

## ON THE EFFICIENCY OF FURNACES AND MECHANICAL FIRING.

BY C. F. DEACON, C. E., BRITISH ASSOCIATION, SECTION G.

Having for some time past given a large share of my attention to the subject of the efficiency of furnaces, I have to bring before you a few results of my experience in this most interesting and important inquiry.

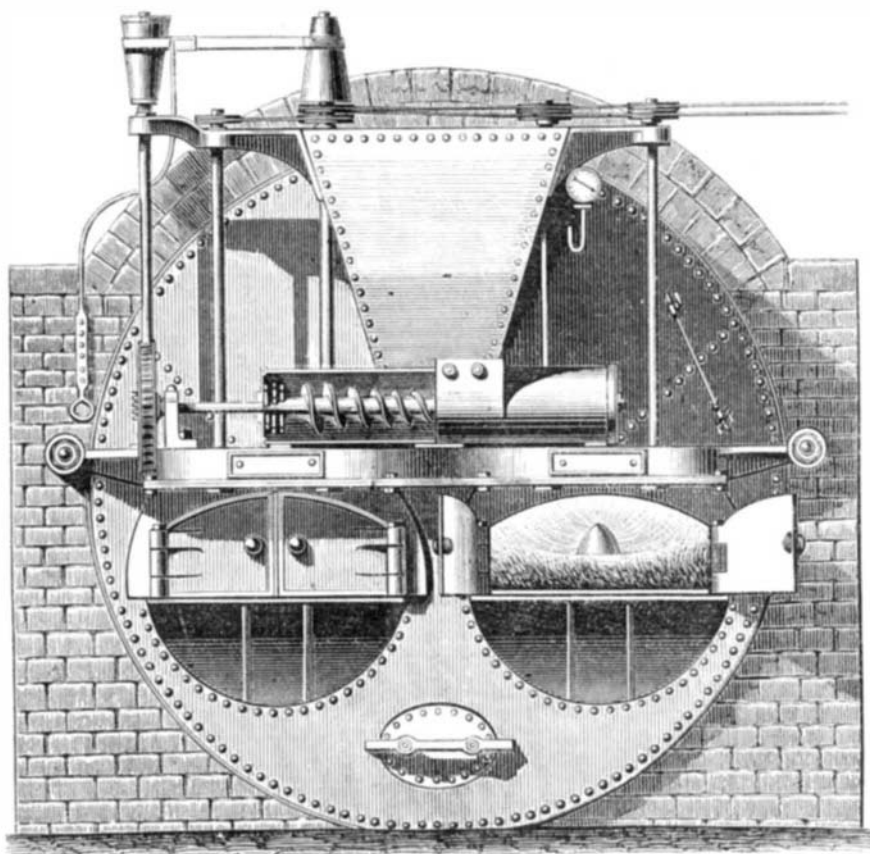
Since the time in which Wye Williams lived and labored, Professor Tyndall and Dr. Frankland have shown that the energy of combustion is within wide limits independent of the density of the air, the natural inference *at first sight* being that in furnaces the temperature of the air does not affect the efficiency. One of Wye Williams' well-known experiments was to introduce a bent plate perforated with fifty-six half-inch holes into the center of a furnace where one or two bars had been removed for its reception. "Adequate mixture," says Mr. Williams, "was thus instantly obtained, as in the argand gas burner; the appearance, as viewed through the sight-holes at the end of the boiler, being even brilliant, and as if streams of flame instead of streams of air had issued from the numerous orifices. It is needless to add that nowhere could a cooling effect be produced, notwithstanding the great volume of air introduced."

Now I cannot at present do more than state the simple fact that I have tried similar arrangements in many different instances and under several different conditions, and that I have rarely failed to produce a cooling effect. The arrangement by which the results have been arrived at may be thus described: A few of the ordinary fire bars are removed from the center of the flue. A pair of longitudinal bearers about six inches apart are then introduced, their upper surfaces being level with the common fire bars. On these bearers are placed small arched transverse bars, each about one inch thick, in contact with one another. Semicircular holes are cast in the transverse surface of these bars, so that when placed together on the bearers they present the appearance of a tunnel about nine inches high pierced with numerous small holes, an arrangement not differing widely from that of Wye Williams, except that the tunnel, being of loose cast-iron pieces, is no more liable to deterioration by heat than common fire bars. If the mere fact of admitting air to the hydrocarbons at the moment of their generation, and in minutely divided lines, is sufficient to insure their combustion, surely nothing could do so more effectually than this arrangement. But the result.

A large quantity of fuel being placed upon the incandescent carbon in the furnace, we have, after the expiration of a few seconds, a splendid display of white flame, not entirely smokeless, but comparatively smokeless, unless the quantity of air admitted is very large; white flame and intense heat—evidence of the precipitation of the carbon particles and of their combustion after precipitation; smoke burning—not smoke prevention; greatly increased temperature of the furnace door, evidence of increased radiation of heat. But, as I said before, in almost all cases a loss of efficiency in the furnace—a reduction in the absolute temperature of the flame. Was Mr. Williams deceived by that radiant heat? I cannot avoid the conclusion that he was in some cases at least. But the furnaces adopted with economical results contained elements not yet described. The ash-pit was divided into three chambers by two vertical sheet-iron partitions, made fast to the longitudinal bearers in such a manner that all air entering it at the central chamber must pass through the arched bars, while that entering by the two side chambers reaches the fuel in the ordinary manner. Now, observe the difference: Here we have a long central fire chamber open to the air only at one end. The air before entering the fire chamber passes over the surface of highly-heated sheets of iron, traverses in turn the cross pieces of the little arched bars and the heated surface of the ribs. Even with this simple change the results are, I believe, in all cases, altered from failure to success. A heating effect has been obtained where a cooling effect only could be produced before.

To sum up my own observations on this subject, I find: (1) That the admission of cold air in quantities sufficient for the complete combustion of the gases in ordinary furnaces is attended with a loss of efficiency in all cases, even if that admission takes place in finely divided streams immediately over every portion of the fuel from which the gases are rising. Radiant heat, and consequent temperature of the furnace door, are enormously increased; smoke, however, is considerably reduced. (2) That by the comparatively slow motion of air over heated surface, and its consequent rarefaction and increase of velocity when issuing from the orifices of the arched bars, a much more perfect chemical union is insured. The flame is not so luminous, but a higher rate of efficiency is obtained. Radiant heat is decreased, the furnace door is rendered less hot, and smoke is more perfectly prevented. The old Cornish system of dead-plate firing when conducted very carefully, and in such a manner that the incandescent fuel at the back of the furnace is never allowed to burn into holes, has, as we all know, certain advantages. But when the back of the furnace is left to itself, I believe it to be a most difficult matter to avoid the admission of cold air *en masse*, a condition which cannot but be attended with loss of

efficiency; and in my attempts to discover the best method of mechanical firing, I could not find that those systems in which the coal had a progressive motion from the front to the back were free from these defects. Such methods appear to me to owe their advantages—for no doubt they have advantages—to other causes than that of the perfect combustion of the hydrocarbons; and is not the comparative freedom from smoke in this system of firing the result, in a great measure, of that union of carbon from the front with carbonic acid from the back, producing carbonic oxide, and inevitable loss of heat—the pernicious principle resorted to by a whole army of smoke-burning patentees? The apparatus which appears to me most correct in principle does not profess to compete with the more perfect mechanical stokers, inasmuch as the clinkers are removed by the firemen in the ordinary manner. In short, since my attention was drawn to the subject, I have come to the conclusion that the principle of what was probably the first attempt ever made in mechanical firing—I speak of Stanley's patent—is capable of the highest possible efficiency. Twenty



MODE OF FIRING FURNACES MECHANICALLY.

years ago nearly every furnace in Lancashire was fed by the apparatus popularly known as the "hopper." In a box on the front of each furnace two fans revolved horizontally. Fuel was drawn from a hopper by rollers which crushed and let it fall on to the two fans, which in their turn propelled it into the furnace. It was possible to adjust the speed in such a manner that the fuel was spread uniformly over the whole surface of the bars. I would merely add that when the two-flued Lancashire boiler replaced the wagon and egg-ended boilers then in use, the hoppers were taken down, possibly in some places applied to the new flue boilers, found not to throw the fuel evenly over the bars, and discarded. In Leeds, however, they are still in use to a considerable extent, probably because some makers there took the trouble to adjust them to their altered circumstances. For a single two-flued boiler the hopper, as now in use at Leeds, requires about twenty toothed wheels, and at least two worms to drive the crushers and other portions; and notwithstanding the fact that the teeth of those wheels are constantly breaking, and that the whole apparatus trembles under the sudden check caused by a large lump of coal falling between the small crushing rollers, manufacturers who have tried it for so many years, give universal testimony as to its economy. I understand that one engineer in Leeds still makes a considerable number of them. This apparatus does not, of course, prevent smoke, but it distributes the smoke from a given quantity of fuel over a longer period than in hand-firing, and reduces its blackness in the same proportion.

Now, does it not appear that if we can retain the manner of throwing on the fuel, very considerably simplify the means, and use it in conjunction with the firebar arrangement already described, we shall have a very efficient furnace and a perfect preventer of smoke? The only drawing I can show you will sufficiently explain the nature of the new arrangement so applied to a two-flued boiler, at a period when the greater part of the improvements were effected. The twenty toothed wheels and two worms have been reduced to one worm and wheel; the two hoppers (one over each flue) to one hopper in the middle of the boiler face. The crushing rollers have been done away with altogether, and an arrangement substituted which crushes and meters the fuel as effectually but much less suddenly. Through the fuel in the middle of the hopper passes a cast-iron screw with a tapering helix of small diameter at the center, but increasing gradually up to the internal diameter of its containing-cylinder outside the hopper. The two halves of this screw are right and left handed, respectively. It has a slow revolving motion, and its action on the coal contained in the hopper is evidently of a nibbling kind, while it metes out to the fans of each flue the desired quantity of fuel. There are other details which have

not been overlooked, such as the well-known heaping up of the coal on the dead plate, the cause of which has been entirely removed. And last, but not least, the whole machine is fixed to a frame made fast to the boiler, by three bolts through the shell, no holes whatever being cut in the boiler face. The fires made by this apparatus are perfectly level, and are absolutely free from even light smoke.

I hold in my hand a report prepared about four months ago, on the efficiency of the apparatus in question. It is founded on very carefully made evaporative experiments, the conclusion being that the feeder, when used for the first time in competition with the best hand-firing that could be obtained, gave an increased efficiency of 9.696 per cent over and above the efficiency already attained with the argand furnace alone. The cost of the combined apparatus is, of course, much lower than that of any of the more elaborate mechanical stokers—little more than one half—but I believe the efficiency is higher.

## Balloons for War Purposes.

The experiments made at Woolwich by balloons inflated at the Royal Arsenal Gas Works have, on the authority of the London *Artisan*, shown that a height of 100 fathoms, at a horizontal distance of 600 fathoms from an enemy, would enable the observers to secure a wide expanse of view. The balloons with which experiments were made at Woolwich were held by two new cords fastened to the net-work, and terminated at two different points on the ground, to give greater stability to the balloon, and to provide against one cord snapping, or being cut by the enemy's fire. By the new system of military telegraphy for field service, and by means of wagons at present being placed in store in the Royal Arsenal, lines of telegraph can be carried through the air from the earth several miles distant. The wire can be paid out as fast as the balloon travels, so that if a captive balloon should break away, communication could be kept up with it for six miles; or two or more balloons can be sent up, and kept in telegraphic communication with each other by means of similar lines, so that telegraphic operations can be made from the balloon to headquarters, and thence to the base of operations.

By means of these new military telegraphic appliances the most rapid intelligence, and consequent speedy word of command, can be given. In sieges, war balloons are useful in giving information of depots, points of attack, batteries, inner intrenchments, the explosion of magazines in marshes, to spy out ambuscades that may be in waiting, to rally columns, and to telegraph points of assembly on attack. The observing officers were enabled to survey an area of thirty square miles. It was found that by practice great skill can be attained in judging of distances, and the relative position of masses of troops; while more minute details could be subsequently obtained at leisure by field glasses as to the position of mountain gorges, passes, limits of woods, and the course of streams. The trials hitherto made have been chiefly carried on by professional aeronauts with hired balloons; and it is believed that the British Government have at the present time no war balloons in store.

The result of the observations of Captain Brackenbury and Captain Noble, sent out from Woolwich on behalf of the English Government to the respective seats of war, together with trials and other sources of information, will, it is believed, result in war balloons being manufactured in the Royal Arsenal, and that officers of royal engineers, from generals downwards, will be trained in their use.

## Diet of Belgian Miners.

The miners of Belgium eat, according to a report recently published in that country, 2 lbs. of bread per day, about two oz. of butter, 1 oz. of coffee and chickory mixed, while for dinner they have in the evening a portion of vegetables mixed with potatoes, weighing at the most 1½ lbs. They have meat on Sundays and festivals, but during the week they drink neither beer nor other fermented liquors. Coffee is their only beverage. Yet these workmen are hardy and healthy.

It is not the coffee which sustains them, for it constitutes but  $\frac{1}{5}$  of the nutritious properties of their aliment, though M. de Gasparin, in a paper read some years ago before the French Academy of Sciences, attempted to prove, from certain tables, that the waste in liquid excretion is less when coffee is drunk than at other times. The miners' coffee is not like the French *café au lait*, for it has but one tenth part of milk in it; he drinks several pints in a day, and eats only bread and butter until the vegetable meal of the evening. The albuminous substance which enters into the rations of the Belgian miner is thus reduced from 23 grammes to 15 grammes of azote. Here is, therefore, proof that life and health can exist throughout a whole population with less nutritive substance than is generally considered necessary.

OZONE AND EXPLOSIVES.—M. Jouglot is said to have discovered that ozone has a tendency to decompose explosive compounds. Nitro-glycerin and chloride of nitrogen explode instantly when exposed to an atmosphere of ozone, while common powder changes so slowly that six weeks' exposure is necessary to its decomposition.