better combustion, but the trough arrangement which he proposes will cause trouble.

CHAIRMAN; Of course that might be subject to modifications in design.

The Hon. Secretary: Meantime the main point is the principle of the arrangement, not the mechanical details. The question is whether it is a good thing to have some system of heating the air as a modification of, or improvement upon, the present system. Mr. Stratton claims that it does. It may not be quite clear to see how he does it, but the main question is whether it would be a good thing to heat the air over what is obtained with the ordinary arrangements. Mr. Stratton says that from his experience you do not get a uniform temperature where you want it. You do not get the best draught through the fire at the parts where it is most required, and he has devised this system with the object of improving that. I have heard engineers arguing that heating the entering air does not do a bit of good, they would sooner not have heating tubes interposed between the fan and the furnaces; this view, however, does not seem correct in theory.

Mr. Silley: I think they are wrong there. I saw the results of a series of experiments carried out with and without heated air and entirely independent of Messrs. Howden & Co. The average saving of fuel with the heated air of combustion worked out at 15 per cent. over that of the cold air. The amount of water evaporated, weight of coal, and everything else were taken into consideration and plotted.

Mr. Robertson: Anybody with any practical experience would draw the same conclusion, that it is a great advantage to have the air heated. When you are firing a boiler you have to look after it most carefully to see that the firemen do not keep the doors open too long, thus allowing too much air in. It has a detrimental effect on the fires at once. Has this system been tried?

The Hon. Secretary: No, Mr. Stratton is one of our members who has been out on a foreign station for some years and has only just come home.

Mr. Robertson: I certainly agree with Mr. Silley on that point, but it is adding complications to the furnace, and unless skilled firemen are employed trouble is likely to be caused, and it will be a hard job to get out of it at times. With forced draught the firebars are to be nicely packed in the first place—you always have to be very careful in putting them in—and often if one bar projects slightly above the other it leads to trouble before many days.

The Hon. Secretary: It would be interesting to have records as to the highest poundage of coal consumed in forced draught per sq. ft. of grate surface.

Mr. Robertson: On the locomotives it is very high, running to between 60 and 70 lb. per sq. ft., but I believe that some marine boilers get as high as 32.

The Hon. Secretary: My attention was called to a case where, in a marine boiler, it was said to be something like 48 lb. to 50 lb., an amount which appeared to me so abnormal that I questioned its correctness.

Mr. Howell: With Queensland coal I think it might get as high as 45, at any rate it is considerably higher than Bulli.

Chairman: Seeing that this is a subject of so much interest to engineers, more of our members might like to say something about it, and I think we ought to reserve, say, next Monday night for the purpose of an adjourned discussion.

Mr. Silley: I do not think we can go much further unless Mr. Stratton comes.

The Hon. Secretary: Mr. Stratton might send a reply to this criticism and the points that have been raised, although I think it would be better if he could be here himself. If it is your wish, I could give a summary of the views that have been expressed to Mr. Stratton, and we would probably have his reply before us next Monday night.

Mr. Robertson: I should like to propose that we adjourn the discussion till next Monday evening.

Mr. Redman: I have pleasure in seconding the proposal, but would add that we should be pleased if Mr. Stratton could be present on that occasion.

Mr. Silley proposed and Mr. Robertson seconded a vote of thanks to the Chairman, and the proceedings then terminated.

ADJOURNED DISCUSSION.

Monday, April 6, 1908.

CHAIRMAN : MR. JAS. ADAMSON, HON. SECRETARY

CHAIRMAN : We are met to-night for the purpose of renewing the discussion on Mr. Stratton's paper, and if you will allow me I will now read Mr. Stratton's reply to the questions that were raised at last meeting. You will gather pretty well from his replies the nature of the questions presented to him, without the necessity of reading over the discussion :

Referring to the question as to how do I get more heat imparted to the air in the proposed than in the present system, the explanation is that in my heater the air comes in contact with about twice the amount of heating surface than it does in Mr. Howden's, which is divided into a right and left-hand compartment in the following way : The air enters the heater at the centre in two volumes, each volume being divided into two or more currents which pass over to their respective ends of the heater, so that each volume only comes in contact or in close proximity, with about half the number of tubes that are in the entire heater.

The heater now proposed is divided into two longitudinal compartments. The air enters the outer compartment through an opening at one end and passes along the whole length of it to an opening at the opposite end, when part passes into a smaller compartment at that end of the heater, and part passes along the inner longitudinal compartment to another small compartment at the opposite end. From these end compartments the air passes into the air casing fixed in front of the boiler, whence it passes into the furnace. By leading the air through the entire length of the heater it comes in contact, or in close proximity, with a greater number of heating tubes than it does in Mr. Howden's heater, consequently the air should get more heat imparted to it ; at the same time also, the heating of the air is less liable to be effected when the air heating tubes are dirty or when the fires are being cleaned.

Mr. Howden seems to have thought that the air was not equally distributed in his heater, as he took out another patent dated December 13, 1906.

In the printed specification he states :—

"In air heaters of the Howden type in which the cold air from the outside branch of the air-supply pipe enters the air-heating chamber on both sides of a cross central diaphragm dividing said chamber and extending to the admission orifice, and the supply pipe is rounded to facilitate the inflow of air to the heater, it is found that the outer half of the heater, that is, the half on which the air-supply pipe terminates, receives a greater volume of air than does the other or nearer half, even though the air entrance of both are of equal area. This arises from the momentum of the current carrying the air past the first half entrance, the air being swept or guided into the outer half entrance at a higher velocity by the curved end of the supply pipe. The consequence of the greater volume entering and passing through the outer half of the heater is that the inner half becomes less effective and the temperature of the waste furnace gases passing through the air-heating tubes is not sufficiently reduced."

Mr. Howden overcomes the defect by fixing a curved plate at the entrance to each half of the heater, which plate divides the branch of the supply pipe into two substantially equal parts.

A query has been put whether more heat is a wise thing, on the ground that it might tend to burn the grate bars, furnace baffles and cheek plates. Mr. Howden, who, I think, is the greatest authority on the heating of the air on account of the great number of experiments and tests that he has made, stated in a paper read at Chicago that the heating of the air required for combustion by the waste gases is an element of the first importance in effecting a high economy of fuel in forced combustion. This, I think, means that the air should be as hot as possible.

I do not see how the heating of the air will damage the fire-grate and baffles. It appears to me that if the supply of air is sufficient to keep a steady flow of air through all the perforations of the baffles, there will be no damage done ; it is the stoppage, or partial stoppage, of the air through the perforations that is the cause of most of the burned and cracked plates. The burning of the cheek and baffle plates is often caused by the baffles not being properly fitted to the furnace front, so that the air, instead of passing through the perforations, escapes in large volumes through holes between the baffles and furnace front.

With regard to the question, would there not be a deal of trouble in clearing out the ashes from the trough and the ash-pit, I may say I do not think there would be much extra trouble in clearing out the ashes either in the trough chamber or in the ash-pit. The ashes could be taken out by means of an opening at the bottom or sides of the trough, by an opening formed on the front end, or by lifting off the fire-grate in one piece. Owing to the higher pressure intended to be used in the trough, the space between the fire bars would have to be small, so that there would be very little ashes falling into the trough.

It is suggested that the greater heat generated in the front of the fire locally would severely punish the furnace doors, fronts and baffles.

I do not see how this would occur if proper means were taken to ensure a sufficient supply of air to the baffle plates. As the cheek baffle plates and door plate are more exposed to the fire than the crown plate, each should have a supply of air direct from air casing, and independent of the crown plate, so as to ensure a proper circulation of air through the perforations. I have noticed in some cases that a considerable amount of air passes out through the perforations of the crown plate or through holes between the baffle plate and furnace front, so that there is very little left to pass through the perforations of the cheek plates ; the result is that the plates get hot and crack.

It is also suggested that the fire bars would suffer, especially with certain classes of coal, due to the confined space between the trough and the fire bars. In reply to this I would point out that the space between the bottom of the trough and the fire bars can be increased so as to avoid that trouble if such should be experienced. In lieu of the trough chamber along the fire-grate, a chamber can be fixed along the ash-pit ; the walls of this ash-pit chamber can extend from the floor of the ash-pit right up to the fire-grate. Extension pieces can be fitted to the walls of this ash-pit chamber, so that any burned part can be easily renewed.

The question as to the admission of air into the fire-box and the consequent lowering of the temperature is the next to respond to, and I may say the only reason why I proposed to form a refractory space and to admit air into the back was to try and retard the great velocity of the furnace gases passing along the confined space between the fire and the shell of the furnace. I thought that it might be possible to reduce the supply of air through perforations in the crown plate. It may be better not to put any air into the back end, but admit it through front baffles. I also propose to fill up the bottom of the combustion chamber so that the back may be cleaned out by a long rake through the furnace door.

I am inclined to keep the arch round the back end of the furnace, so as to prevent the furnace gases passing along in contact with the furnace crown.

In order to allow the space for the gases to pass under the arch, the bottom of the combustion chamber can be formed with a slight slope or curve from the top of the bridge to the back plate of the combustion chambers. By this curve or slope the back end may be cleaned out from the furnace door.

I think those are replies to all the questions that were asked, and it now remains for us to further discuss the matter.

I may read a few prefatory lines from *The Marine Engineer and Naval Architect* in connexion with the system which may refresh our memories of its principal features.

A System of Forced Draught with New Features.

The introduction of forced or induced draught to marine boilers some twenty years ago was not hailed with universal acclamation on account of troubles which occurred in several steamers so fitted, due to fire-box plates buckling, and the fears entertained as to the furnaces collapsing with the fierce heat or to the risk of buckling by localized heat.

At the present day the scruples and fears have vanished and forced draught is accepted as the modern system for marine boilers, and with it most new steamers are fitted. The system now requires no advocates. This being assumed, the question of improvements on the usual system becomes a factor of importance and value to all marine engineers, and that it is so considered may be stated from the references to, and discussions we have heard on the subject, both around the mess-room table and in the reading-room or lecture-hall sacred to such technical matters. Mr. Jas. Macdonald Stratton has evolved, as the result of observation and experience of forced draught, a system which, although substantially the same as those in general use, has some special features, claimed to be improvements in the direction of efficiency and economy. There are two principal aims in the system referred to: a better arrangement of heating the air and at the same time utilizing more of the otherwise waste heat from the products of combustion. With this object an air-chamber is fitted in the uptake, containing vertically placed tubes through which the gases pass on the way to the funnel. So far this is similar to Messrs. Howden's system, but in addition to the usual arrangement there are division plates fitted to direct the current of the air in its passage to the furnaces. These plates are so fitted that the current of air is diverted and directed to obtain the greatest amount of heat from the tube-heating surface, one special object being to avoid the lessened effect due in the usual system in operation, when fires are being cleaned or not burning brightly. A reference to the illustrations will show the improvements which are claimed by the patentee, Mr. Jas. M. Stratton.

From the air-heating chamber the air passes through the openings at the ends of the chamber into an air-casing fixed in front of the boiler; from this air-casing air passes through valve-controlled openings into the front of the furnace, whence it is distributed through perforated baffle boxes over the front of the fire. From the air-casing air also passes through valve-controlled openings into a horizontal chamber fixed in front of the furnace. From this horizontal chamber air passes through an opening in the centre of the chamber into a chamber fixed along the whole or part of the length of the ash-pit.

The front of this chamber is closed either by the ash-pit damper or by a separate damper or plate; the back or inner end may be closed by a damper fixed on hinges so that it can be raised or lowered as desired.

The air passes from the front end of the chamber over the walls of the chamber into the sides and back of the ash-pit. The air passing over the walls of the chamber will keep them from being burnt, but extension pieces may be fixed on to the walls so that any burnt part can be easily renewed. In order to protect the furnace front on each side of the fire door, perforated baffle boxes or slabs of firebrick are placed, and in order to removably fix these boxes or slabs in position they are provided with grooves co-acting with flanged plates or angle irons fixed on the inner wall of the furnace front. By fixing this open top chamber in the front of the ash-pit a much better draught is got through the front of the fire-grate, on account of the air having to rise directly under the said fire-grate.

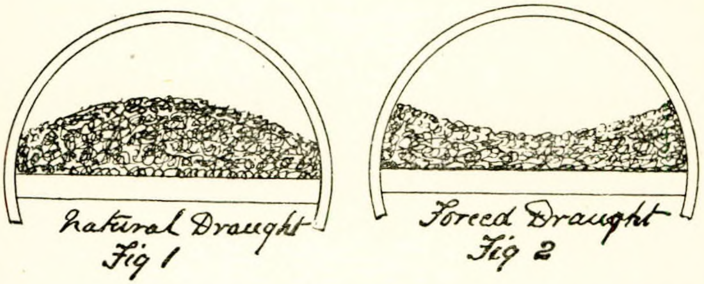
If desired the side walls of the chamber can be carried through the fire-grate so as to form an independent chamber in the ash-pit.

By means of this independent chamber the sides of the fire can be worked with a less air pressure in the ash-pit than at the centre, and it prevents the whole or greater part of the air that is conveyed into the ash-pit escaping through weak or uncovered parts at the sides of the fire-grate without doing any useful work along the central line thereof. Instead of fixing a chamber along the ash-pit, a corrugated or plain plate may be fixed longitudinally along the centre of the ash-pit. On the front end, or it may be in front of this longitudinal plate, a transverse plate is placed so as to form a recess in which the air along the sides of the longitudinal plate is sheltered from the velocity of the incoming air and so is allowed to rise freely up through the fire-grate. This modification should be used with either an open or closed ash-pit.

Mr. W. H. Howell (Member): The only objection that I can see in the system is the chamber on the firebars and the difficulty of cleaning the ashes out of the chamber under the firebars.

Chairman: Do you think Mr. Stratton has answered the question on that point? It is difficult to follow a paper when simply read from the chair, but unfortunately we did not get the author's reply in time to have it printed for members to have copies.

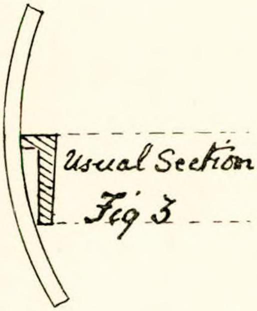
Mr. G. Shearer (Member): Unfortunately I was not here at the meeting last week, but I have looked over the paper and there are one or two points I would like to remark upon. In the first place, regarding the sketches, I think it is a great pity that Mr. Stratton did not make the details of the small sketches clearer, as it is rather difficult, from the letterpress, to follow the air courses; I cannot say that I follow them clearly. There is no doubt that his idea is theoretically correct, but practically I am very doubtful as to whether it would last. I think with casings of that kind in the ash-pits they would have a very short life. Most of us know what trimmers are, and sometimes they have difficulty in raking out their ash-pits without any obstacles, let alone cleaning out extra chambers as Mr. Stratton proposes. I think his idea good, but the cleaning is the trouble. I am afraid we would not get our men to do the work. I do not think it is altogether the fault of the furnace; it is more the fault of the firemen.

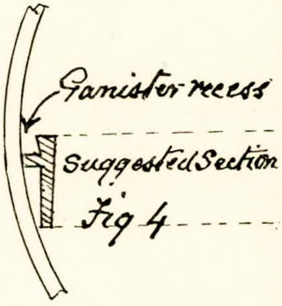


In the ordinary method of firing for natural draught we generally find the fires made up in the form shown in Fig. 1. The fires are either made up level across or arched in that way; but with forced draught the fire ought to be made up in a concave form (Fig. 2), because the forced air has more tendency to flow up the walls of the furnace, as Mr. Stratton says, and if there is an escape in the side bars, then the fire being lighter in the centre than in the wings, the air would naturally find its course through the thinner part of the fire. But here is another point. I do not speak of high-class ships, but some of the intermediate ships, and some of pretty fair class, too, are simply under-engineered; they have not enough engineers on the staff. I know certain ships running out of the port of London with twin screws and only one engineer on watch. Now, how is it possible for one engineer to look after a set of twin screw engines and look after the firemen at the same time? One or the other must be neglected. It is all right in the engine-room as long as everything goes right; but if anything goes wrong attention is paid to that, and consequently the stokehold is neglected and left to the firemen because there is no one there to look after them. Every ship, that is to say, ships with engines of fairly high power, ought to have an engineer in the stokehold, and that engineer ought to be a thoroughly competent man. We were all junior engineers at one time, but what did we know about firing then ? Many of us did not know a good fire from a bad one, and yet it is generally the junior who is sent to look after the stokehold, although his duties are certainly more to look after the water gauges than the fires. I know it takes a young engineer a year or two before he realizes what firing is, what it is to have the fires in proper condition and kept at the proper temperature. In forced draught there is no economy with long fires working at a low air pressure. The most economical results are obtained by working the fires to the utmost, shortening the firegrate and working that portion of the furnace that is left to its highest efficiency. It is no good dallying with forced draught, with long furnaces and the back bars empty, because you are retarding the steam with the empty back bars as you are raising it with the front ones.

CHAIRMAN : That point was raised at our last meeting. You do not say how far it is advisable to go. It was stated that Mr. Howden does not recommend above 25 to 26 lb. of coal per sq. ft. of grate.

Mr SHEARER : You certainly get the best steaming results with the fires at their very best, though more severe on the boilers. A short fire is better than having a long firegrate partly uncovered, and if you take it easy there is not so much economy.





Figs. 3 and 4 represent the wing bar. The web (Fig. 3) is fitted to the corrugations of the furnace, and any space, as a rule, is filleted up with ganister. As these two surfaces move a space is always formed, and the ganister is broken and hauled out when fires are cleaned. Now I would suggest that a dovetail recess should be left in, as shown in Fig. 4; that is to say, we can lower the web, say, $1\frac{1}{4}$ ft. below the surface of the firegrate, filling that space up with ganister, and if we did that it would keep its place. As the ganister or whatever is used generally falls out or is knocked out, but if there was a larger recess in the corner of the bar, as in Fig. 4, it would overcome that.

Mr. W. SPEEDY (Member): There is a recess in the bars used in forced draught.

CHAIRMAN: It was referred to at our last meeting. In recent jobs there is a recess cut there

Mr. N. K. MACLEAN (Member): There is a recess, but not so large.

Mr. SHEARER: The idea just struck me when I saw this paper; I have not seen it in practice.

CHAIRMAN: That was a point raised, how far can we go in safety with regard to the poundage per sq. ft. of grate? Of course, shortening up the firebars would mean increasing the poundage per sq. ft. of grate. Mr. Howell said that in his experience they burned up to 40 lb. with Australian coal.

Mr. HOWELL: Corrinal, a better class of Bulli.

Mr. SHEARER: Of course with Newcastle coal or any of the Northern Australian coals you would burn more.

Mr. HOWELL: It runs about 37 lb. with Corrinal, the Queensland is 42, 43 or 44, and Welsh about 33.

Mr. SHEARER: There is a great deal in the coal. The forced draught gets the credit of doing a good deal, but some coals forced draught will not burn, as the bars get choked with slag.

Mr. SPEEDY: If they get plenty of wind they will.

Mr. SHEARER: You would require to have special grates for it, with some coals that have a great deal of slag in them.

Mr. SPEEDY: It is necessary to alter the bars with Bulli. As soon as you take in the Bulli you take out some of the bars, still working at 3 in. air pressure.

Mr. SHEARER: I am speaking of coal of quite a different nature to the Bulli coal. This coal deposits so much slag that it silts up the firebars. You have not the same difficulty with the natural draught, as the pricker is used with the open ash-pit and the firebars can be cleared. There is a method of dealing with this coal which I think was advocated if it was not originated by Mr. Howden's representative, and who is, I dare say, a man who has had more experience with forced draught than any other man in the City. His plan in using coal of that kind, when he found it would not burn through the firebars silting up, was to put in a special fire-grate. As far as I remember it was in sections and was perforated with ½-in. or ⅝-in. holes. The view of that plate was something like this :—

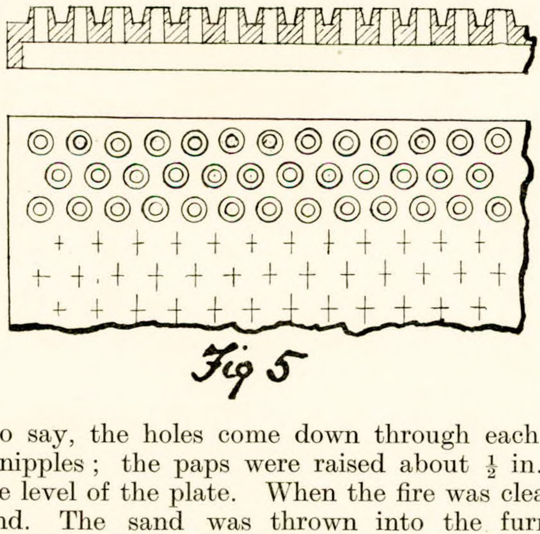


Fig 5

that is to say, the holes come down through each of those paps or nipples ; the paps were raised about ½ in. or ⅝ in. above the level of the plate. When the fire was cleaned they used sand. The sand was thrown into the furnace and filled the plates up to the level of these paps ; that was the only way they could burn coal of that description, because when the slag accumulated they could lift it in a cake and draw it out of the fire door. The sand would not allow it to adhere to the plates. I heard that Mr. Howden had some difficulty with coal of that kind, and as far as I can understand they had to put in these plates to suit that coal, because the coal suited the company if it did not suit the boilers, and he had to put in plates of that kind to carry out the contract. Most people are under the impression that any coal can burn with forced draught as long as it gets plenty of air ; that is true, but you can't get air through choked firebars.

Mr. HOWELL : May I ask Mr. Shearer what is the name of the coal he refers to ?

Mr. SHEARER : It was a Lancashire coal, I understand. I did not handle it myself ; I only know the result.

Mr. J. H. REDMAN (Assoc. Mem.) : Was the sand used every time the bars were cleaned ? It seems to me there would be great difficulty in raking out the back end of the firebars.

Mr. SHEARER : As far as I understand the firegrates were short. They were specially built for Howden's forced draught, and did not want a big firegrate area. However, they managed to burn the coal with that process, and it was the only way they could do it.

Mr. MACLEAN : I have not heard the paper read, and do not know what the discussion has been ; but I suppose it is forced draught that has been under consideration. If I had my way I certainly would not have any system of forced draught, for the sake of the boilers, and I have no doubt that the boiler-makers should raise a monument to Mr. Howden higher than any on earth, because no man has given them more work. With some coal, Yankee slack and other kinds, you will not get European firemen to work the fires as they should. They will not do it. You may show a man how the fires should be kept, and he does it for a time ; but as soon as you turn your back he just goes back to the old style of filling up the furnace, and you will have the cheek plates burnt away very quickly, simply owing to the man keeping his fires to the front of the furnace. He will obey your orders as long as you see him. Another thing is the expansion of the furnaces with the forced draughts. If it were an ideal furnace that would give and not force the tube plates back, forced draught could be worked more advantageously ; but I do not see what Mr. Stratton proposes, not having quite studied the paper.

CHAIRMAN : What is the air pressure you work to usually ?

Mr. MACLEAN : It may be from ½ in. to 6 in. Some are of opinion that forced draught should be used as an auxiliary, an opinion which I quite agree with, in cases, for instance, where you have at any time a bad class of coal to take on board. I think in a former paper read before the Institute such a question cropped up, and it was mentioned that one of the superintendent engineers in London had adopted the principle of adapting his boilers to maintain steam under natural conditions at ordinary times, using forced draught as an auxiliary, which I think was a very wise plan. The furnace illustrated in this small sketch of Mr. Stratton's shows practically one-third of the furnace taken up by the bridge. In another one he has the furnace shortened up by half almost, with a division plate in the centre. What is his intention for that ? He has a baffle operated by a rod at the top of the furnace, and from this I would take it that he intends the air to go up over this baffle. Is that so ?

Chairman : There is one plan which shows the bridge very much shorter than the other. There is an air opening over the fire door right above the furnace.

Mr. Maclean : This blue print shows a plate which goes half way in the ash-pit, and is then carried up almost into the firebars.

Mr. Redman : In the forward end is a box where he proposes to maintain the higher air pressure, while the lower air pressure is in the back part of the furnace.

Chairman : He aims at having the higher air pressure in the centre and reducing it in the wings. The object is to overcome the difficulty Mr. Shearer referred to, of the air clinging to the wings of the furnace, and entering freely by the slack ganister at the wing bars.

Mr. Maclean : The extra heating of the air would be a very good thing, although it is not clear to me how he does this by the series of baffles shown among the tubes. Does he mention the increase in temperature as compared with Howden's ?

Chairman : No, he only says it will be more ; he has no experimental data to work from.

Mr. Maclean : It is simple theoretical so far ? Well, if he manages to increase the air temperature he is in the right direction. We cannot get on nowadays in the large ships without forced draught. I was thinking, when on board the *Lusitania*, on going through her stokehold, which means practically two-thirds of the ship, that without forced draught it would be an utter impossibility to get the power ; they could not get boilers enough in the ship. This air-heating arrangement seems to me to be very good, but with regard to the distribution of the air in the ash-pit, I do not see how it is possible to maintain it. I am afraid the framework would need renewing every month. If the ashes are allowed to remain in the ash-pit any time the bars are liable to come down, and the hotter the air the greater would be the tendency to bring the bars down.

Mr. SHEARER : There is not the slightest doubt regarding the cheek plates being saved, but it entirely depends upon the firemen. You cannot get them to keep the fire back from the cheek plates.

Mr. A. ROBERTSON (Member) : I must disagree somewhat with Mr. Shearer with reference to his remarks about the firing with natural draught. I always understood, and always carried it out, that the correct way was to hollow the fires with natural draught, and with forced draught to keep them as level as possible. The difficulty we always had was to get the firemen to keep the fires thick at the back, and that was an experience that I was very soon taught, not after years of training, as Mr. Shearer suggests it takes young engineers to learn. I think their difficulty is to learn to deal with the men and get them to do what they tell them, not in the fact that the engineers do not know when a fire is right or wrong. In the first ship with forced draught I went to sea in, I went as fourth, and had very good advice from the third. He said : " If you want to find out if the fires are correct, put a rake in the back of the fire, and you will very soon tell, until you have had some practice and can tell by looking at the fire." I quite agree with Mr. Shearer's remarks that to shorten up the bars is advantageous in many cases. With reference to the special firegrate that he sketched, one of the Liverpool ships adopted that with very great success, burning almost any class of coal. Instead of circular holes they had slots. It was of solid cast-iron.

Mr. SHEARER: Were they raised above the surface?

Mr. ROBERTSON: No, flat right through. I should like to ask Mr. Shearer whether he believes in packing firebars tight. It is a point about which there is very much discussion. Some contend that if they are packed in excessively tight, when under ordinary steaming conditions the firebars expand in greater ratio to the furnace and are likely to distort the furnace. Others contend that under steam conditions the bars are slightly slacker, if anything, than when cold. It is a very debatable point. I do not know whether it has ever been proved, but it is a point I should like enlightenment upon.

Mr. SHEARER: Regarding the firebars being packed, and the difference between them when cold and under steaming conditions is simply a question of change of temperature. A firebar, under ordinary conditions, does not get very hot as long as it is in position; it is generally when the firebars get out of their place that they get hot. Very often by having wide firebar spaces small coal gets into the ash-pit, consequently there is a fire under the bar as well as on top of it. That will bring down the whole firegrate at times, which was quite a common occurrence with some coals under natural draught if the ash-pits were not kept clear. But I would fancy that the expansion of the furnace was about equal to that of the firebars under normal conditions.

Mr. ROBERTSON: The temperature of the firebars would be equal, at least, to the temperature of the metal of the furnace, and the expansion of cast-iron is more than that of steel.

Mr. SHEARER: That is so, but it entirely depends upon the air getting in from below the bars. In some cases during cold weather the bottom of the firebars are so cool that you could put your hand on them.

Mr. ROBERTSON: Not on the surface; that is, where you get them packed close.

Mr. SHEARER: Within an hour's time after lighting fires there is enough of ash to protect them from the heat while the air is passing through keeping them cool; that is, in natural draught.

Mr. MacLean: It depends on the coal. Some burn down and some above.

Mr. Shearer: Regarding the question of putting a rake through the fires. That is practically the only way to find out whether it is a good fire or a bad one, but I would ask juniors if they knew when it was in proper condition. I have found plenty who have had a few years' experience and yet did not know by touch whether there was sufficient fuel at the back or not. Firemen are very curious creatures to deal with, and play nice little tricks on engineers if they are not kept in the right grain.

Mr. John Clark (Member): I have listened with great interest to some of the remarks that have been made to-night, and I do not think that the details of the paper can be very well criticized. Mr. Shearer remarked that the stokehold should have more attention than any other department, and his remark bears a great deal of truth. There is one thing that struck me in listening to the remarks to-night—the inefficiency of the human machine. I should like to ask why we do not use a mechanical one. We have them on land, giving great satisfaction, and I understand in one or two cases mechanical stokers are used on board ship with good results. Mr. Shearer referred to a flat grate with airholes. I have heard of that for the same purpose. Mr. Robertson remarked about one with slots. I believe in some cases they are perfectly flat with the holes level with the top surface, and these are doing very well. It is common in destructors, and in destructors at times very high temperatures are realized. With regard to the hot-air chamber, as some of the gentlemen have remarked, it seems rather complicated, and it does seem a little obscure as to the actual track of the air. But, generally speaking, the more the air is split up and brought into contact with the hot surfaces, no doubt it will gather more heat, and I think that is a good point. The blue print shows a nice rounded sweep with a firebrick arch. Theoretically I suppose it is a good thing, but practically I question very much whether it is or not. We know that in the ordinary Lancashire boiler flues there are not, or should not be, any square corners, but I question whether one can say we get a higher efficiency in that way or not. It may do better in marine boilers. Curves conform to the natural sweep of the gases, but the plainer and simpler things are generally the more satisfactory. I am sorry Mr. Stratton has not more information to give us. If he had been here to give us the benefit of his remarks, I am sure they would have been of much interest. Mr. Shearer remarked about forced draught and heated air; but it is open to question whether we do get greater economy by its use or not. It may be obtained on test, but in the long run it seems to me to be very doubtful indeed.

Mr. MacLean: One advantage of the bricking up of the back end would be to keep the gases from impinging on the sides and the back of the combustion chamber.

Chairman: Mr. Stratton refers to the brick arch at the back end of the fire; it is shown on the blue print. That brick arch is almost essential in some cases, as where the tube plate is flanged and bored out at the back end, then the furnace turned to suit, slipped in a good fit and riveted through so that the rivets are exposed to the fierce heat at the back end, where they thus need protection, by means of special brick arches.

Mr. MacLean: We carry a cast-iron bridge to protect the saddle rivets.

Chairman: Do you not find they burn away quickly?

Mr. MacLean: We have to renew them, but they stand better than the firebrick.

Mr. Robertson: Cast-iron bridges made in three pieces have been tried in one company that I know of with boats running out of London. One section is made to drop in over the other.

Mr. MacLean: They would have to be faced up with fire-clay. It is only the framework that would be of cast-iron.

Mr. Howell: Mr. Robertson mentioned about wedging in the firebars. I have heard of wedging the bars, but I think that is bad practice.

Mr. Robertson: That goes to prove what I suggested.

Mr. Shearer: I do not think there is any doubt that the best method is to leave them easy.

Mr. MacLean: If you don't do so, and you have a firebar to put in at sea, you will not be able to do it.

Mr. Shearer: I should like to ask Mr. MacLean, who has had a good deal of experience, his opinion regarding the attendance of the boilers and stoking generally. Should the junior engineer attend the water only, or should a leading fireman, a responsible man—say a donkey man—be the leading man for the stoking on large ships? I am speaking of full-powered steamers.

Mr. MacLean: I think the stokehold ought to have the supervision of the senior man on watch, but unfortunately the senior men do not care so much about it, and would rather give it to the junior. It takes the junior all his time to look after his work. With the erratic firing of the European firemen it is an utter impossibility to keep his water level in the different boilers and attend to the fires at the same time. Consequently, we have a leading stoker, more particularly under the supervision of the senior engineer in charge. It takes the junior's time altogether to look after the water. With forced draught you cannot carry much water in the boiler, or you will have priming. Consequently, the water has to be kept at a pretty low level to prevent that. In some ships, where there are not so many boilers to attend to, the engineer could be the leading man as far as the firing is concerned. I quite agree with Mr. Shearer's remark that the majority of vessels going out of London at the present time are undermanned as regards engineers, in the interests of economy with efficiency.

Mr. Shearer: The point that we are having at present under consideration at the Board of Trade is the manning of ships, and I think we ought to look at the engineering side of the question. Of course the subject is taken up more with the question of deck work, but here we are only dealing with engineers and firemen. My experience is similar to Mr. MacLean's, that the junior engineer has plenty to do in looking after the water, and I would advocate that there should be a leading fireman, not a working man, but simply supervising the work, who would be responsible for the firing. The responsible man would be better paid, of course, and if his job is worth keeping, he will look after it. With regard to heating the air, Mr. Stratton gives us no data in connexion with his plan, but I may mention that I saw a new air heater the other day in connexion with forced draught. It is quite a change from Mr. Howden's, and is something like Fig. 6.

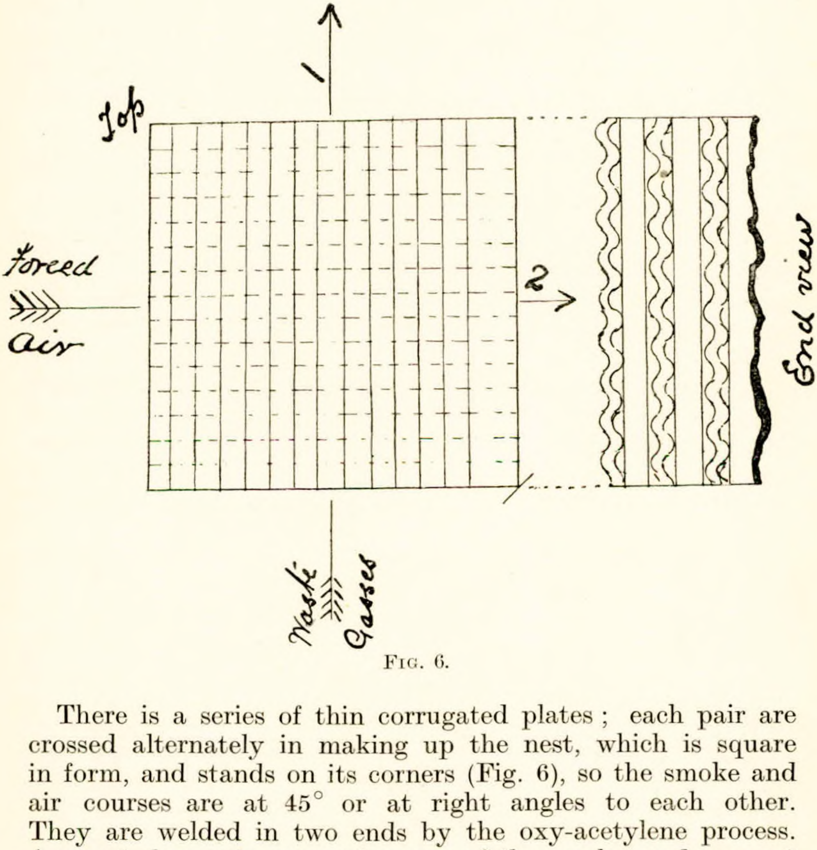


FIG. 6.

There is a series of thin corrugated plates ; each pair are crossed alternately in making up the nest, which is square in form, and stands on its corners (Fig. 6), so the smoke and air courses are at 45° or at right angles to each other. They are welded in two ends by the oxy-acetylene process. Arrow 1 shows the upward course of the smoke, and arrow 2 the downward course of the heated air. They are graded the same, and the smoke or air passes through the alternate spaces.

Mr. MacLean : I suppose you will have each plate welded on the one side and not on the other.

Mr. Shearer : No ; they are welded on two ends. The other two are open (Fig. 6).

Mr. Clark : Is there not a difficulty in keeping that system clean ?

Mr. Shearer : That is the first question I asked, but was told that the changes of temperature prevent anything hanging on ; the change in expansion shakes it off the same as the scale on the coils of an evaporator. They have been experimenting with it for some three years, and it is likely to come to the front ; but I think in the eyes of the practical man the necessity for cleaning would be rather detrimental.

Chairman : Were the plates secured in the uptake ?

Mr. Shearer : Yes ; they take the place of the heating tubes and will be in the same position, but instead of tubes they are corrugated plates ; the gases are led through the one side and the air through the other. I am informed that they get very good results from the system, and it will be placed on the market very shortly. But what I would like to see is natural draught, with forced draught, as Mr. MacLean says, as an auxiliary, to take you out of a calm or to give a little assistance when you are using coal which is hard to burn with natural draught.

Mr. Redman : Would Mr. Shearer prefer induced draught to forced draught or closed stokehold.

Mr. Shearer : As a matter of fact I have had no practical experience with induced draught, but I think the forced draught is the best of the two. There is great difficulty with the fans in induced draught.

Mr. Redman : On land installations an economiser is usually fitted which reduces the temperature of the waste gases before they reach the fan, so that the temperature is about 300 to 400 degrees.

Mr. Shearer : Certainly at the beginning, when it was all theory, you may say, I was under the impression that the induced draught was the better ; but that was when there was so much trouble with the tubes, especially in the Navy, where they had to put in ferrules or tubes 9 in. long to prevent the intense heat of the forced draught driving the water entirely away from the tube plates, distorting the tube ends and tube plates and causing leakage. I thought then the induced draught would be much better. However, I have had no practical experience with it.

CHAIRMAN : Was it not that the forced draught advocates were too greedy at first ? That is to say, Mr. Howden said : " If you put in this boiler you will save bunker space," and in trying to achieve this end they put in too small boiler power for engine power, with resulting evils and troubles ; they thus really hindered forced draught coming to the front for years on account of their short-sighted policy ; whether it arose from enthusiasm alone or exaggeration of the theoretical efficiency with a disregard to other conditions coming into play under actual seagoing experience, I cannot say.

Mr. MACLEAN : There are many causes that tend to bring furnaces down—dirt, scale, insufficient water space due to faulty construction, etc., there being a much greater danger of collapse when using forced draught.

I remember a case of collapse in the furnaces of a steamer built on the Clyde. On her first voyage to India the sides of the furnaces caved in on the line or just above the firebar, the furnaces appearing like the figure 8. This happened on the passage out ; on the return I think the pressure was reduced. There was no apparent cause for the collapse, and on the arrival of the vessel in London the boilers were subjected to the survey of a number of surveyors ; but none could assign any cause. As there was no scale, some said it was due to bad oil used in the impermeator, but as the impermeator had not been used, or any oil internally, this did not hold. At last the whole question was referred to the builders, and, of course, to every engineer and shipbuilder in Glasgow. After careful inquiry, the general opinion was that the furnaces were too close together, not sufficient water space between, the intense heat set up on the sides of the furnace having forced the water from the plate, with the result the plates got heated locally, hence the collapse. To prove this the Messrs. Weir went to considerable expense, and at a meeting of the Institution of Engineers in Glasgow demonstrated by special glass vessels and lamps the action of heat on water—when the flame was low the water boiled, and one could see the globules rising inside the glass. On increasing the flame the water boiled rapidly and began to lift from the glass away from the flame, till there was quite an arch of apparent void between the flame on the glass and the water. By reducing the flame gradually the water came closer and closer to the side of the glass, till it boiled as at the beginning close to the glass. Now if the intense heat of the lamp had been kept up any time the glass vessel would have burst or melted locally, as the furnaces had collapsed under similar conditions. The members present agreed Messrs. Weir had hit on the true cause of the mishap. New boilers were put into the steamer, and there was no trouble afterwards.

Mr. Redman : Generally the water has to find its way up and down as best it can.

Mr. Shearer : Water-tube boilers, for example, Yarrow's, and, in fact, all water-tube boilers, have down-takes, large outside tubes for conveying the water to the bottom of the chambers—which were thought to be necessary to keep up the circulation. In some way or other, however, something went wrong with Yarrow's down-takes, and they took them off, working the boilers without them, and found the boiler worked just as well without as with them, so that they have not been used since. Of course the tubes next the furnace in that class of boiler are at a much higher temperature than those next the shell or casing, and, so far as circulation goes, the water ascends next the hot furnace tubes while it descends through the cooler casing tubes.

Mr. Robertson : Do not the Admiralty enforce fitting the down-take ? I think you will find it is the case, because when we paid our visit to Messrs. Mumford's works it was pointed out that they had to fit a large down-take at the back of the boiler. The engineer said it was possibly of little or no use, but the Admiralty would have it.

Mr. Shearer : They have them in Thorneycroft's and Normandy's and different other types, but I am not aware of it in the Yarrow. It may be the case in the British Navy ; of course there are not so many Yarrow boilers there, at least in the big ships, but I know that Yarrow did away with it.

Mr. Robertson : It was a special point raised at the Colchester works at the time of our visit. Their engineer was an Admiralty man, and he said it was enforced by them.

Mr. Shearer : Well, as far as my experience of water-tube boilers goes, I like the down-take ; it is always a point of safety. Of course circulation in tubes is a very difficult thing to deal with. It takes some very funny turns at times, according as the heat is applied.

CHAIRMAN : I do not know that we are very much further forward from Mr. Stratton's point of view, but I think we seem to be pretty well agreed that he is working in the right direction. First of all, in reference to the heating, that it is a good thing to get more heat into the air before it enters the furnace. That was questioned at our last meeting, whether there was so much benefit derived from the heating of the air as is claimed for it ; but the mere fact of this new apparatus that Mr. Shearer has described being brought out shows that the general opinion is that it is a good thing. Then, as to Mr. Stratton's contention, that the air in the ordinary system does not do its work efficiently, that has elicited the comments as to the arrangement of filling in the grooves with ganister and cutting a recess, showing that his observation is correct as to the difficulty of the air running up the sides. Mr. Stratton's object is to get the air in the centre of the furnace with greater certainty, therefore he increases the pressure there and allows the air to find its way by distribution over the wings at a reduced pressure, due to the fact that it has to go over the side of the trough and find its way to the wing bars. It has been remarked that he has not made it quite clear how the air does go in its passage through the different channels to the furnace. He states that it does pass over a greater area, and therefore absorbs more heat than in the ordinary system ; but it will be made clearer when Mr. Stratton, as he intends, goes more thoroughly into the system experimentally, then brings the matter up again to let us know the result of the experiments made during the summer.

Mr. MACLEAN proposed and Mr. SHEARER seconded a vote of thanks to the Chairman, and the proceedings then terminated.

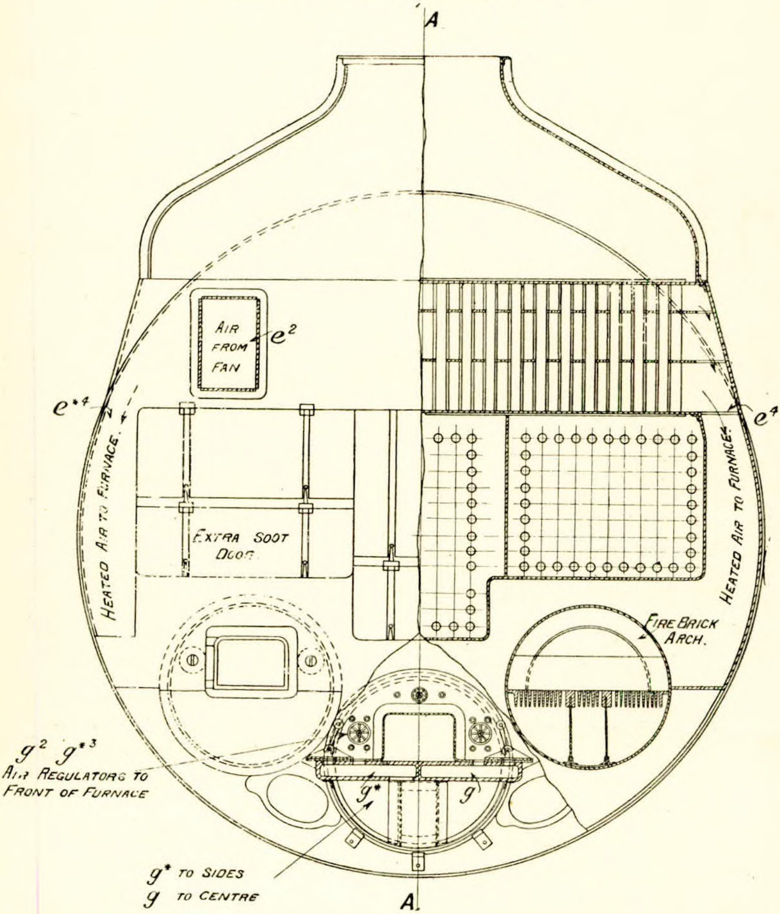
In order to make the arrangement of his improved furnace quite clear, Mr. Stratton has kindly supplied the following letter, sketches and detailed description :—

The principal object of this invention is to provide means for heating the air required for combustion, and to distribute it into the front of the fire, and also into the ash-pit in a more efficient manner than heretofore.

For this purpose an air-heating chamber is fixed in the uptake, and is provided with a number of vertical intersecting tubes through which the waste furnace gases pass.

The air-heating chamber is divided into two longitudinal

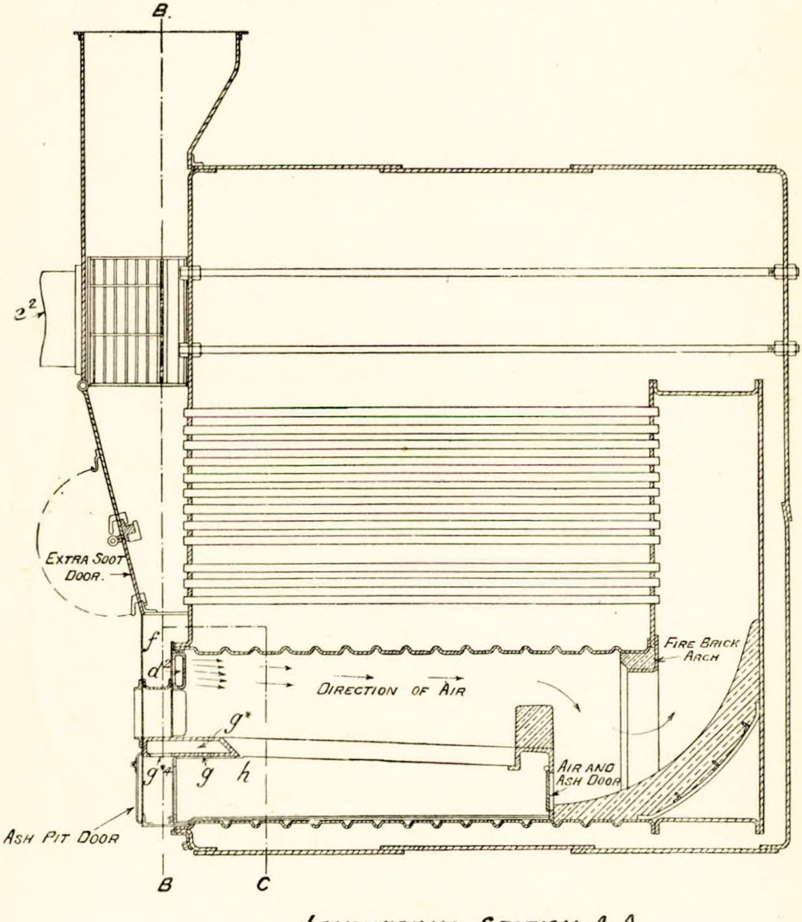
STRATTON'S IMPROVED FURNACE.



TRANSVERSE SECTIONS B. B. & B. C.

compartments. The air enters the outer longitudinal compartment through an opening (e^2) at one end of it and proceeds along the said compartment to the opposite end, whence part passes out of the heater through the opening (e^4) and part

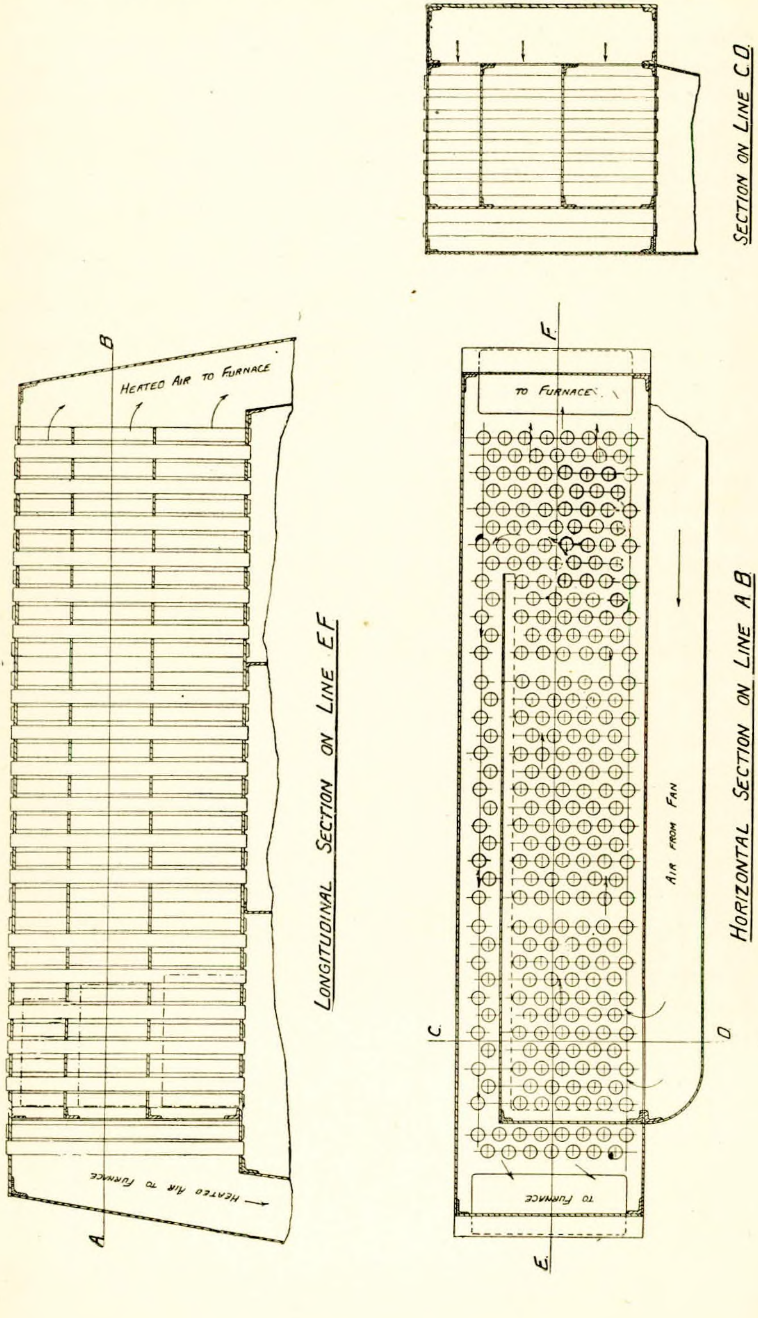
STRATTON'S IMPROVED FURNACE.



LONGITUDINAL SECTION A.A.

proceeds along the inner longitudinal compartment to the other end, whence it passes out of the heater through the opening (e^{*4}). By causing the air to enter one end of the heater and conducting it along the whole length thereof, the air

AIR HEATING CHAMBER.



comes in contact with or in close proximity to a greater number of air-heating tubes than it would do in the heater that is now used in forced draught arrangements, and it gets the benefit of the heat of the waste gases from all the furnaces in the boiler, consequently the heating of the air is less liable to be affected by the cleaning of the fires or by dirty air-heating tubes.

From the end compartments of the heater the air passes through openings (e^4) into the air casing (f), fixed on the front of the boiler. From the air-casing (f) air passes through valve-controlled openings (d^2) into the front of the furnace, and is distributed through perforated baffle plates over the front of the fire.

From the air-casing (f) air also passes through valve-controlled openings (g^2), (g^{*3}), into a chamber (g) fixed across the front of the furnace.

This chamber may be divided into two separate chambers (g^*) (g). From the chamber (g) the air passes through the opening (g) into the front of the chamber (h) which is fixed centrically along the whole or part of the length of the ash-pit.

From the chamber (g^*) the air passes through the opening (g^{*4}) into the front of the ash-pit, whence it passes along the sides of the ash-pit.

Instead of fixing the chamber (h) along the bottom of the ash-pit it may be fixed or hung on the bearer bars.

By means of this separate chamber along the ash-pit two air pressures can be used under the firegrate—a strong air pressure along the centre line of the firegrate and a low air pressure along the sides.

By using two air pressures under the firegrate, there will be less liability of the air in the ash-pit forcing opening through weak spots along the sides of the fire, and so escaping into the furnace above the firegrate without doing any useful work along the centre line of the firegrate.

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VOL. XX.

VISIT TO THE WEST HAM CORPORATION ELECTRIC LIGHT AND POWER STATION,

On Saturday, April 11th, 1908,

AND

VISIT TO MESSRS. JENNINGS' SHOW ROOMS,

On Saturday, May 16th, 1908.

ALSO

PAPER ON THE GENERATION AND ELECTRICAL TRANSMISSION OF POWER FOR MAIN MARINE PROPULSION AND SPEED REGULATION,

By MR. W. P. DURTNALL (MEMBER),

Read at the Franco-British Exhibition,

On Saturday, July 18th, 1908.

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