PART II.

PAPERS.

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BOILER SETTINGS FOR REFRIGERATING AND OTHER HOUSES.

(By Norman Selfe.)

It is probable that most members of this Association have as wide an acquaintance with the manufacture and working of steam boilers as the author has, while some have far more experience in that branch of engineering. The subject is, therefore, brought forward on the present occasion with a good deal of diffidence.

Having, however, had something to do with the formation of this Association, and more or less with its proceedings, since that time, he feels certain that advantages often result from the discussion of such a subject through the interchange of opinions by practical men based on their actual work and experience, and he has thought that this subject would form the groundwork of a very full discussion, in which almost all, including the junior members and students, might take a useful part, and so add to the general store of information that the author and his paper might be almost forgotten when the many crumbs of knowledge that fell were gathered up at the end.

The ice maker is unlike every other manufacturer, in so far that he abstracts heats or energy from the raw material he works upon—instead of putting work into it. Should the advance of scientific knowledge in the future ever bring to light a medium which will enable the heat energy in a pound of water (or the thermal units it can give up—say between its normal temperature and 32 degrees), to be converted directly into its equivalent mechanical energy, by giving motion to a heat engine; then ice will be a bye-product to be got rid of, and ice manufactories, as we know them now, will be for ever gone.

Until such a happy, or perhaps unhappy day arrives, the process of artificial refrigeration and ice-making, will be dependent upon the offices of the steam boiler, unless a natural waterfall (as a source of power), is at its back.

It is almost unnecessary to premise that in the design, manufacture, and working of a steam boiler, as used for commercial purposes in connection with any of the mechanical arts, there are several distinct courses of highly complicated operations involved, chemical and mechanical.

It would be very easy to unload a whole lot of technical terms and complicated formulae into a paper on the present subject, so that it might get the credit that old "Sol Gills" (the chronometer maker immortalized by Dickens) had, of being "chock full of science." The author, however, has great doubts whether there are many people besides the writer who ever trouble to undersand half of the scientific papers that are read before learned Societies, full as they often are of elaborate calculations, and mathematical fireworks, until they get them afterwards in book form.

There are as we all know three kinds of scientific papers; the first is understood by the author and some of his audience; the second is understood by the author; the third one is understood by nobody, and only the author knows exactly what he is driving at.

There are many useful books which deal with the theory of combustion in a furnace, and with the circulation of water in a boiler, now obtainable, and the following remarks will be confined to practical details connected with the subject.

In common with all other steam users the ice maker should look for three special qualities in his boilers:—

FIRST—Economy in first cost, or the greatest steam production for smallest outlay in plant.

SECONDLY—Economy in fuel consumption, or the greatest evaporation of water per pound of coal consumption.

THIRDLY—Economy in maintenance, or the maximum of durability with the minimum of cost for repairs and renewals but there is a

FOURTH point which more particularly concerns him; though only a minor one in itself, it is that which is more particularly under consideration now, namely, "The dissipation of heat by radiation from the boiler and its setting." Such dissipation of heat is a direct loss of power under any circumstances, but in an ice factory the boilers have often to be set in the close neighbourhood of insulated tanks and cold stores, and in such cases the heat given out by them and their settings is a double loss, because it adds to the refrigerating work to be done by the compressor, and thus puts an additional load on the engine and boiler. This particular question, "What is the actual loss of heat by radiation from a boiler and its setting?" does not appear to have received the attention that it deserves from engineers generally.

In the selection of a boiler, the very first consideration, perhaps, should be given to the nature of the water to be evaporated. If it is so good that it leaves no deposit on the plates and tubes from the salts of lime, sodium, or magnesia; and deposits no mud or sediment in the bottom, and at the same time is not so soft or pure as to attack and pit the metallic surfaces; then every form and design, both internally and externally fired, is open for choice; and, other things being equal, that boiler which would give you the greatest heating surface for the least weight of iron or steel in its structure, should be the cheapest. Following this up, and selecting the boiler that would be the lightest for a given area of heating surface we should undoubtedly be led to the consideration of some of the watertube type of boilers.

It is wonderful what progress has lately been made at sea with the "Belville" boilers, in ocean steamships; and on land with the "Root" type, such as those made by Babcock, Wilcox, and other companies. Boilers of this kind have many merits, and are bound to increase in popularity with the common use of higher steam pressures; but when they are loaded with heavy royalties for patents, or have to yield large profits to company manufacturers, as seems to be the case with some, it is doubtful if they are as cheap, under ordinary conditions, as the simple—underfired—multitubular boiler. The underfired boiler is very common in Australia, where it is often spoken of as a "Colonial" boiler, through the introduction of the name by an English manufacturing firm that exported them; but that name should only be applied when they are set over a sheet iron casing with a furnace formed with a thin brick lining so as to radiate as much heat as possible, and raise the general average temperature of Australia without making any more steam. Please do not call them Colonial boilers when they are set with brick walls in a fairly decent way. Drawing Plate I represents one of these underfired boilers as designed by the Author made by Mort's Dock Company, and set to restrict radiation of heat. Others very similar have been working for some years past as Messrs. Hordern's Palace Emporium, Haymarket, where they have been seen by many of our members.

All underfired boilers are liable, as is well known, to be burnt in their bottoms where there is heavy deposit form the water; and in such cases there is danger in their use.

The Babcock boilers are not so liable to be ruined in similar cases, because the tubes take a lot to burn them out, but they are liable to ruin their owners by the waste of fuel. The author has lately had a case of two Babcock and Wilcox boilers, using water to all appearance clean, and in fact, perfectly wholesome as a city supply of potable water, but containinig salts in solution which so coat the inside of the tubes, that after a month's work two boilers evaporate less water than one of them should do. The cost of cleaning these tubes has for years amounted to twice as much money as the interest on the whole cost of the boilers themselves. The samples exhibited show a deposit a quarter of an inch thick, and so hard that three men can only clean 16 tubes a day. The scores show where the steel tools scraped and planed the deposit before it was broken off.

Drawing Plate II. shows another type of boiler, "The Cornish Multitubular," which is "internally" fired. This has been specially designed to take the place of the watertube boilers just referred to, and there is no doubt in the author's mind as to its superiority under the circumstances, not only for higher efficiency as an evaporator, but it is evident that with ordinary attention, water like pea soup could be used in a boiler of that sort.

The underfired boiler in Plate I., as made to specifications, is 5ft. 6in. in diameter, and its shell is 7-16 thick, of soft boiler steel, all drilled after being put together, and intended for a blow-off pressure of 120lb to the square inch. As tested in the factory it must stand 240lbs., without showing a leak as big as a tear. The bottom plate is made all in one piece so, that there are no rivets over the fire; and the longitudinal seams are double rivetted. The mountings are all bolted to solid cast steel blocks which are faced; so that perfect joints can be made, and no leakage whatever be permitted to corrode and destroy the shell. As some engineers do not believe in these cast blocks, and prefer stamped plates, opinions should be expressed on this question. The safety valves are loaded with springs, which are in the author's opinion much safer than levers and weights, and neater than dead weighted valves; here again, however, is great scope for individual opinion. These valves are generally set to blow-off at several pounds above working pressure, and when that happens the steam escapes right clear of the house. Such valves reseat themselves with a minimum reduction of pressure. The author for many years was accustomed to set these boilers in the ordinary way, that is, resting on and carried by the side walls of the furnace; this plan, however, naturally makes it difficult to renew the fire-brick lining, and has other objections. It is now considered by him to be worth all the little extra money involved, to suspend, or sling the boilers from girders as shown, about which, of course, there is nothing new. When thus slung the wall of the open furnace can be carried right up to the water line on each side, and the chimney be led into from the front smoke-box, and such is a very common arrangement. In nine cases out of ten, however, with a new plant it is much more convenient for the chimney to be out of the way—at the back of the boiler, when the arrangement, as shown on the drawing (under which the hot gases traverse three times the length of the boiler intead of twice only), commends itself most to him as the result of experience. There is plenty of experience, however, amongst those present with both cases of settings for these boilers, which should be given in the discussion following.

Members, no doubt, have often seen boiler fronts fitted with hinged doors to their ashpits, which doors project right into the stokehole when open, and were unsightly, if not dangerous, when the boiler was in use. The ashpit doors, as shown on the drawing No. 1 (it will be noted) are not hinged but slide; and they have a ridge at the bottom which runs in a little V groove planed in the bottom angle bar connecting the two sides to the front; this makes a neat and tidy job. The cast iron fronts are bolted together in several pieces, the holes for the connecting bolts being oblong—crossing one another, so that free expansion of the several plates is provided for; and no case of one of them cracking by the heat has occurred.

The stay tubes in these boilers are often swelled at one end, and screwed into both of the tubeplates; and they are always screwed into the back tube plate so as not to require jam nuts near the greatest heat. When screwed at both end the two tube plates are tapped together at one operation.

The plate edges of the boiler are planed, and the boiler is caulked both inside and out. Steam chests are considered a fallacy under modern ideas, by many engineers, because the money it will cost to put on a steam chest will put such an extra diameter to your boiler, that it will not only give the extra steam room of the steam chest, but also an additional area of water surface, which is calculated to reduce risk of priming.

In Plate II., a type of boiler is illustrated which has many admirers, and which has undoubted advantages where there is room available for building it in place. Boilers, very similar (in the office of a London daily paper) have recently been certified by very high authorities (Bryan, Donkin, and Professor Kennedy, F.R.S., and reported in "Engineering") to be evaporating 9.36 pounds of water per pound of coal from water at feed temperature, equal to 10.15 pounds from water at 212 degrees. The size of shell shown on drawing—that is, 7ft. diameter—would carry two 2ft. 9in. furnaces, as is common in Lancashire boilers, and this would give 37½ per cent. more grate service than the one four feet in diameter furnace as adopted; but, although you might burn more coal on the larger area of grate, you would never get such perfect combustion in the two smaller furnaces, as you would do in the one large one, and it is doubtful if you would get any more steam with the two furnaces without great waste of fuel. The lopsided position of furnace no doubt looks very odd, and an engineering friend politely intimated to the author that it was a piece of madness to put it out of the centre of the boiler. There is, however, method involved in this madness. A novice who thinks for himself will soon realise that it must improve the circulation, and it is evident that the more rapid the water circulates and travels over one side of the heated plates, the greater is the amount of heat which must be abstracted from the hot gases on the other side of them. Further than this, in the case of very dirty water and deposit, this boiler is so easy to clean, as all parts are accessible. In order to carry 120lbs. working pressure on this shell and on the furnace of 4 feet diameter, the plates for the former are nine-sixteenths of an inch thick. In the construction of the furnace, "Adamson's" rings are shown, these are welded up and flanged, and turned in a lathe at each joint, but a "Fox" patent corrugated furnace or a "Morrison" Suspension Furnace, made in two lengths, would be obtainable. and be equally suitable. As the mountings on the top of this Cornish boiler are similar to those shown on the underfired boiler. no further reference is necessary to them, and the principal subject of the paper, which is more the brickwork settings and their special features, may be gone into.

Many have been the proposals made at different times for heating the incoming air to the furnace of a steam boiler, by means of the waste heat from the gases escaping to the chimney, and they include double chimneys in which the entering air passes down the outer casing surrounding the chimney proper on its way to the furnace and iron flues for the entering air running through the flue leading to the chimney. Most extravagant ideas have been promulgated as to the saving of fuel to be effected if boiler owners adopt some form of these regenerative operations, by persons who either were ignorant of, or who ignored scientific facts and data. In the Siemen's regenerative Steel and Glass furnaces, and in the Hoffman Brick Kiln, we see this principle in its fullest practical development, if not under the most scientific form, working with marvellous economy compared with old systems of heating, but the conditions differ widely in these cases from those which obtain with the furnace of a steam boiler. The author would wish it to be understood that it was rather on account of the secondary advantages attending it, that is, reduced radiation of heat, and not with the simple idea of saving fuel, that he was led to adopt a modification of the regenerative system to steam boilers. For the general idea of this application he makes no claim to novelty, because it apyears to be at least forty years old.

Most members know how liable the walls of high set Multitubular boilers are to crack or split with the heat, and to let in the cold air to the flues, and also how they require to be strapped with heavy iron buckstays and bolts, the settings continually calling for the bricklayer to do something or other.

The two boilers already referred to, of the same size as those shown in drawing No. 1, but rather longer, were designed about six years ago, and set by the author in the manner clearly illustrated. There is, it will be observed, an inner and outer wall on each side of the boilers, connected together in such a way that the fresh air entering through an opening at the sides near the back end, passes up and down in the space between these walls until it enters the ashpit (the doors in front of which are kept closed, except when ashes are being removed). This entering air, during its passage between the walls, abstracts heat from the inner ones, and so keep the outer walls cool. The outer walls can thus be built of superior bricks, and be nicely finished with paint or enamel, because being no heat to speak of there is no straining or distortion to disfigure them. Now, without raising the question at present as to the number of degrees the entering air is raised in temperature by this regeneration (because it is one he hoped to see worked out during the discussion), it is certain that it must keep the engine-house cooler, by the interception of so much heat otherwise escaping, by radiation. It is also undoubtedly true, that by such increase of temperature before it reaches the grate, the incoming supply of air for combustion is in a better condition to make a rapid combination with the carbon and hydrogen in the fuel, and thus secures more complete combustion, and higher percentage of efficiency.

Incidentally it is a singular thing with these two boilers, that the iron furnace doors keep so cool, that you can place your hand on them, will a full fire burning, but the author is unable to say how much this is due to heating the air and improved combustion. These doors have large brass revolving louvres to admit air as required and the flame plates are full of small perforations to thoroughly distribute it over the fuel, which, no doubt, helps to keep down the heat at the doors. The large cast iron fronts are ground up bright on their bands and moulding, and are enamel painted on their other parts, they keep so cool that this paint never blisters, so that there is little expense beyond the first outlay to make them always look well. Two other and similar boilers, in an adjoining building, are fitted with the same fronts and mountings, but are without the double walls and air flues; they are so much hotter at the front and sides, than those shown in Drawing No. 1, and they radiate so much heat into their machine room, as to forcibly illustrate the difference in the effect of the two systems of setting the same boiler.

Multitubular boilers of this type are no doubt sometimes "built in" with too little space at their backs for the combustion chamber, and in such cases the hot gases do not get a proper chance to become mixed before they pass into the tubes; the consequence is you sometimes find them very hot in the front, from combustion going on in the front smoke box, where it is too late to assist in making steam, and at night fire often shows at the top of the chimney; such defects have been cured by pulling down the backs of the setting and giving more room behind the tube ends, or by admitting more air, so that all the gases should be thoroughly mixed and perfect combustion should take place, before they enter the tubes. Too much stress cannot be laid upon the absolute necessity for plenty of air being supplied to the fuel, and a thorough mixing of the gases being insured; too much air, no doubt, is bad, but too little is worse. Although it is over 40 years since the late Chas. Wye Williams, Director of a Liverpool Steam Company, proved the advantages of Argand air openings, at the mouth of the furnace, and wrote a useful treatise on Combustion and Smoke Prevention, the broad truths, on which such operations depend, are still very largely ignored, and in too many cases rule of thumb prevails.

It will be noticed that in the setting of the Cornish multitubular boiler the air is taken first at the top of the outer side flues near the front end, where the admission is regulated by iron slides; this air passes along the sides to the back end of the boiler, then down under the lower flue below the boiler (from which it is separated by an iron diaphragm) and thence up into the ashpit through an iron conduit, travelling the whole way in the opposite direction to the hot gases (which is theoretically better than the arrangement in the underfired boiler, in which the drafts run side by side). A false floor is laid in the bottom of the large furnace tube under the fire bars to receive the ashes, a door, hinged at the bottom, closes the front of ashpit, and a sliding plate which draws out from under this ashpit floor is so arranged as to prevent the ashes from getting down the air flue when the attendant is cleaning up. The furnace is shown with one of the well-known forms of split bridges to allow additional air to be admitted to the gases of combustion from the ashpit at will, beyond the furnace proper and the air outlets are so arranged as not to allow fuel or ashes to fall in or obstruct them. The advantages of this arrangement with certain fuels or heavy firing is said to be undoubted, and as many schemes of the sort have been tried in the Colony, the results of some of them may be forthcoming.

Our younger members and students are very diffident (and perhaps naturally so) in joining the discussions held in this room, but no one of them need be afraid of contributing a supplement to the foregoing remarks.

For instance, as the weight of air required for combustion and its specific heat is known, and as plenty of practical works give the weight of fuel and weight of air that would be profitably utilised in boilers such as those shown, and further as the conducting power of brick walls is set out in tables on heat conduction, there should be no trouble with any of them in arriving at an approximate estimate as to how much the entering air would theoretically be heated, and how much the radiant heat would be reduced under either of the arrangements shown.

To older members, perhaps, must be left the question as to whether any economy in fuel consumption is to be expected, and if so to what extent from the arrangement set forth.

As no careful practical experiments have yet been made to test either of these questions, the author regrets that he is unable to supply any specific information, and therefore must apologise to some extent for the general character of this paper.

Mr. T. T. Hodkinson said:—No one who read the author's paper on the subject of boiler settings could fail to benefit by such a clear and practical statement of the advantages to be gained by the employment of competent engineers, not only in the designing, but also in supervising the setting up of land boilers. The author exhibited some specimens of scale removed from a boiler, and explained that in order to overcome the trouble (creation and removal of same) he had found it necessary to condemn the boiler and replace it by a new one of his own design, thereby making it possible for a man to go in and scrape the scale out with a shovel. This might be a very good way of getting over the difficulty, but it was rather expensive, and at the same time hardly good engineering practice. One type of boiler would make almost as much scale as another provided the feed water came from the same source, and the mere fact of the scale being easily removable was a poor justification for its presence. The prevention of incrustation had been the aim of many engineers and inventors, and many claims had been put forward for compounds that would do this. Some of them, under certain conditions, were very effective; but the majority left behind them serious trouble in the form of pitting, etc. The author's paper was so general and his invitation to the junior members so cordial, that he (the speaker) hoped to be pardoned for bringing up the question of scale prevention. If admissible, he would like to quote from a paper read before the North-Western Electric Association, at Milwaukee, Wis., on the 19th of January last, by Mr. W. H. Edgar, and members would be able to compare their own experiences with the statements of the author of that paper. Mr. Edgar, after speaking of the ill-effect of using volatile hydrocarbon oils in boilers, said that vegetable compounds only should be used. "Sugars and tannins. The latter taking care of carbonates of lime and magnesia, and the sugar converting the sulphates into saccharates, the latter breaking up oxalates, tartrates, and carbonates, and in the presence of tannin extracts, into tannate of lime, so that but a small proportion of sugar is necessary in the general mixture to handle a water containing both the sulphates and carbonates. The components to be produced according to the impurities found by analysis in a given water.

Boilers treated in this way give no trouble, if they are dosed occasionally." "At the present time some of the largest wholesale druggist houses in the States are making a speciality of the boiler compound business, taking the water, analysing, and working up a preparation to meet each awkward case." Perhaps some of the senior members who had made a special study of boilers and their maintenance would say a few words regarding the desirability of such a course of treatment.