towards the sheep field. What taught him that he could thus reach his game unobserved? A. J. A.

HERE is an instance of "instinct" which shows, I think, that there is no difference whatever between the reason of animals and that of men.

A mare here had her first foal when she was ten or twelve years old. She was blind of one eye. The result was that she frequently trod upon the foal, or knocked it over when it happened to be on the blind side of her, in consequence of which the foal died when it was three or four weeks old. The next year she had another foal; and we fully expected that the result would be the same. But no; from the day it was born she never moved in the stall without looking round to see where the foal was, and she never trod upon it or injured it in any way. You see that reason did not teach her that she was killing her first foal; her care for the second was the result of memory, imagination, and thought, after the foal was dead and before the next one was born. The only difference that I can see between the reasoning powers of men and of animals, is that the latter is applied only to the very limited sphere of providing for their bodily wants, whereas that of men embraces a vast amount of other objects besides this.

The above limitation does not, I think, apply strictly to domestic animals, dogs especially, which seem to acquire some perceptions beyond mere animal ones.

Hull, February 28 C. W. STRICKLAND

Parhelia

ALLOW me to record the occurrence of parhelia here this morning. The phenomenon lasted about twenty minutes, and was fairly brilliant. No halo was apparent, merely a mock sun on either side of the true one, and the line passing through the three, dipped towards the south at an inclination of 2° to 3° to the horizon. E. W. PRINGLE

Uxbridge, March 4

Unscientific Art

As a specimen of Unscientific Art, let me bring to the notice of your readers a two-page engraving in the last number of the *Illustrated London News*, entitled "Capture of Sirayo's Stronghold."

If there is any truth in the laws of perspective the Zulus flying before the cavalry are indeed "sons of Anak."

Scientific Club, March 2 E. W. PRINGLE

Bees' Stings

IN NATURE, vol. xix. p. 385, a correspondent asks whether the identity of bee-poison with formic acid has yet been determined. Some sixteen years ago I made a few experiments with the poison from wasp-stings, and found, to my astonishment, that it was invariably alkaline instead of acid. A living wasp, duly held in the cavity of a perforated cork, was easily induced to sting a piece of turmeric paper; a brown-red spot immediately appeared. A. H. CHURCH

Cirencester, March 1

A NEW PROCESS IN METALLURGY[1]

LONG before human art acquired the knowledge of metal-making, prehistoric man had learned to make fire of the dry stems and branches of trees; in the charred fragments of half-burnt wood we recognise a form of carbon, the first simple elementary body produced by man from the complex natural bodies with which he was surrounded. In the knowledge of the use of fire, then, was the first dawn of art, particularly of that art which deals with the reduction of simple bodies from compound minerals. To convert metallic compounds into metallic elements is the domain of the metallurgist, and the means by which this is effected constitute the basis of metallurgic art. Carbon was thus a necessity to metallurgy—with the knowledge of fire the world emerged from the stone age. From those early times down to the present day, no fusion has been effected without using carbon, which in the form of wood, coal, or charcoal, has been the substance invariably used by the metallurgist for the production of heat, and to enable him to decompose and to smelt metal-bearing materials.

The new process, however, we are about to describe, has for its object the smelting of metalliferous substances without the employment of carbonaceous fuel. The sulphides of iron, lead, and zinc are known to be combustible substances of almost universal occurrence, and when burnt under favourable conditions give rise to a great evolution of heat. We have calculated the relative temperatures thus produced, from which it appears that the temperature at which iron pyrites (bisulphide of iron) burns in air under the conditions most favourable to the development of a high temperature is over 2,000° C., protosulphide of iron burning at about 2,225° C. Zinc sulphide, or blende, gives a temperature of 1,992° C., and galena 1,863° C.; while calculations made in a similar manner with coal, assuming it to be completely burnt, show the temperature attainable to be 2,787° C. These mineral sulphides, which are therefore natural and almost inexhaustible sources of heat and energy, can under certain circumstances be burnt more economically than their heat-giving equivalent of coal.

The best means, however, of utilising this heat-producing property of metallic sulphides is not so apparent as would appear at first sight. Only iron pyrites is sufficiently combustible at a low temperature to burn in the open air, the mass being raised to the temperature at which the oxidation takes place solely by the union of the sulphur and iron with aerial oxygen. In Spain this is carried on in vast heaps of hundreds of thousands of tons, and the operation extends over many months. The oxide of iron that remains is typical of those mineral substances which, once burned in the primeval operations of nature, gave up their stores of heat and force, and became, as it were, inert bodies.

Going back now to the combustion of carbon, it is well known that it burns at widely varying temperatures, as, for example, in our bodies, in a common coal fire, or in a powerful furnace. A great deal of attention and thought has been spent upon the subject of the economy of carbonaceous fuel, and great advances have been made in this direction, yet the expenditure of coal or coke necessary, say, to melt a given quantity of metal, still far exceeds the theoretical limit. The main causes of this discrepancy may be accounted for as follows:—(1) That only a fractional part of the oxygen of the air passed into the furnace acts upon the material to be burnt. (2) That the oxygen is not brought in contact with the combustible matter with sufficient rapidity to attain the necessary temperature for the operation. (3) That gases pass off hot and unburnt; these are now, however, frequently utilised.

There is one metallurgical operation in which the first two sources of loss are perfectly avoided—namely, by blowing air through molten crude iron, as in the Bessemer operation, where, by the burning of small quantities of carbon and silicon contained in the crude iron a very high temperature is attained, which is not the case in the process of puddling, where the oxidation is spread over a considerable period of time, although the same constituents are frequently burnt in similar proportions. But even in the Bessemer process the carbon is only half burned, and a large amount of heat escapes with the carbonic oxide and nitrogen. When, however, we blow thin streams of air through molten sulphide of iron lying upon a tuyère hearth, a high temperature is produced by the perfect combustion which ensues in the midst of the sulphides, and no unburnt gases excepting sulphur vapour escape from the surface of the molten mass. Hot nitrogen and sulphurous acid being the only gaseous products

[1] A paper with full details of the process was read by John Hollway at the Society of Arts on February 12, 1879; Prof. H. E. Roscoe, F.R.S., in the chair.

© 1879 Nature Publishing Group

of the operation (excepting the small quantities of hydrogen from the aqueous vapour of the air), these may be caused to act upon iron pyrites and other mineral matter. When pyrites is thus heated, an atom of sulphur held in feeble combination is in great part expelled, and thus is obtained protosulphide of iron, with which the operation commences, and which can exist in the molten state. Sulphide of zinc thrown into this bath of molten sulphide is converted into oxide: the sulphides of copper, nickel, and silver do not burn at all so long as sulphide of iron is present, and, accordingly, if oxides, silicates, or carbonates of these latter metals are introduced into the molten sulphide of iron, the iron present will take away the oxygen with which the metals are combined and concentrate them into a regulus of sulphides. But the question then arises, How, after fractional decomposition by oxidation, we can separate the sulphides from the oxides? This is accomplished by the addition of siliceous matter introduced into the furnace with the charge of sulphides, so that in the manner explained are obtained from crude materials five principal classes of products, viz.:—(1) sulphur; (2) sublimates of volatile sulphides and oxides; (3) a slag of silicates of certain more oxidizable metals, principally iron; (4) regulus containing the nickel, copper, and silver; (5) sulphurous acid and nitrogen. Under certain circumstances a sixth class of products may be obtained consisting of the metals copper and lead. Thus, when the sulphides of iron and copper present in the bath are treated continuously with the blast of air without the addition of combustible sulphides, a point at length arrives when the whole of the iron present is oxidised, and the regulus in the bath consists of subsulphide of copper. If now a limited supply of air is introduced, the copper is reduced to the metallic state, with the evolution of sulphurous acid. Further experience in the matter may lead to the adoption of this continuation of the process. Again, sulphide of lead present in the bath may be caused to yield metallic lead by partial oxidation. The sulphurous acid can be made into sulphuric acid in chambers or condensed to the liquid state. Thus we have in this new process a metallurgical operation, the necessary heat for the decomposition and fusion being entirely obtained by the combustion of the iron and sulphur contained in the materials operated on.

Some large experiments have been made in order to prove the more important points here enunciated. They are all to be found described in the paper upon the subject in the *Journal* of the Society of Arts, dated February 14 and 21, 1879. A brief record of some of the phenomena witnessed at the February experiments at Penistone may not be uninteresting. At seven in the morning on February 12 last a small party of gentlemen arrived at Messrs. Cammell & Co.'s Penistone Steel Works, in order to see the operation from its very commencement. Two Bessemer converters were ready for the experiments; one of these was charged at 10 A.M. with some molten protosulphide of iron (made by fusing some pyrites in a cupola), and a blast of air was driven through the tuyères. Lumps of sandstone were continuously thrown in together with cupreous pyrites. A flame of the burning vapour of sulphur expelled from the pyrites passed from the converter mouth to the chimney shaft; it was from 6 to 10 feet long, blue at the edges and greenish in the body of the flame. About noon this experiment broke down through an accident, after which the product was taken out. An experiment was then commenced by setting fire to some sulphide of iron by means of about 2 cwt. of coal thrown into the vessel to start the combustion; pyrites and sandstone were then thrown in, in lumps, which rapidly melted, this being continued until midnight (over eight hours). The molten mass in the vessel remaining perfectly liquid, was from time to time partially poured out to make room for the addition of further similar materials. During the whole of the eight hours not an ounce of coal was used, the converter being "fed with stones," and "vomiting forth fire and brimstone," as a gentleman present graphically expressed it. In this latter experiment about eighteen tons of raw pyrites was thus treated, and over four tons of sulphur was distilled and afterwards burnt. More than half a million cubic feet of sulphurous acid and nitrogen left the mouth of the converter at a high temperature, taking away with them a considerable fraction of the heat produced by the oxidation. This was very unfavourable to the success of the experiment, as will be readily understood when this great loss of heat is taken into account. With a suitable plant the heated gases would be utilized to drive off sulphur from pyrites, so as to produce the molten protosulphide required to continue the operation. Heat is not only obtained by the oxidation of the metallic sulphides, but also by the oxidation of iron protoxide to peroxide when the contents of the vessel are over-blown. In an experiment made in July last the oxidation was thus purposely continued. "As soon as the subsulphide of copper began to burn a splendid emerald green flame suddenly appeared, lasting about a minute, and all the lines except those of copper and sodium left the spectrum. During the last few minutes of the blow the mouth of the converter was dull and without flame."

Some of the products of these experiments were shown at the Society of Arts; they consisted of crystalline masses of ferrous silicate and blocks of 50 per cent. copper regulus. No sulphur was collected, it being impossible to do so with Bessemer plant, which, in actual operations, will not be used for the process. These experiments, however, enabled those present to witness, in the course of a few hours, the principal effects produced. "A remarkable spectrum was obtained from the burning sulphur vapour; viewed through a small direct vision spectroscope, many absorption bands were seen occurring at apparently regular intervals from the red to the violet. The lines of sodium, lithium, and thallium were recognizable, but the majority of the lines are of (as yet) unknown origin, though they are the most important, since the changes furnish indications of the progress of the chemical changes taking place in the vessel. The lithium was, probably, derived from the sand introduced with the pyrites."

The process is peculiarly suitable—(1) For the treatment of metalliferous substances which cannot be advantageously utilised by other processes. For the extraction of sulphur by distillation, and simultaneously for the concentration and separation of copper, silver, and nickel from such materials in the form of a metallic regulus; while lead, zinc, arsenic, &c., accrue in the sublimates. (2) For the treatment of cupreous pyrites, large quantities of which exist in many parts of the world where fuel is scarce, and where the present mode of treatment by the cementation (wet) process involves not only the loss of vast quantities of sulphur, which is burnt to sulphurous acid, but causes the destruction of all vegetation within its influence. For example—About one million tons of pyrites, too poor in copper to pay for shipment to the United Kingdom, are annually treated in Spain by the cementation process. Such ores thus treated, containing $1\frac{1}{2}$ per cent. of copper, leave only a small profit, whereas it is calculated that similar ores by this new process will yield a profit more than five times as great. (3) For the treatment of copper and nickel ores, so as to produce a concentrated regulus without employing carbonaceous fuel.

It is therefore obvious that this process will effect a great revolution in the treatment of metallic sulphides, such as iron, cupreous and nickeliferous pyrites, also copper and nickel ores and the refuse gangue of mining operations, which can thus be smelted without the employment of carbonaceous fuel, the necessary heat being obtained by the oxidation of the metallic sulphides.

© 1879 Nature Publishing Group