the tracing-frame, but it is better to make it act on a steel pin in the side of the tail.

By this arrangement of the crank for turning the dividing screw, the stops of the ratchet are brought in contact when the crank is passing its centres, and the motion of the screw so slow that it is not possible for the stops to strike so hard as to do any injury, and the dividing may be done with great rapidity.

Observations on the more recent researches in the Manufacture of Iron. By DR. J. LAWRENCE SMITH, of Charleston, S. C.

(Continued from page 204.)

In the last article on this subject, the operations of the blast furnace alone were alluded to, and among the statements then given, was that of the composition of the gas taken from the mouth of the furnace; which gas contained about 24 per cent. of carbonic oxide, this representing a large portion of the combustible used, which is lost in most of the furnaces now in operation in this country.

M. Ebelman states that the combustion of the gas passing from the mouth of the blast furnace is equal to from $\frac{5.2}{100}$ to $\frac{5.7}{100}$ of the calorific effect of the coal used, and MM. Bunsen and Playfair set it down as $\frac{2.0}{100}$, which last, I am rather inclined to believe, is rather too large a fraction; they spoke of the furnace worked with bituminous coal, and Ebelman had allusion to one worked with charcoal. Without being able to decide exactly what portion of the combustible of the blast furnace is lost, it is sufficient to know that it is far greater than that consumed, to lead at once to the employment of means bringing into use this waste combustible.

The employment of heat lost from the mouth of the blast furnace, for the purposes of metallurgy, &c., has been claimed by many as having been used by them since 1834. The following are some of the claimants:—MM. Thomas and Laures, (civil engineers;) MM. d'Andela-re and de Lisa, (forge masters at Treveray;) M. le Maréchal Marmont, (in Austria;) M. Houzeau Muiren, (of Ardennes;) and M. de Faber Dufaur, (of Wasseraalengen.) All their claims of priority, however, ought to be laid aside, since the operation was performed many years prior to the time that any of them claim to have first employed the lost heat. And as a proof of this assertion, I give the following extract from the *Journal des Mines*, Juin, 1814.—“M. Aubertot, of the department of Cher, and owner of furnaces and other works in excellent condition and management, which he superintends personally, made, several years ago, a great many experiments to discover some means of economizing the amount of fuel used in the working of iron, either by endeavoring to introduce the operation by the catalan furnace, or otherwise. He was led to try what could be accomplished by making use of the flame which passed out of the blast and refining furnace. He first employed it for the cementation of steel, in which he succeeded perfectly; then he used it for calcining lime, also for burning bricks and tiles. Afterwards he passed it into

a reverberatory furnace, in which the temperature was raised sufficiently to heat the blooms and bars, for hammering the one and drawing the other out. Finally he succeeded in producing all the above effects at one and the same time, by causing the flame to circulate through several furnaces side by side."

In 1834, M. Houzeau Muires took out a patent for using the waste heat from the mouth of the blast furnace, for carbonizing wood at the furnace of Bievres, (Ardennes;) in which he states that twice the quantity of charcoal is obtained by treating the wood after his method, than by the ordinary way of burning in the woods. By the heat lost from the furnace, 100 parts of wood gave 35 of charcoal, and from 40 to 45 of *charcoal roux* (half burnt wood.)

But after all, it is not to those who first applied this lost heat to economical purposes that we are indebted for the practical information that is now in our possession; for had they made their arrangements so as to exhibit an undisputed advantage arising out of its adoption, it would not have been so tardy in its progress.

It is to M. de Faber Dufaur, superintendent of the iron works at Wasseraffingen, in the kingdom of Wurtemberg, that most of the credit is due for the present method of converting pig into wrought iron, by using and burning the gases that escape from the mouth of the blast furnace. The best idea that can be given of the manner in which the operations are conducted in the above works, and the advantages accruing therefrom, is contained in the following short extract from a letter written by M. Grouvelle to M. Dumas.*

"The establishment at Wasseraffingen is supplied with ore, three-fourths of which is a hydrated oxide of iron, and the other fourth is an ore in grains. The influence of the first species of ore gave to the pig so bad a quality that it was used altogether for castings. M. Dufaur, by his processes, without altering the operations of the blast furnace, now obtains from the pig a wrought iron of superior quality.

"The first gas furnace put in operation by him was a refining furnace, into which the pig metal was run as it issued from the blast furnace, where the refining was executed with the air of the hot blast. From this the most beautiful results were obtained, and it worked regularly during the year 1837. In 1838, he erected a puddling furnace; and finally, in 1839, he completed his magnificent system for the fabrication of iron, by constructing a furnace for re-heating and welding."

At Wasseraffingen there are now turned out annually, one million pounds of wrought iron in various forms, made in these new furnaces, and owing to the deficiency of moving power, all the pig cannot be worked up. This operation of refining iron by the combustion of gas without any other fuel, has been in successful operation at the above locality for several years, and it has been followed with a great improvement in the quality of the iron, and has reduced the loss to one-fourth of what it was originally.

This method of refining the pig has also been in active operation in

* Comptes Rendus, 1841, p. 382.

a number of places, and whenever properly executed, is always attended with economy and success. M. d'Andelarre, in one of the departments of France, in a letter states, "our puddling furnaces, heated altogether by the gas lost from the mouth of the blast furnace, has been attended with the most complete success, which rarely happens in the first attempts at the application of any improvement, which most generally require long experience. We lighted up our furnace on the morning of the 5th, and put in the first charge at 11 o'clock on the morning of the 6th, and shingled the same at three-quarters past twelve. The accomplishment of the results so quickly passed our expectations, resulting in

"1st. An economy of the total amount of fuel used in the refining of iron, (which, in a furnace with two doors, amounted, in 24 hours, to 6,000 pounds bituminous coal, costing twelve dollars.)

"2d. Improvement in the quality of the iron.

"3d. The loss was very small, being 5 instead of 20 per cent., which it is by the old processes.

"4th. The operations of the furnaces are much improved."

Here we see that the experience of M. d'Andelarre accords exactly with that of M. Dufaur, and already have Russia, Prussia, Sweden and Germany sent commissioners to Wasseralfingen, to study the processes as they are there carried on. The government of Wurtemberg have opened their works to the inspection of all who may wish to make themselves acquainted with their character.

The advantages arising from the employment of the waste gas from the mouth of the blast furnace, is no longer problematical, and as some of those interested in this matter may not be acquainted with the method by which the gas is collected and employed, a few words explanatory of it will not be out of place.

The gas, as it rises through the fire room of the furnace, containing from 60 to 80 per cent. of the combustible effect of the fuel used, is made to pass into a chamber surrounding the upper and outer part of the fire-room, some idea of which may be formed by the representation in fig. 1. B, is the mouth of the furnace; A, A, gas chamber surrounding the upper part of the fire room; D D, pipes connecting the fire room and gas chamber; C, C, pipes to carry off the gas, which is drawn out by means of blowing cylinders and forced into the refining, puddling, or other furnace, through a number of small orifices alternating with other orifices, through which a cold or hot blast of air is thrown that serves to keep up the combustion of the gas when once united; and by regulating the supply of air by means of stop-cocks, the maximum of heat can be obtained. In order to arrive at the maximum of heat, just sufficient air should be admitted to burn all the carbonic oxide and hydrogen contained in the gas coming from the blast furnace. If the amount of air be too small, some of the combustible gases pass out unconsumed; if too great, the excess cools

Fig. 1.

the furnace, and at the same time oxidizes the metals undergoing refining. The regulation of the supply of the blast is of the utmost importance, and is said to be easy of accomplishment.

The differences between the reverberating furnaces worked in this way and those in which coal is used, is that carbonic oxide with a little hydrogen is the fuel, and it is burnt by a full supply of air. It is hardly necessary to say more of the advantages that are to arise out of this important change in the working of iron; for there is no expense for fuel in the refining of the pig, as the gaseous combustible issuing from the mouth of the blast furnace is more than sufficient to refine all the pig made from the furnace. The quality of iron is also improved, as none of those impurities contained in the coal and other fuel can interfere in the working of the iron.*

The sooner these modifications are introduced into our furnaces, the sooner will we be able to place iron in the market at a price to compete with that coming from any other quarter of the world, and entering our ports free of duty; at the same time it will increase the value of those works whose wood-land has been diminished by a too rapid and improvident use of fuel.

I next pass on to make a few remarks about the *refining furnace* used in the working of iron. In these furnaces the air is thrown, by one or two tuyers, into a crucible filled with charcoal, into which the pig to be refined, along with scraps coming from previous operations, is placed in a certain relative position. The change that takes place by the reaction of the air upon the coal, is similar to what occurs in the lower part of the blast furnace, namely, the conversion of the oxygen into carbonic acid, which is immediately changed into carbonic oxide. The analyses of the gases taken from the centre of the furnace, prove that the transformation of the oxygen into carbonic acid corresponds to the position where the workmen constantly place the iron that is about to be forged, and this is just what we should expect as it is the point of maximum temperature.

Ebelman states that the atmosphere which surrounds the melted iron, contains hardly a trace of carbonic acid, either in the blast or puddling furnace; this being contrary to the opinion which is generally admitted, that the decarbonization of the iron takes place by the action of the air during the melting of the pig, but it would appear that this reaction is attributable to the protoxide of iron covering the surface of the mass undergoing refining. In the second period of refining, in the puddling properly speaking, it is easy to deduce from the analyses of the gas, that there is oxidation of a considerable portion of the iron by the oxygen of the air thrown in at the tuyere.

Here again much of the fuel passes off under the form of carbonic oxide, thereby causing considerable waste. Of late years a modification has been introduced into the refining furnaces, even when the waste gases from the blast furnace are not employed; a modification by which none of the combustible is lost. A few words will suffice to explain how this is accomplished.

* If I mistake not, the Dufaur patent has been taken out in this country by Mr. Detmold, and has already been applied to one or two furnaces.—J. L. S.

All the furnaces are modifications of the reverberatory furnace. The fuel is placed upon the grate A, (fig. 2,) and ignited by air thrown in from below the grate, by a bellows or otherwise. The air in traversing the ignited coal is first converted into carbonic acid, and then, if the bed of coal be thick enough, this last will be changed into carbonic oxide. As this, however, is generally not the case, a part of the carbonic acid passes beyond the upper surface of the fuel without having undergone a change, particularly if the blast from below has been strong and abundant. By this operation the chamber B becomes heated, and a mixture of carbonic acid, carbonic oxide, nitrogen, and a little hydrogen passes out of the flue C. The object of the metallurgist, however, is not to permit any carbonic oxide or hydrogen to escape combustion, but to endeavor to add to the heat of the furnace that heat arising from the combustion of these two gases. This is readily accomplished by throwing in a second blast of air, through a number of small orifices just above the surface of the fuel, D; this blast to be regulated as required.

By this process, we re-create, as it were, the maximum intensity of heat, (which first shows itself at the lower part of the fuel on the grate, just where the air becomes converted into carbonic acid,) and in the chamber B, where it is most wanted; for the amount of heat rendered latent by the reduction of the carbonic acid into carbonic oxide, is rendered sensible by the reproduction of the former.

The advantages arising from this method of burning the fuel, are important. In the first place, the heat is diffused over a larger space, thereby heating more uniformly the metal, than when it is placed in the midst of the fuel. Again, fuel of the most inferior quality can be made use of, and as evidence of this in some trials made at Audincourt, it was proved that the reverberatory furnace could be heated to whiteness by burning the gas, and the pig melted and puddled, when a mixture of charcoal dust and earthy matter was made use of as fuel.

Ebelman, whom I have so often quoted in these articles, and who has certainly made the best series of scientific researches upon the subject, says that, instead of employing the action of air upon an excess of charcoal to produce the combustible gas, the vapor of water may, to an extent, be substituted, which produces, in contact with burning charcoal, carbonic oxide and hydrogen.

The heat of the combustion of equal *volumes* of hydrogen and carbonic oxide is about the same, and it can be easily deduced that the decomposition of the vapor of water by the charcoal, determines an absorption of latent heat, equal to that which is produced by the transformation of the same volume of carbonic acid into carbonic oxide. The vapor of water alone passed through the ignited coal produces all the effects just mentioned, but the absorption of latent caloric is so great as to cause the operation to cease in a few minutes. By projecting, however, a mixture of air and the vapor of water through the coal, the operation is said to be carried on advantageously.

It was my intention to have remarked at length about the effects of the hot blast, but it is now so generally admitted that the hot is to be preferred to the cold blast in reducing the iron from the ore, and bringing it to its most refined state, that any thing on the subject at this time would be superfluous. All that is important to make known upon this subject, is the results lately arrived at by M. Scheerer* as to how it is that hot air produces such remarkable effects in the blast furnace.

By calculations based upon his own experiments as well as those of others, he was led to the conclusion that the most elevated temperature that charcoal could produce in burning in air, is 2571° Cent., which is that at which platinum melts. This temperature is situated in the middle of the space upon which the air is projected, and it goes on diminishing towards the exterior, so as to form a space for melting, the centre of which is at 2571° , and the exterior at 1550° Cent. When the hot blast is made use of, the temperature of the centre does not change, but the portion heated to 2571° becomes more extended. The exterior of the mass, which was at 1550° while using the cold air, acquires, when the hot blast is employed, a temperature as many degrees higher as there is difference between the temperature of the two blasts; for instance, if the temperature of the air be 280° C., that of the exterior of the heated mass will be 1830° C.—if 300° C., the latter will be 1850° C.

Thus the influence that hot air exercises, is to extend the space of fusion, which is twice as great with the air at 300° C. as it is when the air is at 0° C.

Amer. Jour. of Sci. and Arts.

Statistics of the Coal Trade.—The Coal Measures of Britain.

The coal measures are not confined to the north of England, in Northumberland and Durham; they are to be found, fortunately for this country, forming large portions of the stratification in many districts of the three kingdoms. From the Grampians to Sussex, and from the German Ocean to the Irish Sea, the predominating geological feature of the British island is the “carboniferous series,” with the most magnificent coal deposits accessible in every direction. These have been the source of Britain’s internal riches, and the great cause of the development of the mechanic arts, which distinguish her above all other countries. Had the granite of the Grampians, it has been said, and said justly, extended into Sussex, or the chalk of Sussex to the Grampians, the whole course of British History would have been changed. Nineteen of our most important manufacturing cities, which lie upon the new red sandstone, drawing from beneath them the coal, iron, and lime—the sources of their manufacturing prosperity—in either case, it is probable, would never have existed.

In Ireland, the coal measures exist in the provinces of Munster, Leinster, and Ulster; in Clare, Limerick, Monaghan, and Kilkenny.

In Scotland, in the shires of Ayr, Renfrew, Linlithgow, Fife, Edinburgh, and Haddington.

* Pogg. Ann. lix. p. 508.