THE *Western Monthly* (Chicago), in its August number, has a very readable article on Sun Spots and their lessons, in which the author discusses the consequences of the obscuration of one part in one hundred and thirty of the sun's visible surface in the present year, and thinks that he is about to open one of the sealed volumes which contains the principles of prognostic meteorology.

THE "Proceedings of the Birmingham Natural History Society and Microscopical Society" for 1869, is another of those records of natural history researches in the provinces, of which we have so many gratifying instances, the more valuable when coming from the centre of a manufacturing district, where the thoughts of men are naturally turned in such very different channels. We have papers of various lengths on mineralogy, botany, microscopy, physiology, geology, entomology, malacology, and other branches of natural history, showing, if not much originality, much careful observant work. Appended are preliminary lists of the flowering plants, mosses, Lepidoptera, and Mollusca found within a radius of ten miles from Birmingham, a by no means inconsiderable array.

THE astronomical and meteorological observations of the National Observatory of Santiago, in Chile, have now been regularly published since 1853, chiefly by Don José Tomas Vergara. They also include the Valparaiso meteorological observations.

CINCHONA culture has now so far advanced in Madras that the Government is preparing to deal with it as an annual crop.

MR. WORTHINGTON SMITH records in the *Journal of Botany* an instance of a fatal case of poisoning by eating the root of the Water-dropwort, *Œnanthe crocata,* an umbelliferous plant common in ditches and wet places. A carter at Staplehurst, in Kent, ate some of the roots whilst at work, supposing them to be the wild parsnip; in about an hour he became unconscious and convulsed, and death occurred in another half-hour, before medical aid could be obtained. The man had fed his horse with roots of the same plant, and the animal also expired about two hours after eating them. There is no doubt that the *Œnanthe* is a virulent poison, but it seems strange that the horse, as well as the man, should not have rejected a plant of so acrid and suspicious a flavour. Several wild Umbelliferæ are among the most dangerous of British plants, and it is probable that the Greek poison *κώνειον* was obtained from others besides the hemlock.

SHARKS appear to have recently again made their appearance in the Gulf of Trieste, and the police have issued a notice forbidding people to bathe in the port or on the coast. For each fish destroyed in the waters between Punto Grona and the castle of Duino a reward of 300 florins (about 30*l.*) is given.

THE Indian Government has selected the Khond Hills for cinchona experiments. If they succeed the cultivation will be thrown open to private enterprise, with the view of further promoting employment and cultivation among the Khonds.

THE extent of the Wurdah coal-field in India has been confirmed, and the seams in Berar have been found to be 45 feet in total thickness.

THE total eclipse of July was observed at Constantinople by the Rev. C. Gribble, H.B.M. Chaplain, formerly of the Royal Navy, a local astronomical observer. He contributes an account to the *Levant Herald* of July 20. The dogs of Constantinople continued barking until about the middle of the eclipse.

WE have had occasion to refer to wild-beast legislation and administration, an important matter in India. A curious discussion has arisen in Bombay. Tigers having come to Salsette and killed several people, the magistrates applied to increase the reward, but the Government have refused, thinking that the report of the presence of tigers there will attract English sportsmen from Bombay.

"A CATALOGUE of Maps of the British Possessions in India and other parts of Asia," published by order of Her Majesty's Secretary of State for India in Council, is a very useful publication for those interested in our Asiatic possessions.

THE first and second quarterly publications for 1870 are issued of Auwers' and Winnecke's "Vierteljahrsschrift der Astronomischen Gesellschaft."

DR. SACHS'S "Lehrbuch der Botanik nach dem gegenwärtigen Stand der Wissenschaft" has reached a second enlarged and partly rewritten edition. It is illustrated with 453 woodcuts.

DR. KARL KARMARSCH'S "Technological Dictionary, English, French, German," of which the second edition is just issued, is a most useful compilation, containing the corresponding terms in these three languages employed in Architecture, civil, military, and naval; Civil Engineering, including bridge building, road and railway making; Mechanics, machine and engine making; Ship Building and Navigation; Metallurgy, mining and smelting; Artillery; Mathematics; Physics; Chemistry; Mineralogy; and generally in the Arts and Sciences.

DR. ENGELMANN publishes the first part of his "Results of Observations in the Leipzig Observatory," comprising those made with the meridian-circle.

M. VIDAL'S statement (says the *Photographic News*), that a sensitive plate, if exposed to light in the camera, and then placed behind the yellow glass window of a dark room, becomes attacked by the yellow rays and yields a fogged image, whereas a sensitive plate previously unexposed to light is not affected in the same manner, has been confirmed by results obtained in America, and detailed in the *Philadelphia Photographer.*

## PAPERS ON IRON AND STEEL

### I.—A VERY COSTLY AND VEXATIOUS FALLACY

I.

"A FRIEND of mine has been converting some common cinder pig-iron into either very fine iron or steel by a very simple process, but does not know who to apply to to learn its value. He is willing to share the profit with anyone who will help him in the matter. I have some small samples of it if you would like to see it, or can tell me who would be likely to interest themselves in the matter. From what I can make out I should think it would make good steel, for it will harden and temper now."

The above, quoted from a letter I have recently received, is a typical sample of a number of others I have had at different times, and it represents the labours of quite a multitude of patient, long-suffering, and miserably deluded investigators. The published specifications of abandoned patents make painful record of wasted money, time, and ingenuity; and suggest dark tragedies of ruined hopes, all arising from the same misunderstanding of the changes which take place in the conversion of *ordinary* pig-iron or cast-iron into *merchantable* steel.

The most humiliating feature of this delusion is that it is not the offspring of popular ignorance, is not prevalent among the beer-drinking class of iron-workers, who sign their names with a ×, but crops out among intelligent self-taught men, who have studied the chemistry of iron and steel as expounded in recognised chemical books. The costly fallacy I allude to is directly traceable to the teachings of our highest scientific authorities. As NATURE is now largely circulating among the class of self-taught and energetic men who supply this ever-recurring crop of victims, and also among those who most unwittingly and unwillingly have deceived them, there can be no better medium through which to effect the demolition of this mischievous error.

By reference to almost any text-book on chemistry, it will be found that cast-iron is described as a compound or mixture of iron and carbon; that steel is another compound or mixture of iron and carbon, but with a less proportion of carbon; and that wrought iron is nearly free from carbon. Further, we are told that the ordinary method of making steel is, first to remove all the carbon from the cast or pig-iron by making it into wrought or bar-iron, and that this bar-iron is afterwards converted into steel by causing it to take up a new dose of carbon in the cementing furnace. The natural inference of a thinking reader is, that this is a clumsy complication, especially if he knows that the process of cementation is slow and costly, that on account of the irregular diffusion of the carbon in the blistered bars, other expensive processes of shearing, tilting, casting, &c., have to follow. Why not at once produce the steel from cast-iron by a process of decarburisation which shall stop at the right point, *i.e.*, when the 3 or 4 per cent. of carbon of the cast-iron is reduced to the one or one and a half per cent. required to produce steel? By doing this, not only the cost of converting wrought-iron into steel, but also the cost of puddling to produce wrought-iron will be saved; and steel, which is but a carburet of iron intermediate between cast and wrought-iron, instead of being so much dearer than either, should be made at an intermediate cost, or cheaper than wrought-iron.

If he dips further into the literature of the subject, and reads the history of the manufacture of iron, he will find further confirmation of such reasoning, as he will learn thereby that the direct production of steel is an ancient art, and that weapons of renowned quality were made from steel thus produced.

By reference to one of the most recent and elaborate English treatises on the subject, Dr. Percy's "Metallurgy," he will find on page 778 that this is described as "the ancient method, which is still extensively practised on the Continent, especially in Styria;" and further down on the same page that "if steel be regarded simply as iron carburised in degrees intermediate between malleable and cast-iron, then it is obvious that the latter during its conversion into the former in the processes of fining and puddling, must pass through the state of steel." On page 805 of the same work he will find further confirmation of his theory in the words, "it is obvious that steel must be produced by melting malleable and cast-iron together in suitable proportions."

I might multiply quotations from this and every other work I have seen in which the chemistry of iron and steel is treated, and show by each of them that the thousand-and-one of unfortunate inventors who have struggled in vain to make steel directly from English pig-iron, have been encouraged in their delusion by the teachings of high chemical authorities.

"If steel be regarded simply as iron carburised in degrees intermediate between malleable and cast-iron," these inventors are perfectly justified in seeking some substance which at the melting heat of cast-iron shall give off a definite quantity of oxygen; and they have logical grounds for believing that by bringing such a substance in contact with the molten cast-iron, and properly regulating its quantity, they may burn out just that surplus carbon which makes all the stated difference between cast-iron and steel. As a multitude of compounds when thus heated do give off oxygen, a vast field of effort is open, and accordingly every available peroxide and decomposable oxygen salt has been administered by strange devices to the melted iron, the same obvious substances used over and over again, and the same failures continually repeated by expectant inventors ignorant of what each other have done or are doing. Gas and vapours have been blown over the surface and under the surface, and through from bottom to top of melted cast-iron, and all (including Mr. Bessemer) have failed to produce merchantable steel from ordinary English cast-iron, without first making it into malleable or wrought-iron.

The reason of this is, that the removal of the surplus carbon is only a small portion of the work which has to be done in order to convert cast-iron into steel of any commercial value. Several other substances have to be removed also; *and no process has yet been discovered by which these impurities can be removed without at the same time removing the carbon in corresponding degree.* I put this in italics because I am convinced by experience of its great practical importance; because I do not find it clearly and distinctly enunciated in any general or special treatise; and further, because I have seen so plainly that the want of clearly understanding it is the rock upon which so many unfortunate inventors have split.

These inventors have not been informed with anything like the necessary degree of distinctness, that the Styrians and others who have made, or are making, steel directly from cast-iron, have started with a very different material to that which bears the same name of cast-iron in England; the difference being sufficiently great to alter totally the conditions of the problem. The cast-iron of the Styrian steel-makers is a nearly pure carburised iron; *our* cast-iron is a carburised, silicised, phosphurised, and sulphurised iron; *their* problem in steel-making is, merely the partial decarburisation of their cast-iron; *ours* is the total desilicisation, the total dephosphurisation, and the total desulphurisation in addition to this. Now, the partial removal of carbon from iron is one of the very easiest problems in practical metallurgy, while the complete removal of silicon, phosphorus, and sulphur, is among the most difficult.

To illustrate the grossness of the fallacy which represents the difference between cast-iron and steel as merely, or "essentially," due to carbon, I may state that on looking down a tabular statement of the analyses I have recently made of thirty brands of ordinary English pig-iron (excluding hæmatite pigs), I find that seven among them contain less than 2 per cent. of carbon, or an average of 1·77 per cent. Now this is below the percentage of carbon which exists in some of the finest and most expensive samples of cast-steel. Therefore, to convert these particular brands of cast-iron into the finest steel, the carbon must neither be increased nor diminished, and if, as Dr. Percy says, the differences between steel, wrought-iron, and cast-iron, "*essentially* depend upon differences in the proportion of carbon," all these brands of pig-iron should be described as steel rather than cast-iron.

Nevertheless they are utterly worthless for any of the purposes for which steel is used, and the common result of the costly experiments of the inventors who endeavour to make steel directly from English pig-iron, is to produce a material very much like them. They usually succeed perfectly in their effort partially to decarburise the pig-iron. They take out, say one half of the carbon, and with it a considerable portion of the silicon, and *some* of the phosphorus, sulphur and manganese; but to make a *perfect* steel they must take out *all* of these latter, and leave nothing but pure iron and carbon. Absolute perfection is not, of course, practically attainable in steel-making, but it is approximated in exactly the same degree as the purification of the iron from everything excepting the carbon is effected.

The most notable modern attempt to produce steel directly by the simple decarburisation of English cast-iron was that of Mr. Bessemer. His first idea was to blow air through melted cast-iron, and thereby to oxidise the carbon, and then, when a sufficient degree of decarburisation was effected, to stop the blowing. He supposed that when by this means the proportion of carbon was reduced to about one and a half per cent. the result would be useful steel. He failed entirely in this; he never succeeded in producing merchantable steel from ordinary English cast-iron by this method.

The Bessemer process, as at present conducted, consists in first oxidising simultaneously all or nearly all the carbon and silicon, and then adding to the decarburised iron a new dose of carbon, by means of a known quantity of spiegeleisen of known composition; thus reverting to the old Sheffield principle of first bringing the cast-iron to the state of wrought or decarburised iron, and then adding carbon to convert it into steel.

It is commonly represented that the failure of the early attempts at direct steel-making by the Bessemer process arose simply from the difficulty of determining the right moment at which to stop the blow, and thereby to regulate the proportion of carbon; and that the whole advantage of the spiegeleisen is the means it affords of doing this. Dr. Percy says:—"In attempting to produce steel by the methods specified by Bessemer, it has hitherto been found very difficult, if not impracticable, *at least in this country*, to ascertain with certainty when decarburisation has proceeded to the right extent, and when therefore the blast should be stopped. Accordingly the plan now adopted is to decarburise perfectly, or nearly so, and then add a given proportion of carbon in the state in which it exists in molten spiegeleisen, the precise composition of which should of course be known."* Neither in Dr. Percy's nor any other account of the Bessemer process do I find that the necessity of complete decarburisation as a means of completely separating the silicon is fairly appreciated.

If merchantable steel could be made from English pig-iron by simply stopping the blow before complete decarburisation, Mr. Bessemer would surely have produced some good steel in the course of his long and costly efforts which preceded the idea of introducing the spiegeleisen, for it must be remembered that the quantity of carbon required in steel extends over a very wide range—that steel may contain from 0·40 to 2·00 per cent. of carbon, and that steel with every degree of carburisation within this wide range is in demand in the market at good prices, provided it be free from phosphorus, silicon, &c. Nothing is practically easier than to stop the blow at such a moment as shall ensure a degree of carburisation somewhere between this wide range; and there can be no doubt that, in his early experiments, Mr. Bessemer, like other inventors of direct processes, made an abundance of iron that was duly carburised within the above-stated limits, although he failed to produce useful steel.

Dr. Percy's qualification, "at least in this country," is rather curious. He has probably learned that steel has been directly made in Sweden (though he does not mention it in his work) by the Bessemer process, and he seems to attribute this to the superior ability of the Swedish operators, enabling them "to ascertain with certainty when decarburisation has proceeded to the right extent." I differ entirely from Dr. Percy in this conclusion, being convinced that Mr. George Brown, the manager of the Bessemer Department at the Atlas Works, Sheffield, who was the first to work the Bessemer process with commercial success, is better able (on account of his much greater experience and thorough knowledge of the work) than any of the Swedish manufacturers, to determine when any required degree of decarburisation has been attained. It is not the superior skill of the Swedish operators that has enabled them to make steel directly by the Bessemer process; but the fact that they, like the Styrian workers, used a very superior charcoal-iron to start with; and that the blowing out of all the carbon was not absolutely necessary for the sufficient purification of this quality of iron.

W. MATTIEU WILLIAMS

* "Metallurgy," "Iron and Steel," p. 814. The italics are my own.

## ON THE NATURAL LAWS OF MUSCULAR EXERTION

THE experiments published by Mr. W. Stanley Jevons, in NATURE on the 30th June last, illustrate well two laws of muscular exertion which were established by experiments made by myself in 1862 and 1863. These laws may be thus stated:—

Law 1. The work given out by a single group of muscles, in a single contraction, is constant.

Law 2. When the same group of muscles is kept in constant action, the total work done by them until fatigue sets in, multiplied by the rate at which they are compelled to work, is constant.

Mr. Jevons' first series of experiments, in which different weights were thrown by the arm to various distances on level ground, illustrates the first law. In throwing weights in this manner, the arm, after a little practice, instinctively pitches the weight at the angle corresponding to the maximum range, and as the maximum range is proportional to the square of the velocity of projection, it may be used to replace that velocity squared, in estimating the work done by the arm.

The total work done is the same as if the weight used and the weight of the arm were concentrated at the centre of oscillation of the loaded arm, regarded as a compound pendulum.

Let us assume

$w$ = weight held in hand;
$x$ = weight of arm;
$v$ = velocity of centre of oscillation.

By Law 1, the work done is constant and is represented by

$$(w + x)\, v^2 = \text{const.} \qquad (1)$$

Let

$V$ = velocity of hand;
$l$ = radius of oscillation;
$a$ = length of arm.

then

$$v = V\frac{l}{a} \qquad (2)$$

It is easy to show (assuming the arm to be a uniform cylinder) that

$$\frac{l}{a} = \frac{2}{3} \cdot \frac{(3\,w + x)}{(2\,w + x)} \qquad (3)$$

By means of (2) and (3), equation (1) becomes

$$\frac{(w + x)\,(3\,w + x)^2}{(2\,w + x)^2} \times R = A; \qquad (4)$$

where $R$ denotes the range (proportional to $V^2$) and $A$ denotes a constant, if Law 1 be true.

Mr. Jevons' experiments give the following corresponding values of $w$ and $R$.

| $w$ | $R$ |
|---|---|
| 56 lbs. | 1·84 ft. |
| 28 " | 3·70 " |
| 14 " | 6·86 " |
| 7 " | 10·56 " |
| 4 " | 14·61 " |
| 2 " | 18·65 " |
| 1 " | 23·05 " |
| ½ " | 27·15 " |

We are required to assign certain values to $x$ and $A$, which will make equation (4) best coincide with the eight simultaneous values of $w$ and $R$ found by observation.

I find by trial that these values are

$x$ = 8·1 lbs.
$A$ = 262·2.

If we solve equation (4) for $R$, we find

$$R = \frac{A\,(2\,w + x)^2}{(w + x)\,(3\,w + x)^2} \qquad (5)$$