

through which the gases pass and become thoroughly mixed, and through which the regurgitation of the flame is effectually prevented.

The patentees claim, "the arrangement, as herein described, of the pieces of lime or other material, and the mode of regulating their movement as they are consumed and rendered unfit for the purpose of producing a uniform and brilliant light, by the ignition of oxygen and hydrogen gases or their compounds thereon."

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*New Maximum Thermometer.*

This instrument, contrived by M. Doulcet and constructed by M. Baudin, is nothing more than the ordinary minimum alcohol thermometer; except that the glass index has but one bulb in place of two, and terminates in a point at its outer end. When this instrument is hung vertically with the bulb uppermost, the index falls until the point touches the lower edge of the liquid: here it stops; now, if the liquid expands, the index will fall farther, but, if it contracts, the adhesion is not sufficient to lift the index, which remains in its place. It is said even to be very firm, so that severe jars will not displace it, and the best method of re-adjusting the instrument, is to warm the bulb until the liquid again reaches the point; the index is then easily moveable.—*Cosmos.*

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*On the Composition of Cast Iron and Steel.* By M. E. FREMY.

From the London Chemical News, No. 77.

The phenomena determining the production of steel have always occupied the attention of chemists and manufacturers, but at the present moment the study of this question has assumed an exceptional importance. In fact, the construction of machines and the manufacture of fire-arms are extending the applications of steel, and necessitate its production as economically as possible, consistently with preserving its valuable properties. To resolve this problem, of so much interest to metallurgical industry, chemistry ought to throw fresh light on the theoretical questions relating to the production of steel, and to free manufacture from the uncertainty and empirical methods which retard its due development.

The theories hitherto proposed to explain the phenomena of steeling, are evidently inadequate to guide the metallurgist wishing to produce steel either by the cementation of iron by charcoal or by decarburizing cast iron by special puddling.

Thus, the influence of manganese and that of tungsten in the process of steeling is not easily explained. The utility of nitrogenized organic substances and certain saline matters in aiding solution, is denied by experienced metallurgists. Some are of opinion that the best quality of cemented steel is obtained by the action of carbon on pure iron; others, that cementation can take place only under the influence of the nitrogen of the air. In either case, theory does not tell us why certain irons yield the best steel, while others, to all appear-

ance as pure, produce a very inferior quality. It is well known that the difficulties in the fabrication of steel obtained by puddling are such as often to discourage the most skilful manufacturers.

This uncertainty in the methods of steeling is found likewise in the theories proposed for explaining the production of steel. Some chemists are of opinion that solid carbon acts directly on iron, penetrates the metal, and circulating in its mass, converts it into steel. Others, among whom Leplay and Laurent are conspicuous, believe that cementation is invariably owing to the action of a gaseous carburetted compound of iron. Laurent goes so far even as to say that in the cementation boxes the vapor of the volatilized carbon effects the acieration.

The action exercised on iron by cyanides widens the field of the theory of cementation. A familiar experiment in chemistry has been utilized in practice: it consists in converting iron into steel by heating it with an alkaline cyanide or ferrocyanide. And, again, M. Caron, in a recent and interesting communication to the Academy, states that cyanide of ammonium, which is formed in the cementation-boxes, acts on iron like alkaline cyanides and rapidly converts it into steel.

The papers published on the subject of acieration have, doubtless, enriched science with many new and important facts; above all, they have particularized the circumstances which appear to determine this process most readily, but they have thrown no new light on the theoretical questions relating to the chemical constitution of steel. The writers still aver that steel is a carburet of iron, which they place chemically between iron and cast iron.

My opinion as to the composition of steel differs entirely from those hitherto accepted. I hope to be able to prove that steel is not a carburet of iron, and that there exists a series of steels resulting from the combination of iron with metalloids, metals, and even with cyanuretted bodies.

I am not acquainted with a single unequivocal experiment tending to show that steel is a combination of pure carbon and iron. Minute proportions of foreign bodies, not always detectable by analysis, can modify the properties of iron. When it is proposed to study the action of pure carbon on iron, there are necessarily other bodies present besides those whose mutual action we desire to determine. Without referring to the impurities taken up from the crucible, there are the influence of the gases from the furnace, which penetrate the apparatus; the action of the atmospheric elements which the charcoal does not absorb; or the presence of the various substances contained in the charcoal itself,—all of which circumstances are wholly disregarded.

In an experiment with diamond-dust, which I shall presently state, the influence of foreign bodies have been equally unheeded.

I shall now recal the fact I have already submitted to the Academy, which is, that steel, when dissolved in acids, leaves a residue in no point resembling pure carbon, and which, by its properties and composition, is nearly allied to certain carburetted products; thus, both

synthetical and analytical experiments are far from proving that steel contains nothing but carbon and iron.

To determine the true constitution of steel, and to ascertain whether there does not exist a series of bodies differing in composition, as tungsten steel differs from that of charcoal, yet allied by certain common properties, I propose to submit iron to the action of all the bodies capable of influencing the phenomenon of acieration.

I think that nitrogen ought to take the first place in this examination. Such was the object of my last communication to the Academy.\*

I have applied myself to free nitride of iron from the excess of metal it is capable of retaining, and to produce, as far as possible, a definite compound.

But in the nitration of iron, as in the carbururation of this metal, there are different degrees. Before forming under the influence of nitrogen, the scales which come off, and which, according to my experiments, contain 9.5 per cent. of nitrogen, the general properties of the metal undergo profound modifications; while preserving a certain malleability, it becomes white and fibrous. The iron in this state is still metallic, but, nevertheless, is strongly nitrogenized. It is this nitrogenized iron which I submit to the Academy, and which has undergone the processes connected with steeling which I am about to describe.

Desiring to study the successive or simultaneous action of nitrogen and carbon on iron, I was first obliged to find out a simple and easily graduated method of carbururation as certain as the process for the nitration of iron by ammonia.

The action of illuminating gas on iron possesses all these advantages. In fact, I have proved that if dry coal-gas is passed at red heat during two hours on iron, I obtain a very regular carbururation, and the metal is converted into a grey cast iron, graphitic, very malleable, and in every way comparable to the best cast iron produced by wood charcoal. I present to the Academy a specimen of cast iron formed under these circumstances.

By employing ammonia and coal-gas, I possess two easily regulated processes, which enable me to study, either isolatedly or simultaneously, the action of ammonia and carbon on iron.

The result of my experiments is, that when iron is submitted to the action of coal-gas I obtain cast iron only; but when the carburetted gas is made to react on previously nitrogenized iron, the characteristics of steel are evident in the metallic compound. A very remarkable fact here appears, which is, that the properties of the steel in some measure depend on the quantity of nitrogen first imparted to the iron. If the nitration has not been carried on a sufficient time, the coal-gas, in acting upon iron, produces a body intermediate between steel and cast iron; if, on the contrary, the metal has undergone a sufficient degree of nitration, the gas produces a steel of magnificent grain. The specimens which I presented to the Academy were formed in this manner. I have thus been enabled to realize M. Despretz's anticipations, and to determine what influence nitride of iron exercises on the phenomena of steeling.

\* *Chemical News*, Vol. iii. p. 276.

When, instead of making nitrogen and carbon react successively on the metal, I have passed a mixture of ammonia and lighting-gas on red-hot iron, the metal has immediately changed to steel, which varies with the relative proportions of the two gases.

In the experiments here described, I believe I have for the first time produced steel by means of the successive action of two gases on iron—one, ammoniacal gas, furnishing nitrogen; the other, lighting-gas, furnishing carbon; and what appears to me to make the steel thus obtained still more interesting is, that with it cementation is no longer effected with wood charcoal, but with coal-gas. I ask metallurgists whether these experiments, which, in a theoretical point of view, throw light on the phenomenon of cementation, will not one day be practically utilized. Would it not be a curious circumstance in the cementation of iron were wood charcoal superseded by the products of the distillation of coal?

These facts establish positively the important part nitrogen plays in the phenomena of steeling. It remained for me to ascertain whether nitrogen, evidently a cementing agent, remains in the metallic compound, or whether its only use is to present carbon to the iron in a state favorable to chemical combination.

To resolve this interesting question, I submitted steel, obtained with ammonia and lighting gas, to the influence of the agent which could prove the presence of nitrogen in steel with the greatest nicety, viz: pure and dry hydrogen.

By heating in hydrogen some steel prepared in my laboratory, I immediately detected the presence of nitrogen in this metallic compound; for during the whole of the experiment it disengaged considerable quantities of ammonia.

After thus re-finding nitrogen in steel obtained by the action of ammonia and lighting-gas on iron, it became interesting to submit ordinary steel to the same proofs, and to ascertain whether these metallic compounds are equally nitrogenized.

To this end I have operated on steels of various sorts, all in high commercial estimation. My experiments were made successively on Jackson's French, Huntsmann's English, and Krupp's German steel.

(To be Continued.)

*On the Amounts of Lead contained in some Silver Coins.* By Messrs.

CHARLES W. ELIOT and FRANK H. STORER.

From the London Chemical News, No. 77.

From our experiments upon the impurities of commercial zinc,\* we found that this metal almost invariably contains lead. In the preparation of silver at the United States Mint, zinc is used for the purpose of reducing chloride of silver,† and a sample of zinc similar to that

\*Memoirs of the American Academy, 1860 [N. S.], viii. 57.

†Booth and Morfit's Smithsonian Report on Recent Improvements in the Chemical Arts. (Washington, 1851,) p. 56. Compare Wilson's Report on the New York Industrial Exhibition, in *Dingler's Polyt. Journal*, 1855, cxxxv. 119.