(For the Scientific American.)

Marine Boilers.

The furnace of a boiler should be so constructed as to render combustion as perfect as possible, but it can do no more than produce carbonic acid. If only one half of the oxygen necessary to form carbonic acid, combines with carbon, the result will be carbonic oxyd, a product of imperfect combustion. A certain supply of atmospheric air, therefore, is necessary. But this supply may be too copious or too scant; it may enter the furnace too rapidly or too slow, but it cannot be too high for rapid combustion. It is also evident that the quality of the fuel must have a controlling influence upon these various conditions. Wood as a fuel for marine boilers is out of the question,—we can only consider mineral coals—anthracite and bituminous—as fit for ocean steaming. It is not my intention here to analyze these varieties, I only notice them in so far as their peculiar qualities require peculiar mechanical arrangements for good combustion.

Soft or bituminous coal requires more time to be consumed, economically, than hard coal. The large bulk of hydrogenic and bituminous compounds, mixed up with floating particles of carbon, which result from the burning of soft coal, require to be thoroughly mixed with heated air before perfect combustion can take place. The mechanical arrangements to effect this are of great importance, but may be overlooked when hard or anthracite coal is consumed. This fuel admits of a much more rapid consumption, and of a powerful blast, while the draught of a soft coal furnace should not be very strong.

Experience has not yet settled the most economical speed of consumption of mineral coals. Watt's rule was to allow one superficial foot of grate surface for every ten superficial feet of heating surface, and this rule produces good results with natural draught. The boilers of the Collins' steamers are undoubtedly the most efficient and best constructed boilers now in use, either here or in Europe. According to Mr. Isherwood, those of the "Arctic" contain 0·357 feet of grate for 11·84 feet of heating surface, for every effective horse-power, or 33 feet of heating surface for 1 foot of grate.

According to the same author, whose account of the performance of the "Arctic," published in the "Journal of the Franklin Institute," appears to be reliable, the average consumption of anthracite during six trips, was 7980 lbs. per hour. The aggregate grate surface of the four boilers of that steamer is 588. feet, which gives 13·57 lbs. of coal per hour for each foot of grate. In boilers of ordinary construction, with natural draught, half the weight of soft coal would be a fair consumption.

Chemists who have examined the evaporative power of various fuels, agree that one lb. of good mineral coal, perfectly consumed, will evaporate over 11 lbs. of boiling water. Experiments on a larger scale will seldom evaporate more than 9 to 10 lbs. The boilers of the "Arctic," during those six trips, evaporated 7½ lbs. of steam from water of 110° by one lb. of anthracite, and this is one of the highest results that has been obtained in the regular working of marine boilers. It is evident, therefore, that there is room left for improvements. There is still a waste of fuel in the Collins' steamers, which arises from imperfect combustion, the result in part of a faulty construction, and no doubt in part is attributable to imperfect stoking. Much of course depends upon the mode of firing, nor is it always practicable, to carry on this important part of the service according to the best rules.

In attempting to improve the construction of boilers, we may receive good hints from an examination of the condition and working of other furnaces, in which good combustion and a high degree of heat are important objects. Furnaces used in the manufacture of iron, such as blast, puddling, heating, and annealing furnaces, may be referred to.

Perfect combustion can only take place under such circumstances as are favorable to the developement of intense flame and heat. Aside from the necessary quantity of air, supplied at a certain rule, and heated if possible, there are other contingencies upon which success depends: a very important one is the nature of the material which surrounds the furnace, forms its walls and roof, and comes into immediate contact with the fire. The question then at once arises, can the process of combustion be successfully carried on in a narrow furnace, surrounded by iron walls and roof, in contact with water, which absorbs the heat at a rapid rate? Most certainly not. Who would undertake to heat and puddle iron in a furnace built of iron plate in contact with water? Iron water boshes are sometimes resorted to, but they have a tendency to retard the process, and should be avoided if possible. Such furnaces are constructed of good fire-brick, which is a slow absorbing and slow conducting material, and after being glazed over by the strong heat, will strongly reflect it. By this strong reflection and non-absorption, the process of combustion is supported in an eminent degree, so much so that a degree of heat is obtained far exceeding the temperature of any boiler furnace. As little heat as possible should be absorbed by the walls or roof of a boiler furnace; every endeavor should be made to reflect and concentrate the fire. Imperfect combustion in any furnace most generally arises from the fact that the heat is not allowed to accumulate and to concentrate. The sole object of a boiler furnace should be to favor combustion, and to develope flame and blaze, and this can only be accomplished under the influence of a highly concentrated and excited action. The caloric stream thus fully elaborated, on leaving the furnace, is then allowed to expand itself, and to be absorbed by the interior surface of the boiler.

I may remark here, by way of general comment upon furnaces for heating houses, that the whole tribe of *Patent Furnaces*, with which the country is blessed, have all, more or less, grown out of erroneous notions, and are the offspring of a profound ignorance of the laws of combustion and of heat. Aside from the vitiated air they supply, they are all wasting fuel at an enormous rate. This subject is better understood in the north of Europe, where long winters and scarcity of fuel have taught men to build furnaces on correct principles.

The temperature of a puddling or heating furnace has to be raised to about 3000°, this can only be accomplished under the reflecting and reverberatory action of the walls and roof. A concentrated blast may produce a greater heat at a certain point, but it will not be diffused. Under the above circumstances, and by means of a strong blast, from three to four times as much fuel may be consumed on the same surface of grate in one unit of time, as can be accomplished in a common boiler furnace. In a well constructed heating furnace, at my rolling mill at Trenton, N. J., 8,000 lbs. of anthracite are consumed in ten hours for the heating of 18,000 lbs. of charcoal hammered blooms, on a grate of twenty superficial feet, which is equivalent to 40 lbs. per hour on one foot of grate. This cannot be accomplished in the furnaces of the Collins' steamers, which consume 13½ lbs. per hour on one foot of grate.

In the above a principle is delineated, which to my knowledge has been entirely overlooked, and which must be satisfied before we can attain much higher results.

Another glaring defect in all marine boilers, those of the Collins' steamers not excepted, is the want of room, necessary for a due mixing of the gases, and a full developement of the blaze.

Large quantities of fuel in a narrow and low furnace, cannot be consumed without waste. In order to become fully excited and most positive in its action, the blaze of a fire must be at liberty to extend and elongate in the direction of the draught, to a distance corresponding to its bulk, and without meeting absorbing obstructions. For illustration, I again refer to heating and puddling furnaces. This fact can be readily ascertained in an experimental furnace with adjustable roof. The brightest fire will burn under the highest roof, while the depressing action of a low roof will damp it and reduce the temperature of the furnace.

Economy of space is an important consideration in the planning of a marine boiler, but this may be carried so far as to seriously interfere with the grand object of the boiler. In an efficient boiler, the extension of the furnace should form an empty area, which serves as a receptacle for the caloric stream, where the gases become thoroughly mixed and fully ignited, before their caloric is expended upon the boiler surface. And for the purpose of allowing ample time to the heat to be absorbed by the tubes, the above space, together with the tube area, should be as large as possible. The arrangement must be so, that the draught between the furnace and the chimney should be very slow, so that all the caloric, or nearly all may be absorbed before the unconsumed gases are allowed to escape.

The boilers of the "Arctic" have 33 feet of heating surface for 1 foot of grate surface; this allowance is scarcely enough for hard coal; 40 to 1 will not prove an excess. But this proportion depends in a great measure upon the velocity of the draught, through the area which contains the tube or heating surface. The larger this space, or the longer its extent, the slower the motion of the gases will be, or the more extended their travel, consequently the longer they will remain in contact with the tubes. It is a very general defect in marine boilers, that the draught from the furnace to the chimney, through the tube area, or through the flues, is nearly uniform, and too rapid. The "hanging sheets" in the boilers of the Collins' steamers were designed to arrest this rapid flow, but they are not sufficient. The fact is that the common plan of flue or tube boilers does not admit of a thorough application of the important principle in question, hence the necessity of a radical change.

Other questions of importance have to be considered in the planning of a marine boiler. Strength, facility of construction and repairs, provisions against unequal contraction and expansion, against incrustation, facility of blowing out, and of cleaning, safety against exposure of heating surface, when the ship is rolling or careening, all these are important points, but more or less understood. By the above remarks I have only attempted to direct attention to such points as are not generally understood, and consequently neglected.

In a new plan of boilers, which I have invented, all the essential conditions of perfect combustion, radiation, and absorption, are fulfilled, and is calculated to produce much higher results than have been obtained heretofore.

In conclusion I will yet remark that the subject of *artificial* draught is in a great measure an open question yet. The common fan-blast will answer very well under certain conditions, but in marine boilers, I am satisfied, *exhaustion* by proper mechanical means will work better. The control of large and connected fires can be better maintained by *exhaustion* than by *blast*, and also more economically.

John A. Roebling, Civil Engineer.

Niagara Suspension Bridge, May 29, '54.

Copal Varnish.

As we have had many inquiries respecting the preparation of the above varnish, the following article by Prof. Heeren, taken from "Dingler's Polytechnic Journal," will be read with interest:—

"There is no difficulty in dissolving copal in fatty and volatile oils when the resin has been previously fused; by this process, however, a more or less distinct coloration is produced, and the natural hardness of this fine resin is injured. It has therefore been often attempted to dissolve copal without previous fusion; but, as is well known to all who have occupied themselves with this question, great difficulties have been found in effecting the solution. Directions have been given to soak the pounded copal in ether or ammonia until it swells up into a gelatinous form, and then to dissolve it in strong alcohol; but this process never succeeded with the author though he tried it repeatedly. Others recommend hanging the copal in a small bag in a retort, in which absolute alcohol is gently boiling. This method also failed, in the author's hands, in producing even a tolerably concentrated varnish.

The best prescription appears to the author to be that given by Freudenvoll in his treatise on the preparation of varnishes. According to him, 4 ozs. of West India copal are dissolved in a mixture of 4 ozs. oil of turpentine, and 6 ozs. alcohol of specific gravity 0·813; or a mixture of 3 ozs. sulphuric ether; 4 ozs. oil of turpentine, and 4 ozs. alcohol of specific gravity 0·851.

When engaged in testing this process, which gave very good results, the author found a small variation, which he describes as follows, particularly efficacious:

Two sorts of copal occur in commerce, the East and West Indian. The former is usually in small, irregular, rounded pieces, with a finely-verrucose surface, the resemblance of which to the skin of a goose has obtained for it the name of "goose copal." It is of a somewhat yellow color, and is preferred for the manufacture of a somewhat oily copal varnish, because it acquires less color by fusion than the West Indian. The latter does not possess a warty surface; it is very pale in color, often nearly colorless, and occurs in large irregular fragments, partly with a rounded surface and partly with a shelly fracture.

West Indian copal only can be employed in the following solution, the East Indian forming only gelatinous lumps, but never a solution. The solvent is a mixture of 60 parts by weight of alcohol of specific gravity 0·813; 10 parts by weight of sulphuric ether; 40 parts by weight of oil of turpentine, in which 60 pounds of copal are to be dissolved for the production of a varnish of an oleaginous consistence. Solution takes place, even in the cold, without any previous gelatinous swelling of the copal; but it is effected much more rapidly with the assistance of a gentle heat. As, however, single pieces are often found in the West Indian copal, which instead of dissolving only swell up in the fluid, by which the rest of the solution is spoiled, it is advisible to select only the large and perfectly clear pieces for the purpose of varnish making, and to test each first of all as to its solubility. This little trouble is richly repaid by the certainty of the result.

To test this quality, a small splinter of the copal is put into a small test tube; a little of the solvent fluid is then poured in, and the whole is heated. If the copal dissolves completely in a few minutes without becoming gelatinous, it is good.

When the desired quantity of good copal has been got together in this manner, it is to be pounded to a tolerably fine powder, which is to be put into a glass retort or flask, the necessary quantity of the solvent added, and the whole heated and shaken until solution is effected. To clear the varnish, which may appear somewhat dull, from dust or other impurities, it may be allowed to stand a long while until these settle; or if it be desired to effect this quickly, it may be filtered through blotting-paper, placed as a filter in a glass funnel; the filter must not project above the edge of the funnel, so that the latter may be closed by a glass plate laid over it. The passage of the thick varnish is of course very slow, but the varnish is obtained perfectly clear in this manner; and if the copal employed were very clear, it is nearly colorless. It dries rapidly, but like all turpentine varnishes, retains a slightly sticky surface for some days."

Cooling Soda Water; Saving Ice.

A. M. Denig, of Columbus, Ohio, has made a very useful improvement in the cooling of liquors, such as soda water, whereby considerable ice is saved. It consists in the arrangement of a single flued copper chamber, inside of a non-conductor similar to an ordinary water cooler, and placing the whole apparatus upon the counter instead of under it. The ice being placed in the flue (which is of sufficient capacity) keeps the soda water always cold at the place where it is drawn. The stopcock inside of the non-conducting chamber, is attached to the cooling chamber on one side, and the exit pipe on the other,—thus drawing every glass of soda from immediate proximity to the ice. The saving of ice in the use of this improvement is said to be nearly 50 per cent. over any other mode, twenty pounds being amply sufficient to run a fountain any day during the season. To those who do not continually draw soda, and to whom saving ice is any object, this apparatus is no doubt a valuable acquisition.