THE

# Edinburgh

# JOURNAL OF SCIENCE,

EXHIBITING

A VIEW OF THE PROGRESS OF DISCOVERY

IN NATURAL PHILOSOPHY, CHEMISTRY, MINERALOGY, GEOLOGY, BOTANY,
ZOOLOGY, COMPARATIVE ANATOMY, PRACTICAL MECHANICS, GEOGRAPHY,
NAVIGATION, STATISTICS, ANTIQUITIES, AND THE FINE AND USEFUL ARTS.

CONDUCTED BY

**DAVID BREWSTER, LL.D.**

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PRUSSIAN ACADEMY OF SCIENCES; MEMBER OF THE ROYAL SWEDISH ACADEMY
OF SCIENCES; OF THE ROYAL SOCIETY OF SCIENCES OF DENMARK,
OF THE ROYAL SOCIETY OF GOTTINGEN, &c. &c.

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# CONTENTS

OF THE

# EDINBURGH JOURNAL OF SCIENCE.

## No. XV.

### I. NATURAL PHILOSOPHY.

### II. CHEMISTRY.

### III. NATURAL HISTORY.

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## NOTICES TO CORRESPONDENTS.

J. R. had better send his Reply to Mr RUMBALL on the " Position of the Focus in the Eye," to the *Philosophical Magazine*, that the error and its correction may appear together; though we think the paper already contains its own refutation.

We have received the following HOURLY METEOROLOGICAL OBSERVATIONS on the 17th July 1826 from Germany.

1. Vienna University Garden.—2. General Fallow's Private Observatory.—3. Wiessenau in Lower Carinthia.—4. M. St Leopold near Vienna.—5. Newstadt, near Vienna.—6. Alpine Region of the Schneeberg on the frontiers of Austria and Styria.—7. Laybach.—8. Gorrie.—9. Prague.

For the 15th January 1827 from

1. Vienna University Garden.—2. ——— Neuthor Bastey.—3. Laybach.—4. Rosalia Capelle near Forchtenau.—Watch-house on the Hohenleuthe.—6. Baden.

AN AMATEUR IN METEOROLOGY will, we trust, excuse us for not publishing the Meteorological Journal which he has sent. If he has no objection we shall willingly print an abstract of it. We could fill twenty consecutive numbers with very valuable Meteorological registers; but we doubt if the occupation of even a small part of each number with such materials would either promote science or gratify our readers.

We agree with a CONSTANT READER that our SMALL TYPE is rather too minute for a winter evening and for eyes turned of fifty, but we cannot alter it at present, though we may diminish the quantity of it. At the end of No. XX. or Vol. X. we shall begin a new series, and shall consider seriously his proposal.

Δ's interesting paper on the Cold Caves of Monte Testaccio at Rome will appear in our next, as the present number was filled before its arrival. He will find the barometrical observations at the Observatory for several years in Blackwood's Magazine, and in the Edinburgh Magazine.—He is requested to notice an error in p. 137 of the proof sent to him in the sum divided by 18, which affects his general results We have therefore divided his paper, the remainder of which will appear in next number. In answer to his question we beg to inform him, Kitchener's Pancratic eye tube has many advantages. It was described long ago in Dr Brewster's Treatise on Optical Instruments.

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## No. XVI.

I. NATURAL PHILOSOPHY.

II. CHEMISTRY.

III. NATURAL HISTORY.

IV. GENERAL SCIENCE.

## NOTICES TO CORRESPONDENTS.

Dr Forchhammer's interesting Paper will appear in our next Number, and we hope to hear again from him soon.

We shall be glad to receive the rest of Professor Schow's Communication as soon as possible.

Δ's Meteorological Paper is unavoidably postponed till next number. We have made the addition to it which he requested.

Professor Hansteen's paper did not reach us till too late for the Number. It will appear in No. xvii.

We beg that he will favour us with the results of the Hourly Observations at Christiania and Drontheim for 1827, which he mentions; and we shall be glad to hear of the success of his labours in Siberia.

Mr Marshall's Quarterly Meteorological Journal has not reached us as usual.

Mr Haidinger's valuable paper, which has only this moment reached us, will appear in next Number.

## ERRATA.

Page 69, line last, *for* 631 *read* 431.
75, — 5, — discovered *read* described.
81, — 10, — sheets *read* streets.
85, — 35, — coal *read* coals.

The reader is particularly requested to correct the following errors in the first part of the Memoir on the Horary Oscillations of the Barometer at Rome, which was printed in our last number.

Page 115, third line from bottom, *for* "now on the tube," *read* "moved on the tube."
116, at bottom of the small table, *for* 26.945 Eng. in. *read* 29.945 Eng. in.
118, col. 5, l. 2, (obs. No. 33,) *for* 57 *read* 56.
— col. 4, (obs. No. 57,) *for* 016 *read* 30.016.
— — — (obs. 74,) *for* 806 *read* 29.806.
121, col. 2, (obs. 328,) *above* "7" *insert* "April."
124, col. 5, last line but one, *for* 775 *read* 755.
— col. 10, l. 6, *for* 020 *read* 30.020.
125, col. 10, l. 17, *for* 057 *read* 059.
126, col. 10, l. 5, *for* 163 *read* 183.
127, col. 10, l. 13 from bottom, *for* 30.945 *read* 30.045.
128, col. 5, l. 20, (opposite 5A.) *for* 077 *read* 083.
— — — l. 21, (opposite 6A.) *for* 083 *read* 098.
— — — l. 22, (——— 7A.) *for* 098 *read* 107.
— — — l. 23, (——— 8A.) *for* 107 *read* 116.
— — — l. 24, (——— 9A.) *for* 116 *read* 127.
— — — l. 25, (——— 10A.) *for* 127 *read* 144.
— — — l. 26, (——— 11A.) *for* 144 *read* 147.
— — 10. 8th line from bottom, *for* 264 *read* 269.
— — — 6th ——————— *for* 254 *read* 258.

THE

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JOURNAL OF SCIENCE.

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## ART. I.—*Biographical Sketch of* ALEXANDER VOLTA, *Professor of Natural Philosophy at Como.*

ALEXANDER VOLTA was born at Como on the 18th February 1745, and was descended from an ancient family of that city. Among the misfortunes of his infancy, his friends have enumerated that of having a foolish nurse, and to this cause they have ascribed the slow developement of his mental powers. The first exhibition of his talent was a piece of poetry; but even in his poems, which were composed in Latin and Italian, he already pointed out the subjects which were likely to demand the efforts of his genius. He soon published, indeed, a paper in prose on the phenomena of electricity, and on a new apparatus destined to carry on the discoveries in this branch of physics.

After having completed the course of studies in the university of Como, he was appointed regent of it, and subsequently obtained the chair of natural philosophy. From Como he went to the university of Pavia, where he devoted to science the labours of thirty years, and dignified the name of his country with deeds of intellectual renown, which fixed the attention of Europe, and formed an era in the history of the human mind.

One of the first inventions of Volta was that of the electrophorus, which he described in June 1775, and of which he published an account in *Rozier's Journal de Physique* for September 1776. This ingenious instrument consists of a metallic and a resinous plate, by the successive contact of which electricity may be perpetually developed. M. Wilcke had made some considerable approaches to that invention, and consequently the honour of it has been claimed for him by his countrymen; but there can be no doubt that the electrophorus, as an instrument, is an invention entirely new, and that its eminent author was not even acquainted with the previous experiments of the German philosopher. *

During his summer vacations, he was in the habit of performing journeys of considerable length. In 1777 he travelled through Switzerland, and, accompanied by his friend the Count J. B. Giovio, he paid a visit to the celebrated Haller at Berne, when that great man was sinking under the accumulated infirmities of age and disease. They visited also Voltaire at Ferney.

In 1776 and 1777 Volta published some remarkable letters on the inflammability of air disengaged from marshes. They were addressed to Father C. J. Campi, and were afterwards translated into French and German. In the same year he invented his hydrogen lamp, and his electrical pistol, instruments which are well known to all who have attended an experimental course of chemistry and physics. The hydrogen lamp now forms an elegant piece of furniture, in which a light can be at all times obtained. A stream of hydrogen gas is made to issue from a small aperture by means of the pressure of a column of water, and the gas is kindled by a spark from an electrophorus placed below. About the same time Volta discovered the eudiometrical process of determining the relative proportions of the two gases, oxygen and azote, which compose atmospherical air. A given measure of hydrogen gas being put into a glass tube with a quantity of atmospheric air, it was inflamed by the electric shock, and the quantity of oxygen was indicated by the diminution of volume.

During his travels in Tuscany in 1780 he studied with particular care the fires which burn among the Apennines, on the road from Bologna to Florence, and which are known by the

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* See Wilcke, *Disputatio Physica Experimentalis de Electricitatibus contrariis*, Rostock, 1757; and *Edinburgh Encyclopædia*, vol. viii. p. 423. Art. ELECTRICITY.

name of the *Vulcanetto di Pietra Mala.* Of these he published a description, in which he first explained how these fires, as well as those which spring from the ground near the ancient city of Velleja, arise from the combustion of atmospheric air disengaged from the ground.

In 1782 Volta invented an electrical condenser for rendering sensible small quantities of the electrical fluid; and in the same year he performed a tour through Germany, along with his celebrated colleague M. Scarpa. After his friend parted with him, he extended his tour to Holland, England, and France. On his return from that journey he introduced into Lombardy the culture of the potato, which he had observed in Savoy; and the peasants who first cultivated this valuable article of food were rewarded with the prize offered by the Patriotic Society of Milan.

The curious experiment of Galvani in 1790 on the electricity of the muscles of frogs gave a vigorous impulse to physical inquiry throughout Europe. Volta took a deep interest in the new science to which Galvani's experiment has given the name, and he had the good fortune to establish it on a scientific basis, and to extend its boundaries by the most important discoveries and inventions. Valli, Fowler, and our countryman Dr Robison, had preceded Volta in their galvanic inquiries, and the latter had made a slight approach to the invention of the pile, by discovering the sensation of taste which was excited when the tongue was applied to the edges of a number of plates of zinc and silver placed alternately upon each other.

The first researches of Volta were transmitted to the Royal Society of London in 1793, in the form of two letters to Mr Tiberius Cavallo, entitled *Account of some discoveries made by M. Galvani of Bologna, with experiments and observations on them.** These letters contain a perspicuous account of the discoveries of Galvani, with a notice of many curious experiments of his own. He overthrows the opinion of Galvani, that the animal body has an analogy to the Leyden phial; he found that two different metals were necessary to produce the effect; and he concluded that muscular contractions arise from

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* *Phil. Trans.* 1793, vol. lxxxiii. p. 10.

small portions of electricity liberated by the mutual action of the metals. He found that the nerve was the organ on which the Galvanic influence immediately acted, but that, if a part of a muscle be laid upon two different metals, and a communication established between them, a contraction is produced. He then explains all the phenomena on the principle, that when two metals are brought into contact a destruction of the electrical equilibrium takes place; and the one of them gives to the other a portion of its natural electricity, the one becoming positive and the other negative. He regards this as a new law of electricity, and he lays claim to the merit of its discovery.

The great discovery of Volta, and that upon which his reputation will always rest, is that of the pile, which is now known by the name of the Voltaic pile. This grand invention was made previous to 1800, and having been elected a Fellow of the Royal Society of London in 1791, he communicated an account of it in two letters to Sir Joseph Banks, which appeared in the *Philosophical Transactions* for that year. In consequence of the war, however, which then raged between England and France, one portion of the paper reached Sir Joseph several months before an opportunity occurred of sending the remainder. Hence the publication of the invention was delayed; but the apparatus was constructed in London, and very curious experiments were made with it by different gentlemen in that city before the original paper of Volta was laid before the public. This instrument consisted of two perfect and one imperfect conductor of electricity, viz. silver and zinc, or copper and zinc, which were the perfect conductors, and a piece of card or leather soaked in salt water and a little smaller than the metal plates, which formed the imperfect conductor. When one hand was placed on the uppermost conductor, and the other on the lowest, a shock was felt similar to that of the Leyden phial. Its chemical actions were still more important, and are too well known to require any notice in this sketch.

In 1821 Volta was invited to Paris. He repeated in the presence of the First Consul, and before the Institute, his experiments with the pile. These experiments were highly successful; and in order to mark an epoch so remarkable in the history of science, that distinguished body presented him with a gold medal with this inscription, *A Volta, la Classe des Sciences Mathematiques et Physiques*. In the following year the Institute sent him another, with the inscription, *A Volta, associé etranger;* and most of the academies of Europe were proud to enrol his name in the list of their members.

From Paris Volta repaired to Lyons to assist, in the character of deputy from the university of Pavia, at the meeting which was convoked in that city to elect a President of the Italian Republic. When the election was over he was seized with a serious illness, which obliged him to remain some months at Lyons, and afterwards at Geneva, where he experienced the most hospitable reception from the learned professors of that city, with whom he had long been on habits of the most intimate friendship.

The honours which our author thus received in foreign countries were followed by others conferred upon him at home. He was raised to the rank of a count, and thus became a senator of the kingdom of Italy. In this capacity he was obliged to spend part of the year at Milan, and he repaired every evening to the parties of Paradisi, President of the Academy, at whose house were assembled the most distinguished individuals of the country.

In the year 1804 he had obtained leave to retire from his professorship, on the condition of his giving a few lectures every year. On this occasion Napoleon said to him, "Great men die on the field of honour." Volta never forgot this saying, and after the fall of Buonaparte he said, in allusion to it, "He, however, has not kept his word with me."

Living in a frontier town, Volta was one of the first Italians who presented himself to Buonaparte when he entered Italy for the first time. His fellow-citizens sent him in 1796, along with Count T. B. Giovio, to request the protection of the conqueror. From that time Buonaparte never lost an opportunity of honouring Volta. He conferred upon him the orders of the Legion of Honour, and of the Iron Crown, and the titles of Count and Senator of the kingdom of Italy; and at the formation of the national Institute of Science and Letters, when they were deliberating in his presence whether they should draw up a list of the members in an alphabetical order, Buonaparte wrote at the head of a sheet of paper *Volta*, and delivering it to the secretary, he said, "Do as you please at present, provided that name is the first." Volta married in 1794, and had three children. He took a particular charge of their education, and he felt most bitterly the loss of one of them, who had given great promise of being a mathematician. In returning to spend the remainder of his days in his paternal mansion at Como he experienced the greatest comfort from the affection and tender solicitudes of his family. He had now given up his studies, and having been seized with a fever, he died after two days illness on the 5th March 1827. His death was universally lamented, and at a meeting of his fellow-citizens, called on purpose on the 23d of March, it was resolved to strike a medal, and erect a monument to his memory. On the modern façade of the public schools of Como, in the middle of the busts of Pliny, Giovio, and other great men who were natives of this place, an empty niche was left as a compliment to the genius and modesty of Volta.

To all the domestic virtues, Volta added the most sincere piety, and his last moments were marked with expressions of religious feeling. As a citizen he was highly esteemed, and his fellow-countrymen entrusted him with all their public concerns, which he managed with the utmost intelligence and integrity.

In 1816 a complete collection of his works was published by the Chevalier Vincent Antinori at Florence, entitled *Collezione delle Opere del Cav. Conte Alexandro Volta*. It was dedicated to Ferdinand III. Grand Duke of Tuscany, and is embellished by an excellent likeness of the author by Morghen. In order to complete this collection it is necessary to add, 1. The Latin poem which we have already mentioned. It treats of the principal phenomena of physics and chemistry. 2. An Italian poem on Saussure's Voyage to Mont Blanc, and some other pieces in verse. 3. Observations and experiments on vapours: and 4, A number of articles on physics and chemistry, either unpublished, or scattered through the pages of periodical and other works.

## Art. II.—*Concerning Coloured Spectra from Flame, Moon, and Starlight, and from Electric Light.* * By the late M. Le Chevalier Fraunhofer, Member of the Royal Bavarian Academy of Sciences at Munich.

It is already known that the coloured spectrum which is produced by means of the prism from the light of a lamp does not show the dark fixed lines which are contained in the spectrum from sunlight; but instead of it there is in the orange a light line, which is more distinct than the rest of the spectrum. It is double, and is found at the same place where in the spectrum from sunlight the dark double line D stands. The spectrum which arises from the light of a flame, kept up with a blowpipe, contains several distinct light lines. It is of much greater advantage in optical experiments, that, with a proper *blowing* of the flame, the light of its *anterior half* is not further dissected through the prism, and consequently is *simple homogeneous* light. This light has, as far as I have hitherto investigated it, the same refrangibility as the ray D from sunlight. *Simple homogeneous* light going out in all directions is from known reasons very difficult to produce, and never to be obtained directly by prisms; and hence this flame is of great utility in many experiments.

By means of the very large electrical machine in the cabinet of natural philosophy of the Royal Academy of Munich, I obtained a spectrum of *electric light*, in which I recognized a great number of light lines; and I have determined the relative place of the lightest lines, and the proportions of their intensity. The light of the *moon* has given me a coloured spectrum, which, in the lighter colours, shows the same fixed lines as the sunlight, and precisely in the same place.

The light of the *moon* being too feeble, I could not very distinctly perceive the fixed lines in the darker colours. For the observation of *the spectra from the light of the fixed stars*, and for the purpose, at the same time, of *determining the refrangibility of their light*, I have lately prepared particular

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* This article forms a supplement to the paper of M. Fraunhofer, which we published in our last Number, p. 251.

instruments entirely for this purpose. With a telescope having an object-glass four inches diameter, I have obtained from it several interesting results, although the experiments are by no means finished. The flint-glass prism of this instrument has an angle of 37° 40′, and the same diameter as the object-glass. The angle which the ray falling on the prism forms with that coming out of it is about 26°, so that if the refrangibility of light of one star were ever so little different from that of another the difference could still be very easily observed. In order to observe and determine with accuracy this difference, if it does exist, I have applied another smaller telescope, which is fastened to the other, and crosses it at an angle of about 26°, namely, under the angle formed by the ray falling on the prism, and the ray proceeding from it; the entrance of the star is observed at the wire of the smaller telescope without a prism by one observer, whilst another notices the entrance of a part of the spectrum of the same star through the larger telescope, which is furnished with a micrometer screw, the moveable edge of which the observer, by means of the screw, places in such a manner that at the moment when the star passes across the wire of the smaller telescope without a prism, one of the fixed lines of the spectrum shall intersect the edge in the larger telescope.

The instrument, without altering the micrometer, is then directed to another star, to enable us to discover whether its light has the same refraction. If at the moment when this star intersects the wire of the lesser telescope the same colour of the spectrum, or the same fixed line, is at the edge of the micrometer of the larger telescope, the refraction of these two sorts of light is equal. As these experiments require two observers, Mr Soldner, the astronomer, had the goodness to make them with me. These experiments, however, are, as I have said, only to be considered as commenced, and I must yet make essential alterations in the instrument, in order to obtain still greater accuracy, and also to gain more time for observation.

We have not hitherto found a *fixed star*, the light of which, in regard to *refraction*, differs perceptibly from the light of the *planets*. Whenever the fixed lines of the spectra are seen distinctly, this instrument affords a certainty within ten seconds, and for the orange rays within half a minute. Since the whole refraction through the prism amounts to about 26°, a difference, which in the whole refraction amounts to $\frac{1}{9360}$, could be perceived with this instrument; and this would not amount to the fourth part of a second in the horizontal refraction of the atmosphere. It is well known that some astronomers have hitherto doubted whether the tables of refractions should not be different for different stars. By the above mentioned experiments this doubt would seem to be resolved. The continuation of them will, I hope, lead us to complete certainty on this subject.

In order to observe the *fixed lines* of the different stars with this large instrument, the atmosphere must be very favourable, which is rarely the case.

The spectra from the light of *Mars*, and from that of *Venus*, contain the same fixed lines as the spectrum from sunlight, and precisely in the same place, at least as far as relates to the lines D, E, *b*, and F,* of which the relative situation could be precisely determined. In the spectrum from the light of *Sirius*, I was not able to perceive fixed lines in the orange and in the yellow colours. In the green, on the contrary, a very strong streak is perceived, and two others very strong in the blue. They do not appear to resemble any of the lines from planetary light.

We have ascertained their place with the micrometer. *Castor* gives a spectrum which resembles that of *Sirius*. The streak in the green has, notwithstanding the weak light, so much intensity that I could measure it, and I found it exactly in the same place as in the green of the spectrum of Sirius.

The streaks in the blue I could indeed distinguish, but the light was not sufficiently strong to ascertain their place. In the spectrum of *Pollux* I recognized many weak, but fixed lines, which looked like those of Venus. I saw the line D

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* The line *b* lies in the green between E and F. It is properly composed of three strong lines, two of which are nearer to each other than the third.—*Vide* my "*Treatise on the Power of Refraction and Separation of Colours,*" *&c.* p. 280 and 309.

very well, and it is exactly in the same place as in the light of the planets.

*Capella* gives a spectrum, in which, at the places D and *b*, the same fixed lines appear as in that of sunlight. The spectrum of *Betalgeus* contains numerous fixed lines, which, with a good atmosphere, are sharply defined; and although, at the first view, it does not seem to have any resemblance to the spectrum of Venus, yet similar lines are found as in the spectrum of this fixed star, precisely in the same places where D and *b* are in sunlight. In the spectrum from *Procyon* some lines are perceived with difficulty, and not so distinct as to determine their place with certainty. But in the orange I think I have seen a line at the place D.

MUNICH, *July* 14, 1823.

## ART. III.—*Narrative of the Proceedings and Scientific Observations of the late Mission to Ava.*[*]

THE Mission left Rangoon on the 1st September, and reached Henzada on the 8th. Here we were received with much polite attention by the future Viceroy of Pegu, who has the rank of a Wungyi, or councillor, the highest enjoyed by a subject. He was very solicitous, however, to prevent our going further, intimating that he was himself vested with full powers to treat with us upon every possible subject.

He had no opportunity, however, of exercising his plenipotentiary powers upon the present occasion, for the Mission, disregarding his pretensions, on the afternoon of the 10th quitted Henzada, and on the afternoon of the 14th, a few miles beyond Myanaong, or Loonzay, entered the hilly region, which is the proper geographical boundary of the Burman race—all to the south being the Delta or *debouchement* of the Irawadi, and the true country of the Peguans or Talains.

Pursuing our journey with hills now pressing down to the river on both sides, and which struck us at the time as pecu-

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[*] A printed copy of this interesting paper has been kindly forwarded to us by a Correspondent in India.

liarly picturesque and beautiful, after passing through the long tiresome champaign of the Delta of the Irawadi, we reached Prome on the evening of the 15th. This is one of the largest towns in the Burman empire, and appeared to be not less populous than Rangoon. The inhabitants since the war had returned to their homes—the place was in a good measure restored, and although it had been long the head-quarters of the British Army, there was now no reaction or persecution. All this bore favourable testimony to the moderation of the Myowun, or governor, whom we found an extremely respectable man.

We left Prome on the 17th, and on the 20th reached Patnagoh and Melloon, the scene of the conferences in December 1825, which led to the first treaty, which was never ratified or even transmitted for ratification, a breach of engagement for which the Burmese received signal castigation on the spot.

On the 21st we left those places, and on the 22d reached Renangyoung, or the " fetid oil brooks,"—in other words, the Petroleum wells. In the afternoon we visited the wells and the remarkable and sterile country which surrounds them, abounding everywhere with fossil remains of one of the last great changes which the globe has undergone.

On the 23d we left Renangyoung, and in the course of the forenoon passed Senbegyoung, from which leads the best road from Aracan, and by which Major Ross and a battalion of sepoys proceeded in the month of March last.

On the morning of the 24th we reached Pugan, and staid there for that day, and part of the following, examining the curious antiquities of this place, the most remarkable in the Burman dominions, and the extensive ruins of which, if such evidence were not too well known to be delusory, might lead to the supposition, that in former ages the Burmese were a people more powerful and civilized than we now find them.

On the 27th we passed the confluence of the Kyen-dwen and the Irawadi. The prospect afforded by their junction is far from imposing. Both rivers are here confined to a narrow bed, and the tongue of land which divides them is so low, and covered with reeds, that it may easily be mistaken for an island, and consequently the smaller river to be only a branch of the larger.

The prospect hitherto presented in a route of little less than four hundred miles was that of a country imperfectly cultivated and inhabited, and by far the greatest part of which was covered with a deep forest, or with tall reeds and grass, among which there was scarcely any evidence of culture or occupation. We were now, however, within fifty miles of the capital, and the scene began greatly to improve. The country became level, the nearest ranges of hills to the east being at least thirty miles distant, and the Arracan mountains to the west not less than fifty in the nearest part, and sixty or seventy in the distant. The villages and cultivation had increased very considerably, but neither here nor anywhere else did we see evidence of a dense population or active industry.

At two o'clock in the afternoon we passed Yandabu, where the treaty was dictated to the Burmans, and sailed within a stone's throw of the great tree where Sir A. Campbell's tent was pitched, and the conferences were held.

On the afternoon of the 28th we reached Rapatong, a village on the east bank of the river. This was the spot at which the Burmans contemplated making their last effort, had the British army not been arrested in its progress by the treaty of Yandabu. Here they were encamped under the old chief Kaulen Mengyi, the whole disposable force not exceeding a thousand men, and the greater number of these consisting, not of soldiers, but of the personal retainers and menial servants of the chiefs. Two forced marches would have carried Sir A. Campbell to Ava on a good high road, with nothing to resist him but the dispirited fugitives just mentioned. In the evening we reached Kyaoktalon, twelve miles from Ava. A short way before coming to that place, a deputation, headed by a secretary of the Lotoo, met us to compliment us on our arrival, and usher us into the capital.

On the morning of the 29th we left Kyaoktalon. After we had proceeded a few miles, an order from the court arrived, requesting that we might stop where we were, as it was the intention to send down a deputation of persons of superior rank to conduct us. The promised deputation, consisting of a Woonduck and three Saredaugyis accordingly came, and on the morning of the 30th we arrived at the capital, anchoring about two miles below the city, opposite to the place appointed for our temporary residence. Thousands flocked down to the bank of the river out of curiosity to see the steam vessel. A similar curiosity was displayed everywhere else on our journey, nearly the whole population of towns and villages turning out to see her.

On landing we were received with ceremonious politeness by a Wungyi and Atwenwun, the two highest classes of officers under the Burmese government. These were the individuals who had negociated and signed the treaty of Yandabu. The politeness which dictated the selection of these two individuals was obvious.

Our audience, under various pretexts, was put off from day to day until the 21st of October. In the meanwhile we were treated with attention. The expences of the whole mission were paid, and we were put under no other constraint than that of not being permitted to enter the walls of the town, a liberty which would have been contrary to established etiquette. Meanwhile the negociation had commenced, and on the 13th, 14th, and 15th, we were present, by special invitation, at the annual display of boat races, which take place yearly when the waters of the Irawadi begin to fall. The king and queen, with the princes and nobility, were all present. The splendour of this pageant far exceeded our expectation, and would have made a figure in the *Arabian Nights' Entertainments*, as one of the good things got up by virtue of Aladdin's lamp.

The period chosen for our presentation was that of one of the annual festivals, when the tributaries, princes, and nobility offer presents to his majesty, and their wives to the queen.

Boats were sent for our accommodation, and about ten o'clock in the forenoon we reached the front of the palace. An elephant was appropriated to each of the English gentlemen, and the procession moved on until arriving at the Ringdau, or Hall of Justice, which is to the east side of the palace, where we were detained for nearly three hours, to afford us an opportunity of admiring the pomp and magnificence of the

Burmese Court, but above all, to afford the court an opportunity of displaying it.

At that place the whole court, with the exception of his majesty, passed in review before us, beginning with the officers of lowest rank, and ending with the princes of the blood. The courtiers were in their dresses of ceremony, and each chief was accompanied by a numerous retinue, besides elephants and horses. The retainers of Menzagyi, the queen's brother, the most powerful chief about the court, could not have been fewer than three hundred.

We were at length summoned into the royal presence. The etiquette insisted upon with Colonel Symes seemed not to have escaped the recollection of the Burman officers, and they would have had us to practice the same ceremonies he had been necessitated to submit to, but times had changed. These ceremonies consisted in making repeated obeisances to the walls of the palace, and in walking bare footed, or at least without shoes, across the court-yard. All this we peremptorily refused, although the officers who led the procession showed us a very good example in prostrating themselves repeatedly, by throwing their bodies prone upon the bare ground. Upon reaching the bottom of the stairs leading to the hall of audience we voluntarily took off our shoes, passed through the long hall, and seated ourselves in front of the throne. His majesty did not keep us long waiting. After a hymn had been chaunted by a band of Bramins in white, he made his appearance upon the opening of a folding-door behind the throne, and mounted the steps which led to the latter briskly. He was in his richest dress of state—wore a crown, and held in his hand the tail of a Thibet cow, which is one of the Burman regalia, and takes the place of a sceptre.

He was no sooner seated than her majesty, who, whether on public or private occasions, is inseparable from him, presented herself in a dress equally rich with his, and more fantastic. Both had on a load of rich jewels. She seated herself on his majesty's right hand. She was immediately followed by the little princess, their only child, a girl about five years of age. Upon the appearance of the king and queen the courtiers humbly prostrated themselves. The English gentlemen made a bow to each, touching the forehead with the right hand. The first thing done was to read a list of certain offerings made by the king to some temples of celebrity at the capital. The reason for doing this was assigned. The temples in question were said to contain relics of Gautama, to be representatives of his divinity, and therefore fit objects of worship. His majesty having thus discharged his religious obligations, received in his turn the devotions and homage of the princes and chiefs.

The king did not address a word in person to the officers of the mission, but an Atwenwoon, or privy-councillor, read a short list of questions, as if coming from the king. These, as far as I can recollect, were as follows:

" Are the king and queen of England, their sons and daughters, and all the nobility of the kingdom well?

" Have the seasons been of late years propitious in England?

" How long have you been on your voyage from India to this place?" &c.

Betle, tobacco, and pickled tea, were after this presented to the English gentlemen, a mark of attention shown to no one else. They afterwards received each a small ruby, a silk dress, and some lackered boxes. This being over, and a few titles bestowed and proclaimed throughout the hall, the king and queen retired, the courtiers prostrating themselves as when they entered. Their majesties had sat in all about three quarters of an hour. The Burman court, upon the present occasion, appeared in all the pomp and splendour of which it is capable, and the spectacle was certainly not a little imposing. The princes and nobility were in their court dresses, of purple velvet, with a profusion of lace and gold. The hall of audience is a gorgeous and elegant apartment supported by ninety-six pillars, and the whole is one blaze of rich gilding.

In going through the court-yard the white elephant, and some other royal curiosities were shown to us, and we stopped for a moment to see an exhibition of tumblers, buffoons, and dancing girls.

After the audience the gentlemen of the mission were occupied for several successive days in paying visits to the heir-apparent, the Prince of Sarrawadi, the dowager queen, and the queen's brother. By all these personages they were received with marked politeness and attention. The ladies presented themselves on these occasions as well as the men. There was no reserve in respect to the fair sex.

The negotiation was then renewed, and on the 23d of November, besides settling some points respecting frontier, a short treaty of commerce of four articles was concluded.

The mission continued at the Burman capital in all about two months and a half, and quitted it on the 12th of December, after being honoured with two audiences of his Majesty, the one on occasion of catching a wild elephant, and the other on that of weaning a young one, favourite diversions of the king. On the occasions in question his Majesty threw off all reserve, and conversed freely and familiarly with our countrymen. On the day of departure presents were sent for the governor general, and each of the English gentlemen received a title of nobility.

The Irawadi which, swollen by the periodical rains, was deep and broad in coming up, was found in descending to have fallen from twenty to thirty feet, and the navigation consequently proved extremely intricate and tedious. The steam vessel was in all a-ground fifteen days, and frequently ran the risk of being totally lost. The voyage to Rangoon occupied thirty-five days, which, in a small boat suited for the river, ought to have been performed in ten. At Pugan, about eighty miles below Ava, the mission was for the first time informed of the insurrection of the Talains. At Henzada and Donabew the inhabitants were seen flying from the seat of insurrection. The insurgents were first seen at Paulang. This place, where the river is not above sixty yards broad, was strongly stockaded in three places, and the Talains were seen standing to their arms. The steam vessel came to for a few moments to request a safe passage for the baggage and boats which were behind, and for the boats of some merchants which accompanied them, amounting in all to about twenty-two. Boats put off immediately, and the Talains came on board without the least hesitation. They were full of friendly professions, and requested only our neutrality. Our visitors saluted us in the manner of English sepoys, standing up. This they said was the positive order of his Talain majesty, who declared he would permit no one henceforth to crouch in his presence, or that of any other chief. They also boasted that they treated their prisoners after the English fashion, that is to say, disarmed them and set them at liberty without offering them any personal violence. They claimed the greater merit for this, on account of the conduct observed by the Burmans towards them, who, they alleged, put all their prisoners to death, or, as they expressed it, "divided them into three parts."

On the morning of the 17th the mission reached Rangoon. The Burman flag was seen flying on one side of the river, and the Talain on the other, not 600 yards asunder. The town of Rangoon was invested on all sides by the Talains, and the suburbs had been burnt to the ground. We had hardly been at anchor half an hour, and were engaged in reading our letters and newspapers, when the garrison made a sortie, and an action took place, reckoned the most considerable since the commencement of the insurrection. On both sides it was paltry and contemptible to the last degree. The Talains in one place caught sleeping or cooking fled to their boats, and were soon seen crossing the river in great numbers. At another post between the town and the great Pagoda they were more vigilant, and easily repulsed a feeble and cowardly attack made by the Burmans. On the 23d the mission left Rangoon, and in less than four-and-twenty hours reached the new settlement of Amherst, in the harbour of which we found lying the company's ships Investigator and Ternate, and a large fleet of gun-boats. To these in a few days were added the large merchant ships *Almorah*, *Felicitas*, and *Bombay Merchant*, with two trading brigs and some schooners. This was a curious spectacle in a harbour which was not known to exist ten months ago. The settlement contains from sixteen to seventeen hundred inhabitants. Maulamhyeng, the military cantonment, twenty-seven miles further up the river, contains twice this number, chiefly camp followers. Neither of them had a single inhabitant a few months back, but on the contrary were covered with a thick forest. This fine country already produces some of the necessaries and comforts of European life, in a degree which under all circumstances is remarkable. Fowls are to be had in abundance for five rupees per dozen; a milch buffalo and calf for fifteen rupees; fish is in abundance and of excellent quality. The best kinds are the Calcop, the large mullet, and the Mangoe-fish. It is curious that this last is found in plenty both in the rivers of Rangoon and of Martaban, with roes for nine months of the year, or from December to August inclusive, whereas in the Hoogly three months is the utmost limit of their season.

On the 26th the mission proceeded to Maulamhyeng, and on the 28th ascended the Ataran river in the steam vessel. This stream, which is deep and free from danger, might be navigated for fifty miles up by vessels of 3 to 400 tons burden. It leads to Teak forests, distant about seventy-five miles, inexhaustible in quantity, and of the largest scantling.

On the 8th of February the ship *Bombay Merchant* having been taken up for the accommodation of the mission, the members embarked that evening, and on the following morning sailed for Calcutta.

The following is a very brief sketch of what has been observed by the mission in the department of science. In the departments of mineralogy and geology it is to be regretted that no scientific observer accompanied the mission. Our party, however, were assiduous collectors, and the collection brought back is so extensive, that it would afford men of science a very tolerable notion of the mineralogical and geological constitution of the countries which were visited. From between the latitude of 15° and 16°, to between that of 18° and 19°, is a low alluvial country, forming the *debouchement* of the Irawadi river. Here not a mountain or a stone is to be found, except in a very few places, such as Rangoon and Syriam, where a little cellular clay iron ore presents itself in low hills. In about lat. 18° 30′ we quit the Delta of the Irawadi, the native country of the Talain race, and enter at once into a hilly region, which extends almost all the way to Ava, or to about the latitude of 21° 50′. The Irawadi in all this course is skirted by hills of from about 3 to 500 feet high. The lowest portion of these is composed of breccia, calcareous sandstone, cellular clay iron ore, with beds of sand and clay, and the highest of blue mountain limestone. The lowest portions are alluvial, and highly interesting to the geologist. The gentlemen of the mission discovered in these abundance of sea shells, with fossil wood and bones. Among the latter are the bones of the fossil elephant or mammoth, * fossil rhinoceros, various ruminant animals, alligators, and tortoises. An immense collection of these has been brought round for the government. Some of the bones are of great size, and all completely petrified. There are among them the teeth and such other portions of the skeleton as will enable the experienced naturalist to determine the *genera* and species to which they belonged. These were obtained close to the celebrated petroleum wells. From their great induration, and having been little rolled, they are generally in a very perfect state. The bones, as well as the fossil wood, are found superficially in gravel, the same situation in which similar diluvian or antediluvian remains have been found in other quarters of the globe.

The ranges of mountains to the east and north of Ava, as far as twenty miles, and those close to the city on the western bank of the river, are all of marble, and this of many varieties. The white statuary marble, some of which is very beautiful, is brought forty miles down the river from a mountain on its eastern bank.

The great ranges of mountains dividing the Burman dominions from Arracan on one side, and Siam on another, are reasonably supposed to be primitive. In the last direction the roots of these seemed to extend to the new settlement of Amherst, where we find granite, quartz, and mica slate. Some continuous low ranges in the Martaban district are composed entirely of quartz rock. Blue mountain limestone is a frequent formation in the same district, from which lime of much purity is manufactured. Detached rocks of this substance are scattered over the plains. These rise abruptly and perpendicularly to the height of from 3 to 500 feet, and in one place to 1500. They contain some spacious caves, which have been converted into places of worship. One of these rocks is so re-

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* This is a mistake. They belong to the mastodon, as will be seen from a subsequent account of them in this Number, page 56.—Ed.

markable that it deserves particular mention. Its perpendicular wall confines the Ataran for several hundred yards on its right bank. About its middle it is penetrated by a branch of the river, which flows quite through it by a magnificent arch. This is a highly picturesque object.

Neither the proper Burman or Talain country appear to be rich in metallic ores, with the exception of those of iron, tin, and antimony. The principal consumption of the country in iron is supplied from the great mountain of Poupa, on the eastern side of the Irawadi, and near the latitude of 21°. Lao, the country of the Shans, as it is denominated by the Burmans, is, on the contrary, extremely prolific in metals. The singular passion of the Burmans for the study of alchemy has brought collections of the ores of Lao into the market of Ava, and this circumstance enabled the gentlemen to make collections of them. The ores thus obtained consisted of those of iron, silver, lead, copper, and antimony. The Shans possess the art of smelting all these, and bring them in their metallic state into the market of Ava. The silver ores in the Burman dominions are, however, wrought to the greatest advantage by the Chinese. The mines exist about twelve days journey to the north-east of Bamoo, towards the Chinese frontier.

The celebrated sapphire and ruby mines, which have always afforded, and still continue to afford, the finest gems of this description in the world, are about five days journey from Ava, in a direction E. S. E.. and at two places called Mo-gaot and Kyat-pyan. The different species of sapphire, both in their crystallized and rough state, and the matrix, or rather gravel, in which they are found, were seen, examined, and collections made. In these mines are found the following gems or stones; the red sapphire or oriental ruby, the oriental sapphire, the spinelle ruby, the white, the yellow, the green, the opalescent, the amethyst and girasol sapphire, blue with a reddish reflection, with the common corundum or adamantine spar in large quantities.

The oriental ruby, perfect in regard to water, colour, and freedom from flaws, is scarce and high-priced even at Ava. The blue sapphire is more common and cheaper. One specimen exhibited to us weighed 951 carats, but it was not perfect. The red sapphire never approached this magnitude. The other varieties are all rare, and not much esteemed by the Burmans, with the exception of the girasol sapphire, of which we saw two or three very fine specimens, and the green sapphire or oriental emerald, which is very rare. The king makes claim to every ruby or sapphire beyond a hundred ticals value, but the claim is one not easy to enforce. The miners, to avoid this sage law, break the stones when they find them, so that each fragment may not exceed the prescribed value. His majesty last year got but one large ruby. This weighed about one hundred and forty grains avoirdupois, and was considered a remarkable stone. Sapphires and rubies form a considerable article of the exports of the Chinese, who are the cleverest people in the world in evading the absurd fiscal laws made by themselves and others. The use they put them to is that of decorating the caps of their mandarins or nobility. Precious serpentine is another product of the Burman empire, which the Chinese export to a larger value.

The gentlemen of the mission examined carefully the celebrated petroleum wells, near which they remained for eight days, owing to the accident of the steam vessel taking the ground in their vicinity. Some of the wells are from thirty-seven to fifty-three fathoms in depth, and are said to yield at an average daily from one hundred and thirty to one hundred and eighty-five gallons of the earth oil. The wells are scattered over an area of about sixteen square miles. The wells are private property, the owners paying a tax of five per cent. of the produce to the state.

This commodity is almost universally used by the Burmans as lamp oil. Its price on the spot does not, on an average, exceed from 5d. to 7½d. per cwt. The other useful mineral or saline productions of the Burman empire are coal, saltpetre, soda, and culinary salt. One of the lakes affording the latter, which is within six or seven miles of the capital, was examined by the gentlemen of the mission.

The success of the mission has been the completest in the department of botany. This will readily occur to our readers, when they recollect the talent, zeal, industry, and skill of the gentleman at the head of this branch of inquiry. Dr Wallich has been left behind at Amherst to complete his inquiry into the resources of the valuable forests of that and the neighbouring districts. Until this be effected the full extent of his successful researches cannot be known. The number of species collected by him amounted, when the mission left him at Amherst, to about sixteen thousand, of which five hundred and upwards are new and undescribed. Among these last may be mentioned seven species of oak, two species of walnut, a rose, three willows, a raspberry, and a pear; several plants discovered by him are so remarkable as to constitute themselves new *genera*. Among the latter may be mentioned one which has been called Amherstia, in compliment to the Lady Amherst. This constitutes probably the most beautiful and noble plant of the Indian Flora. Two trees of it only are known to exist, and these are found in the gardens of a monastery on the banks of the Salwen. The number of specimens brought to Calcutta amount to little less than 18,000, among which are many beautiful live plants for the botanical garden, chiefly of the orchideous, scitamineous, and liliaceous families. Dr Wallich when at Ava obtained permission of the Burmese government to prosecute his botanical researches on the mountains about twenty miles from Ava. In these, which are from 3 to 4000 feet high, he spent eight days, and brought from them some of the finest parts of his collection. These mountains contain several plants which are common to them with the Himalaya chain, but the greater part of their Flora is rare and curious. The botany of the new provinces to the south is considered to be highly novel and interesting, combining in a great degree the characters of the Floras of continental India and the Malayan countries.

In economical botany a good deal has been effected. The tree producing the celebrated varnish has been discovered and described, and the process of extracting and using the varnish observed. * The different mimosas producing catechu have also been determined, and the processes for extracting the drug observed. The localities of the different teak forests throughout the Burman empire, as well as the quality and price of the timber, have been ascertained. The valuable forests of this tree, discovered in our recent cessions, were

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* See a subsequent article in this Number.—Ed.

upon the point of being minutely explored by Dr Wallich. Lieutenant Scotland, under the instructions of Sir A. Campbell, had, just before the arrival of the mission at Amherst, made a journey by land to the Siamese frontier, in the course of which he passed through two teak forests towards the source of the Ataran river. The largest of these was five miles in breadth, and scarcely contained any other tree than teak, many of which measured from eighteen to nineteen feet in circumference.

One of the oaks already mentioned, and which grows to a large size, is found in great abundance close to the new settlement of Amherst; and should it prove a valuable timber, which is most probable, it may be obtained with every facility. A fine durable timber, called by the Burmans thinghan, and which they place next to the teak, or almost on an equality with it, is found every where throughout the new provinces. Dr Wallich has ascertained this to be the *Hopea odorata* of Roxburgh. Another valuable timber, the uses of which are well known in our Indian arsenals and timber yards, the sondree, *Heritiera robusta*, is found largely in the maritime parts of the Martaban district, and of a size much exceeding what is brought from the Sunderbunds of the Ganges. Of these woods, and many others in use amongst the natives, although as yet unknown to us, specimens will be brought to Bengal by Dr Wallich, for the purpose of subjecting their qualities to rigid experiment.

In the department of zoology, if we except the fossil bones already described, the inquiries of the gentlemen of the mission have not been so successful. The features of the animal kingdom, indeed, differ much less from those of Hindustan than the vegetable. Still there is no doubt much room for discovery, when the countries are leisurely explored by experienced naturalists. In the Martaban provinces, the forests of which teem with the elephant, the rhinoceros, the wild buffalo, ox, and deer, a new species of the latter is believed to exist. In the upper provinces a species of mole-rat is very frequent, and thought to be an undescribed animal. Some of the officers of our army imagined that they had ascertained the existence of the jackal and fox in the upper provinces of the

Burman empire, but this seems to be a mistake. It is a singular fact, that neither these animals, nor the wolf, hyena, or any other of the genus *canis* is found there, with the exception of one animal, which is yet undescribed, and the howl of which it was that was mistaken for that of the jackal. The feline tribe, especially the larger species, are but rare in the upper provinces of the Burman empire, but too frequent in the lower. The night before we left Maulamhyeng, a tiger was shot in the heart of the cantonment by a party of officers who lay in wait for him. Two or three of the smaller species of this family, found in Martaban and Pegu, are thought to be as yet unknown to naturalists. In Martaban, two new species of pheasant have been found, of which living specimens have been sent to Calcutta. The celebrated elephant must not be forgotten. At Ava there is but one albino elephant. This, a male of about twenty-five years of age, was repeatedly seen and examined by the gentlemen of the mission, and his majesty has made a present to the governor-general of a drawing of the animal in its state caparison, which is no bad specimen of Burman art.

As connected with this department may be mentioned the existence at Ava of a man covered from head to foot with hair, whose history is not less remarkable than that of the celebrated porcupine man, who excited so much curiosity in England and other parts of Europe near a century ago. The hair on the face of this singular being, the ears included, is shaggy, and about eight inches long. On the breast and shoulders it is from four to five. It is singular that the teeth of this individual are defective in number; the molars or grinders being entirely wanting. This person is a native of the Shan country, or Lao, and from the banks of the upper portion of the Saluen or Martaban river. He was presented to the king of Ava as a curiosity by the prince of that country. At Ava he married a pretty Burmese woman, by whom he has two daughters. The eldest resembles her mother, the youngest is covered with hair, like her father, only that it is white or fair, whereas his is now brown or black, having, however, been fair when a child, like that of the infant. With the exceptions mentioned, both the father and his child are perfectly well formed, and indeed for the Burman race rather handsome. The whole family were sent by the King to the residence of the mission, where drawings and descriptions of them were taken. Albinos occur now and then among the Burmese, as among other races of men. We saw two examples. One of these, a young man of twenty, was born of Burmese parents. They were ashamed of him, and considering him little better than a European, they made him over to the Portuguese clergyman. The reverend father, in due course, made him a Christian.

## ART. IV.—*On the Fœtus of a Polydactylous Horse having the Toes separated by a Membrane.* By M. G. ST-HILAIRE, Member of the Institute.

THE extremely brief notice of this rather singular specimen of a peculiar kind of deformity in the horse scarcely furnishes a sufficiently accurate account to be submitted to our readers. It would seem that the distinguished naturalist to whom we owe the publicity of the very singular specimen alluded to, having proceeded to the south of France for the express purpose of conducting in safety to Paris the camelopard, of which a notice will be found in another part of this Number, examined on his route whatever museums existed; and in that belonging to the veterinary school at Lyons he met with the fœtus, the peculiar mal-conformation of whose feet gave rise to his brief notice.

For the benefit of those not sufficiently acquainted with the doctrines of comparative anatomy originally laid down by Aristotle, and likewise in order to render M. St-Hilaire's notice intelligible to the generality of our readers, we shall very briefly state the osteology of the horse's foot, and compare it with those of other animals, and with man.

The pectoral extremities of the horse, or his fore-legs, are composed essentially of the same elements as the human arms, and the bones of each may be arranged and described in this way:—

| Bones of | *In Man.* | *In Horse.* | |
|---|---|---|---|
| the shoulder, | 2 | 1 | The clavicles are wanting. |
| Do. arm, | 1 | 1 | |
| Do. fore-arm, | 2 | 2 | Only when the animal is young; when old the ulna, which at all times in the horse is an imperfect bone, becomes firmly united to the radius. |
| Do. carpus, | 8 | 7 | The part of the limb corresponding to these bones is very generally, but very improperly, called the knee. |
| Do. metacarpus, | 5 | 3 | One complete and two incomplete, imperfect, or *rudimentary.* |
| Do. fingers. | 14 | 3 | |

The horse, then, has but a single toe or finger, and not three, as some anatomists have said. The extremely imperfect and rudimentary metacarpal bones can never be called imperfect toes in strict language; nevertheless they really constitute the elements of toes, which have been formed in this imperfect and *rudimentary* manner, because they were not wanted for the safe progression of the animal, inasmuch as we apply this term to the short toes of the pig, which have a metacarpal and digital bones, are detached and protected by a nail similar to the more perfect or longer ones. On the contrary, all that remains of such toes in the horse are two small perfectly rudimentary metacarpal bones; there is not the slightest vestige of any digital bones or phalanges.

It sometimes happens, as may be seen in museums, that the imperfect toes of certain animals (as in the pig for example) occasionally are found perfect, or, in plain language, grow to the same length as the more perfect ones, and of this we have seen one or two instances in the pig, all four toes being in these specimens of equal length and strength, or nearly so. Now this seems to be the case with the fœtus of the horse described by M. St-Hilaire, and if so, as we doubt not, is the only instance recorded, unless we consider as such the horse described by Suétonius, and said to have belonged to Cæsar; but to enable us to decide on this point neither the description of Suétonius nor of the French naturalist, will be found sufficiently minute. M. St-Hilaire describes the fœtus he examined to have been about eight or nine months old. He states that it is polydactylous only in the fore-feet; and that the left foot has three toes nearly equal, but the right only two. The toes are said to be connected by a membrane, a kind of periosteum insulating the metacarpal bones and toes, and even passing beyond them about six lines. Now M. St-Hilaire imagines that this membrane extended to the envelopes of the placenta, but this is merely a conjecture, and one founded on a hypothesis.

It is not improbable that the description of the fœtus in question may ultimately form the subject of a distinct memoir; and should this happen we shall not fail to give it an early place in this Journal. R. K.

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## ART. V.—*On the principles of Dynamics, particularly as stated by French Writers.* By the Rev. W. WHEWELL, M. A. Trinity College, Cambridge. Communicated by the Author.

DURING the course of the last century, a question was started, and repeatedly discussed among mathematicians, " whether the principles of Mechanics were *necessary* or *contingent* truths?" that is, whether the science could be established upon axioms, drawn from the nature of things, and the relations of our ideas, or whether it was indispensable for the proof of its doctrines to recur to experiment and observation? It might, perhaps, have been expected that such a question would have been easily decided, and that for its solution it would only have been requisite to inspect any scientific treatise on mechanics which pretended to strict logic in the deduction of its fundamental propositions; and where, of course, these principles would be proved in the simplest manner which was possible. If, however, we examine the works of authors of the most undoubted science and ingenuity up to the most modern times, we shall find differences of principle among them which seem to show that this discussion has not even yet led to any opinion which possesses elementary clearness, and has found universal reception.

With respect, indeed, to the question above referred to, of the necessary or contingent nature of the proof on which these doctrines must rest, it seems now to be allowed by the general voice of those who have treated of such subjects, and is in fact demonstrable, that the evidence of mechanical and of geometrical science are altogether different in kind. That while the latter depends for its truth on the nature of the human mind alone, and its self-produced stores, the former must necessarily derive some part at least, both of its materials and its rules, from the impressions made on us by the external world. This is more particularly the case with regard to that portion of mechanics which refers to motion. For the propositions which concern bodies at rest, *(statics,)* whether or not they are to be ranked with the truths of geometry in other respects, agree with these at least in this, that the certainty of them is involved in the definitions by which they become intelligible, and that they require us to borrow from experience nothing but the ideas which are the subject of their operations.

But in *dynamics* the case is different, and besides being obliged to derive from observation the phenomena about which we reason, we are also under the necessity of taking from the same source the laws according to which the phenomena succeed and determine each other; the business of the science being to reduce these laws to the simplest form and smallest number, and then by recombining these, to account for, and calculate all mechanical events. Now, with respect to this analysis of such complex occurrences into their simplest and fewest laws, it appears that writers have arrived at different results. It will therefore appear not to be superfluous or unprofitable to show what is the greatest degree of simplicity to which the fundamental doctrines of mechanics can be reduced; what are the considerations which make it impossible to carry the simplification further than this point, and unscientific to stop short of it; and how far the mode in which the principles of the science are stated in works of the most acknowledged reputation can be considered as possessing this philosophical simplicity combined with logical strictness.

The leading distinction which may be considered as prevailing at present upon this subject is that between the English writers, who, following Newton, make *three* laws of motion the foundation of dynamics; and the foreign, and more particularly the French writers, in whose Treatises on Mechanics the elementary principles of the science are in various ways simplified and established. The most distinguished among the latter deduce, as will be shown, *two* independent principles from experience; and what I wish especially to offer to the consideration of mathematicians is the question how far these systems can be identified, and which is the more true and logical one:—Whether with three laws we have something superfluous, or with two something defective.

In stating the three laws of motion for the purpose of this comparison, we must, in order to avoid confusion and false reasoning, reject entirely their application to statics. If we do this, (which has not always been sufficiently attended to,) and express them in the simplest form as they regard the motion of bodies, we shall have them as follows:—

Law 1. A body in motion, not acted upon by any force, will move on in a straight line with a uniform velocity.

Law 2. When any force acts upon a body in motion, the *change* of motion which it produces is in the direction, and proportional to the magnitude, of the force which acts.

Law 3. When pressure communicates motion to a body, the moving force is as the pressure.

If we carefully look in the best French treatises for the principles which they borrow from experience, we shall find them to be these two:

*First*, *The law of inertia*, that a body not acted upon by any force would go on for ever with a uniform velocity.

*Second*, That the velocity communicated is proportional to the force.*

The first of these principles coincides with the first law of motion, which the best French, as well as English writers, agree in considering as a result of experience.† The second and third laws of motion are both reduced to the second principle of the foreign mechanicians; and the point to be considered is, whether the steps of this part of the reasoning are allowable and satisfactory.

The principle that the *velocity* communicated is as the pressure, leads immediately to the inference that the *accelerating force* is as the pressure, and consequently, for the same body,

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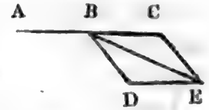
* See Note A, p. 36.

† See Note B, p. 37.

the *moving force* is as the pressure. And the same inference may be extended to a body twice, three times, &c. as large, by considering it as made up of two, three, &c. such bodies, each acted upon by the same pressure. And thus this principle leads directly to the third law of motion.

The question, therefore, now becomes, whether the second law of motion be included in the third? and this is what the foreign writers alluded to, assert, and pretend to prove. The proof is of the following kind.

Let a body be moving in a direction A B with any velocity B C. At the point B let it be acted upon by any force in the direction B D. It will describe an intermediate line B E *by the second law of motion.* But this intermediate direction is also deduced from the principle that the *velocity is proportional to the force,* in this manner.



The body being at B, and moving with the *velocity* B C, is in *the same condition* as if it were at that instant acted upon by a *force* which is represented by B C. But in that case it would be acted upon by two forces represented by B C and B D, and hence, by the statical composition of forces, it might be considered as acted upon by a single force B E, the resultant of B C and B D. Hence, since the velocity is proportional to the force, the body will move in B E with a velocity represented by B E.

In this case we consider a velocity as depending upon a force without any respect to the time; and it is therefore clear that the forces must be instantaneous or impulsive; and that this is the case will also appear from referring to the demonstrations here pointed at.

Thus Laplace, *Mec. Cel.* Ch. ii. Art. 5, assumes "f *la force dont un corps est animè en vertu de sa vitesse,*" and then compounds such forces by the law of statics. It appears by the proof that he supposes the force to be impulsive. (His object is to prove by experiment that these forces are proportional to the velocities.)

Poisson, *Dyn.* Ch. ii. Art. 212. Takes, "un point sollicitè par deux forces, du genre de celles qui agissent instantanement sur le mobile et qui l'abandonnent ensuite à lui-meme." He then compounds these by the law of statical composition. He proves that the velocities are proportional to the forces, (pressures) by observing that it is an hypothesis, (Art. 193,) and that the agreement of its results with experience shows it to be the law of nature.

It will appear from a careful consideration of these proofs, that, first, it is taken for granted that any velocity *may* be produced by an *instantaneous* force: That 2*d*, it is proved from experiment that this force is *as* the velocity: That 3*d*, it is taken for granted that we may, at our choice, at any instant, consider the body either as possessing the velocity, or as acted upon by the force which would produce it: And that 4*th*, it is also taken for granted that these instantaneous forces acting together may be compounded according to the laws of statics.

But I shall endeavour to show that there are steps in these reasonings, (and I believe that the considerations generally employed by French writers in the elementary portions of mechanics cannot be resolved into any more satisfactory than these,) which are on several accounts liable to objections.

I. In the first place, I would object to the supposing all velocities in bodies to be produced by forces acting instantaneously, that is, acting at a single indivisible and uncontinued moment of time. For the fact really is, that there are no such forces in nature, and that forces of impulse and impact, which appear at first sight to operate in this manner, seem to do so only in consequence of a vague and imperfect mode of conceiving them, and do in reality produce their effects by a continued pressure acting for a short but finite portion of time. And this is the case with all forces which ever come under our observation; insomuch that we cannot in strictness suppose any such process as a body at rest acquiring *at once* a finite velocity without going through the intermediate degrees of velocity. And even if we allow that we can conceive such an operation taking place, yet it must, it would seem, also be granted, that the process would be different *in kind* from any of the real actions of bodies one upon another, and therefore it may deserve serious consideration whether it can, in sound reasoning, be made the foundation of deductions which are to be applied to cases of continual pressure.

This is a step in the mode of obtaining the first principles, which, I confess, appears to me entirely fallacious, but which must, I think, at least be allowed to be unscientific and unphilosophical. The idea of instantaneous force is introduced merely to be got rid of. It is not deduced from nature, but it is borrowed from the imagination, and made the foundation of the science; and must again be dismissed before we can apply our conclusions to any of the phenomena of the universe.

It is true that we may conceive physical impact after the manner in which it is generally understood; that is, as continuing during a small definite time, for instance one-tenth of a second; and we may then imagine such impact to represent all other forces. By this means the force will be a pressure of the kind which really exists; but then we shall lay the reasoning open to the objections which the assumption of instantaneous force seems intended to avoid, namely, the necessity of introducing the *time* during which the force is supposed to act.

II. Supposing, however, we allow this substitution of impulsive for permanent forces, we shall, I think, find ourselves met by new difficulties. It is to be proved or assumed, (Law 3,) that this impulsive force is proportional to the velocity which it produces, and this is proved from experiment, in a demonstration (Laplace, Art. 5,) which assumes that these forces thus *producing velocity* may be compounded according to the law of composition of forces which is established in *statics*. Now nothing can be clearer than that the statical combination of forces cannot apply to the composition of impacts, without complete alteration of the use of terms, and the meaning of the proposition. The definition of statical force, and every step of the process, supposes the forces to be employed in producing *equilibrium*, which cannot in any manner apply to impulsive or instantaneous forces. And this objection is so obvious, and apparently so insurmountable, that I am at a loss to imagine how reasoners so acute as those whose demonstrations I am considering, can have passed it over; at the same time, I think no person can examine the proofs to which I have referred, without seeing that they are altogether dependent upon this vicious reasoning.

The fact, perhaps, may be, that the authors who have adopted this fallacious train of reasoning have not sufficiently reflected that the meanings of our words in science are the creations of our definitions, and that we cannot assume any thing respecting the things meant, which is not either implied in the definition, or deduced from observation. Thus they perhaps considered the word *force* to represent a quality connected with the velocity, but necessarily of such a nature that it was subject to all the same laws which apply to statical force.[*] If such an opinion were adopted, it might manifestly become the foundation of error; for the correspondence between the laws of statics and dynamics, instead of being complete, as it is thus assumed to be, might have been partial only. It might, for instance, have been true that two forces acting in the *same* direction produced the same dynamical effect as their *resultant*, though it had not been true that when they acted *obliquely* to each other the dynamical effect was that of their resultant.[†] In this case the velocity could have been as the force, when the force acted in the direction of the motion, but not necessarily in other positions. It does not appear, therefore, that we can *a priori* say generally either the force in dynamics is proportional to the force in statics, or that it is not. So far as the demonstration is concerned, it might have been *so* in some cases, and otherwise in others. And this perhaps may explain the oversight which I wish to point out. There is no question as to what is *the truth* in these cases; but there may be some who consider it a matter of philosophical importance whether this truth is *deduced* from assumption or from observation, and it is to those that this examination is addressed.

III. But the most important question is the one concerning the satisfactoriness of the next step in the reasoning. After supposing it shown that a velocity AB results from a force AB, it is taken for granted that when a body moving with a velocity AB is acted on by a force BD, we may suppose that, instead of the body having the *velocity* AB, it is at that instant undergoing the action of the *force* AB, so that the two forces

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[*] See Note C, p. 38.

[†] Suppose, for instance, that two forces, $a$, $b$, acting at an angle $\theta$, produced a velocity proportional not to $\sqrt{(a^2 + b^2 + 2\,a\,b \cos.\,\theta,)}$ but to $\sqrt{(a^2 + b^2 + 2ab\,(\cos.\,\theta + \sin.\,\theta))}$. In this case, as well as in the other, when $\theta = 0$, the result is $a + b$, and when $\theta = \pi$, the result is $a - b$.

AB, BD, act at the same point of time.* We *resolve* the velocity AB, as it were, into the force which may have produced it at a former period. Now, it seems hardly self-evident, that, assuming a pressure of ten pounds, or a blow of a certain momentum, to have produced this velocity, we may at any future period substitute this pressure for the velocity. It is true, it may be said that it makes no difference at what interval of time we suppose these forces to act, and that therefore we may first suppose the force AB to act, and then BD at an indefinitely short distance of time, which comes to the same thing, supposing them to act simultaneously. But when we are requiring the strictness of demonstration, it may still I think be replied, that there may be an essential difference between the *successive* and the *simultaneous* action of forces; and that it is by no means clear that their action, one *after* the other, however small the interval may be, is the same thing as their acting *together*. I would even ask any one whether this is manifestly clear in the case of the real physical impact of two balls upon a third. At any rate, it can hardly be said to be self-evident, and therefore ought not to be assumed in a demonstration of the nature of that which we are now considering.

If these objections to the deduction of the second law of motion from the third are well-founded, it will appear that the proper and philosophical method is to deduce the second independently from observation, as English writers are in the habit of doing.

It may here be remarked, that if the second and third laws were connected in the way which some have supposed, either of them might be made the fundamental one, and the other might be deduced from it. Thus assuming the second law, we might, by the same kind of reasoning as that which we have been discussing, prove the truth of the third.

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* *Poisson,* tom. i. p. 309. Le point se mouvra uniformement sur la diagonale, &c.

En chaque point de cette droite le mobile sera dans le même etat que si la force R agissait actuellement sur lui et lui imprimait la vitesse *mc*.

If the velocity has been produced by a force which acted during a finite portion of time, however small, the replacement of the velocity by the force is a supposition attended with still more embarrassing difficulties.

Let a body be acted on by a force 2 F. This is equivalent to two forces, F and F. The first would produce a velocity V, and therefore the second may be considered as acting upon the body *already moving with the velocity V.* But hence by *the second law of motion* it would *add* a velocity V, and hence the whole velocity would be 2 V; and similarly we might prove that a force *m* F would produce a velocity *m* V, which is easily seen to be an expression of the *third law* of motion.

The preceding are the principal objections which I wish at present to propose. Perhaps some may be at first disposed to think the question rather one of words and definitions than of principles. It will, however, appear on close consideration to be something more. For *two* different principles obtained from observation cannot be made *one* by any mere alteration of phraseology. To those who feel an interest in the strictness of scientific logic the question will not appear unimportant. It is in fact the question, whether, after carrying the process of induction and generalization as far as is requisite, in order to obtain the *three* laws of Newton, we can carry it one step farther, and include *one* of these laws in *the other.* It is the question, whether the third law of motion be capable of being considered as a particular case of the second. The preceding considerations seem to disprove such a dependence.

The manner in which the French writers have tried to establish such a connection has been by including both in the principle that *force is as velocity.*

But that this apparent simplification is made at the expence of accuracy of language seems certain. To express the two cases clearly, we might say, 1st, that when force acts on a body already in motion, the velocity *compounded* with the former velocity is proportional to the force; and, 2d, that when different forces act on the same body, the velocity *generated* is proportional to the force. And these two propositions are different, and should be established separately, as appears by considering that each might be true though the other were false. Thus the proof given by Laplace, that velocity is proportional to force, depends upon this fact, that a body struck upon the surface of the earth moves in the direction in which it is struck. And this proves the *former* of the two cases just mentioned. For if the body be moving from west to east, and is struck from north to south, it moves exactly southwards; showing that the velocity compounded with its former motion (arising from the earth's motion) is parallel to the force impressed. But this parallelism might have occurred, had the velocity impressed in the south direction been of any magnitude whatever, and depended in any manner whatever upon the force impressed. And again, though the above rule for compounding the velocity impressed with the previous velocity had not been true when a force acts *obliquely* to the motion of the body, it might still have been true that in forces or pressures acting directly the velocity impressed is as the force. And, on this supposition, a body partaking of the earth's motion, and struck eastwards or westwards, would have the same relative motion communicated to it as if it had been at rest, and had received the same impulse.

I shall conclude by stating the difference of the two laws which I have considered briefly thus: Suppose that in a ship in motion a ball were made to impinge directly upon an equal ball, (in a direction different from that of the ship's motion) so that they should move on together. Then, if the second law of motion were false, they would move in a direction different from that of the impact; and if the third law were false, they would move with a velocity different from half the original velocity.

These and the foregoing reflections seem to show the propriety of keeping distinct the second and third laws of motion. Others may view the subject in a different manner, and be of another opinion; but at any rate it is desirable to bring the question under the consideration of mathematicians, that it may receive that degree of thought which is requisite for its final decision.

## NOTES.

(A.) *Laplace*, tom i. p. 18. Voila donc *deux* loix du mouvement, savoir, la loi d'inertie, et celle de la force proportionelle à la vitesse, qui sont donnés par l'observation. Elles sont les plus naturelles que l'on puisse imaginer, et sans doute elles dérivent de la nature même de la matiere: mais cette nature etant inconnue, elles ne sont pour nous que des faits observés: *les seuls*, au reste, que la mecanique emprunte de l'experience.

*Poisson*, tom i. p. 178. Au reste, cette loi et l'inertie de la matiere sont les *deux seules* hypotheses sur lesquelles toute la dynamique est fondée; mais à cet egard la theorie du mouvement est moins etendu que celle de l'equilibre, car celle-ci ne depend absolument d'aucune supposition.

(B.) Some attempts have been made to *demonstrate* the first law of motion independently of experience. It may be instructive to notice some of these proofs, as remarkable instances how far men of great talents and acuteness may impose upon themselves, and imagine they are producing arguments when they are in fact only variously combining and transposing a few abstract terms.

One of these demonstrations is given by D'Alembert, *Dynamique*, art. 6.

" Un corps mis une fois en mouvement par une cause quelconque, doit y persister toujours uniformement et en ligne droite, tant qu'une nouvelle cause, differente de celle qui l'a mis en mouvement n'agira pas sur lui, &c.

" Car, ou l'action indivisible et instantanée de la cause motrice au commencement du mouvement suffit pour faire parcourir au corps un certain espace, ou le corps a besoin pour se mouvoir de l'action continuée de la cause motrice.

" *Dans le premier cas* il est visible que l'espace parcouru ne peut etre qu'une ligne droite décrite uniformement par le corps mû. Car, passé le premier instant, l'action de la cause motrice n'existe plus, et le mouvement neanmoins subsiste encore: il sera donc necessairement uniforme, puisque un corps ne peut accelerer ou retarder son mouvement de lui-même." &c. &c. It is clear that we here have the very principle which is to be proved brought as an argument.

" *Dans le second cas*, puisqu'on suppose qu'aucune cause étrangère et differente de le cause motrice n'agit sur le corps, rien ne determine donc la cause motrice à augmenter ni à diminuer," &c. The whole proof occupies two quarto pages.

Mr Playfair has also given a demonstration that a body in motion will, if undisturbed, move with a uniform velocity. (*Outlines*, sect. ii. art. 60.) "For," says he, "if its velocity changes, that change must be according to some function of the time," &c. As $V = C + At^m + Bt^n + \&c.$ "Now there is no condition involved in the nature of the case by which the coefficients A, B, &c. can be determined to be of any one magnitude rather than that of any other," &c. Hence he infers, that A and B, &c. are $= 0$ and $V = C$.

It is manifest that the question is not what is the law of the velocity of a body *from the nature of the case, i. e.* from our definitions, but what it is *in fact?* Where would be the contradiction if we asserted that the law of velocity was expressed by the equation $V = C\varepsilon^{-t}$?

(C.) That moving force is something existing in nature, with properties independent of our definitions, seems to be assumed when language is used like the following.

*Laplace*, tom i. p. 14. *La nature de la force motrice etant inconnue*, il est impossible de savoir *a priori* si cette force doit se conserver sans cesse, &c.

P. 15. La force n'etant connue que par l'espace qu'elle fait decrire dans un temps determiné, il est naturel de prendre cet espace pour sa mesure. Mais cela suppose que plusieurs forces agissantes dans le même sens, feront parcourir un espace égal à la somme des espaces que chacune d'elles êut fait parcourir separement, ou *ce qui revient au même, que la force est proportionnelle a la vitesse.* C'est ce que nous ne pouvons pas savoir *a priori* vu notre ignorance sur *la nature de la force motrice:* il faut encore sur cet object recourir à l'experience; car tout ce qui n'est pas une suite necessaire du peu de donnés que nous avons sur la nature des choses, n'est pour nous qu'un resultat de l'observation.

*Poisson*, tom i. p. 278. La vitesse communiqué à la mobile par une force qui agit sur lui pendant un temps determiné est une fonction du nombre qui represente l'intensite de cette force; le peu de donnés que nous avons sur la nature des forces ne nous permet pas de determiner *a priori* la forme de cette fonction.

It is assumed in what follows that this function is the same for the case of a body at rest and a body already in motion.

## ART. VI.—*On the probable cause of the North-East Winds which occur in the Spring in most parts of Great Britain.* By Mr SAMUEL MARSHALL. Communicated by the Author in a Letter to the EDITOR.

THE winds of the torrid zone mostly blow in the same direction, or in opposite directions in stated periods, but this is not the case in the temperate zones. Here the direction of the wind perpetually varies, and "as fickle as the wind" is proverbial in this country. The evident irregularity of the winds has long perplexed philosophers to assign an adequate cause for such variations, and perhaps little more can be advanced to this day than the very general conclusion, that "*partial changes of temperature are the chief general causes of all winds.*"

In the torrid zone, whilst the barometer seldom varies but in a trifling degree in the temperate zone, it is not less fickle than the wind. This indication of a loss of weight in the atmosphere can arise only from a local diminution of elasticity in this fluid.

On this general ground, therefore, I conceive may be explained the cause of the only periodical wind which we have in this island, I mean that from the north-east, which prevails generally from about the middle of April to the 7th or 8th of May, and sometimes longer; as for instance in the present year it prevailed till the 18th, which is later by several days than is generally the case.

In Sweden and Norway the face of the country is covered with snow to the middle of May or longer. This frozen covering, which has been formed during winter, grows gradually shallower to the 15th or 16th of May, or until the sun has acquired 17° or 18° of north declination; while, on the other hand, the valleys and mountains of England have received an accession of temperature of 24° or 25°. On this account, when the temperature of Sweden and Norway is cooled down by snow of 32°, that of Britain is 24° or 25° higher than that of the preceding countries. Because, while the ground is covered with snow, the rays of the sun are incapable of heating the air above 32° (the freezing point.) For this reason the air of England is 24° or 25° more heated than that of the before-mentioned countries. The air of Sweden and Norway will then of course, by the laws of comparative specific gravities, displace that of England, and from the relative situation of those countries with this country will produce a north-east wind. This current is in common stronger by day than by night, because the variation of temperature in the air of Great Britain is at that time the greatest, being frequently from 50° to 60° about noon, and sinking to 32° in the night.

I do not submit this hypothesis as capable of determining the exact duration, or the existence of this current of the air during the whole of the period I have mentioned, but think it highly probable that it will account for a north-east wind prevailing at this particular season, as observations prove that it does.

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## ART. VII.—*On the Systems of Double Stars which are supposed to be Binary ones, from the observations of* Sir W. HERSCHEL, and Messrs HERSCHEL and SOUTH.

IN a preceding Number we have given an account of sixteen systems of double stars which have been demonstrated to be binary ones, from the observations of Sir W. Herschel, and Messrs Herschel and South. We proceed now to those systems which will probably turn out to be binary, from the observations of the same astronomers.

1. 65 *Piscium*, R. Asc. $0^h$ 40′. Decl. N. 26° 43′.

This star is a double one, and is a very pretty object, both stars being of the seventh magnitude. The angle of position in 1783.15 was 30°. 95, *n p* or *s f*. In 1822.86 it was 25°.80. The rate of decrease, from these and other observations, is 0°.117 per annum; and if we suppose it to revolve uniformly in a circle, its period would be 3077 years. The distance in 1783 was $1\frac{1}{3}$, the diameter of the large star. In 1819 M. Struve made it 5″.77. The distance seems like the angle to be subject to a slow variation.

2. I. 68, R. A. $4^h$ 49′. Decl. N. 1° 23′.

This star is double. The two are both of the 10th magnitude, a star of the 5th magnitude following it to the south. In 1783.06 the position was 84° 54′ *n f*, and in 1825.04 it was by Mr South's observations at Passy, 83° 49′ *s f* or *n p*, and the distance 2″.565. Hence here has been a change of 11° 17′ in forty-two years, or —0°.269 yearly. This star is likely to prove a binary system, and should therefore be carefully watched.

3. 32 *Orionis*, R. A. $5^h$ 21′. Decl. N. 5° 48′.

The two stars are in contact with a power of 303. They are unequal. In 1785 the angle of position was 52° 10′ *s p*. In 1822, 66° 49′ *s p*, and distance less than 1″.3. The measures of this star are of the utmost difficulty. It may be a binary system.

4. I. 70, R. A. $9^h$ 26′. Decl. N. 21° 53′.

The two stars are of the 9th and $9\frac{1}{2}$ magnitude. In 1782.86 the angle of position was 36° 24′ *s p*. In 1825.03 it was 21° 39′ *s p*, and the distance 2″. 97. The annual change has therefore been + 0°.35, a quantity too great to arise from error of observation.

5. I. 84, R. A. $6^h$ 26′. Decl. N. 41° 43′.

This is a very close double star, of the 9th and 10th magnitude. A power of 133 shows it double, and a power of 303 distinctly separates the two stars, which are of a light-blue colour. It is extremely difficult to measure. In 1783.25 the angle of position was 14° *n f*. In 1824.58 it was 4° 59′ *n f*, and the distance 1″.664. The annual change is +0°.219.

6. I. 69, R. A. $6^h$ 51′. Decl. N. 53° 1′.

The stars are of the $8\frac{1}{2}$ and $8\frac{3}{4}$ magnitude. In 1782.87 its position was 77° 24′ *s f*. In 1824.59 the position was 66° 54′ *s f*, and the distance 3″.891. The annual change is — 0°.252.

7. III. 48, R. A. $7^h$ 15′. Decl. N. 20° 48′.

The stars are of the 8th and $9\frac{1}{2}$ magnitude. In 1783 the position was 43° 54′ *n f*, and the distance 6″.25. In 1824.21 the position was 50° 44′ *n f*, and the distance 6″.516. The annual change in the angle is therefore — 0°.166.

8. 31 Bode. Can. Min. R. A. 7ʰ 31′. Decl. N. 5° 43.′

The stars are excessively close, and nearly equal, being η *Coronæ* in miniature, but smaller and much more difficult to separate. They are of the 10th and 10½ magnitude. A power of 133 gives no suspicion of its being double, and 303 just separates their discs. In 1781, Nov. 28, the position was 27° 21′ *s f*. In 1820.79 Struve made it 40° 46′ *n p*, and the distance 1″ or 1½″. In 1823, Feb. 19, Mr South made the position 37°.8, and since 1781 the angle has changed 10° yearly.

9. ζ *Cancri*, R. A. 8ʰ 2′. Decl. N. 18° 11′.

The stars are pretty unequal. Although beautifully defined and round, it is not to be seen triple.

In 1781.89 its position was 88° 16′ *s p*, and the distance 8″. In 1802.11 it was 81° 47′ *s f*. In 1820.29 Struve found it 71° 21′, and in 1822.14 Messrs Herschel and South made it 68° 17′ *s f*, and the distance 6″.24. This gives a mean annual change of — 0°.5813. "The change of position," says Messrs Herschel and South, "has also been accompanied with a considerable diminution of distance; and farther observations must decide whether this is the result of rectilinear or orbitual motion. If the former, the minimum of distance will be obtained in about forty years from the present time, and the change during that period much less rapid than heretofore. On the other hand, an orbitual motion will be indicated by the distance continuing to diminish beyond that limit, and probably too by an acceleration in the angular motion. A certain acceleration, indeed, is already perceptible, 10° having been described in the first twenty years, and 13½° in the last; but no great reliance is to be placed on this, as the earlier measures depend solely on single observations. Meanwhile the change remarked by Sir W. Herschel in his paper of 1804 is fully confirmed, both by M. Struve's observations and our own."—*Phil. Trans.* 1824, part iii. p. 115.

**10. 24** *υ Cancri*, **R. A. $8^{h}$ 16′. Decl. N. 25° 7′.**

The stars are of the 7th and 8th magnitude, and seem to have experienced a great change both in angle and in distance. In 1783 the angle was 32°, 9′ *n f*, and the interval only one and a-half the diameter of the large star, which can hardly exceed 4″ from centre to centre. In Feb. 14, 1822, the angle was 52° 13′ *n f*, and the distance 6″.05. This gives an annual motion of — 0°.514. M. South found the difference of declinations of the two stars 4″.85. When this is computed for the angle and distance observed by Messrs Herschel and South it comes out 4″.78.

**11.** *o* **84** *Virginis*, **R. A. $13^{h}$ 34′. Decl. N. 4° 27′.**

The stars are exceedingly unequal, the large one being *white*, and the small one decidedly *blue*. In 1782.12 the position was 29° 5′ *s p*, and the distance 2½ diameter. In 1802.31 the position was 30° 1′. In 1821.33 Struve makes it 35° 54′, and in May 3, 1821, Messrs Herschel and South make it 40° 9′ *s p*, and the distance 3″.91. "The distance," says Messrs Herschel and South, "has certainly diminished considerably. With regard to the angles one of the three positions must be erroneous; and if one be correct, there is no doubt of a sensible, or perhaps even a considerable annual motion."

**12.** *ξ Scorpii*, **R. A. $15^{h}$ 54′. Decl. S. 10° 52′.**

The stars are of the 4th and 8th magnitude. In 1722.36 the position was 1°, 23′ *n f*, and distance 6″.38. In 1819.5 Struve made it 21° *n f*, and the distance 9″.31. In 1822.46 Messrs Herschel and South made it 11° 37′ *n f*, and the distance 6″.77. "The large star of ξ has not been seen double by us," says Messrs Herschel and South. This is perhaps a binary system, with a mean annual motion of — 0°.256.

**13. 59** *d* **Serpentis, R. A. $18^{h}$ 18′. Decl. N. 0° 5′.**

The stars are of the 7th and 8th magnitude. The large one being *white* and the small one *blue*. In 1781.79 the position was 44° 33′ *n p*, and the distance 1 or 1⅓ diameter. In 1802.34 it was 42° 25′, and the distance 4 or 5 diameters. In 1819.61 Struve found it 40° 5′, and the distance 3″.76. 1825.54 it was

48° 34′, and the distance 4″.46. The increase and subsequent decrease of the distance "agrees," says Messrs Herschel and South, "with the idea of a rapid rotation of one star about the other in a plane nearly passing through the eye, the small star being at its greatest elongation about 1802. The inference is an interesting one, as this star seems not unlikely to furnish another example, in addition to those already known, of a sidereal occultation, which the difference of colours of the two stars, and the rapidity of their motion, will render a most curious phenomenon.

14. 4. ε *Lyræ*, R. A. 18h 38′. Decl. N. 39° 27′.

The stars are unequal, and both white. In 1779.83 the position was 56° 5′ *nf*, and the distance 3″.49. In 1803.83 it was 59° 14′. In 1819.69 Struve made it 60° 42′, and in 1821.02, 64° 18′, and the distance 3″.76. In 1822.12 Messrs Herschel and South made it 64° 7′, and the distance 4″.01. The annual change is here only 0°.19.

15. ζ *Sagittæ*, R. A. 19h 41′. Decl. N. 18° 43′.

The stars are very unequal. The large one is *white*, and the small one *blue*. In 1781.88 the position was 34° 10′ *n p*, and distance 8″.83. In 1802.45 it was 40° 41′. In 1819.74 Struve found it 39° 32′. In 1823.69 Messrs Herschel and South found the position 44° 32′ *n p*, and the distance 8″.82. "The discrepancy," says Messrs Herschel and South, "between our measures and that of M. Struve is very extraordinary, and is the more to be lamented as these stars form, perhaps, a binary system."

## ART. VIII.—*Account of the Indian Penance of Gulwugty, or Churuk Pooja.*[*] By R. H. KENNEDY, M. D.

I do not recollect to have seen a description by a medical writer of the Indian penance of Gulwugty, or swinging with the whole weight of the body suspended on a pair of hooks perforating the integuments of the loins. The process itself is so

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[*] From the *Transactions of the Medical and Physical Society of Calcutta*, vol. ii. p. 293-299.

appalling to an ordinary spectator, and the after consequences seem so singularly disproportionate to the apparently serious nature of the injury endured, that it deserves consideration.

On the western extremity of the old cantonment of the Bombay Dekkan division was the village of Seroor, whence the station was named, and on the south eastern extremity of the camp was the village of Hingny, the distance betwixt the two being about three miles. At each of these villages was a pagoda of peculiar sanctity; and at certain periods, as far as I can remember once in nineteen years, it was deemed a necessary ceremony that the car of Gulwugty penance should be dragged from Seroor to Hingny, with devotees suspended from the mast during the whole route. The car was dragged by as many volunteer labourers from the spectators as could be yoked to it, and proceeded at a rapid rate when a sufferer was undergoing the torture; but it remained still in the interval of unloosing one and fixing another, no progressive motion being lawful unless with a devotee pendant from the hooks. The spectators and officials assured me that such a circumstance had never occurred as the car's being unable to reach its destination through the want of mortifiers of their flesh; the penitents or devotees were always sufficiently numerous to keep the hooks occupied from one pagoda to the other.

The car was four-wheeled, and about the size of an English farmer's waggon, rather broader but not so lofty, of the coarsest possible construction, being built of half beams rather than planks, and exceedingly heavy; upon this was a platform ample enough to hold about twenty persons. A mast twelve feet high was erected in the centre, across which, fitting on an iron pivot, was balanced transversely a pole about fifteen feet in length, divided however unequally, the iron ring which fixed on the pivot being inserted into it about four feet from the heavy end, and of course about eleven from the smaller. To the first was suspended a square scale of wood capable of containing four or five persons, and from the latter the hooks hung by a chain.

The process of the penance was as follows. A devotee, having the hooks fixed in his back, as shall hereafter be described, the number of persons that were requisite to balance his weight and the lever, from his greater share of the pole, generally four or five stept into the scale at the short end of the transverse beam, and depressing it by their weight as low as the pivot would allow, to an angle of about 70°, they gave the cross beam a circular motion on the pivot by pulling themselves round the mast, which they could touch, or were pushed round by other assistants who crowded on the platform; whilst the poor penitent, dangling at the fearful height of at least twenty feet from the ground, was swung round with a rapidity scarcely describable, and the car mean while dragged forward by the multitude till the sufferer himself prayed to be released from his painful and perilous situation. The longest period I witnessed any one person endure the torture was seven minutes and a half, the generality were satisfied with two minutes. The bold and heroic went up with "sword in hand, and shield on arm," as if accoutred for action; the meeker characters held their beads in their hands, and continued repeating the names of their gods. The total number who underwent the penance was about fifty, and the time required for the car to travel from one village to the other was more than seven hours, two of which were spent within the limits of the village which closed the procession, the car at that time scarcely moving onwards a foot with each individual, in order by such slowness of advance to indulge as many as wished to offer themselves for the ceremony.

The hooks were precisely similar in shape, but rather stronger than the flesh hooks of the London markets, the points by no means particularly sharp, nor the iron polished to any remarkable brightness. No preparatory perforation of the integuments was made previously to introducing the hooks; but they were forced through, one after the other, with as much unconcern as can be imagined, the operator no more interested to be tender in the office than as if he considered the patient as accustomed to the ceremony, and as little affected by it as himself. The only care was to avoid a flesh wound; and the extent to which the integuments were disengaged from the muscles beneath, even in the youngest and stoutest persons, exceedingly surprised me. To effect this the patient was laid on the ground, and his back violently rubbed with abundance of oil; this being dried off with sand, another friction equally violent took place with soap scraped into such thin fragments as powdered and disappeared under the hand. This being again dried with sand, the operator's principal assistant, sitting on the patient's shoulders, commenced with his heels a process of kneading, jerking, and working the integuments over the loins, so as to loosen or slacken them, with a roughness of manual but completeness of success that, as I have already said, struck me with astonishment. This being done, or rather in the intervals of this process, the operator continued gathering up by little and little a fold of the integuments in his left hand, as would raise up the skin for the introduction of a seton, and when he had mastered as much as he could with his utmost exertion force up, he then shoved his hook slowly and deliberately through it, always directing the point outwards. One hook being fixed, the other was speedily introduced on the opposite side in the same manner, the operation of fixing both taking generally about three or five minutes, depending upon the muscularity of the subject. After the patient had swung to his own content he was taken down by the cross pole being lowered nearly to the ground, from the weights at the opposite end removing from the scale; then being laid flat on the ground the hooks were drawn forth, but without the least precaution to save pain. I did not observe a single instance of the skin having yielded or being rent. The appearance was invariably four wounds in a straight line, thus, *o o o o*, the two made by one hook being always four and sometimes five inches apart from each other. The curative process was simplicity itself. The principal assistant again seated himself on the patient's shoulders, and applying his heels to the wounded parts laboured to squeeze out any blood or lymph that might be extravasated. One operator sucked the wounds, and another applied a kind of dry poultice of cow-dung and turmeric, the Hindoo specific for every shock that "flesh is heir to." The sufferer's kumur-bund (girdle) supplied the bandage, which was tightly applied round his loins, and he forthwith joined in the ceremony of swinging his comrades, as alert and unconcerned to appearance, as if the whole he had undergone were but a jest. I had an opportunity of examining daily, until their perfect cure, seven of the devotees, who were our battalion sepoys or camp followers. In no one instance was pus formed, or did inflammation of any consequence whatever follow; nor did one quit his duty, or apply for hospital relief. And further, I had reports to be relied on of nearly twenty others from distant villages, whither I sent hospital servants to make inquiries after the poor people who had swung, not one of whom suffered in any important degree beyond a temporary soreness and stiffness in the loins. None but a medical man who has witnessed the process could suppose it possible that so little injury should result from so apparently serious an operation. The natives of course think it the miraculous interference of the god Cunda Row, in whose honour the torture is endured, a very natural conclusion, for even among our officers, who in great numbers attended to witness the spectacle, there were not a few whom it was difficult to impress with a satisfactory conviction that the whole was but a natural result from natural causes; and that the skill of the operator, and the antiphlegmonous habit of his own constitution, was the safeguard of the patient.

## ART. IX.—*Account of the Method of Drawing Birds employed* by J. J. AUDUBON, Esq. F. R. S. E. In a Letter to a FRIEND.

AT a very early period of my life I arrived in the United States of America, where, prompted by an innate desire to acquire a thorough knowledge of the birds of this happy country, I formed the resolution, immediately on my landing, to spend, if not all my time in that study, at least all that portion generally called leisure, and to draw each individual of its natural size and colouring.

Having studied drawing for a short while in my youth under good masters, I felt a great desire to make choice of a style more particularly adapted to the imitation of feathers than the drawings in water colours that I had been in the habit of seeing, and, moreover, to complete a collection not only valuable to the scientific class, but pleasing to every person, by adopting a different course of representation from the mere profile-like cut figures, given usually in works of that kind.

The first part of my undertaking proved for a long time truly irksome. I saw my attempt flat, and without that life that I have always thought absolutely necessary to render them distinguishable from all those priorly made; and had I not been impelled by the constant inviting sight of new and beautiful specimens which I longed to possess, I would probably have abandoned the task that I had set myself, very shortly after its commencement.

Discoveries, however, succeeded each other sufficiently rapidly to give me transient hopes, and *regularity of application* at length made me possessor of a style that I have continued to follow to this day.

Immediately after the establishment of this style, I *destroyed* and disposed of nearly all the drawings I had accumulated, (upwards of 200,) and with fresh vigour began again, having all my improvements about me.

The woods that I continually trod contained not only birds of richest feathering, but each tree, each shrub, each flower, attracted equally my curiosity and attention, and my anxiety to have all those in my portfolios introduced the thought of joining as much as possible *nature as it existed.*

I formed a plan of proceeding, with a view never to alter it very materially. I had remarked that few works contained the females or young of the different species; that in many cases, indeed, those latter had frequently been represented as different, and that such mistakes must prove extremely injurious to the advancement of science. My plan was then to form sketches in my *mind's eye*, each representing, if possible, each family as if employed in their most constant and natural avocations, and to complete those family pictures as chance might bring perfect specimens.

The knowledge I had already acquired of the habits of most of them enabled me to arrange my individuals in rough outlines, finishing probably at the time only one of the number intended to complete it, and putting the drawing thus begun aside, sometimes for *months*, and sometimes for *years*.

I knew well that closet naturalists would expect drawings exhibiting, in the old way, all those parts that are called by them *necessary characteristics;* and to content these gentlemen I have put in all my representations of groups always either parts or entire specimens, showing fully all that may be defined of those particulars.

My drawings have all been made after individuals fresh killed, mostly by myself, and put up before me by means of wires, &c. in the precise attitude represented, and copied with a closeness of *measurement* that I hope will always correspond with *nature* when brought into contact.

The many foreshortenings unavoidable in groups like these have been rendered attainable by means of squares of equal dimensions affixed both on my paper and immediately behind the subjects before me. I may thus date the *real* beginning of my *present collection*, and observations of the habits of some of these birds, as far back as 1805, not, however, continued always with the same advantages that attended me during the first ten years that I spent in America, for since then I have often been forced to put aside for a while even the thoughts of birds, or the pleasures I have felt in watching their movements, and likewise to their sweet melodies, to attend more closely to the peremptory calls of other necessary business.

The long journies that I have performed through different parts of the country have been attended with many difficulties and perplexing disappointments, some of which have several times made my mind waver whether I should or should not abandon them all for ever.

Being quite unknown amongst naturalists, I have had to depend on my own exertions alone, without either correspondents or friends. I have followed slowly to be sure, but constantly my object. I have often listened to the different observations of men who accidentally had made remarks on different species of birds, but seldom, except when with the rough hunters and squaters of the frontiers, have I discovered naked facts in such relations. This has dissuaded me from ever taking any account given me for granted, until corroborated either by my own ocular opportunities or accumulated repetitions. The astonishing tendency that men have to *improve nature in* *their way*, by embellishing each of their descriptions of habits without any farther object in view than that of entertaining the better their hearers, has frequently deterred me from listening at all to such accounts, and has brought my physical system to a solitary state of habits and manners so different from those that usually accompany men, that frequently I feel uneasy, as well as awkward, if more than one or two companions are about me. To the improvement of my observations I have found this no detriment. On the contrary, I am persuaded that alone in the woods, or at my work, I can make better use of the whole of myself than in any other situation, and that thereby I have lost nothing in exchanging the pleasure of studying *men* for that of admiring the feathered race.

Pursuers of natural curiosities are extremely abundant in our age. New, quite unknown subjects are those the most sought for. The dried skin of an exotic specimen, of which the *colour* has not been described minutely, draws all attention, whilst the *habits* of that same specimen are scarcely inquired after, and those of individuals more interesting, being nearer and more easily obtained, are abandoned, and the pleasure, as well as the profit that might be derived from a complete study of their manners, and faculties, and worth, are set aside. I must acknowledge to you that that kind of curiosity has not animated me half so much as the desire of first knowing well all those commonly about me,—a task that in itself I discovered to be extremely difficult, but through which I found the means of at least drawing valuable deductions.

I have *never* drawn from a stuffed specimen. My reason for this has been, that I discovered when in museums, where large collections of that kind are to be met with, that the persons *generally* employed for the purpose of mounting them possessed no further talents than that of filling the skins, until *plumply formed*, and adorning them with eyes and legs generally from their own fancy. Those persons, on inquiry, knew nothing of the anatomy of the subject before them; seldom the true *length* of the whole, or the *junction* either of the wings and legs with the body; nothing of their *gaits* and *allurements*; and not once in a hundred times was the bird in a natural position.

I would not from this have you conclude that museums and collections of stuffed specimens are entirely useless. On the contrary, I think them extremely well fitted to enhance (in youths particularly) the desire of examining afterwards the same subjects at large in all their beauty, the only means of detecting errors. But in forming works entirely with a view to distinguish the true from the false, nature *must* be seen first alive, and well studied, before attempts are made at representing it. Take such advantages away from the naturalist, who ought to be artist also, and he fails as completely as Raphael himself must have done, had he not fed his pencil with all belonging to a mind perfectly imbued with a knowledge of real forms, muscles, bones, movements, and, lastly, that spiritual expression of feelings that paintings like his exhibit so beautifully.

Among the naturalists of the time, several who are distinguished have said that representations of subjects ought to be entirely devoid of shades in all their parts; that the colouring of the figure, that must be precisely profile, cannot be understood by the student if differently represented. Why then should the best artists of the same age give us pictures with powerful breadth of lights and shades? and why, still more strange, should every individual who looks on such paintings feel not only pleased, but elevated at the grand conception of the painter, and at the nobleness of the subjects being so much like through their effect? My opinion is, that he who cannot conceive and determine the *natural* colouring of a shaded part, need not study either natural history or any thing else connected with it.

If I have joined to many of my drawings plants, insects, reptiles, or views, it has been with the hope to render them all more attractive to the generality of observers; and as I can assure you that all these were copied with the same exactness with which all the birds are represented, you will no doubt view them with as much pleasure.

Do not be surprised at finding that I have trampled upon many deeply-rooted prejudices and opinions attached to the habits of several individuals by men who had only heard and not seen. My wish to impart truths has been my guide in every instance;—all the observations respecting them are my own.

All the authors who have formed works of natural history have attached to the representation of each species a minute description of all their parts. This was done probably because the subjects were never or very seldom offered to view of their natural size; or perhaps, indeed, because these very authors were well aware of the want of accuracy in those figures, seldom drawn by themselves. In my work I wish to curtail these extremely tiresome descriptions; more anxious that those who study ornithology should compare at once my figures with the living specimen, than with a description so easily made to correspond with the drawings by any person who merely knows the technical appellations of each part and feathers, with the name of the colours chosen by authors for that purpose.

I shall neither describe the eggs of the species that I have procured nor the number. A glance at the drawings will answer the more readily, as you will see classed under each the date of the season, and the average number deposited by each bird when ready for incubation. Not so with the nests. I would wish to see these so well described *en masse*, that the young naturalists, when in the woods, would be able to know the artist by his work. This is often a difficult task, the more with those species who will oftentimes form their nests *differently*, and of *different materials*, according to localities and climate, and those that oftentimes take possession of that of quite another species.

If the greater number of figures given in a work are received as perfectly correct in all their parts, by comparing them with good specimens, and through such an examination the author is greeted with public confidence, why should the reader be tormented with descriptions? Where is the amateur of paintings who could bear the reading of a description of the structure, muscles, and expression of the face of such a man as Rembrandt, after gazing at the portrait of that eminent artist by himself? The study of ornithology must be a journey of pleasure. Each step must present to the traveller's view objects that are eminently interesting, varied in their appearance, and attracting to such a degree, as to excite in each individual thus happily employed the desire of knowing all respecting all he sees.

I would have liked to raise an everlasting monument, commemorating with a grand effect the history and portraits of the birds of America, by adding to each drawing of a single species a vignette exhibiting corresponding parts of the country where the specimen is most plentifully found; but having no taste for landscape-painting, and unable to employ a competent assistant for such a purpose, I with deep regret have relinquished the idea. I mention this to you, my dear friend, with hopes that at some future period some one better seconded by pecuniary means or talents may still engage in the undértaking. Sorry, notwithstanding, that as time flies Nature loses its primitiveness, and that pictures drawn in ten, or twenty, or more years, will no longer illustrate our delightful America pure from the hands of its Creator!

## ART. X.—*Account of the Cave of Booban, near Punduah, in the Cossyah Mountains.*

In perusing a number of the *Calcutta Journal* published some years ago, we were particularly struck with the description of a remarkable cavern in the Cossyah Mountains, written by M. Duvaucel, a Frenchman. We were desirous of transferring to our pages that account of so remarkable an object; but we were deterred from doing this by the dread of imposing upon our readers for truth what might turn out to be an entire fiction. We accordingly wrote to a correspondent in India, to whom this Journal is under many obligations, to ascertain if there was such a cave, and if possible to obtain a description of it. We have been accordingly favoured with the following materials.

Captain Fisher, surveyor of Sylhet, accompanied by Major Watson, Captain Wildman, and Mr Sullivan, went to explore the cave. They took with them two miles length of twine, and fastened one end at the mouth of the cave, in order to measure the distance to which they penetrated. The following description of it was drawn up by the learned editor of the Calcutta Government Gazette, from materials furnished by Captain Fisher.

The cavern of Booban is situated in one of the lower ranges of the Cossyah Mountains, at the distance of about three hours' walk, in a north-east direction from the Bazaar of Punduah, and at an elevation, probably of six hundred feet above the adjacent plains. The access to it is by no means difficult, though the passage of three hills, which occur in the last hour's journey towards it is fatiguing, as the ascents, though short, are singularly steep, one of them actually subtending an angle of 46°. These hills are composed of sandstone, but their bases are strewed with fragments of various rocks, chiefly granite and limestone, apparently the debris from the higher regions of the mountain chain. The mouth of the cavern, which is found in the face of a limestone mountain, is not in itself remarkable, neither do any external circumstances indicate the existence of the vast hollows to which it affords access. The aperture is small, its dimensions precluding the intrusion of more than one person at a time, and the entrance is completed by a scrambling descent of about thirty feet over masses of rock to a comparatively level space, which, however, is involved in total darkness. By the aid of lighted torches it may be here seen that the cavern has already expanded considerably, and that its sides are covered with numerous stalactites, crystals, and petrifactions, all, however, of the limestone family, of which rock alone the cavern is entirely formed. The passage here is about twelve to fifteen feet in width, and the height varies from about twenty to forty feet, estimated from the base to the highest part of the naturally arched roof. In advancing, this latter dimension of the cavern is found to vary greatly, sometimes increasing to seventy or eighty feet, and at others diminishing to ten or twelve. The breadth, however, continues nearly uniform. These remarks apply solely to the branch which appears to have been always followed by the few Europeans who have visited the cavern, and which has been explored from the entrance to the distance of about a mile, where a steep and wide cavity fills up the whole breadth of the passage, and presents an obstacle to further ingress, which, owing either to want of time or proper conveniences, no one has yet surmounted.

When the party had run out one mile of the rope they were stopped by this cavity, which resembled the interior of a cathedral. About fifty yards from this all farther passage was prevented by a chasm about forty feet deep, which it was impossible to descend without a ladder, so that the party was obliged to return.

The general direction of the branch which was now visited is north-east, a course from which may be inferred the probable existence of a debouche in the opposite face of the mountain, an inference which is strengthened by the fact, that a cold blast of air is sensibly felt in most parts of the cavern. Perhaps the most remarkable appearances which offer themselves to notice in an examination, however cursory, of this curious phenomenon, are the numerous fissures or openings, which occur at various altitudes in the sides, and which seem to form the entrances of new branches or ramifications, by which the mountain should appear to be perforated in every direction.

A few days after Captain Fisher and his party returned, Mr Ellis, accompanied by Mr Wardlaw and Lieutenant White, visited this cave, and passed two days in it. They slept in it, and examined the different courses, but they could not advance so far in any of them as in the one which led to the chasm.

## ART. XI.—*Account of the Fossil Bones discovered on the left bank of the Irawadi in Ava.* *

THE collection of fossil bones brought from Ava by Mr Crawford is very large, and consists of fossil bones, fossil shells, and fossil wood.

Of the fossil bones the most numerous and remarkable are those of an animal about the size of a large elephant. In the sketch given in your paper of the late mission to Ava these are stated to be the bones of the mammoth. This is a mistake. The mammoth is an extinct species of the elephant, differing from the two living species, the African and Indian. The remains of this animal have only been found in Europe, and chiefly in Siberia. The Burman fossil bones are unquestionably those of the mastodon, as may be clearly seen by com-

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* From the *Calcutta Government Gazette,* March 21, 1827. See page 19.

paring, as I have done, the grinders with those of the Indian elephant, as well as the accurate descriptions and representations of both in the work of Cuvier. In the different species of elephants the crown of the molares or grinders is marked by superficial transverse bands. In the mastodon the form is widely different, the crown being marked by deep transverse furrows and ridges, the latter divided into two or more obtuse pyramidal points or mamillæ. It was this singular appearance which made the mastodon a long time be considered erroneously as a carnivorous animal. Five species of the genus mastodon are supposed by Cuvier to have been discovered, and I imagine the bones now under consideration will be found to constitute a sixth species, for the molares, on which he principally rests for his specific distinctions, differ very materially from the representations which he has given of the ascertained species. The mastodon of Ava, if it be a distinct species, will be found equal in size to the great mastodon of Ohio, which is reckoned to be equal in size to the Indian elephant. A grinder which I examined measures in circumference between sixteen and seventeen inches, and the circumference of a *humerus* round the condyles is not less than twenty-five inches. Several of the grinders and bones, however, apparently of an animal of the same species, are much smaller than these, but this is probably on account of their belonging to younger individuals. I need hardly observe that our mastodon, like others of the same genus, and all the species of the elephant, had tusks. Several fragments of these, but no entire tusks, are contained in the collection.

The next most remarkable remains of the collections after those of the mastodon are those of the fossil rhinoceros. There are several molares of an animal of this genus in the collection. Cuvier describes four species of the fossil rhinoceros to have been ascertained, all differing from the living species. The bones now found bear a striking resemblance to one of the species represented by Cuvier, but the molares are considerably larger than any of those which he has represented.

The collection seems to me to afford evidence of the existence of two other animals of the same family with the elephant, mastodon, and rhinoceros, at least teeth which I have seen in it exactly resemble two species of a genus represented in the work of Cuvier, and to which he gives the name of *Anthracotherium.*

The other teeth of quadrupeds which exist, and which I am able to recognize, are those of an animal of the horse kind, and those of an animal of the ruminant family, apparently of the size of the buffalo. There are of course a great many bones which I have not the skill to determine.

Among the remains are numerous specimens of those of a crocodile, which I conjecture to resemble the long-nosed alligator of the Ganges, the native name of which has been corrupted by naturalists into *Gavial.* It is singular that this description of alligator, as far as we know, is not at present found in the rivers of Ava.

In the same situation with the bones were found considerable quantities of fossil shells. Some of these were filled with blue clay, but far the greater number with hard siliceous matter. The shells which I have seen are of the genus Turbo and genus Tellina, and the productions of fresh water, although they do not, at the same time, resemble the present shells of the lakes and rivers of the neighbourhood.

The fossil wood is found in the same situation with the bones and shells. This is in vast quantity, the hills and ravines being strewed with blocks and fragments of various sizes, some of them five and six feet in circumference.

The fossil remains now sketched are found on the left bank of Irawadi, and within four and six miles inland from the river, between the 20th and 21st degrees of north latitude, and close to the celebrated wells of Petroleum. The aspect of the country is very remarkable. It is composed of sand-hills and narrow ravines, very sterile, and for a tropical country very deficient in vegetation. Among the sand there are beds of gravel, with ironstone and calcareous breccia. The whole is evidently a diluvial formation. The few scattered trees which exist in this tract consist of some Acacias, a Celtis, a Rhus, a Barringtonia, a Zizyphus, and some Indian fig-trees. To say whether or not the fossil timber found belong to the same species as these would be a matter of difficulty; but, upon the whole, it may be said, that the blocks appear too large to warrant a belief that it does.

The fossil bones, as well as the shells and wood, are all found superficially, or rather indeed upon the surface, for all of them were more or less exposed. Notwithstanding this exposure they have suffered very little decomposition. They are not rolled or suffered from attrition, for their sharp edges and processes are preserved with great distinctness, the inference from which is, that the individuals to whom they belonged died, or were destroyed on the spot on which they are now found. In one respect the bones differ essentially from all fossil bones of which I have heard. They are complete petrifactions, and all of them more or less deeply coloured with iron. Their substance is siliceous, and some of them are so hard as to strike fire with steel. This no doubt accounts in a good measure for their perfect state of preservation.

The wild quadrupeds of the neighbourhood at present are a leopard, a cat, a deer, and the hog. The bones of these do not seem to exist among the fossil remains, nor is there any evidence of those of the elephant, or of any carnivorous animal. As amongst similar remains in other parts of the world, not a vestige is to be discovered here of the human skeleton.

I need hardly attempt the refutation of the idle notion which has been entertained by many, that the fossil remains found on the banks of the Irawadi have been generated by a petrifying quality in the waters of that river. Abundance of organic matter may be seen on the shores of the Irawadi, both animal and vegetable, undergoing the common process of decomposition as elsewhere. There can, I think, be no doubt that the fossil bones, shells, and wood, are here, as similar remains are admitted to be elsewhere, all the result of the last, or one of the last, great catastrophes which changed the face of the present globe. They are in fact the remains of a former state of our world, when the greater number of the present races of animals had no existence, and above all, before man was called into existence.

The collection is altogether both extensive and curious, and the more worthy of attention, since it is, as far as I am aware, the first of any moment that has ever been discovered in the

East. I shall be anxious to hear that it falls into the hands of those who are capable of appreciating and examining it.

We have been promised a selection from these bones for the museum of the Royal Society of Edinburgh, and we may therefore have an opportunity of resuming this curious subject.

## ART. XII.—*On the Mean Temperature of the Equator, as deduced from Observations made at Prince of Wales's Island, Singapore, and Malacca.* By DAVID BREWSTER, LL. D. F. R. S. Lond. and Sec. R. S. Ed.

I HAVE already had occasion to treat of the subject of the temperature of the equator in consequence of Mr Atkinson's attempt to controvert the deductions of Baron Humboldt, which I had used as the data for my climateric formulæ, and to fix the tropical heat at a much higher degree than had been done by any preceding author.

From observations made at various places in Ceylon and Batavia, I was led to conclude that the mean temperature of the equator did not exceed 80½°.[*] Since that time I have taken measures to obtain observations made still nearer the equator, and I have been in expectation of receiving them through the kindness of a correspondent in India, whose zeal for the promotion of science is unbounded.

I observe, however, in the last part of the *Transactions of the Royal Asiatic Society*[†] a series of meteorological obser-

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[*] See this *Journal*, No. xi. p. 117—120. In the same Number, p. 136, we have given an abstract of Baron Humboldt's own able defence of his deductions.

[†] We earnestly hope that Mr Colebrooke, the distinguished director of this flourishing institution, will use the influence which he possesses in recommending the establishment of meteorological registers in different parts of India, and in collecting and publishing in the *Transactions of the Asiatic Society* the various meteorological observations which are made throughout our extensive dominions in the East, especially those made near the equator. The council of the Asiatic Society of Calcutta have, we observe, taken up this subject, and we expect much from the enlightened zeal of its members. As the subject of climate is so intimately connected with the diseases of the human frame, we take the liberty of

vations made at Prince of Wales's Island, within 5° of the equator, and at Singapore and Malacca, within 1° and 2° of it, and as these are the very points where observations have been most wanted, I have endeavoured to deduce from them the mean temperature of these places, and thus to determine the mean heat of the equator itself. This element is one of the most important in meteorology. It is not only necessary for ascertaining the law of the distribution of heat in different latitudes; but, by its accurate determination in different meridians, we may expect to throw light on that curious speculation, in which a connection is supposed to exist between the distribution of heat and the distribution of the magnetic influence over the globe. We shall begin with the observations at Singapore, as being made nearest to the equator.

### 1. SINGAPORE.

North latitude 1° 24′. East long. 104°.

The observations at Singapore were made with instruments kept under a thatched bungaloo by Lieutenant-Colonel William Farquhar. They were made at six in the morning, at noon, and at six in the evening.

| | | 1822. |
|---|---|---|
| Mean annual temperature at 6h and 6h, | - | 79° 45 |
| ———————— 12h noon, | - | 84 0 |

In order to deduce the mean daily temperature from these observations we shall make use of the corrections deduced from the hourly observations made at Leith Fort for 1824 and 1825. The mean daily temperature, for example, ex-

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suggesting to the Medico-Physical Society of Calcutta the propriety of taking it under their patronage, and of thus adding greatly to the already high interest which their memoirs possess.

It would be of the greatest importance to meteorology if a set of *hourly meteorological observations* could be instituted at Calcutta, Bombay, Madras, Singapore, Malacca, and some station on the elevated plains of Hindostan. What we have been able to accomplish at Leith, and to continue for four years, and what has been accomplished more recently at Christiania and Drontheim by Professor Hansteen, may surely be easily executed under the genial sky of the East, and by means of the wealth and leisure which there abound.

ceeds that of 6ʰ A. M., and 6ʰ P. M. by 0° 29, and is less than that of noon by 2° 51. Hence we have

| | |
|---|---|
| Mean daily temperature deduced from that of 6ʰ and 6ʰ, - - | 79° 74 |
| ——————————— 12 noon, | 81 49 |
| Mean of the two, | 80° 47 |

As the corrections now applied belong to a northern climate, marked with the vicissitudes of summer and winter, they cannot be strictly applicable to tropical regions, where the variations in the monthly temperature are so exceedingly small. We have therefore deduced the corrections from the hourly temperatures of the three summer months, during which the variations of the daily curve must have a greater resemblance to those of the torid zone. These corrections, though different from those used above, produce, as will be seen presently, very little difference in the mean results. These corrections are —3.08 and —3.00, and they give.

| | |
|---|---|
| Mean daily temp. deduced from 6ʰ and 6ʰ . | 79° 37 |
| ——————————— 12 noon, | 81 80 |
| Mean of both, | 80° 18 |
| Hence the mean annual temperature of Singapore for 1822 was - - - - | 80° 18 |

1823.

| | |
|---|---|
| Mean annual temperature of 6ʰ and 6ʰ - | 79° 0 |
| ——————————— 12 noon, | 83 7 |

By applying the same corrections as before, viz. those deduced from the summer months, we have

| | |
|---|---|
| Mean daily temp. deduced from 6ʰ and 6ʰ - | 78° 92 |
| ——————————— 12 - | 80 70 |
| Mean of both, | 79° 81 |
| Hence the observed mean annual temperature of Singapore for 1823 was - - | 79° 81 |
| And the observed mean annual temperature of 1822 and 1823, - - - - | 80 00 |

Mean annual temp. calculated from my formula
of T = 81° 8 sin. D + 1, - - 81° 36

Difference, 1° 36

## 2. MALACCA.

North latitude 2° 16′. East longitude 102° 12′.

The observations at Malacca were made in 1809 by Lieutenant-Colonel William Farquhar, and the instrument was kept within the Old Government House.

Mean annual temperature at 8ʰ - - 77° 67
———————— 4 - - 82 33

The corrections deduced from the Leith observations are + 1° 24 and — 2° 97, which gives

Mean daily temperature deduced from 8ʰ - 78° 91
———————— 4ʰ - 79 36

Mean of both, 79° 18

But by applying the corrections deduced from the summer months only, viz. + 1° 24′ and — 3° 95′, we have

Mean daily temperature deduced from 8ʰ - 78° 91
———————— 4ʰ - 78 38

Mean of both, 78° 65

Hence the observed mean annual temperature
for Malacca for 1809 is - - - 78° 65

Do. calculated from my formula T = 81° 8 sin.
D + 1, - - - - - - - 81 02

Difference, 2° 39

## 3. PRINCE OF WALES'S ISLAND.

North latitude 5° 25′. East longitude 100° 19′.

The observations at Prince of Wales's Island were made for 1815, 1816, 1820, 1821, and for 1823. They were taken in George Town, and those for the two latter years were made in the Library. We have also a set made on Government

Hill, but as we do not know the height of this station we cannot use them in the present inquiry.

1815-16.

The observations for this year extend from June 1815 to July 1816. They were made at intervals of three hours, viz. at $6^h$, $12^h$, 3, and $9^h$ P. M.

| | |
|---|---|
| Mean temperature at $6^h$ A. M. | 76° 1 |
| ———— 12 noon, | 79 6 |
| ———— 3 P. M. | 81 5 |
| ———— 9 P. M. | 79 1 |

The corrections for these hours deduced from the observations at Leith are + 2° 61 ; — 2° 5 ; — 3° 20 ; — 0° 43. Hence we have

| | |
|---|---|
| Mean daily temperature deduced from $6^h$ | 78° 7 |
| ———— 12 | 77 1 |
| ———— 3 | 78 2 |
| ———— 9 | 78 7 |
| Mean of the four, | 78° 2 |

But by applying the corrections taken from the summer months, viz. + 3° 5 ; — 2° 9 ; — 3° 9 ; + 0° 7, we have

| | |
|---|---|
| Mean daily temperature deduced from $6^h$ | 79° 6 |
| ———— 12 | 76 7 |
| ———— 3 | 77 6 |
| ———— 9 | 79 8 |
| Mean of these, | 78° 4 |
| Hence the mean annual temperature of Prince of Wales's Island for 1815-16 is | 78° 4 |

———— 1820-21.

The observations for this year were made at $7^h$ A. M. 12 noon, and 4 P. M., and the results were,

| | |
|---|---|
| Mean annual temperature at $7^h$ | 77° 8 |
| ———— 12 | 81 6 |
| ———— 4 | 83 1 |

The corrections for these hours deduced from the observations at Leith, are + 1° 98; + 2° 51; + 2° 972. Hence we have

| | | |
|---|---|---|
| Mean daily temperature deduced from $7^h$ | - | 79° 8 |
| ——————————— 12 | - | 79 1 |
| ——————————— 4 | - | 80 1 |
| Mean of these, | | 79° 67 |

But by applying the corrections taken from the summer months, viz. + 2°.46 ; — 3°.03 — 4.24 we have

| | | |
|---|---|---|
| Mean daily temperature deduced from $7^h$ | - | 80° 3 |
| ——————————— 12 | - | 78 6 |
| ——————————— 4 | - | 78 9 |
| Mean of these, | | 79° 26 |

Hence the mean annual temperature for 1820–1 is 79° 26

### 1823.

The observations were made only on the first eleven months of this year, and were recorded at $8^h$, $12^h$, and $4^h$.

The results are as follows:

| | | | |
|---|---|---|---|
| Mean temperature at $8^h$ | - | - | 78° 85 |
| ————————— 12 | - | - | 82 90 |
| ————————— 4 | - | - | 83 89 |

The corrections for these hours deduced from the Leith observations are + 1°.24 ; — 2°.51 ; — 2°.97, and we have,

| | | |
|---|---|---|
| Mean temperature deduced from $8^h$ | - | 80° 09 |
| ——————————— 12 | - | 80 39 |
| ——————————— 4 | - | 80 92 |
| Mean of these, | | 80° 47 |

But by applying the corrections taken from the summer months, viz. + 1°.25 ; — 3°.03 ; — 4°.24, we have,

| | | |
|---|---|---|
| Mean temperature deduced from $8^h$ | - | 80° 10 |
| ——————————— 12 | - | 79 87 |
| ——————————— 4 | - | 79 65 |
| Mean of these, | | 79° 87 |

| | |
|---|---|
| Hence the mean annual temperature for 1823 is | 79°.87 |
| We therefore have | |
| Mean annual temperature for 1815–16 - | 78° 4 |
| ——————————— 1820–21 - | 79 26 |
| ——————————— 1823 - | 79 87 |
| Mean of these, | 79° 18 |
| Observed mean annual temperature of Prince of Wales's Island from three years observation. | |
| Do. calculated by my formula of $T = 81^{\circ}.8$ sin. $D + 1$ - - - | 79 93 |
| Difference, | 0° 75 |

From these calculations it appears that the mean temperature of three different points of the Malay Peninsula is *lower* than that which is deduced from formulæ founded upon Humboldt's estimate of the equatorial temperature. As we do not know the altitude of the places of observation, a slight increase must be made in reducing them to the level of the sea; but this is too small to alter in any way the general conclusion which the observations authorize.

If we now deduce from the same observations the mean temperature of the equator by means of the formula.

Equatorial temperature $= \frac{T}{\text{cos. lat.}}$ we shall have

| | |
|---|---|
| Mean temp. of equator from Singapore observations | 80° 03 |
| ——————————— Malacca do. - | 78 71 |
| ——————————— Prince of Wales do. | 79 53 |
| Mean temperature of the equator, | 79° 42 |

Hence it follows that the mean equatorial temperature is considerably less when deduced from the observations made in the Malay Peninsula, than when it is deduced from the observations in Ceylon, Batavia, and Hawai, as the following table shows.

| | | No. of sets of observation. | |
|---|---|---|---|
| Mean temp. eq. from Ceylon observation | | 5 | 80° 66 |
| ——————— Batavia | do. | 4 | 81 08 |
| ——————— Hawai | do. | 1 | 79 67 |
| ——————— Malay Peninsula | do. | 3 | 79 42 |
| The mean of which, taking into account the number of observations in each set, is | | - | 80° 44 |

We may therefore safely conclude from these results, that in fixing the mean temperature of the equator at 81½°, Baron Humboldt has exhibited that sagacity which characterizes all his researches; and that the climateric formulæ in which we have adopted his determination represent better than any other the great mass of observations which have been made in the different parts of the globe. Even if the observations at Pondicherry * were made with care, and at those times of the day which give the mean daily temperature, it would be unphilosophical to regard such a solitary example of high temperature as affecting, in the slightest degree, general results deduced from numerous observations, made at various and distant points of the equinoctial zone.

## Art. XIII.—*A Metallurgic Memoir on the Nature and History of the Argillaceous Carbonate of Iron.* By Hugh Colquhoun, M. D. Communicated by the Author. (Continued from vol. vii. p. 242.)

These are the general mineralogical features which distinguish the ironstone. We shall now proceed to divide the subspecies into its principal varieties.

1. *Common Compact Argillaceous Carbonate of Iron.* This is the general type of the species, and, as such, the extreme variations of which it is susceptible in colour, fracture, texture, and hardness, have been already noticed. It is sometimes so much impregnated with bituminous matter, that its external

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* Its mean temperature is stated at 85°.28′.

appearance assumes the resemblance of bituminous schist, and, occasionally, even of certain coals.

2. *Nodular or Reniform Ironstone.* The characteristic of this variety is its occurrence in detached, subglobular, or irregularly shaped masses. A considerable variation is found to prevail among the different specimens in this class. Thus the structure, which is generally uniform and compact, is sometimes changed to concentric lamellæ, especially when the external surface has undergone decomposition. Sometimes, also, the nodules, instead of being solid throughout, contain a cavity in the centre. This cavity is occasionally empty, at other times it contains some extraneous body. In most cases, this enclosed matter consists of crystallized carbonate of lime. It is sometimes abundant enough to fill the entire hollow, though generally it merely occupies it partially, in the form of a regular geode, shooting out at the same time in thin veins towards the exterior surface of the nodule. A specimen of this description formerly received the name of *septarium*, or *ludus Helmontii.* In other instances, which are of much rarer occurrence, the cavity includes a quantity of the ironstone itself either in the state of a powder or in the form of a detached and solid ball. When the latter case occurs, and the entire nodule is shaken in the hand, a rattling sound is heard to proceed from the interior, and it was on listening to this property of a somewhat rare variety of ironstone, that the ancients considered it to be a quality sufficiently unusual and unaccountable, to justify the idea that the stone itself possessed some excelling and peculiar virtue. They accordingly held it to be an amulet of great value, and esteemed it a sovereign preservative, and remedy against diseases. It received the name of *ætites* or *eaglestone*, from a belief that the eagles transported it to their nests.

3. *Columnar or Concretionary Ironstone.* The occurrence of this variety of the ore is rather uncommon. It consists of columns which are aggregated together, and lie in a direction parallel to each other. These concretions are sometimes connected by a thin crust of carbonate of lime, but at other times they appear to be aggregated together without any extraneous

cement, in the same manner as the columns which compose a mass of starch.

4. *Oolitic, Lenticular, or Granular Ironstone.* The characteristic of this variety, (which is found chiefly imbedded in schist,) consists in its being formed of an aggregation of rounded particles of the mineral, generally held together by the interposition of some extraneous cement. Several remarkable specimens of this variety have been described by the French chemists, one or two of which deserve to be particularly noticed. In the *Annales des Mines*, vol. iv. p. 355 and 633, M. Berthier has described two sorts of granular ironstone. The first was found at Anzin (département du Nord,) associated with coal, and was composed of globular grains of the size of small peas, agglutinated together by a bituminous schist. The second was obtained from the vicinity of the village of Pourain, in the department of Yonne, and was remarkable for its occurrence in a tertiary formation where it seemed to be contemporary with potter's clay. This sort was found in roundish masses of various sizes, some of them very large, irregularly distributed through a ferruginous sandy clay, situated in the neighbourhood of a bed of ochre. The globules were weakly cemented together by a thin incrustation of grey coloured clay, which quickly softened when immersed in water. Another remarkable specimen, in which the grains were found to be strongly bound together by bitumen, is described by MM. Combes and Lorieux.[*] It was taken from a pretty thick bed, in the immediate vicinity of a stratum of coal at Lasalle (Aveyron.) The grains were of a greyish colour, which strongly contrasted with the dark hue of the cement. The composition of the ore was rather remarkable, and as it differs materially from any of the analyses of the British specimens which have been given in an earlier part of this treatise, we shall take this opportunity of mentioning it here. The principal constituent was carbonate of protoxide of iron (in the proportion of 62 per cent.) mixed with small quantities of the carbonates of lime and magnesia, and with not less than 17 per cent. of bitumen and water, and 11½ per cent. of sul-

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[*] *Annales des Mines*, viii. 631.

phuret of iron. Massive pyrites occurred abundantly in the neighbouring beds, but that which existed in the mineral was in a state of such extreme division, that it could not be observed even with the aid of a magnifying glass.

5. The last distinct variety of the ore may be made to include all the minute varieties of external form, which are the result of the contact of some organized body, as a fish, a shell, a vegetable. All these are not uncommonly met with. M. Berthier has given a particular description of a specimen of this kind, which affected the form of trunks of trees. It was found in a district (département du Cantal) belonging to an alluvial formation.[*]

It is worthy of remark that in every specimen of this ore, the partial decomposition of the carbonated protoxide of iron, (a process of frequent occurrence,) has the effect of introducing into the composition of the mineral a mixture of the peroxide of iron or of the hydrated peroxide, according to circumstances. The hydrate thus formed is occasionally met with, prevailing over a considerable tract of country. It is always found to retain the form of the original carbonate, whether that had existed in the shape of bands, nodules, or otherwise. In general it possesses most of the characters of common iron ochre: but, as the transformation of the carbonated protoxide into the hydrated peroxide does not seem to occasion any sensible diminution of the bulk of the ore, it is of lighter specific gravity than the genuine hœmatites.[†] The infiltration of water, acting in a slow and imperceptible manner, seems to be the cause which produces this decomposed form of the ore.

There are many localities, however, where the hydrated peroxide of iron is never observed, but where, on the contrary, it is an extremely frequent occurrence to find a portion of a stratum converted into the simple peroxide. We possess the strongest reason for believing that the decomposition of the ore, on all such occasions, has been effected through the agency of *heat*. Whenever the stratum of ore is observed to have

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[*] *Journal des Mines,* xxvii. 477.

[†] Berthier, *Sur les mineraux de fer, appelés mines douces. Ann. des Mines,* ix. 825.

undergone this alteration, it is very generally found to have come into the vicinity of *whinstone.* And the individual characters of this rock, as well as its geological relations to the strata in which it occasionally makes its appearance, conspire to prove that it has been forced up from beneath in a state of igneous liquefaction, among the minerals which compose the coal formations at some period subsequent to their consolidation, and that it has, of course, induced more or less alteration upon them, in proportion to their comparative liability to suffer decomposition from the application of heat. The colour of the ironstone thus altered depends both on the extent to which the decomposition had proceeded, and on the nature of the extraneous ingredients which it happened to contain: it varies from red to purple and reddish black.

The five subdivisions above described seem to mark the leading varieties which occur in the ironstone. The next point of view in which we have proposed to regard it is its geological character. In this part of the subject we shall confine ourselves to giving a rapid and general delineation of the most prominent features of its history.

One of the most striking geological peculiarities of the argillaceous carbonate of iron, is its almost universal occurrence in the immediate vicinity of a stratum of coal. How important this circumstance is to the manufacture of iron, we shall notice afterwards in speaking of the smelting of the ore, but at present we shall only remark that so invariable a connexion appears to subsist between the two minerals, that the discovery of the one in any situation, is the surest proof which can be obtained of the near vicinity of the other. In those immense isolated basins, the independent coal formations, which are found scattered throughout Britain, and many parts of the continent of Europe, the argillaceous carbonate of iron is always found to constitute a component mineral. It belongs therefore to that portion of the crust of the earth which has been distinguished by the appellation of secondary. There are some continental mineralogists, indeed, who state that it has also been found occasionally associated with minerals of the transition series; but if the fact be so, at least no instance of it appears to have yet been met with in this country.

In many respects the geological habitudes of this ore are very analogous with those of the other minerals of which the coal basins are composed: they are distinguished however by some peculiarities of their own. Thus the ore generally occurs in regular strata, more considerable in point of number than extent. In ordinary cases, the strata dip from the directly horizontal position, with a declination varying from one yard in four, to one in ten. But there is no particular angle of inclination to which they are limited. They are sometimes found lying quite horizontal, and, on other occasions, where the formation has undergone some violent convulsion, they suddenly rise up in a direction which is nearly vertical. Faults or dykes also occasionally make their appearance in the strata of ironstone, as in the other strata which compose the independent basin, and these, without their occurrence being always referable to any adequate apparent cause, have the effect of abruptly breaking the continuity of the bed of ore, and of either elevating or depressing the whole succession of strata, however they may be composed, on one side of the break, for several hundred yards out of their natural course. In this manner these dykes completely disjoin what seems formerly to have been connected, and severely perplex the miner whose operations are often thereby brought to a sudden and unexpected pause.*

It seldom happens that a single stratum of the ore is discovered by itself, and apart from all connexion with other beds of ironstone. On the contrary, the strata which occur together are often very numerous, varying from about ten to thirty or forty, in the same tract of country, but all of them differing both in the chemical and mechanical constitution of the ores

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* It may be observed that the manner in which the miners use the term *dyke* is not strictly accurate, for they apply it indiscriminately to every disturbance which takes place in the equable and progressive extension of strata. In its correct application, however, the term is nearly synonymous with *vein*, and denotes a vertical fissure which is filled up with some foreign mineral. An abrupt elevation or depression of strata, unaccompanied by the interposition of any extraneous body, is, properly speaking, a *slip*. The very common occurrence of faults compounded of the *slip* and *dyke* has probably been the cause of these two terms being so frequently confounded.

themselves, and also in the nature, extent, and relative position of the beds of other minerals which are contiguous to them. Sometimes the several strata of ore have a considerable number of layers of argillaceous schist, as slate-clay, clay-slate, bituminous schale, &c., or coal, or limestone interposed in every variety of arrangement between them; and more rarely there are found to be beds of marle, sandstone, indurated clay, &c., which similarly alternate with these strata of ore, and with each other. But it does not always happen that two strata of the ore are separated by any number of interposed minerals, or that they are situated at any distance whatever from each other in the coal formation. They are often found lying the one superimposed immediately upon the other, and yet each completely distinct in its properties and composition. It is indeed impossible to discover any general principle of arrangement as prevailing among the various strata which compose the coal basin.

In so far as we have hitherto examined, the general geological character of the iron-ore is completely analogous to that of the other minerals composing the coal formation. There is, however, one very decided and anomalous peculiarity of occasional occurrence, which distinguishes it from all the others. It is not always met with in the shape of a continuous stratified mass, as the schist, the coal, the limestone occur in their respective beds; but on the contrary, it is very frequently distributed in distinct, independent nodules which are found imbedded, in very different degrees of abundance, in some other mineral. It sometimes happens that these nodules lie in a horizontal position, and at regular distances from one another, forming, in fact, a regular stratum, which is excavated as eagerly by the ironsmelter as the ordinary uninterrupted strata. More frequently, however, they are disseminated in the most promiscuous manner throughout the whole extent of the stratum in which they exist imbedded, and are found abundantly in some parts of the stratum, while in others not far distant, they are altogether wanting. A regular stratification of nodules is termed *a line of balls* by the miners; when irregularly diffused, they are called *flying balls* or *lunkers.* The former seem to occur exclusively in argillaceous schist, the latter, for the most part also make their appearance in schist, but they are occasionally found imbedded in other minerals, such as indurated clay, limestone and coal. * A continuous stratum of the ore is termed a *band of ironstone.*

The *bands* of ironstone are found to vary in thickness from half an inch to sixteen inches, but they most frequently run from six to eight inches thick.

The *balls* or nodules have generally a flattened form, and it is invariably observed that the long diameter lies in a direction strictly parallel to the stratum in which they are imbedded. They present themselves of every size from a few inches to four or five feet in horizontal diameter, and rather less than half these dimensions vertically. Their weight varies from a few ounces to upwards of a ton. Those of most general occurrence seldom exceed twelve inches in their long diameter. The external surface of the balls is smooth, and its predominant colour inclines to red. In structure, they are compact, except in those rare cases where they are found to consist of concentric lamellæ, and which occurs when the exterior portion of the carbonate of iron has begun to undergo decomposition. Upon being fractured, they exhibit nearly the same appearances as the band ironstone.

There is a very singular peculiarity which is occasionally observed in these balls of ironstone, and which belongs in an eminent degree to some individual stratifications of them, although it cannot be said to be possessed universally by all the nodules situated in any stratum. A considerable quantity of a black-coloured bituminous substance is found to be inclosed within the nodule. This bitumen is soft and slightly elastic. It is destitute of taste, and is inodorous when cold, but emits a weak bituminous odour upon being slightly heated. It burns without leaving any earthy residue, according to an experiment of Mr Mushet. † Many balls have been lately excavated in the coal field around Glasgow which contained on examination

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* I am not aware that balls of ironstone have been met with in Scotland imbedded in coal; but an instance of this kind, occurring at Anzin in France, is related by MM. Clere and Tournelle in the *Annales des Mines,* iv. 345.

† *Philosophical Magazine,* iii. 47.

half a cubic foot of this bitumen. Mr Mushet has remarked that the bitumen is of rarest occurrence in those nodules in which the calcareous spar is most abundant.

The Hatchetine, lately discovered by the Reverend Mr Conybeare, appears to be a very pure form of this bituminous substance. It was found "filling small contemporaneous veins lined with calcareous spar and small rock crystals in the ironstone of Merthyr Tydvil." The most remarkable feature distinguishing it was its colour, which was yellowish-white. It had the external appearance, and many of the mechanical properties of wax; being soft, inodorous, inelastic, and melting at a very low heat. *

Such are the general geological characteristics of the argillaceous carbonate of iron. On looking at the share which the carbonate of iron occupies in the crust of the earth, it seems susceptible of division into three leading classes. To the first of these may be assigned all those important ores which occur in primitive or transition formations. They are characterized by a crystalline structure, and must all be ranked as varieties of the sparry iron ore. To the second class may be referred the ores which present themselves in the secondary formations. These belong, for the most part, to the coal basins, but strata of them are also found, though very rarely, in the calcareous beds which lie immediately above these formations. They constitute the *argillaceous* ores, which are the peculiar object of this memoir. To the third class remain the very scanty examples of those ores which are found in alluvial districts. It is probable that the ores found in such situations will fall to be classed sometimes along with the sparry iron-ore, sometimes with the argillaceous carbonate.

Having now pointed out the general characters of ironstone viewed as a mineral, and subdivided it into its several mineralogical varieties, and having also given a brief notice of its geological history, we may proceed to consider it, in reference to the chemical nature and affinities of the various ingredients which enter into its composition. This indeed is the most important point of view in which we can regard a mineral which

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* *Annals of Philosophy*, New Series, i. 136.

may be truly denominated the basis of the most interesting of all our metals, the material for the most important of all our manufactures, and the most powerful instrument in the hands of civilized man for advancing the arts, and for adding to the comforts of the species. It probably has been by an application of some of the more elementary processes of chemistry, that simple fusion was first employed to extract the iron from the ore in which it was concealed. The manifold uses of the developed metal could not fail to command the continued and eager attention of men, as soon as its extrication was first discovered. And a long and careful experience has at length carried forward to a stage of very considerable advancement, the art of mingling in the furnace, along with the ores, such foreign bodies as have been found best fitted by their individual or combined chemical properties, for aiding the action of heat, in extricating the pure metal. And besides this, owing to the same power which different sorts of earthy matter possess of mutually fluxing one another, it has been discovered that when two ores, each of which smelted separately would yield its iron with the greatest reluctance, are taken and fused together, they not unfrequently give up the joint product of both their metals with comparative ease.

In viewing the ironstone, then, as a subject of the metallurgic art, and in selecting those varieties to each of which the same fluxes will be available, we shall find that it may be subdivided as follows.

1. *The pure carbonate of iron.*—Under this head, the smelter will comprehend all those ores in which the extraneous ingredients are too small in amount to be capable in any sensible degree either of favouring or of resisting the liquefying operations of the blast-furnace. It is rare to met with ores thus constituted; for they are generally combined with some earthy ingredient requiring a peculiar flux. Of these extrinsic bodies the most common are bitumen or coal, sand, clay, lime, and magnesia. But the sand or clay frequently occur not singly, but mixed with large proportions of carbonate of lime; and all these three substances are often found united with a very considerable amount of bitumen. According to the manner in which the ore presents itself, as combined with

one or other, or with several of these substances, it assumes a different character in the eyes of the ironsmelter, and must be differently treated by him in respect of the preparatory calcination and the application of his fluxes. There are still other occasional constituents of the ore which are fortunately of comparatively rare occurrence, but which bear so very decided a character in their effect on the operations of the iron manufacturer, that it is indispensable to take some notice of them here. These are sulphur and phosphorus. Keeping in view these ingredients, as each of them constituting a distinct class of ironstones, according to its predominance, we shall find that the ore must be divided into the following classes. Besides first, the *pure carbonate of iron*, the preponderance of bitumen or coal will form the second class or *bituminous carbonate of iron*. When sand is the principal ingredient, as this requires to be treated with a peculiar kind of flux, it will form a third class, the *siliceous carbonate of iron*. If clay be a large constituent of the ironstone, for the same reason, it forms a fourth class, the *argillaceous carbonate of iron*. This is by far the most abundant variety of the ore; and when the amount of clay lies within moderate limits, it affords a cast-iron of excellent quality. As the same set of fluxes act, with nearly equal effect upon lime and upon magnesia, and besides, as the carbonate of magnesia, when it occurs in the ore, is almost invariably accompanied by carbonate of lime, these two constituents, which are both alkaline earths, may be said to possess but one character, and to form, in regard to the metallurgist, but one class of ores, the fifth in the present order, and which may be called the *calcareous carbonate of iron*. When it happens that several of these extraneous substances enter into the composition of the mineral, a different mode of treatment by the smelter is required, and new classes of the ore are thereby formed. These seem to be fitly described, according to the respective preponderance of the mixed ingredients, and form, sixth, the *calcareo-siliceous*, if sand be the principal and lime the secondary constituent; seventh, the *calcareo-argillaceous*, if clay hold the place of the sand in the previous class; eighth, the *bitumino-siliceous*, if coal or bitumen be the ingredient that is associated in the ore with the sand; ninth, the *bitumiho-argillaceous*; and tenth, the *bitumino-calcareous*,—terms which sufficiently explain their own meaning, in conformity with the foregoing nomenclature. To the eleventh and last class, belong the *sulphureous and phosphorized ores*, or those whose constitution, whatever it may be in other respects, is contaminated by the presence of sulphur or phosphorus.

These are the leading classes into which the ore of iron may be divided when it is regarded as a subject of manufacture. And as we have already endeavoured to give a mineralogical and geological account of this ore, we shall not dwell longer upon the first of the crude materials used in the smelting of iron, but shall proceed to examine the nature of those which remain. These are fuel and limestone.

## Section 2.—*On Fuel and Fluxes.*

After examining the nature of the ironstone, which is the subject, and the basis of the ironsmelter's manufacture, the class of crude materials still remaining to be considered, consists of those with which he treats the ore, for the purpose of detaching its metallic ingredient. This class is composed of fuel and fluxes. By the application of the first of these, the oxide contained by the ore is reduced to the metallic state. But this process of reduction constitutes only a single stage in the course of the ironsmelter's operations. The iron thereby developed remains dispersed, in small particles, throughout the substance of the ore; and even the intense heat of the blast-furnace would prove inadequate to combine these particles together, and extricate the solid metal in a united state, unless some thing more than mere fuel were employed. It is necessary to bring the earthy matter, with which the metallic particles are intimately intermixed, to a state of thin fusion and liquidity, before they can associate into small masses, and then, by their superior specific gravity, subside together to the bottom of the furnace. But as there is generally one earthy ingredient, the amount of which is greatly predominant over the others in each ore, and as all the simple earths, and even the greater number of their binary mixtures are infusible by the heat of the blast-furnace, it is necessary for the smelter to call in the aid of some other agent for the purpose of reducing them to a state of liquidity. Every substance resorted to with this intention is termed in the metallurgic art, a *flux*, and it is one of the most interesting parts of the art of manufacturing iron to investigate the nature of fluxes, and the manner of employing them. It generally happens, that, by a judicious intermixture of different kinds of ironstone in the furnace, the preponderating earthy ingredient in one has the effect of a flux upon the preponderating earthy ingredient in the others: and thus, by the mutual action of the constituents of two or more ores amongst each other, the earthy ingredients of the whole are simultaneously resolved into a liquid, and the extricated metal of each flows into a common mass at the bottom of the furnace. But it is very seldom that these earthy ingredients, in their state of natural commixture with their respective ores, can admit of having their requisite proportions so accurately adjusted, as to flux each other thoroughly and completely; and it becomes therefore necessary to introduce into the furnace some earth, whose exclusive and important function it is, to effect the complete fusion of the other earthy ingredients, and which is on that account termed a flux. We shall first consider the nature of the fuel which is used by the smelter, and next that of his fluxes.

### 1. *On Fuel.*

A short space of time only has elapsed, since the charcoal obtained from wood constituted the material which was in universal use, for the purpose of deoxidizing iron ores, and for supplying the carbon by which the reduced metal is subsequently converted into cast iron. But the manufacture of cast iron must always be in a very imperfect condition, where-ever the operations of the blast-furnace are entirely dependent upon wood charcoal. The cast iron produced by that carbonaceous material, although eminently adapted for the manufacture of malleable iron or of steel, is intrinsically far less valuable than that produced by the coke of pitcoal. It cannot be remelted, and cast into moulds with the same facility and advantage as the latter, being less fusible, and being more rapidly decarburetted and converted into pure or malleable iron, when kept for some time in a state of fusion. Nor, under such circumstances, could the manufacture of cast iron ever become very extensive; for even a single blast-furnace consumes an enormously large quantity of fuel, and would require therefore a considerable extent of forest-surface to maintain it in regular action. Many attempts were made in England, as early as the beginning of the seventeenth century, to substitute the coke of pitcoal in the blast furnace for wood charcoal; but they all appear to have failed in succession, partly, no doubt, owing to the strong prejudice which prevailed against the introduction of a novel mode of manufacture, but in a much greater measure from the very different management which it demanded, and which at that period was necessarily very little understood. The manifest importance, however, of rendering available to the purposes of the blast-furnace a material which could be supplied to an almost unlimited extent, was a sufficient stimulus to incite the iron manufacturer to persevere in the investigation, in spite of the opposition of prejudice, and even of the discouragement of practical difficulties. The properties of coke became by degrees more accurately known, and the alterations which its use rendered necessary in the form, and in the management of the blast-furnace, were thereby appreciated. And to such perfection has the process of manufacturing iron by the coke of pitcoal now been carried, that this mineral has not only almost entirely superseded the employment of wood, but it has been the means of advancing the manufacture itself in this country, to an extent which is unparalleled in the history of any other age or nation. It has now been ascertained by long experience, that there is no other fuel which is so well fitted, at once to supply the heat of the furnace, and at the same time to endure the powerful blast which is incessantly forced upon it. It may now be said to be essential to our iron manufacture, which would indeed be almost annihilated, were the supply of it withdrawn. How great a source of admiration and gratitude must it always be, to regard the immense profusion in which this invaluable mineral discloses itself, and the intimate connexion and neighbourhood which subsist between it, and the ore of iron. How important are its inexhaustible treasures to the country, which must otherwise have been compelled either to relinquish the manufacture of iron, or to lay under wood immense tracts of what are now fertile corn-fields, in order to supply, at an enormous expense, a much more imperfect fuel for the furnace. Nor is it possible to omit contemplating one of the momentous consequences of such an order of things, these subterranean labourers who, in many districts of the island, pursue with incessant toil their invaluable occupation. A shaft is sunk, wide excavations are opened up, and tier above tier, at various depths below the surface of the earth, and sometimes below the bed of a river, or of the ocean itself, a succession of extensive sheets are seen to penetrate the bowels of the earth; so that in a tract of country, which for ages may have been disregarded as an unproductive waste, numerous villages with their busy throng of inhabitants find an existence which could never have been theirs, but for the fruitful source of wealth which is yielded by the coal mine. And thus it happens, in many parts of this industrious and enterprizing country, that a dense population are making the bosom of the earth to resound with the pick-axe below, while the surface is opened by the plough above, or it may be, is furrowed by the rapid keels which bear abroad the commerce of Great Britain.

In applying coal to the smelting of ironstone, it is found to be absolutely necessary to reduce it to the form of coke, by keeping it in an ignited condition, until the whole of its volatilizable constituents are separated and expelled. This process occasions the loss of a vast quantity of valuable combustible matter, but it is altogether indispensable. It is obvious that a large portion of the heat which is developed during the combustion of coal must be absorbed by the liquid and gaseous products which are volatilized from it, and consequently, that the blast-furnace could not possibly be maintained by coal in the same state of ignition as by coke. But, independently of this important consideration, there are circumstances which render the employment of coal in its natural state altogether impracticable. Were it introduced into the furnace without being coked, it would necessarily soften, and run into an entire solid cake, the instant it became ignited. The superincumbent strata of materials would be converted in like manner into a solid mass, partly in consequence of the condensation of the oily bitumen expelled from the ignited coal, and partly through the heat transmitted from the lower part of the furnace. The furnace thus becoming choked up, the free circulation of air through it, which is indispensable to the maintenance of the ignition, would be totally interrupted. To prevent these consequences, the whole volatilizable matter is always carefully expelled from the coal, before it is introduced into the furnace.

The coals of this country vary extremely, both in regard to the nature of the coke which they furnish, and to the kind of extraneous ingredients with which they are united. And when attention is given to the purposes which the coke has to serve in the furnace, it will easily appear, that the value of any coal to the ironsmelter will be very materially affected by each of these circumstances. A light, open-textured coke would be totally consumed in the continued and intense heat of the blast-furnace, long before it could have time to discharge its important functions of deoxidizing the ore, liquefying its earthy ingredients into a glass or slag, and supercarburating the reduced metal. A coke of loose aggregation, and liable to shiver into small fragments upon being struck, which is of common enough occurrence, would not only be apt to impede the free passage of air through the furnace, but it would be burnt away with too great rapidity, and it would be incapable of withstanding the mechanical force of the blast. It is essential therefore that the smelter should be careful to employ a coke which may, as much as possible, be hard, of compact structure, sonorous when struck, capable of enduring rude treatment without crumbling, and not of a texture that is seamed with numerous clefts. These qualities, unfortunately, are not found united in the coke that is supplied by our most abundant coals, but nevertheless, wherever any of them is very deficient, the coal should be systematically rejected by the ironsmelter as quite unfit for his furnace.

The extraneous substances which require to be noticed as being usually found in coal may be divided into two classes, iron pyrites, and certain earthy bodies. Nothing can be more injurious to the metallic product of the ironstone than the presence of the sulphur contained by the iron pyrites, which is, unfortunately, very generally distributed among the coals of this country. So great a contamination is it considered, that the visible presence of iron pyrites to any amount in a coal is enough to cause its immediate rejection by the iron-smelter. There are some of the best coals which are almost entirely free from it; but, in many others, it is found to exist in various proportions, and sometimes to prevail so largely diffused in certain strata, that they cannot be applied even to the ordinary purposes of domestic fuel. The distribution of the iron-pyrites in any stratum of coal is in most cases extremely irregular. Where the contamination is greatest, the pyrites sometimes exists in large isolated masses, which are either pure, or but slightly intermixed with carbonaceous matter. At other places of the same stratum, it will almost entirely disappear, leaving the coal nearly, if not altogether, free from its presence. A similar inequality in the distribution of iron pyrites may be observed on examining detached fragments of the coal belonging to such strata. It is generally found to exist in small disconnected portions, in thin veins, or in incrustations; while the coal which is immediately contiguous and circumjacent to these visible intermixtures, is absolutely untainted with sulphur.

The extraneous earthy matters which occur associated with coal are of two kinds, the argillaceous and the stoney. The first of these exists diffused through the whole constitution of the coal, in a state of so minute division, and so intimate mechanical incorporation, that it is quite invisible even with the aid of a magnifying glass. It appears to be universal in its distribution among the coals, just like the small proportion of clay which is similarly diffused among its kindred ironstones, and limestones, or like the trifling amount of bituminous matter which occurs in those minerals and in the schists by which they are accompanied.

The stoney matter which is found in coal occurs very irregularly distributed through it, and is visibly distinct from its substance. It is most frequently found in the shape of thin and semitranslucent crusts, or veins traversing the coal, parallel to each other, and in a direction which is perpendicular to the general stratum. These again are not unfrequently intersected at right angles by another set of similar veins, which also are perpendicular to the general stratum. Besides these, there are sometimes found, though very rarely, crystalline incrustations of gypsum, or calcareous spar. Isolated masses of stoney matter which is sometimes siliceous, but oftener argillaceous, are frequently met with in the coal strata. All these stoney intermixtures are distributed with so much irregularity, that it is very often impossible for the ironsmelter to say with precision, what may be the average quantity or quality of the earthy matter contained in any given mass of his coal. For the same reason, it is quite an uncertain test of the precise effects which any particular coal will produce in the furnace, to examine the nature and amount of the earthy matter, which is obtained by incinerating a small fragment of it. The portion examined may, according to circumstances, contain a large excess, or exhibit a great deficiency of earthy constituent, when compared with the average composition of the coal composing the stratum.

There are only two kinds of coal in this country which can be considered to be of general interest to the ironsmelter. These are the splint coal and the cherry coal, or, as it may be properly enough termed, the bituminous free coal. The blind coal, an imperfect kind of anthracite, is indeed used with great advantage in most of the smelting establishments in the south of Wales, but compared with the others already mentioned, both that and the cannel and caking coals are of rare occurrence.

Cherry coal, on account of the remarkable brilliancy of its lustre and the evenness of its fracture, surpasses in beauty all the other varieties of coal. Its colour is intense black. Its fracture in the direction of the stratum is slaty, and from this cause, when in masses, it generally affects a tabular form: in other directions, the fracture is either even or flatly conchoidal. It is extremely friable, and when broken has a peculiar tendency to separate into rectangular-shaped fragments. The lustre of its fractured surface is strongly splendent. The purer specimens, in the smoothness and glossy aspect of their fracture, in their intense black colour and brilliant lustre, have a considerable general resemblance to some of the most beautiful specimens of native asphaltum.

It is very frequently penetrated by vertical foliæ of earthy or siliceous matter, of various thickness, and it also appears to be more subject to contamination by iron pyrites than the splint coal.

Although cherry coal, when burnt in the open air, has little or no tendency to agglutinate or run into a cake, yet it is always found to be converted into a uniform mass, in the process of coking, just as if the whole had consolidated after having been in a state of complete fusion. Its coke possesses the following properties. It is light, of an open and vesicular texture internally, much more liable than that of the splint coal to shiver, and crumble into small fragments, and it is extremely combustible. Owing to its porousness and combustibility, it cannot resist, for any length of time, the action of a strong blast furnace; and, for many years past, it has been the practice in Scotland to throw the air from the condenser with very great power into the furnace, with a force indeed that is equivalent to the pressure of a column of mercury of 6 or 8 inches, so that the use of coke from cherry coal is quite inadmissible. It would be consumed in the intense heat of such a blast, long before it had effected the complete reduction and supercarburation of the iron. But as this species of coal is by far the most abundant in the country, it seems to be by no means improbable, that it may yet come to be employed in the reduction of the less refractory ores, for which a blast produced by a more moderate pressure will of course suffice. It might probably be rendered available, also, in the manufacture of those kinds of cast-iron at a low degree of carburation, which are intended to be afterwards decarburetted, and converted into malleable iron.

The coke of the splint coal is the only one which can be used with advantage in the blast furnace, as it is at present managed in this country. The splint is, in its general appearance, the least beautiful of all our coal. Its colour is greyish or brownish black; its lustre is, for the most part, comparatively dim, as the fractured surface is frequently of a dull and earthy aspect. The fracture is even, or nearly so, and the fragments into which it breaks are of an angular or indeterminate form. The genuine splint coal has no disposition to separate into rectangular fragments, and it is harder, much more compact, and much more difficultly frangible than the cherry coal.

The splint coal is in many cases considerably injured by being very unequal and diversified; so much so that the same mass has frequently the appearance of being composed of a succession of distinct layers. Most of these layers are of a dull earthy aspect, but they sometimes alternate with others which possess the splendour that characterizes the cherry coal. The splint coal frequently contains also thin, interrupted layers of an incoherent shining substance resembling pounded wood charcoal, which crumbles to a powder on the slightest pressure. It is found to occur most frequently between the surfaces of any two substrata of the coal, which, while they differ more or less from each other in composition and appearance, are laid in juxtaposition to each other in the general stratum. It is deposited along the longitudinal fracture of the coal, in a layer whose thickness in general does not exceed that of a common wafer, or of writing paper, though it occasionally amounts to the eighth part of an inch. The existence of this interposed substance is always injurious to the coal in which it is present to any extent, for it disturbs the cohesion and continuity of those two surfaces of the mineral between which it lies, and of course gives to the coal, especially after being coked, a tendency to shiver and fall in pieces by splitting up in the direction in which it runs.

The splint coal yields a coke which possesses in very great perfection all those properties which are most essential to its utility in the smelting of iron. Although it originally contains a large quantity of bituminous and volatilizable matter, it is much less subject to agglutination during the coking process, than the cherry coal. The coke obtained from it is hard, dense, heavy, and difficultly frangible. It emits a clear ringing sound when struck. It is so compact in its grain that, even when its continuity is broken by wide and numerous rents, as is too often the case, it remains still capable of enduring pretty rude treatment without being thereby shivered or split. This is therefore the coal upon which the ironsmelters of Scotland at present place their chief reliance.

These are the two kinds of coal which abound most in the northern division of Great Britain. We shall now take a short glance at their nature and constitution.

The composition of coals in general may be said to consist of a bituminous principle or principles, and of an earthy ingredient. Upon the application of heat to the bitumen, it is resolved into carbon and certain volatilizable combinations, such as bituminous oil, and carburetted hydrogen gas. The carbon when thus reduced forms the coke which is employed by the smelter. In regard to the earthy ingredient, although perhaps universally present in all coal, it is nevertheless so extremely variable in its amount, and so very changeable in its own nature, that it may with propriety be regarded as a substance which is only accidentally present, and which therefore does not form an essential constituent in the composition of coal. But there are various views in which it is important to ascertain something of the nature and amount of this earthy ingredient, and we shall now consider it a little more particularly.

This earth may be produced in a separate form by incinerating the coal under the free access of the atmospheric air, until the whole of the carbonaceous matter is consumed. It then always presents itself under the shape of a fine powder. The colour of the powder is sometimes white, but at other times it inclines to red; and it is material to notice this, because the red indicates the presence of oxide of iron, and affords a presumption that the coal in which it occurs may be contaminated with iron pyrites.

The general composition of this earthy matter is found to consist of silica and alumina, joined with inconsiderable quantities of lime, magnesia, oxide of iron, and sulphate of lime. Sometimes the siliceous ingredient preponderates so very much, that all the others above mentioned are of insignificant amount. But in general the alumina is also a preponderating ingredient, a fact which might prove of some consequence in investigating the origin of coals; for, the well known and almost invariable intermixture of a little bituminous matter with the minerals composing the argillaceous and calcareous strata, on the one hand, and on the other, the distribution of a small amount of clay among the limestones and coals, seem to have been produced by analogous causes.

In order to determine both the proportionate amount, and also the composition of the earthy ingredient of the coals used in Scotland by the iron manufacturer, several specimens were taken both of the splint, and of the cherry coal. It was easy to discover the first of these points; but the incineration of the coal proved to be a work of so much tediousness, that it was necessary to conduct the analyses upon very small quantities only, and the results, therefore, so far as regards the quantitative proportions of the ash, are stated not without some diffidence as to their minute accuracy.

A very perfect specimen of splint coal, on being incinerated, left 4.28 per cent. of a pure white-coloured earthy residue. One hundred parts of this residue, on being analyzed, proved to be composed of the following parts:

| | |
|---|---|
| Silica | 75 |
| Alumina | 12 |
| Peroxide of iron | 4 |
| Lime | 2 |
| Sulphate of lime | 7 |
| | 100 |

When calcined in a strong red heat, in a covered platinum crucible, which, again, was inclosed within a second, in order to exclude as much as possible the atmospheric air, this coal afforded 52.76 per cent. of coke.

Upon incinerating a specimen of a different splint coal, which was not quite so perfect in its characters as the last mentioned, there was left 3.82 per cent. of ashes of a pure white colour. The constituents of these ashes bore the following relative proportion to each other:

| | |
|---|---|
| Silica | 58 |
| Alumina | 32 |
| Magnesia | 2 |
| Lime | 1 |
| Oxide of iron | Trace |
| Sulphate of lime | 7 |
| | 100 |

This coal, treated in a similar manner with that which was first analyzed, was found to yield 55.80 per cent. of coke.

Three specimens of cherry coal, obtained from different beds, afforded respectively 0.79, 1.87, and 1.66 per cent. of earthy residue; and 50.76, 52.16, and 52.93 per cent. of coke. The residue from the first was white-coloured, with a pale reddish yellow shade; in the second and third, the red colour was more distinct. They consisted, respectively, in 100 parts, of

| | (1.) | (2.) | (3.) |
|---|---|---|---|
| Silica - | 42 | 40 | 66 |
| Alumina - | 37 | 22 | 16 |
| Lime - - | 0 | 3 | 0 |
| Magnesia - | 0 | 2 | 0 |
| Peroxide of iron | Trace | 18 | 11 |
| Sulphate of lime | 21 | 15 | 7 |
| | 100 | 100 | 100 |

The first of these specimens possessed in perfection all the external characters of cherry coal: and the last two, although of a more friable composition than usual, differed in no other respect from ordinary cherry coal; agreeing with it perfectly, both in their external appearance, and also in the nature of the coke into which they were converted by calcination.

These were the results of some analyses of the earthy matter contained in various specimens of the splint and cherry coals. In regard to the latter, as the amount of its earthy constituent appeared to be very decidedly less than had been found either in the experiments of Mr Mushet or of Dr Thomson, the former of whom states it at 1.75′,* and on another occasion at 4.05′ † per cent., and the latter at 10 per cent., ‡ a different analytical process was resorted to, in order to put the results above stated to the test. The former method had consisted in reducing the coal to a very fine powder, and then igniting it in a platinum capsule placed over a spirit lamp, until it was reduced to a white ash. The new method was by taking a determinate quantity of the same coal, and defla-

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* *Philosophical Magazine*, iii. 13. † *Ibid.* xxxii. 313.

‡ *Annals of Philosophy*, xiv. 81.

grating it, by small portions at a time, with a sufficient quantity of nitre in a platinum crucible. By this process it was evident that the whole of the earthy ingredients of the coal would be retained by the alkali of the nitre. In order to separate these, after the deflagration of the coal had been completed, the alkaline residuum was supersaturated with nitric acid, the solution was evaporated to dryness, and the dry saline mass was then digested with water. The silica was by this means extricated in an insoluble state, and the alumina was afterwards precipitated from the remaining liquid by boiling it with an excess of carbonate of soda. The results which were furnished by this analysis corresponded, as nearly as could have been expected, with those obtained from the preceding ones, in respect both to the quantity, and to the relative proportions of the earthy ingredients of the coal.

### 2. *On Limestone.*

We have already explained the purpose for which a flux is resorted to by the ironsmelter. Almost the only flux he ever employs is limestone, a mineral which is, fortunately for him, found in the utmost profusion as a component rock of the independent coal basins. It has the property of promoting the fusibility of almost all the earthy mixtures which occur in the ironstone. But there are certain mixtures of these earthy ingredients on which limestone acts with much more efficacy, as a flux, than it does upon others, and it is therefore of importance to attend, not only to the quantity of iron-ore and of limestone which are thrown together into the furnace, but also to the earthy ingredients which may exist in either of these minerals. The extraneous substances contained by the limestones are generally of the same nature with those which we find in the ores. They are carbonate of protoxide of iron, carbonate of magnesia, clay, sand or siliceous clay, and carbonaceous or bituminous matter. And it is fortunate for the ironsmelter that the limestone associates with these, in at least as great a variety of proportion as the ironstone does. From this circumstance, it only requires that the smelter who does not wish to make his business a mere mechanical routine, should study the nature of all the limestones which are situated conveniently within his reach, as well as of his iron ores, and by doing so, he will find himself enabled in almost all cases, by a judicious selection, to charge his furnace with a compound mass of ironstones and limestones, the respective earthy ingredients of which shall be mutually adapted to flux each other under the heat of the blast furnace.

The efficacy of limestone is peculiarly conspicuous in the smelting of siliceous ores. Silica and the protoxide of iron unite, on being ignited together, in the proportion of four parts of silica to 4.5 parts of the oxide, forming a very fusible compound; and in this state of union, their mutual affinity is so strong, as to be undisturbed by the exhibition of any excess of carbonaceous matter. It is impossible thereby to reduce the oxide to the state of metal. But lime has a yet stronger affinity for silica than the protoxide of iron possesses. Accordingly, when it is joined in the furnace with a siliceous ore, it unites with the silica, and the oxide of iron being now no longer protected by a more energetic affinity, is easily reduced by the exhibition of a due dose of carbon. In this way a quantity of metal is set at liberty and obtained in a state of purity, which under other circumstances would have been absorbed by the scoria and have gone to waste.

Those limestones which have been for a long series of years employed at the Clyde Iron Works afford a practical illustration of the fact that a limestone is not by any means to be always valued according to its purity, but, on the contrary, that a certain admixture of some earthy matters may aid its power as a flux, in acting upon the earths of the ore with which it is to be associated in the furnace. They are only of two kinds, and are brought from two different strata at Crossbasket already mentioned in the vicinity of Glasgow. These strata are found overlying a coal formation, and between the uppermost of them and the cultivated soil, there is interposed only a thin stratum of sandstone. The upper stratum, distinguished at the works by the name of the upper post limestone, is about eighteen inches in thickness. The lower stratum is situated about eighteen inches under this, the intervening space being occupied by a bed of indurated clay, which is full of the remains of shells. It is termed the lower post limestone, and is between three and four feet in thickness.

On comparing specimens from each of these strata, their characters proved to be as follows.

The limestone belonging to the upper stratum had a blackish grey colour and broke with a rather fine-grained, earthy, uneven fracture. The lustre of the fractured surface was almost dull. It was not altogether free from an intermixture of small particles of iron pyrites, and contained dispersed through its mass, a few remains of shells. On subjecting it to analysis, it was found composed of

| | |
|---|---|
| Carbonic acid - | 42.92 |
| Lime - - | 49.53 |
| Magnesia - - | 1.73 |
| Protoxide of iron - | 2.50 |
| Insoluble matter, consisting of | |
| Silica - - | 2.14 |
| Alumina - | 0.60 |
| Peroxide of iron - - | 0.55 |
| Carbonaceous matter - | 1.11 |
| | 101.08 |

The limestone of the lower stratum was of a brownish grey colour, and its fracture was fine-grained, splintery, and uneven. Its structure was more distinctly crystalline than that of the other, and its fractured surface had a glimmering lustre. It also contained traces of iron pyrites. On analysis, its constituents were found to be

| | |
|---|---|
| Carbonic acid - | 43.51 |
| Lime - - | 34.28 |
| Magnesia - | 9.73 |
| Protoxide of iron - | 9.29 |
| Insoluble matter, consisting of | |
| Silica - - | 1.96 |
| Alumina - - | 0.80 |
| Peroxide of iron - | 0.41 |
| Carbonaceous matter - | 0.48 |
| | 100.46 |

It is evident, from comparing these two analyses, that the upper post limestone is very greatly superior in purity to the limestone of the lower. Their extraneous ingredients are also associated in very different proportions. But notwithstanding this, a long experience has established the fact at the Clyde Iron Works, that they have no mode of employing a flux so efficacious, as by joining the two limestones in equal proportions in the furnace. Neither limestone taken singly is found so efficient as when both are joined in equal quantities.

We have now completed the first part in our proposed metallurgic treatise, and have considered the nature of ironstone, fuel and fluxes, the three classes of crude materials that form the elements, out of which it is the ironsmelter's art to produce the most important of our metals. The methods of assaying these crude materials, and the processes by which they are prepared for the furnace, together with other particulars relating to the iron manufacture, will form subjects of examination in the subsequent parts of this memoir.

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## ART. XIV.—*Description of the new Fluid Telescope recently constructed by* Messrs W. and T. GILBERT *on a plan suggested by* PETER BARLOW, Esq. F. R. S., Mem. Imp. Ac. Petrop. In a Letter to the EDITOR.

DEAR SIR,

IN reply to your letter I beg to forward for insertion in your next Journal a description of my new telescope, which I hope you will find intelligible. I have also added some of the tests to which I have submitted it; but as I have not yet had it at Woolwich, and having been rather unfortunate on the nights when I have been at Woodford, where it has been made under the direction of Messrs W. and T. Gilbert, these are not so numerous as I could wish. I hope, however, soon to have it here, when I shall have better opportunities of trying its power. A distance of twenty miles between an observer and his instrument is no trifling impediment to astronomical observation, particularly at this season of the year, when the state of the weather is so uncertain.

You are aware, that the correcting medium I have employed as a substitute for the flint lens is sulphuret of carbon. This is enclosed between two plate glasses, ground and polished to the proper curves, and placed at any distance behind the plate front lens, from actual contact to two-thirds of the focal length of the plate, every thing else being adjusted accordingly. This being premised, it may be observed, that in the usual construction of achromatic telescopes, the two or three lenses composing the object-glass are brought into immediate contact, and in the fluid telescope proposed by Dr Blair the construction is the same, the fluid having been enclosed in the object-glass itself. Nor could any change in this arrangement in either case be introduced with advantage; because the dispersive ratio between the glasses in the former instance, and between the glass and fluid in the latter, is too close to admit of bringing the concave correcting medium far enough back to be of any sensible advantage. The case, however, is very different with the sulphuret of carbon. The dispersive ratio here varies (according to the glass employed) between the limits .298 and .334; which circumstance has enabled me to place the fluid correcting lens at a distance from the plate lens equal to half its focal length; and I might carry it still farther back, and yet possess sufficient dispersive power to render the object-glass achromatic. Moreover, by this means the fluid lens, which is the most difficult part of the construction, is reduced to one-half, or to less than one-half of the size of the plate lens; consequently, to construct a telescope of ten or twelve inches aperture involes no greater difficulty in the manipulation than in making a telescope of the usual description of five or six inches aperture, except in the simple plate lens itself: and what will be thought perhaps of greater importance, a telescope of this kind of ten or twelve feet length will be equivalent in its focal power to one of sixteen or twenty feet. We may therefore, by this means, shorten the tube several feet, and yet possess a focal power more considerable than could be conveniently given to it on the usual principle of construction. This will be better understood from Fig. 1. of Plate III.

In this figure A B C D represent the tube of the 6 inch telescope, C D the plate object-glass, F the first focus of rays, *d e* the fluid concave lens, distant from the former 24 inches. The focal length M F being 48 inches, and, consequently, as 48 : 6 : : 24 : 3 inches, the diameter of the fluid lens. The resulting compound focus is 62.5 inches; it is obvious, therefore, that the rays *df*, *ef* arrive at the focus under the same convergency, and with the same light as if they proceeded from a lens of 6 inches diameter, placed at a distance beyond the object-glass C D, (as C′ D′), determined by producing these rays till they meet the sides of the tube produced in C′ D′, *viz.* at 62.5 inches beyond the fluid lens. Hence, it is obvious, the rays will converge as they would do from an object-glass, C′ D′, of the usual kind, with a focus of 10 feet 5 inches. We have thus, therefore, shortened the tube 38.5 inches, or have at least the advantage of a focus 38.5 inches longer than our tube; and the same principle may be carried much farther, so as to reduce the usual length of refracting telescopes nearly one-half, without increasing the aberration in the first glass beyond the least that can possibly belong to a telescope of the usual kind of the whole length. It should, moreover, be observed, that the adjustment for focus may be made either in the usual way or by a slight movement of the fluid lens, as in the Gregorian reflectors by means of the small speculum. In the latter case the eye-piece is fixed, which may probably be convenient for astronomical purposes, in consequence of the great delicacy of the adjustment.

It is obvious, from what is stated above, that a great range is open to experiment, as to the determination of the best position of the fluid lens. If, as has been stated, the opening of the glasses has of itself a tendency to produce irrationality, and that the degree and quality may be changed by different distances, it is of course desirable to find that distance where the quality and degree of irrationality from this cause may counteract that due to the irrationality of the spectra, and thus produce either a complete rationality, or at least the minimum of irrationality. I believe I am already very near this point; because, unless this were the case, we could scarcely expect to find the stars so perfectly colourless and well-defined as they are in this instrument, although it is true that any errors, either in colour or spherical aberration, are only those due to a 3-inch aperture, with 6½-inch focus, which, under any circumstances, would not be very great; and this, again, I must beg leave to observe, is an important advantage, viz. that, with the errors due only to such a telescope, we have constructed one of double that aperture, viz. 6 inches, and focal length of 10 feet 6 inches.

The following are amongst the most severe tests to which this telescope has been at present submitted. *Polaris* appears a beautiful picture of a sun and planet. The small star in Aldebaran is so bright as to be seen the instant that the eye is applied to the telescope. The small star in α Lyræ is a little less obvious, but still distinctly visible. ε *Persei* is seen very clearly double, as is also ω *Aurigæ* and the double star ξ *Aquarii* is so well-defined, that no question can be entertained as to the inequality in the size of the two stars, although this has been hitherto considered rather doubtful. I hope soon to be able to submit this telescope to more numerous and severe tests. I have omitted to state, that the highest power I have yet used is *four hundred*.—I remain, Dear Sir, your's truly,

PETER BARLOW.

WOOLWICH, *November*, 19 1827.

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## ART. XV.—*Notice respecting the Varnish and Varnish Trees of India.*

HAVING received from George Swinton, Esq. of Calcutta, in India, very considerable quantities of the Indian black varnishes, viz. the varnish of Sylhet, and the varnish from Rangoon in the Burman empire, for the purpose of ascertaining their qualities, and their applicability to the arts of this country, we are desirous of laying before our readers the information respecting these valuable substances which was sent along with them, and an account of some observations which we have made upon them.

In the years 1755, 1756, and 1757, a good deal of interest was excited respecting the varnish trees of the East, in consequence of a discussion which took place in the *Philosophical*

*Transactions* between the Abbé Mazeas, Mr Philip Miller, and Mr John Ellis. Mr Miller was of opinion that the *Carolina toxicodendron* was the same plant with that which Kæmpfer describes as yielding the varnish of Japan, but Mr Ellis seems to have proved very clearly that this was not the case. This shrub is known in Japan by the name of *Sitx*, or *Sitzdju*, and was chiefly cultivated in the provinces of *Tsi*, * *Kocko*, and *Fijo*. According to Kæmpfer it is thus obtained. They first slit the bark of the branches of the shrub in different places with a knife. From these wounds there flows out a white clammy juice, which soon turns black when exposed to the air. The same juice is contained in the leaves and stalks of the plant. This juice has no other tasteable quality but that of heating without turning sour; but it is dangerous to handle, being of a poisonous nature. When they make these incisions in the branches of the trees, they place wooden vessels under them to receive the juice as it drops from the wounds; and when these become dry, and will afford no more juice, they make fresh wounds in the stems of the shrubs near the roots, so that all the juice is drawn out of them. They then cut down the shrubs to the ground, and from the stock new stems arise, which in three years are fit to tap again. This native varnish scarcely wants any preparation, but if any dirt should happen to mix with it, it is strained through a coarse gauze to cleanse it. It is then put into wooden vessels, covering it with a little of the oil called *toi*, and stretching a skin over it to prevent it from evaporating. Kæmpfer then goes on to state, that other sorts of varnish are collected in Siam, Corsama, &c. inferior in quality, and produced by other plants; but one of the best he says is produced from the *Anacardium*, or *Cashew Nut* tree. This latter varnish he says is used without any mixture for staining black.

The Sylhet varnish which we have received from India was made to order for Mr Swinton. It consists of *two* parts of the juice of the *Bhela*, (the *Seme-Carpus anacardium*, the tree which bears the *marking nuts* of India,) and *one* part of

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* May not the name of *Tsi-tzi* given to the Rangoon varnish have been originally applied to the varnish from Tsi or Sitz-Tsi?

the juice of the Jowar. The articles varnished with it at Sylhet are of the most beautiful glossy black, and it seems equally fitted for varnishing *iron*, *leather*, *paper*, *wood*, *or stone*. It has a sort of whitish gray colour when first taken out of the bottle; but in a few minutes it becomes perfectly black by exposure to the air. In the present temperature it is too thick to be laid on alone, but it may be rendered more fluid by heat. In this case, however, it is too clammy, and seems to dry very slowly. When diluted with spirits of turpentine it dries more rapidly, but still with less rapidity than is desirable.

The *Tsi-tsi*, or varnish of Rangoon, is less known than the Sylhet varnish. Mr Swinton considers it to be made from the juice of the Bhela, or *Seme-Carpus anacardium* alone. It appears to have the same general properties as the Sylhet varnish, but dries more rapidly.

The varnish from the *Kheeoo*, or varnish tree, may be the same as the Rangoon varnish; but it is at present considered to be different. The Kheeoo grows particularly in Kubboo, a valley on the banks of the Ningtee, between Munnipore and the Birman empire. It grows to such a large size, that it affords planks upwards of three feet in breadth, and in appearance and grain it is very like mahogany. A British officer who travelled through Kubboo in the beginning of the present year, and an abstract of whose journal is now before us in MS., gives the following account of the method of obtaining the varnish from the Kheeoo.

" The Sepoys felled a Kheeoo, or varnish tree, at Mure, of which I took the measurements as follows:

| | |
|---|---|
| Height to first branch, - - - | 42 feet. |
| From lowest branch to extreme of top one, - | 18 |
| Diameter when hewed, - - | 2½ |
| Circumference of do. - - | 7¼ |

This, comparatively with others of the same species, is a small tree. I measured the circumference of one, which, near the ground, was *thirteen* feet. I had an opportunity of ascertaining the process of extracting the varnish from the tree, which is by making incisions in several parts of the trunk, to which choonghas are fastened so as to receive the varnish which oozes from them. The incision is only through the bark. The choonghas are allowed to remain *two* days. One tree affords about a gallon. The varnish is extracted annually from each tree at the commencement of the rains. No after preparation is required to render it fit for use. The tree is at present (Jan. 17th, 1827) in blossom. The bark is nearly the same as the bark of the Saul, but somewhat lighter in colour. The leaf resembles that of the horse-chesnut more than any other I can recollect."

The varnish tree of Martaban, which we presume must be the same as the Kheeoo, has been particularly examined by an eminent botanist, who gives the following account of it: "The varnish tree is found in great plenty and perfection at Martaban. The tree *is very distinct not only in species, but genus, from the varnish tree of Sylhet, and that of the Malay Archipelago, China, and Japan.* It has been named *Melanorhea usitatissima*, and a very fine object it is, especially when in fruit, the latter being supported by five or six spreading red and very large wings. The varnish, when good and fresh, is of a rather pale rust colour, which by exposure to the air becomes jet black."

Before concluding this notice, we shall give an account of some observations which we made upon the constitution of the Sylhet and Rangoon varnishes, in order to determine the change which takes place in them when the colour passes from a whitish brown to a deep black. A small quantity being put between two plates of glass, the plates were pressed together till the thin film of varnish which they enclosed was translucent. Upon examining this film with a powerful microscope, it was obvious that the fluid was not a homogeneous one, but was organized, and consisted of an immense congeries of small parts, which exhibited the finest example of mottled or striated colours. These particles dispersed the sun's rays in all directions like a thin film of unmelted tallow, or like organized fluids, such as the blood and milk.

After standing two days exposed to the action of the air, I found that the portions which the air did not reach, viz. that between the glass plates, exhibited the same constitution as before; while that which was squeezed out between the glasses, and on which the air freely acted, had become of a fine colour like that of treacle. I now placed this portion between two plates of glass, and found, to my great surprise, that the organized structure of the fluid was entirely gone, that it was perfectly homogeneous, and showed the sun of a beautiful red colour, as when it is seen through a thin film of pitch, or through a darkening glass. The action of the air had completely disorganized the vegetable juice, and reduced it to a state of homogeneous fluidity. The application of heat seemed to accelerate this organization; but I have not been able to produce the same effect by the action of heat upon the varnish when not exposed to the air.

We now opened one of the Bhela nuts, the fruit of the *Seme-Carpus anacardium*, and found that the juice of it when placed between plates of glass, was nearly as homogeneous and transparent as the Rangoon varnish when acted upon by the air. There were, however, small portions of it which exhibited an organized structure.

## ART. XVI.—*Account of the Poisonous Qualities of the Vegetable Varnishes from India and America.*

HAVING experienced and witnessed in more than one case the singular effects produced upon the human body, by a poisonous vapour which is exhaled from the Sylhet varnish, we have been induced to collect the information which the experience of others has already made known.

This information, however, had ceased to be of any use, for the varnishes in question are supposed, even by our countrymen in India, to be devoid of any noxious quality. We are informed by Mr Swinton of Calcutta, that the Munnipoores who were lately in that city, when questioned respecting the Kheeoo varnish, described it as of a poisonous nature, causing the hands and face to swell, and producing an intolerable itching. A British officer then in Munipoore denied the truth of this, and stated that the varnish was perfectly harmless, being always laid on by the hand. Although the Munipoores were not likely to be mistaken in a matter which must have frequently come under their observation, yet it never occurred to me that the poisonous qualities which they ascribed to the Kheeoo varnish were likely to belong to the Sylhet varnish; and I accordingly made numerous experiments with the latter, without any suspicion of its possessing deleterious properties. Having laid it in its undiluted state upon part of an iron railing, a maid servant accidentally rubbed her arm against it. In one part of the arm touched by the varnish the skin was at the same time slightly ruffled, but on other parts touched by the varnish the skin was perfectly sound. In a few days all these parts were inflamed, and became extremely itchy. A congeries of angry pimples followed, which were hard at their base and extremely red. These pimples have remained more than three weeks without healing; and what is very strange, fresh ones have appeared on parts of the arm which the varnish never touched.

One of my sons, who had been the principal operator in putting the varnish on the iron, and who from the coldness of the weather was obliged to render it fluid by holding it above the fire, was thus peculiarly exposed to the vapour exhaled from it when hot, and also during the time that he was laying it on. A few days after, his hands, which the varnish had never touched, were covered with red pimples, exactly the same as those already described. The effect gradually extended up his arm, and in two days afterwards his face and eyes were swelled to a most alarming degree, both cheeks being a mass of small red pimples. The itchiness was intolerable, but there was neither fever nor pain, and the swelling disappeared after six or seven days. We at first ascribed these effects to the nettle-rash; but after reading the account given by Dr Joseph Papa of the effects of the Indian varnish, and comparing the pustules with those on the arm of the maid-servant, there could not be the least doubt that the varnish was the cause of the disease.

The account now referred to was drawn up in 1701 by Dr Joseph del Papa, physician to the Cardinal de Medicis, and was communicated to the Royal Society by the celebrated botanist Dr Sherard. The following is an abstract of it.

" The using and handling of the Indian varnish, while laying it on objects to be varnished, having produced such extraordinary effects on Signior Ignatio, and more remarkably on his maid-servant, viz. great swellings of their heads and eyes, and in their arms, and indeed almost their whole body, with an intolerable itching, inflammation and pimples, is so new and extraordinary as to call forth our wonder and curiosity. There are indeed some juices of roots and herbs, which by touching our flesh either inflame or ulcerate it, or produce swellings, pustules, and itchings; but all these cause the disorder only where they touch, and do not spread their invisible venom over other parts of the body. In short, I know not an instance of any one thing, which, either touched with the hand, or insinuating itself by its fumes into our body, is able to produce almost over the whole skin inflammations, swellings, itchiness, and pustules, as if the whole body were stung with an infinite number of wasps, for such are exactly the effects produced by this varnish.

"This varnish exerts all its malignity against the skin, the viscera and blood being untouched; besides, I observed that the maid, at the same time that almost her whole skin was hard, inflamed, swelled, and full of pustules, had yet no fever, no pain in the head, nor any inward illness. This varnish, therefore, is only an enemy to the skin; and that this mischief should attend it, it is not necessary that the varnish should be heated, for when cold it emits the same steams, which insinuate themselves into the body, especially when touched and handled.

"I have several times spread a great deal of this varnish hot upon the naked skin of poultry, and they never received any hurt from it either internal or external. I have caused other fowls to swallow crumbs of bread steeped in the varnish, and they seemed to like it very well; others I have pricked in the heart till the blood came, and then anointed it all over with varnish, which, instead of hurting them, proved a balsam to heal them. Having once, however, spread some of it on the naked breast of some fowls, leaving it sticking there for three days, I afterwards found between the dried varnish and the flesh, the place all festered, and full of a yellowish serum, but without any further harm. I have attempted the same thing on dogs and cats, but without success, for these animals with their tongues and claws soon take off all the varnish from their bodies, and take no hurt by it."

The poisonous qualities of the Japan varnish are mentioned also by Kæmpfer, who states that it exhales a poisonous vapour, which occasions great pains in the head, and causes the lips of those who handle it to swell; on which account the artificers when they use it are obliged to tie a handkerchief over the nose and mouth to prevent these effects.

Although the *Poison Wood tree* of New England, the *Rhus vernix* of Linnæus, is different from the varnish trees of India, yet it resembles them in its poisonous qualities. The Honourable Paul Dudley informs us that it poisons two ways, "either by the touching or handling of it, and that its scent when cut down in the woods, or on the fire, has poisoned persons to a very great degree. One of my neighbours was blind for above a week together with only handling it, and a gentleman in the country, when sitting by his fireside in the winter, was swelled for several days with the smoke or flame of some poisonous wood that was in the fire. It has this effect only on some particular persons and constitutions, for I have seen my own brother not only handle but chew it without any harm at all; so that by the same fire one shall be poisoned, and another not at all affected. But this sort of poison is never mortal, and will go off in a few days by itself like the sting of a bee; but generally the person applies plantain water, or sallad oil and cream. As to its operation within a few hours after the person is poisoned, he feels an itching pain that provokes a scratching, which is followed by an inflammation and swelling; sometimes a man's legs only have been poisoned and have run with water."

Dr William Sherard, in describing the same tree, states, that the wood is as cold as ice, and that when laid on the fire, out of five or six persons sitting by it, some will swoon, faint, or yawn, continuing so for some days, others but a few hours, and others of the company not at all. I handle, says he, cut, and burn it with impunity, and so it is with several others, I suppose according to their constitutions. It was never known to kill any body, but only to do hurt to some persons."

In treating of the different species of Rhus which were supposed to resemble the varnish tree, Mr Ellis mentions "that the *Rhus Sinense*, when first it began to extend its leaves in the small stove, had so remarkably a disagreeable smell, that he frequently complained of getting the headache, and a sickness of his stomach, by remaining too long near it; and after it was removed into the great stove, where, notwithstanding that building was very spacious, and near twenty feet high, yet, as it grew most luxuriantly, we could not without pain continue long near it."

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## ART. XVII.—*Observations on the Generation of the Lobularia digitata*, Lam. (*Alcyonium lobatum*, Pall.) By R. E. GRANT, M. D., F. R. S. E., F. L. S., Professor of Zoology in the University of London. Communicated by the Author.

IN various observations and experiments on the structure and economy of Zoophytes found inhabiting the Frith of Forth, I have already shown that in many *silicious*, *calcareous*, and *horny* species, the minute reproductive gemmules by which these animals propagate, are highly organized portions of the gelatinous substance of the parent, which possess the power of swimming freely to and fro, for a considerable time after their separation, by the rapid vibration of very small ciliæ covering their surface. Although I had not an opportunity of observing this singular phenomenon in any zoophyte which discharges its ova through the bodies of polypi, I was induced from analogy to believe that the motions observed by Cavolini in the ova of the Caryophyllia and Gorgonia, which are discharged through polypi, were produced by similar organs, and that these organs in the same situation are probably of much more general occurrence in this class of animals than has yet been observed. During the month of October I procured some specimens of the white variety of *Lobularia digitata* from the Frith of Forth, with their ova in a state of maturity, which afforded me the means of observing the process of generation, not only in a species whose ova pass through polypi of a very complicated structure, but also in a zoophyte with a *fleshy* and contractile axis, differing much from those I had already examined. Both the red and white varieties of this animal of various shades of intensity, are found in every part of the Frith of Forth from this to the opposite shore, adhering in large masses to stones, shells, and fuci. At low water we observe it hanging in numerous fleshy lobes from the under and sheltered surface of rocks; after storms, quantities of it are often left on shore, adhering to marine plants and animals which have been torn from their seat; and by accompanying the dredgers daily employed in the Forth we constantly find it brought up by the dredges from deep water, spreading on all kinds of solid substances lying at the bottom, as broken bottles, glasses, shells, &c.

Jussieu examined the structure of this animal with the microscope, on the coast of Normandy, more than eighty years ago, and has given accurate representations of many parts of its structure (*Mem. de l'Ac.* 1742.). Mr Ellis, who mentions it as occurring in great plenty round all the coasts of the British islands, has given many excellent figures illustrating its internal structure, the appearance and situation of its ova, and their mode of passing out through the bodies of the polypi (*Phil. Trans.* liii. Pl. XX.). He has placed groups of 5 — 8 loose ova in each of the canals below the polypi, and similar groups in the transparent bodies of the polypi below the stomach, which are represented passing up one after another towards the mouth. It is to be regretted that he has not left a full description of the interesting appearances represented in these figures. Dr Spix of Bavaria, without noticing the accurate and elegant plates of Mr Ellis, and with a low estimation of the labours of our distinguished countryman, has given several figures to illustrate the mode of generation of the Lobularia (*Ann. du Mus.* t. xiii. Pl. XXXIII.), which differ as much from nature as they do from the plates of his predecessor. He has represented the head of the polypus as consisting of a large round vesicle or stomach, to the sides of which are closely applied eight thick cylindrical claviform tentacula covered with minute papillæ; descending from the stomach he has represented a long narrow tapering tube, and the ova are placed in a single line, inclosed in a small curved canal, like a string of beads. His observations correspond with his figures. He states that the tentacula appear to be filled with globules of air; that the polypus can withdraw the tentacula into its mouth; that the body of the polypus is not thicker than a hair; and that the polypi die contracted. He mentions also that each of the round red globules which are discharged through the mouth, is an *ovarium*, containing, within a distinct capsule, a multitude of small eggs like those of a fly, an appearance which he has represented in the figures, and he is thence led to inquire whether all zoophytes may not in the same manner be oviparous. It is singular that this author commences his observations by stating that Mr Ellis generally mistook the ova of zoophytes for ovaria, an error which he has not shown to belong to the great British zoophytist, but which he has himself obviously committed with regard to the Lobularia. Lamouroux has corrected some of the errors of Spix, and has given elegant magnified figures to illustrate the anatomy of the polypi of this animal, (*Hist. des Pol.* Pl. XIII.); but as he examined the Lobularia only in spring, he could detect no trace of ova or ovaria in its structure, and was therefore unfortunately prevented from throwing any light on this interesting part of its economy.

On laying open the white Lobularia in the direction of its canals, I found in all these cavities numerous small red-coloured spheres of a regular form and soft consistence, and about the fifth of a line in diameter. Many of them much smaller, and of a white colour, adhered to longitudinal white lines at the upper end of the canals. There were several of these longitudinal rows of ova at the base of each polypus, and most of them were connected by peduncles or tubes to the white longitudinal folds of the canals. The smallest had the strongest connection, those of a larger size were connected only by a slender filament, and the largest red ova were quite free. The white folds to which the ova adhere, are continuous with the eight longitudinal folds seen within the polypi. There were generally about twenty small white ova in each canal, besides ten or twelve perfectly formed, and of a red colour. Most of the mature ova were collected together near the basis of the polypi, where they were quite loose, of a deep red colour, and of a larger and more equal size than those attached to the folds of the canals. Their appearance closely resembled the figures of Mr Ellis; they were quite visible to the naked eye, and when a section of the animal was placed in water the red ova fell out separately, and sunk slowly to the bottom. The red colour of these ova is mentioned by Dr Spix, the ova of the Gorgonia and Madrepore have a red colour, and the ova of the *Medusa aurita*, Lin. are described by Dr Rosenthal (*Zeitsch. für Phys.* i. B. s. 328.) as round bodies of a red colour, and somewhat lengthened form, which "in their mature state move backwards and forwards in a lively manner without altering their form." The ova of the Lobularia exhibited various shades of colour, from white to deep red, according to their size and maturity. By pressing the red ova between the forceps they were found to consist of a distinct transparent membranous capsule, filled with a gelatinous matter, which appeared under the microscope to be composed of the same small globules or monade-like bodies which compose the ova of other zoophytes, and almost all the soft parts of animals. They did not produce the slightest effervescence in nitric acid, although every part of the fleshy substance of the adult Lobularia contains calcareous matter. By remaining a few days in spirits, or in fresh water, the ova entirely lost their red colour, and assumed a yellowish-white appearance even in the centre of entire lobes.

After a specimen of the animal had remained for some hours suspended in its natural vertical postion in a crystal jar filled with pure sea-water, and its polypi had fully extended themselves, I was delighted to find the large red ova beginning to descend from the interior of the canals into the transparent bodies of the polypi, where I could easily observe their progress with the aid of a lens, through the sides of the glass vessel. They advanced slowly and only when the polypi were distended. In the space of twenty-four hours ova were seen in the bodies of most of the polypi; some polypi had only one, several had two or three, and in others groups of four or five ova were observed together placed without any regular order. Many of the polypi had no ova, in others the mouth was seen distended with a single ovum in the act of being discharged, and a few ova were found lying separate at the bottom of the jar. All those which had descended into the bodies of the polypi, and those found loose in the jar, were of the full size and deep-red colour. None of the imperfectly formed white ova were detached from the sides of the canals, or seen in the polypi. I collected carefully the loose ova from the bottom of the jar, and on placing them in a watch-glass with sea-water I could perceive with the naked eye that they continually changed their situations, gliding to and fro with an almost imperceptible motion. Viewed with the aid of a lens, their motions were obvious; they were seen to contract themselves frequently during their progressive motions, and sometimes they appeared revolving round their axis. When placed under the microscope, and viewed by transmitted light, they appeared as opaque spheres surrounded with a thin transparent margin, which increased in thickness when the ova began to grow, and such of the ova as lay in contact united and grew as one ovum. A rapid current in the water immediately around each ovum, drawing along with it all loose particles and floating animalcules, was distinctly seen flowing with an equal velocity as in other ciliated ova, and a zone of very minute vibrating ciliæ was perceptible, surrounding the transparent margin of all the ova. The progressive motion of the ova, always in a direction contrary to that of the current created by their ciliæ, was very obvious, though less rapid than in any other zoophyte in which I have observed the same remarkable phenomenon. The specimen suspended in the glass jar filled with pure sea-water I now brought so close to the transparent side of the vessel, that I could examine through it, with the assistance of a powerful lens, and without disturbing the animal, the motions and progress of the groups of ova passing through the colourless bodies of the polypi. To the naked eye at first sight all appeared motionless. The deep vermilion hue of the small round ova, and the colourless transparency of the outer covering of the polypi, formed a beautiful contrast with the pure white colour of the delicate longitudinal folds, the central open canal, and the slender filaments which wind down from its sides towards the clusters of white ova at the base; but the living phenomena discovered within were even more admirable than the beautiful contrast of colours, the elegant forms, and the exquisite structure of all the parts. When observed with a lens the ova were seen to be in constant motion, and quite free within the bodies of the polypi. They moved themselves backwards and forwards, and frequently contracted their sides, as if irritated or capable of feeling. I could observe none passing upwards between the stomach and the sides of the polypi. They never assumed the appearance of a string of beads inclosed in a narrow shut curved tube, as represented by Spix, but swam freely in the water which distended the polypi, as figured by Ellis. Their motions in the polypi, though circumscribed, were so incessant, that by watching attentively I could observe them with the naked eye, and they became more conspicuous as the ova advanced to the open base of the stomach. From their restlessness, as they approached that last passage which separates them from the sea, they seemed to feel the impulse of a new element, which they were impatient to enjoy, and by following the direction of that impulse they appeared to find their way into the lower open extremity of the stomach, without any organic arrangement to lead them into that narrow canal. In their passage through the stomach, which was effected very slowly, the spontaneous motions of the ova were arrested, unless some imperceptible action of their ciliæ, or some contractions of their surface, might tend to irritate the sides of that canal, and thus direct or hasten their escape.

The clusters of ova found in autumn at the base of the polypi of the Lobularia, have no relation to the ovaria of higher animals. They are true gemmules or buds which grow from the sides of the internal canals; they are nourished by umbilical cords; they fall off and escape when mature; and, as in other zoophytes, they leave no trace of their existence behind. Their spontaneous motion establishes the existence of this remarkable property in a tribe of zoophytes with a fleshy axis, where it had not before been observed, and opens to our contemplation a new and singular arrangement for aiding and directing the passage of these delicate reproductive globules, through the complicated bodies of animals where irritability is nearly extinct. It would be highly interesting to trace how far up in the scale of animals this simple arrangement takes place to facilitate the exit of the embryo from the inert body of the parent. The above remark of Dr Rosenthal respecting the Medusa, shows that it takes place in the class of Radiated animals; and I have shown in a former number of this *Journal* (No. xiii. p. 121.), that in the class of Molluscous animals, the escape of the fœtus from highly complicated ovaria, as those of the Buccinum, is effected in like manner by the rapid vibration of ciliæ placed on the surface of the young. The transformation of the ova above described, from their moving, irritable, and free condition of animalcules, to that of fixed and almost inert zoophytes, exhibits a new metamorphosis in the animal kingdom, not less remarkable than that of many reptiles from their first aquatic condition, or that of insects from their larva state. Ulvæ and confervæ have been seen to resolve themselves into animalcules, *(Schweigger's Beobacht. auf N. R.* s. 90.*)*, and Professor Aghard has seen these animalcules reunite to construct the plants. Mosses and Equiseta are found to originate from confervæ, *(Mém. du Mus.* tom. ix. p. 283.*)*, and all the land confervæ with radicles appear to pass into the state of more perfect plants. The Oscillatoriæ which cover the stones in our fresh water pools with a green and velvety crust, resolve themselves into animalcules and lively moving filaments, whose motions have been described by Saussure, Vaucher, and others. The globules of our blood have been seen to arrange themselves into fibres, *(Phil. Trans.* 1818. p. 172.*)*, and the densest fibres have been resolved into their regular component globules. But few known changes in the vegetable or animal kingdom are more singular than that which the ova of zoophytes present in passing from the state of lively, free, and spontaneously moving bodies, to that of fixed horny roots, or equally inert calcareous cells.

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## ART. XVIII.—*Description of an Apparatus for Impregnating Liquids with Gases.* By JAMES KING, Esq. Communicated by the AUTHOR.

IN the year 1820 I had the pleasure of suggesting to Dr Hope the construction of an apparatus for impregnating liquids with gases. That eminent chemist had one of them made for his own use, and another was executed for Dr Fyfe; but as no account of it has yet been published, you would oblige me by inserting the following brief description of it in *The Edinburgh Journal of Science*. The advantages of this apparatus are, that it does away with bent tubes and luted joints of Woolf's, all of which can be ground with ease. The liquid to be impregnated is advantageously exposed to the gas. As there are no lutings, it can be put up and in action in a few minutes, and as quickly dismounted; and not at all liable to derangement. In Fig. 2. Plate III. A is the retort; B the receiver for the condensable part of the product; C contains the liquid to be impregnated, which is filled up to the dotted line D; E is a vessel open at the bottom, into which the liquid ascends during the action of the apparatus; F is to keep up pressure on E, when the stopper is out; G is a conical stopper to increase the pressure on the whole. A stop cock at H would be very convenient, to examine a little of the liquid as the operation goes on. This can be introduced at G; and if the safety tube described in the last number of this work were applied at the top, in place of the conical stopper at G, it would render it more complete.

## Art. XIX.—*Account of the Assamese Method of Blasting Rocks.* Communicated by a Correspondent in India.

An Assamese stone-cutter has shown me a mode of blasting rocks, which I think superior to any thing practised in England, and you may perhaps consider it worth communicating to *The Edinburgh Journal of Science*. The old mode of ramming has you know been superseded of late by the use of loose sand poured over the powder; but whatever may be the case with the softer description of rocks, I have always failed in this way here, except in one instance, probably owing to the excessive strength and hardness of the granite and primitive greenstone, on which the experiment has been tried at least a dozen of times, and in holes nearly a foot deeper than is stated to be necessary in the *Supplement to the Encyclopædia* and *Philosophical Magazine*, where the method with sand is described. The following is the result of the Assamese plan.

A hole was bored about twenty-six inches deep and one and a-half inch diameter in a large block of greenstone. It was tried to blast this rock with powder and loose sand, and the latter was blown out. The same charge of powder was then put in, and the mouth of the hole closed with a wooden plug about five inches long, with a touch hole bored through it, and driven into the aperture with a mallet. Between the powder and the lower part of the plug an interval of several inches was left, and the communication was perfected by means of a tin tubule filled with powder, and passed through the centre of the plug. On firing it the rock was rent in every direction to the distance of four feet, and several large pieces were detached, one of them weighing fully a ton. The advantages are, that the plug is as safe and more efficacious than the sand, and that with it the force if it goes out may easily be replaced, whereas with sand it becomes necessary to have recourse to the tedious operation of again scooping out the contents of the hole as far down as the charge of powder. The only time I succeeded with sand was when the hole was bored near the exterior edge of the rock, and then a slice was cut off. It may be proper to mention that the sand used was the ordinary kind procurable from the river banks, and rather fine-grained. I think it is probable that the method above explained would be applicable to bursting or rendering cannon unserviceable. The great effect produced is, I conceive, chiefly owing to the interval left between the charge of powder and the plug, as it is well known to sportsmen that a gun will certainly burst as the barrel opens, if a ball or charge of shot be not properly rammed down.

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## ART. XX.—*Memoir on the Horary Oscillations of the Barometer at Rome.* Communicated by the Author.

AMONGST the various branches of the science of meteorology few have been so little investigated as the horary variations of the barometer; and indeed till lately so little has it been attended to, that in few meteorological essays or treatises which I have seen has it been noticed, and in still fewer has it elicited *facts* or *discussions* proportioned to its interest and singularity. The principal hints on the subject which I have seen are contained in Nos. iv. and viii. of *The Edinburgh Journal of Science*, and in Mr Daniell's admirable essays, particularly the *last* edition.

In the course of the hourly observations which I made at Rome on the 15th of January last, and formerly transmitted to this *Journal*, the horary changes which took place on the mercurial column that day led me to believe these oscillations to be much more regular and better defined than the sequel proved to be the case.

Stimulated by this conviction, in the beginning of February I commenced a series of observations to be made each day as frequently as convenience would allow, which I continued every subsequent day of my residence in Rome. Those who do not travel with a professedly scientific aim too often find their limited residence in any particular place so much occupied by the new scenes daily presented to them, that no time is left, even if they had the inclination, to institute any thing like a series of regular experiments; and hence, to the detriment of science, we find that little or nothing is derived from those who, enjoying the advantages of visiting various climates and latitudes, might make the most important physical investigations. As a traveller, then, I must make this my apology for whatever barrenness may be found in these observations, made during a limited residence in the ancient mistress of the world, where so much tends to divide our attention and withdraw it from abstract speculation. At Rome my business was to *make* the observations which lay by for reduction at a future period. During fifty-four days of residence in February, March, and April, about 470 observations have been made with the data of thermometrical correction for each. When on my return to Scotland, I reduced all these results with the utmost accuracy into the form of tables; and when I came to determine the value of the several quantities, I regretted to find that the sums were considerably irregular, and did not rise and descend with the same steadiness from hour to hour as *any one* day's observations within the tropics might have exhibited; and I was led to believe that the number of data I proceeded on was not sufficiently great or regular to separate the small diurnal changes from the mass of adventitious variations of pressure which we experience in the temperate zone. I afterwards noticed that some additional results, included with the rest by rather a circuitous operation, (with a view of enabling me to include the whole of my observations) appeared to increase these discrepancies; I shall therefore give the results obtained both with and without these supplementary numbers; but more of this when we come to the table of final reductions.

When I found that my computations did not produce such clear results as I had hoped, I was tempted to relinquish the idea of ever presenting them to the public; and I may be allowed to state, in a few words, why I now hazard them for insertion in this *Journal*. 1*st*, then, from the very imperfections of this branch of science, and the discrepancies which every where occur in the best journals of barometrical oscillations in the more northern latitudes, I am bold enough to hope that these observations as they stand may add a faint glimmering to the weak light already thrown upon this phenomenon. 2*d*, No observations have, I believe, been yet made in Italy with a view of elucidating this point, and there are no results from the latitude of Rome, or in any part of Italy in Humboldt's table. 3*d*, Though I cannot pretend to determine to a nicety the hours of maximum and minimum, and to trace the precise progress of oscillation from hour to hour, yet a general idea will easily be obtained on both these points, and the range of variation be the same within a minute fraction of what we should have inferred it to be from independent observations. *Lastly*, I am in hopes that this memoir may stimulate to exertion travelling and other meteorologists in this department of their study, than which none requires more continued exertion and minute accuracy; and to such as have time and inclination I trust that my type of calculation and reductions may serve as a guide in treating their observations in that rigorous manner which is so highly desirable.* It will now be proper to make a few

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* I am encouraged to express the latter hope, from observing how deeply Mr Daniell recommends a very studious attention in this particular. "Let the meteorologist," says he, "be assured, that it is only by the same painful care to *minutiæ* that his own favourite science can ever be

remarks on the construction of the instrument, and the precautions taken in the use of it.

The barometer was made by myself, and was on Sir Henry Engelfield's construction. I here give the note of its dimensions.

| | Inch. |
|---|---|
| Tube, internal diameter, | 0.150 |
| external diameter, | 0. 22 |
| Cistern, area for rise of mercury, | 9216 — 484 = 8732 |
| But, internal area of tube, | 225 |

Quotient or correction of cistern level, $\frac{1}{38.81}$

The correction of level then being $\frac{1}{38.81}$, I have always in practice considered it $\frac{1}{40}$. The tube was of Roman manufacture, much thinner than the English ones, and I fear not so perfectly equal. It was boiled over a spirit-lamp with the utmost care, and ever after exhibited the most brilliant flashes of electrical light *in vacuo*. The cistern was close and of hard wood, but with a piece of cork inserted in the bottom to admit the air; and although, after being much carried about, for a time it did not perform well, yet hung as it was *constantly* during these experiments in the same part of the same room, I have no reason to believe that it was the least sluggish in its variations. Attached to the case was a small thermometer graduated by myself with the Fahrenheit and Centigrade scales; the former has always been used. I likewise graduated the inches of mercury on a slip of brass fixed to the case, and a vernier, now on the tube, which showed to $\frac{1}{500}$ of an inch. Though I cannot pretend that my graduation was all to that degree of exactness, yet it certainly read off much

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raised to that standard of exactness of which there can be no doubt that it is susceptible, but from which it is to be lamented it is at present so far removed." In another place, "Observers will render a much greater service to science by devoting less of their time to the inspection of their instruments, and more to applying the proper corrections." Should that intelligent philosopher ever read these pages, I think I can assure him that few observations have ever received more attention than mine with regard to the boiling of the mercury in the tube, the accuracy of the observations, and the precision of the corrections.

more accurately than to *hundredths*, which was my principal aim. The positive height of the mercurial column, and consequently the neutral point, were not accurately determined during my stay at Rome, as I had no dividing engine or method sufficiently accurate of measuring off a given quantity; the position of the scale of inches was therefore only approximate. On my way to Florence the instrument was accidentally broke, and I had recourse to the published journal of the Collegio Romano at Rome, to reduce it to the standard of the instrument there observed. I selected sixteen corresponding observations at *noon* in February.

| | My observ. Bar. Eng. Inch. | Ther. | Coll. Rom. French Inches. | |
|---|---|---|---|---|
| | | | In. | Lin. |
| Feb. 4. noon. | 30.031 | 57 | 28 | 1 .4 |
| —— 5. —— | 30.250 | 58 | 28 | 3 .2 |
| —— 6. —— | 30.048 | 57 | 28 | 0 .3 |
| —— 10. —— | 30.072 | 54 | 28 | 1 .0 |
| —— 12. —— | 29.886 | 54 | 27 | 9 .3 |
| —— 13. —— | 29.790 | 55 | 27 | 9 .3 |
| —— 14. —— | 29.874 | 53 | 27 | 11.0 |
| —— 15. —— | 29.886 | 52 | 27 | 10.3 |
| —— 17. —— | 29.900 | 51 | 27 | 11.2 |
| —— 19. —— | 30.118 | 54 | 28 | 1 .3 |
| —— 20. —— | 30.020 | 54 | 27 | 11.3 |
| —— 21. —— | 29.906 | 56 | 27 | 10.3 |
| —— 22. —— | 29.760 | 57 | 27 | 7 .7 |
| —— 23. —— | 29.624 | 56 | 27 | 8 .2 |
| —— 24. —— | 29.937 | 53 | 27 | 11.6 |
| —— 26. —— | 30.176 | 52 | 28 | 2 .8 |
| Sums, | 479.258 | 873 | 447 | 2 .2 |
| Means, | 29.954 | 54.6 | 27 | 11.38 |

= 26.945 Eng. inches.
29.954

Diff. 00.009

By a very unexpected concordance the difference amounts to only $\frac{9}{1000}$ of an inch, a variation in this case quite to be neglected, as a *very* small difference of level would occasion it. The Collegio Romano stood nearly on the same street, and on very flat ground, and the level of both barometers was probably almost exactly the same, viz. about 120 feet above the sea. Hence I assume the heights given to be correct, and the neutral point is considered at 30.000 inches, as this agreement took place only $\frac{5}{100}$ lower. The capillary attraction of the instrument comes to be by Mr Daniell's estimate in boiled tubes 0.044. The instrument during the whole observations hung in the same spot, except a few days in January, (including the 12th and 15th,) when, though in another house, I consider the difference of level to have been next to nothing. As to the precautions taken to ensure accuracy, I shall simply state, that *every one* of the observations has been made with great care *by myself personally*, excepting only one or two morning ones on the 12th and 15th January; that the whole corrections and calculations have been performed by myself from the best data; and that in the whole series *not a single* dubious observation has been made use of. I now give the first table, including the original observations, as transferred to my register.

## TABLE I.

| No. | Day. Feb. | Hour. | Barom. | Ther. | No. | Day. Feb. | Hour. | Barom. | Ther. |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 10 M. | 29.840 | | | | 3 A. | 30.252 | 59 |
| | 2 | 8½ M. | 892 | 56 | | | 4 | 236 | 60 |
| | | 10 M. | 886 | 55 | | | 5 | 226 | 58.5 |
| | | 10½ A. | 854 | | | | 6 | 222 | 58 |
| | 3 | 11½ M. | 814 | | 20 | | 8 | 226 | 58 |
| | 4 | 10 M. | 960 | 57 | | | 9 | 224 | 58.5 |
| | | 11 | 30.018 | 57 | | | 10 | 224 | 58.5 |
| | | 1 A. | 044 | 58 | | | 11 | 224 | 57 |
| | | 9 | 120 | 57 | | 6 | 8 M. | 194 | 57 |
| 10 | | 10 | 164 | 57 | | | 9 | 150 | 55 |
| | | 11 | 174 | 58 | | | 10 | 118 | 57 |
| | 5 | 8 M. | 210 | 58 | | | 11 | 094 | 58.5 |
| | | 9 | 224 | 56 | | | 12 | 048 | 57 |
| | | 10 | 243 | 56 | | | 1 A. | 020 | 57 |
| | | 11 | 250 | 58 | 30 | | 5 | 29.996 | 57 |
| | | 12 | 250 | 58 | | | 6 | 970 | 57 |

| No. | Day. Feb. | Hour. | Barom. | Ther. | No. | Day. Feb. | Hour. | Barom. | Ther. |
|---|---|---|---|---|---|---|---|---|---|
| | | 7 | 29.938 | 57 | | | 11 | 29.800 | 55 |
| | | 8 | 908 | 57 | | | 2¼ A. | 756 | 54 |
| | | 9 | 870 | 56 | | | 4 | 750 | 54 |
| | | 10 | 850 | 55 | | | 9 | 778 | 54 |
| | | 11 | 832 | 56 | 80 | | 10 | 800 | 54 |
| | 7 | 8 M. | 774 | 56 | | | 11 | 800 | 54 |
| | | 9¼ | 740 | 55 | | | 12 | 796 | 54 |
| | | 9¾ | 654 | 55 | | 13 | 8 M. | 800 | 55 |
| 40 | | 2 A. | 650 | 56 | | | 9 | 800 | 55 |
| | | 7 | 622 | 56 | | | 10¼ | 790 | 55 |
| | | 8 | 594 | 55 | | | 12 | 790 | 55 |
| | | 9¼ | 574 | 56 | | | 5 A. | 770 | 54 |
| | | 10 | 574 | 56 | | | 8 | 768 | 54 |
| | | 11¾ | 574 | 56 | | | 11¼ | 758 | 54 |
| | 8 | 8 M. | 600 | 56 | 90 | | 12 | 760 | 54 |
| | | 10 | 626 | 54 | | 14 | 9 M. | 800 | 54 |
| | | 11 | 650 | 56 | | | 10 | 856 | 54 |
| | | 2¼ A. | 630 | 55 | | | 11 | 858 | 52 |
| 50 | | 5 | 690 | 54 | | | 12 | 874 | 53 |
| | | 8 | 718 | 55 | | | 1 A. | 886 | 53 |
| | | 9 | 768 | 55 | | | 2 | 892 | 53 |
| | | 10 | 806 | 54 | | | 4 | 900 | 53 |
| | | 11 | 850 | 54 | | | 5 | 910 | 53 |
| | 9 | 9 M. | 938 | 55 | | | 10 | 916 | 53 |
| | | 9¾ M. | 980 | 55 | 100 | | 11 | 918 | 53 |
| | | 1 A. | 016 | 55 | | | 12 | 918 | 53 |
| | | 2 | 036 | 55 | | 15 | 8 M. | 902 | 54 |
| | | 3¼ | 050 | 55 | | | 9 | 890 | 50 |
| 60 | | 8 | 078 | 54 | | | 10 | 878 | 51 |
| | | 12 | 094 | 54 | | | 11¾ | 866 | 52 |
| | 10 | 8 M. | 086 | 55 | | | 2 A. | 864 | 52 |
| | | 10 | 070 | 52 | | | 7 | 890 | 52 |
| | | 12 | 072 | 54 | | | 8 | 890 | 51 |
| | | 5 A. | 100 | 54 | | | 9 | 896 | 51 |
| | | 10 | 100 | 54 | 110 | | 10 | 896 | 51 |
| | | 11½ | 100 | 54 | | 16 | 11 | 896 | 51 |
| | | 10 | 074 | 54 | | | 8 M. | 896 | 51 |
| | 11 | 10¾ | 096 | 55 | | | 9 | 894 | 50 |
| | | 2 A. | 068 | 55 | | | 9¾ | 888 | 49 |
| 70 | | 7 | 050 | 54 | | | 1 A. | 892 | 51 |
| | | 8 | 042 | 54 | | | 2 | 892 | 51 |
| | | 11 | 016 | 54 | | | 8 | 904 | 51 |
| | | 12 | 006 | 54 | | | 9 | 906 | 51 |
| | 12 | 9 M. | 806 | 55 | 120 | | 10 | 907 | 50 |
| | | 10 | 790 | 55 | | | 11½ | 908 | 50 |

| No. | Day. Feb. | Hour. | Barom. | Ther. |
|---|---|---|---|---|
| | 17 | 8 M. | 29.900 | 52 |
| | | 9 | 900 | 51 |
| | | 10⅓ | 900 | 51 |
| | | 12 | 900 | 51 |
| | | 1 A. | 902 | 52 |
| | | 7 | 924 | 52 |
| | | 8 | 950 | 51 |
| | | 9 | 950 | 51 |
| | | 10 | 958 | 50 |
| 130 | | 11 | 960 | 51 |
| | 18 | 10 M. | 30.018 | 52 |
| | | 2 A. | 056 | 52 |
| | | 5 | 080 | 52 |
| | | 7 | 100 | 52 |
| | | 8 | 108 | 51 |
| | | 10 | 118 | 51 |
| | | 11 | 120 | 51 |
| | 19 | 8 M. | 118 | 51 |
| | | 1 A. | 118 | 54 |
| 140 | | 7 | 120 | 54 |
| | | 8 | 124 | 54 |
| | | 9¼ | 132 | 34 |
| | | 10 | 110 | 53 |
| | | 11 | 106 | 53 |
| | 20 | 9 M. | 066 | 54 |
| | | 10 | 040 | 54 |
| | | 12 | 020 | 54 |
| | | 1 A. | 014 | 54 |
| | | 2 | 000 | 54 |
| 150 | | 3 | 29.996 | 55 |
| | | 5 | 966 | 55 |
| | | 6 | 962 | 55 |
| | | 7 | 962 | 55 |
| | | 8 | 958 | 55 |
| | | 11 | 950 | 55 |
| | | 12 | 950 | 55 |
| | 21 | 9 M. | 940 | 56 |
| | | 10 | 918 | 56 |
| | | 12 | 906 | 56 |
| 160 | | 1 A. | 896 | 56 |
| | | 2 | 872 | 56 |
| | | 6¼ | 850 | 56 |
| | | 7 | 834 | 56 |
| | | 8 | 840 | 56 |
| | | 12½ | 816 | 56 |
| | 22 | 1 M. | 812 | 56 |
| | | 1⅓ | 29.808 | 56 |
| | | 9 | 802 | 57 |
| | | 10 | 790 | 57 |
| 170 | | 11 | 788 | 57 |
| | | 12 | 760 | 57 |
| | | 2¼ A. | 724 | 57 |
| | | 8 | 666 | 57 |
| | | 11 | 646 | 57 |
| | | 12 | 624 | 57 |
| | 23 | 10 M. | 626 | 58 |
| | | 11 | 624 | 57 |
| | | 12 | 624 | 56 |
| | | 5¼ | 650 | 55 |
| 180 | | 7 | 700 | 55 |
| | | 8 | 726 | 55 |
| | | 9¼ | 748 | 55 |
| | | 10 | 786 | 55 |
| | | 11 | 800 | 55 |
| | 24 | 7¼ M. | 855 | 55 |
| | | 8 | 874 | 56 |
| | | 9 | 892 | 54 |
| | | 10 | 916 | 53 |
| | | 11 | 930 | 54 |
| 190 | | 1¼ A. | 946 | 53 |
| | | 4 | 950 | 54 |
| | | 5 | 950 | 54 |
| | | 10 | 962 | 54 |
| | | 10¾ | 964 | 54 |
| | 25 | 9 M. | 970 | 53 |
| | | 10 | 984 | 53 |
| | | 1 A. | 990 | 53 |
| | | 2 | 990 | 53 |
| | | 7 | 996 | 52 |
| 200 | | 10 | 30.002 | 52 |
| | | 11 | 020 | 52 |
| | 26 | 9 M. | 144 | 53 |
| | | 9¾ | 170 | 53 |
| | | 12 | 176 | 52 |
| | | 2¼ A. | 200 | 52 |
| | | 3 | 200 | 51 |
| | | 6¼ | 238 | 50 |
| | | 9 | 258 | 51 |
| | | 10 | 288 | 50 |
| 210 | | 11 | 310 | 50 |
| | 27 | 9 M. | 350 | 49 |
| | | 10 | 376 | 49 |

| No. | Day. Feb. | Hour. | Barom. | Ther. | No. | Day. Mar. | Hour. | Barom. | Ther. |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 A. | 30.404 | 51 | 260 | | 10½ | 29.962 | 60 |
| | | 10 | 404 | 50 | | | 11½ | 974 | 61 |
| | | 12 | 408 | 50 | | | 11 A. | 30.006 | 59 |
| | 28 | 9 M. | 410 | 52 | | | 12 | 046 | 59 |
| | | 5½ A. | 364 | 52 | | 6 | 8 M. | 100 | 59 |
| | | 9 | 358 | 51 | | | 9 | 122 | 58 |
| 220 | | 11 | 358 | 51 | | | 6 | 150 | 59 |
| | Mar. | 11½ | 356 | 51 | | | 8 | 170 | 59 |
| | 1 | 8 M. | 356 | 52 | | | 9 | 180 | 59 |
| | | 9 | 330 | 50 | | | 10 | 198 | 60 |
| | | 10 | 330 | 50 | 270 | | 11 | 202 | 59 |
| | | 11 | 334 | 52 | | 7 | 8 M. | 240 | 59 |
| | | 12¼ | 328 | 53 | | | 10 | 258 | 58 |
| | | 1¼ A. | 314 | 53 | | | 11 | 262 | 58 |
| | | 2 | 314 | 53 | | | 2 A. | 276 | 59 |
| | | 5 | 300 | 53 | | | 6 | 276 | 59 |
| 230 | | 6 | 300 | 53 | | | 7 | 276 | 59 |
| | | 9 | 294 | 52 | | | 8 | 296 | 59 |
| | | 10 | 290 | 53 | | | 9 | 300 | 59 |
| | | 11 | 276 | 53 | | | 10 | 312 | 58 |
| | 2 | 8 M. | 274 | 55 | 280 | | 11½ | 316 | 58 |
| | | 9 | 274 | 53 | | 8 | 8 M. | 320 | 59 |
| | | 10½ | 260 | 53 | | | 10 | 307 | 59 |
| | | 11 | 242 | 54 | | | 11 | 306 | 59 |
| | | 12 | 284 | 55 | | | 1 A. | 296 | 59 |
| | | 12¾ | 274 | 54 | | | 2 | 288 | 60 |
| 240 | | 11 A. | 200 | 53 | | | 6 | 260 | 59 |
| | | 12 | 174 | 53 | | | 7 | 248 | 58 |
| | 3 | 8 M. | 176 | 55 | | | 10 A. | 30.248 | 58 |
| | | 10 | 172 | 55 | | | 11 | 238 | 58 |
| | | 11 | 160 | 56 | 290 | 9 | 8½ M. | 196 | 59 |
| | | 12 M. | 30.154 | 57 | | | 9½ | 196 | 60 |
| | | 1 A. | 148 | 59 | | | 10 | 196 | 60 |
| | | 9 | 136 | 56 | | | 10¾ | 174 | 60 |
| | | 10 | 124 | 56 | | | 7 A. | 110 | 60 |
| | | 11 | 124 | 56 | | | 9 | 102 | 60 |
| 250 | 4 | 9 M. | 104 | 58 | | | 10 | 096 | 60 |
| | | 1 A. | 050 | 60 | | | 11 | 100 | 60 |
| | | 2½ | 020 | 62 | | 10 | 9 M. | 070 | 60 |
| | | 6 | 29.950 | 61 | | | 10 | 058 | 60 |
| | | 7 | 950 | 60 | 300 | | 11 | 060 | 60 |
| | | 9 | 938 | 59 | | | 1 | 040 | 61 |
| | | 10 | 928 | 58 | | | 2 | 018 | 61 |
| | | 11 | 936 | 58 | | | 3 | 008 | 61 |
| | 5 | 8¼ M. | 946 | 59 | | | 4 | 29.990 | 60 |
| | | 9 | 952 | 59 | | | 6 | 976 | 59 |

| No. | Day. Mar. | Hour. | Barom. | Ther. | No. | Day. Apr. | Hour. | Barom. | Ther. |
|---|---|---|---|---|---|---|---|---|---|
| | | 9 | 29.994 | 60 | | | 9 | 30.258 | 61 |
| | | 10 | 996 | 58 | | | 10 | 258 | 62 |
| | | 11 | 30.002 | 59 | | | 11¼ | 250 | 62.5 |
| | 11 | 8 M. | 120 | 60 | | | 2 A. | 238 | 63 |
| 310 | | 9¼ | 150 | 59 | | | 3 | 238 | 63 |
| | | 10 | 170 | 58 | | | 8¼ | 224 | 61 |
| | | 1¼ A. | 206 | 59 | | | 9 | 230 | 61 |
| | | 3 | 226 | 59 | | | 10 | 220 | 60 |
| | | 6½ | 244 | 58 | 360 | | 11½ | 220 | 60 |
| | | 10¾ | 296 | 58 | | 11 | 8¼ M. | 218 | 61 |
| | | 12 | 314 | 58 | | | 9½ | 208 | 61 |
| | 12 | 7 M. | 340 | 59 | | | 11¼ | 198 | 61 |
| | | 9 | 350 | 57 | | | 2¼ A. | 192 | 63 |
| | | 0 | 350 | 58 | | | 3 | 192 | 63 |
| 320 | | 11 | 350 | 58 | | | 4 | 192 | 63 |
| | | 12 | 352 | 59 | | | 7½ | 196 | 61 |
| | | 12 | 848 | 61 | | 11 | 9 A. | 200 | 61 |
| | | 5 | 320 | 60 | | | 10¼ | 204 | 61 |
| | | 0 | 290 | 58 | 370 | | 11½ | 204 | 60 |
| | | 11 | 274 | 58 | | 12 | 8 M. | 226 | 62 |
| | 13 | 17¼ M. | 252 | 59 | | | 9 | 230 | 62 |
| | | 8 | 238 | 61 | | | 1½ A. | 260 | 65 |
| | 7 | 9 A. | 162 | 53 | | | 3 | 275 | 63 |
| | | 0 | 144 | 53 | | | 10 | 296 | 61 |
| 330 | | 11 | 124 | 53 | | | 11 | 305 | 62 |
| | 8 | 18 M. | 146 | 60 | | 13 | 10 M. | 358 | 64 |
| | | 9 | 158 | 61 | | | 10¾ | 378 | 63 |
| | | 1½ A. | 158 | 61 | | | 1 A. | 378 | 64 |
| | | 2 | 158 | 61 | 380 | | 3 | 580 | 64 |
| | | 4½ | 156 | 61 | | | 3½ | 379 | 64 |
| | | 6½ | 180 | 60 | | | 7½ | 379 | 63 |
| | | 8½ | 198 | 60 | | | 10 | 378 | 62 |
| | | 9½ | 210 | 60 | | | 11¼ | 378 | 62 |
| | | 0 | 222 | 60 | | 14 | 7½ M. | 370 | 63 |
| 340 | | 11½ | 226 | 60 | | | 8¼ | 370 | 64 |
| | 9 | 18 M. | 240 | 60.5 | | | 11 | 354 | 63 |
| | | 0 | 258 | 61 | | | 1 A. | 342 | 64 |
| | | 11 | 258 | 63 | | | 2 | 322 | 64 |
| | | 12 A. | 258 | 63 | 390 | | 3¾ | 302 | 64 |
| | | 3 | 258 | 63 | | | 4½ | 294 | 64 |
| | | 6 | 258 | 61 | | | 7 | 278 | 64 |
| | | 8 | 256 | 61 | | | 9¼ | 258 | 62 |
| | | 9 | 256 | 61 | | | 11 | 256 | 63 |
| | | 11 | 256 | 60 | | 15 | 7½ M. | 184 | 63 |
| 350 | | 11½ | 260 | 60 | | | 8 | 160 | 63 |
| | 10 | 8 M. | 256 | 60 | | | 8½ | 146 | 62 |

| No. | Day. Apr. | Hour. | Barom. | Ther. |
|---|---|---|---|---|
| | | 1 A. | 30.100 | 61 |
| | | 2 | 080 | 61 |
| 400 | | 3 | 058 | 61 |
| | | 4 | 048 | 61 |
| | | 7¼ | 010 | 61 |
| | | 8½ | 010 | 61 |
| | | 9 | 020 | 61 |
| | | 10 | 020 | 61 |
| | | 11 | 008 | 61 |
| | 16 | 8 M. | 29.990 | 62 |
| | | 9½ | 990 | 63 |
| | | 10 | 990 | 63 |
| 410 | | 12¼ M. | 990 | 63 |
| | | 1 A. | 968 | 64 |
| | | 2 | 958 | 64 |
| | | 4 | 962 | 62 |
| | | 5¼ | 950 | 62 |
| | | 7 | 962 | 62 |
| | | 8 | 970 | 62 |
| | | 9 | 970 | 62 |
| | | 10½ | 982 | 62 |
| | | 11 | 986 | 62 |
| 420 | 17 | 7½ M. | 982 | 63 |
| | | 8 | 994 | 63 |
| | | 9 | 996 | 63 |
| | | 10 | 996 | 63 |
| | | 11½ | 30.008 | 63 |
| | | 12½ | 010 | 63 |
| | | 2 A. | 014 | 64 |
| | | 2¾ | 010 | 64 |
| | | 5 | 016 | 63 |
| | | 6¼ | 016 | 62 |
| 430 | | 10 | 018 | 62 |
| | | 11 | 018 | 62 |
| | | 11¾ | 018 | 62.5 |
| | 18 | 7½ M. | 020 | 63 |
| | | 8 | 016 | 64 |
| | | 9 | 30.020 | 64 |
| | | 10 | 020 | 64 |
| | | 11 | 020 | 63 |
| | 19 | 6½ A. | 020 | 63 |
| | | 8 | 018 | 63 |
| 440 | | 9 | 016 | 62 |
| | | 10 | 016 | 62 |
| | | 11½ | 018 | 63 |
| | 20 | 8 | 010 | 63 |
| | | 9¼ | 010 | 63 |
| | | 10¼ | 014 | 63 |
| | | 11 | 014 | 63 |
| | | 12 | 014 | 62 |
| | | 2¼ A. | 016 | 63 |
| | | 2¾ | 016 | 63 |
| 450 | | 5¼ | 000 | 63 |
| | | 10¼ | 29.996 | 63 |
| | | 11½ | 994 | 62 |
| | 21 | 8 M. | 990 | 64 |
| | | 8½ | 990 | 64 |
| | | 10 | 30.000 | 65 |
| | | 7½ A. | 29.986 | 66 |
| | | 8 | 972 | 66 |
| | | 10 | 964 | 66 |
| | | 11 | 960 | 65 |
| 460 | 22 | 9 M. | 958 | 65 |
| | | 1 A. | 950 | 66 |
| | | 2 | 948 | 64 |
| | | 3 | 948 | 65 |
| | | 8 | 950 | 64 |
| | | 10 | 948 | 65 |
| | | 11½ | 942 | 64 |
| | 23 | 7 M. | 950 | 64 |
| | | 7¾ | 946 | 66 |
| | | 10 | 948 | 64 |
| 470 | | 11 | 950 | 64 |

N. B. The preceding temperatures are from the attached thermometer.

The preceding table being the results of the simple observations, as inserted in my register, the next object was to reduce them, 1*st*, By interpolating numbers for such intermediate hours as it was evident could be done with sufficient accuracy, and by reducing the heights which happened to be taken at fractionary parts of hours to the whole hours. 2*d*, By applying the correction for level, being $\frac{1}{10}$ and the neutral point 30.000. 3*d*, By making the correction for the temperature of the mercurial column, which was done from the following table, interpolated from that given in Daniell's *Meteorological Essays*.

TEMPERATURE.

| Barom. | 47° | 48° | 49° | 50° | 51° | 52° | 53° | 54° | 55° | 56° | 57° | 58° | 59° | 60° | 61° | 62° | 63° | 64° | 65° | 66° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29.5 | 38 | 41 | 44 | 46 | 48 | 50 | 53 | 55 | 58 | 61 | 64 | 66 | 69 | 72 | 74 | 76 | 79 | 81 | 83 | 86 |
| 30. | 38 | 41 | 44 | 46 | 48 | 51 | 53 | 56 | 59 | 62 | 65 | 67 | 70 | 72 | 75 | 77 | 80 | 82 | 85 | 88 |
| 30.5 | 39 | 42 | 45 | 47 | 49 | 52 | 54 | 57 | 60 | 63 | 65 | 68 | 71 | 74 | 76 | 79 | 81 | 84 | 86 | 89 |

The upper line contains the temperatures, the other three the corrections in 1000ths of an inch. It may at first appear that the following table might have been consolidated with the first, but the number of interpolations and changes in the hours render that impossible. To prevent repetition, the uncorrected heights are not again given, nor the interpolated ones; but any one may be found by applying the two corrections *contrary* to their signs to the corrected number in the last column, which number — 044 for capillary action, and + .138 for a reduction to the sea-shore (from about 120 feet above it) will give the true height of the barometer at 32°, and at the level of the Mediterranean.

## TABLE II.

| Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. | Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 8 M. | +3 | —62 | 29.829 | | 9 | —3 | —65 | 30.058 |
| | 9 | +3 | —60 | 827 | | 10 | —4 | —65 | 103 |
| | 10 | +3 | —59 | 824 | | 11 | —4 | —67 | 111 |
| 4 | 10 M. | +1 | —65 | 894 | 5 | 8 | —5 | —67 | 148 |
| | 11 | +0 | —65 | 953 | | 9 | —5 | —62 | 157 |
| | 12 | —1 | —67 | 966 | | 10 | —6 | —62 | 172 |
| | 1 A. | —1 | —67 | 978 | | 11 | —6 | —67 | 177 |

| Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|
| | 12 | — 6 | —67 | 30.177 |
| | 3 A. | — 6 | —70 | 176 |
| | 4 | — 6 | —73 | 157 |
| | 5 | — 6 | —69 | 151 |
| | 6 | — 6 | —67 | 149 |
| | 7 | — 6 | —67 | 151 |
| | 8 | — 6 | —67 | 153 |
| | 9 | — 6 | —69 | 151 |
| | 10 | — 6 | —69 | 151 |
| | 11 | — 6 | —65 | 153 |
| 6 | 8 M. | — 5 | —65 | 124 |
| | 9 | — 4 | —59 | 087 |
| | 10 | — 3 | —65 | 050 |
| | 11 | — 2 | —69 | 023 |
| | 12 | — 1 | —65 | 29.982 |
| | 1 A. | — 1 | —65 | 954 |
| | 5 | + 0 | —65 | 931 |
| | 6 | + 1 | —65 | 906 |
| | 7 | + 2 | —65 | 875 |
| | 8 | + 2 | —62 | 848 |
| | 9 | + 3 | —62 | 811 |
| | 10 | + 3 | —59 | 794 |
| | 11 | + 4 | —62 | 774 |
| 7 | 8 M. | + 6 | —62 | 718 |
| | 9 | + 6 | —58 | 696 |
| | 9¾ | + 9 | —57 | 606 |
| | 10 | doub | tful | |
| | 2 A. | + 9 | —60 | 599 |
| | 7 | + 9 | —60 | 571 |
| | 8 | +11 | —60 | 545 |
| | 9 | +11 | —60 | 521 |
| | 10 | +11 | —60 | 525 |
| | 11 | +11 | —60 | 525 |
| | 12 | +11 | —60 | 525 |
| 8 | 8 M. | +10 | —60 | 550 |
| | 9 | +10 | —57 | 565 |
| | 10 | + 9 | —54 | 581 |
| | 11 | + 9 | —60 | 599 |
| | 2 A. | + 9 | —57 | 573 |
| | 5 | + 8 | —54 | 644 |
| | 6 | + 8 | —55 | 652 |
| | 7 | + 7 | —56 | 660 |
| | 8 | + 7 | —57 | 668 |
| | 9 | + 6 | —59 | 715 |
| | 10 | + 5 | —56 | 775 |
| | 11 | + 4 | —56 | 798 |
| 9 | 9 M. | +2 | —59 | 29.881 |
| | 10 | +0 | —59 | 935 |
| | 1 A. | —0 | —59 | 947 |
| | 2 | —1 | —59 | 976 |
| | 3 | —1 | —59 | 987 |
| | 8 | —2 | —56 | 020 |
| | 12 | —2 | —56 | 036 |
| 10 | 8 M. | —2 | —59 | 025 |
| | 9 | —2 | —54 | 022 |
| | 10 | —2 | —51 | 017 |
| | 11 | —2 | —53 | 016 |
| | 12 | —2 | —56 | 014 |
| | 5 A. | —2 | —56 | 042 |
| 10 | 10 A. | —2 | —56 | 30.042 |
| | 11 | —2 | —56 | 042 |
| | 12 | —2 | —56 | 042 |
| 11 | 10 M. | —2 | —56 | 016 |
| | 2 A. | —2 | —59 | 007 |
| | 7 | —1 | —56 | 29.993 |
| | 8 | —1 | —56 | 985 |
| | 9 | —1 | —56 | 977 |
| | 10 | —1 | —56 | 968 |
| | 11 | —0 | —56 | 960 |
| | 12 | —0 | —56 | 950 |
| 12 | 9 M. | +5 | —59 | 752 |
| | 10 | +5 | —59 | 736 |
| | 11 | +5 | —59 | 746 |
| | 2 A. | +6 | —56 | 709 |
| | 4 | +6 | —56 | 700 |
| | 9 | +6 | —56 | 728 |
| | 10 | +5 | —56 | 751 |
| | 11 | +5 | —56 | 751 |
| | 12 | +5 | —56 | 747 |
| 13 | 8 M. | +5 | —59 | 746 |
| | 9 | +5 | —59 | 746 |
| | 10 | +5 | —59 | 738 |
| | 11 | +5 | —59 | 736 |
| | 12 | +5 | —59 | 746 |
| | 5 A. | +6 | —59 | 720 |
| | 6 | +6 | —59 | 719 |
| | 7 | +6 | —56 | 719 |
| | 8 | +6 | —56 | 718 |
| | 9 | +6 | —56 | 715 |
| | 10 | +5 | —56 | 712 |
| | 11 | +6 | —56 | 709 |
| | 12 | +6 | —59 | 707 |

| Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. | Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| 14 | 9 M. | +5 | —56 | 29.749 | | 10 | +1 | —46 | 29.913 |
| | 10 | +4 | —56 | 804 | | 11 | +1 | —48 | 913 |
| | 11 | +4 | —51 | 811 | 18 | 10 M. | —0 | —51 | 967 |
| | 12 M. | +3 | —53 | 824 | | 2 A. | —1 | —51 | 30.004 |
| | 1 A. | +3 | —58 | 836 | | 3 | —2 | —51 | 012 |
| | 2 | +3 | —53 | 842 | | 4 | —2 | —51 | 020 |
| | 3 | +3 | —53 | 847 | | 5 | —2 | —51 | 027 |
| | 4 | +3 | —53 | 850 | | 6 | —2 | —51 | 037 |
| | 5 | +2 | —53 | 859 | | 7 | —2 | —51 | 047 |
| | 10 | +2 | —53 | 865 | | 8 | —3 | —48 | 057 |
| | 11 | +2 | —53 | 867 | | 9 | —3 | —48 | 062 |
| | 12 | +2 | —53 | 867 | | 10 | —3 | —48 | 067 |
| 15 | 8 M. | +2 | —56 | 847 | | 11 | —3 | —48 | 069 |
| | 9 | +3 | —46 | 847 | 19 | 8 M. | —3 | —48 | 067 |
| | 10 | +3 | —48 | 833 | | 9 | —3 | —50 | 065 |
| | 11 | +3 | —50 | 823 | | 10 | —3 | —51 | 063 |
| | 12 | +3 | —51 | 817 | | 1 A. | —3 | —56 | 057 |
| | 11 A. | +3 | —51 | 817 | | 7 | —3 | —56 | 061 |
| | 2 | +3 | —51 | 816 | | 8 | —3 | —56 | 065 |
| | 7 | +3 | —51 | 842 | | 9 | —3 | —56 | 071 |
| | 8 | +3 | —48 | 845 | | 10 | —3 | —53 | 064 |
| | 9 | +3 | —48 | 851 | | 11 | —3 | —53 | 054 |
| | 10 | +3 | —48 | 851 | 20 | 9 M. | —2 | —56 | 008 |
| | 11 | +3 | —48 | 851 | | 10 | —1 | —56 | 29.987 |
| | 12 | +3 | —48 | 851 | | 11 | —1 | —56 | 973 |
| 16 | 8 M. | +3 | —48 | 851 | | 12 | —1 | —56 | 963 |
| | 9 | +3 | —46 | 851 | | 1 A. | —0 | —56 | 958 |
| | 10 | +3 | —44 | 845 | | 2 | —0 | —56 | 944 |
| | 11 | +3 | —46 | 848 | | 3 | +0 | —59 | 937 |
| | 12 | +3 | —46 | 848 | | 4 | +1 | —59 | 913 |
| | 1 A. | +3 | —48 | 847 | | 5 | +1 | —59 | 908 |
| | 2 | +3 | —48 | 847 | | 6 | +1 | —59 | 904 |
| | 8 | +2 | —48 | 858 | | 7 | +1 | —59 | 904 |
| | 9 | +2 | —48 | 860 | | 8 | +1 | —59 | 900 |
| | 10 | +2 | —46 | 863 | | 9 | +1 | —59 | 896 |
| | 11 | +2 | —46 | 863 | | 10 | +1 | —59 | 893 |
| | 12 | +2 | —46 | 864 | | 11 | +1 | —59 | 892 |
| 17 | 8 M. | +3 | —51 | 842 | | 12 | +1 | —59 | 892 |
| | 9 | +3 | —48 | 845 | 21 | 9 M. | +1 | —62 | 859 |
| | 10 | +3 | —48 | 845 | | 10 | +2 | —62 | 858 |
| | 11 | +3 | —48 | 845 | | 11 | +2 | —62 | 852 |
| | 12 | +3 | —48 | 845 | | 12 | +2 | —62 | 846 |
| | 1 A. | +2 | —51 | 853 | | 1 A. | +8 | —62 | 837 |
| | 7 | +2 | —51 | 875 | | 2 | +3 | —62 | 813 |
| | 8 A. | +1 | —48 | 903 | | 6 | +4 | —62 | 796 |
| | 9 | +1 | —48 | 903 | | 7 | +4 | —62 | 776 |

| Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. | Day. Feb. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| | 8 | + 4 | —62 | 29.782 | | 10 | — 4 | —53 | 30.113 |
| | 12 | + 5 | —62 | 761 | | 12 | — 4 | —51 | 121 |
| 22 | 1 M. | + 5 | —62 | 755 | | 1 A. | — 5 | —51 | 142 |
| | 2 | + 5 | —62 | 747 | | 3 | — 5 | —48 | 147 |
| | 9 | + 5 | —65 | 742 | | 6 | — 6 | —46 | 163 |
| | 10 | + 5 | —65 | 730 | | 9 | — 6 | —49 | 205 |
| | 11 | + 5 | —65 | 728 | | 10 | — 7 | —47 | 234 |
| | 12 | + 6 | —65 | 700 | | 11 | — 8 | —47 | 255 |
| | 1 A. | + 6 | —64 | 686 | 27 | 9 M. | — 9 | —45 | 296 |
| | 2 | + 7 | —64 | 671 | | 10 | — 9 | —45 | 222 |
| | 8 | + 8 | —64 | 610 | | 11 | —10 | —47 | 336 |
| | 9 | + 8 | —64 | 604 | | 12 | —10 | —47 | 343 |
| | 10 | + 9 | —64 | 597 | | 1 A | —10 | —49 | 345 |
| | 11 | + 9 | —64 | 591 | | 10 | —10 | —47 | 347 |
| | 12 | + 9 | —64 | 569 | | 11 | —10 | —47 | 349 |
| 23 | 10 M. | + 9 | —66 | 569 | | 12 | —10 | —47 | 351 |
| | 11 | + 9 | —64 | 569 | 28 | 9 M. | —10 | —52 | 348 |
| | 12 | + 9 | —61 | 569 | | 5 A. | — 9 | —52 | 302 |
| | 5 A. | + 9 | —58 | 594 | | 6 | — 9 | —52 | 305 |
| | 6 | + 8 | —58 | 622 | | 9 | — 9 | —49 | 300 |
| | 7 | + 8 | —58 | 650 | | 10 | — 9 | —49 | 300 |
| | 8 | + 7 | —58 | 675 | | 11 | — 9 | —49 | 300 |
| | 9 | + 6 | —58 | 692 | Mar. | 12 | — 9 | —49 | 296 |
| | 10 | + 5 | —59 | 732 | 1 | 8 M. | — 9 | —52 | 295 |
| | 11 | + 5 | —59 | 746 | | 9 | — 8 | —47 | 274 |
| 24 | 7 M. | + 4 | —59 | 787 | | 10 | — 8 | —47 | 274 |
| | 8 | + 3 | —62 | 815 | | 11 | — 8 | —52 | 274 |
| | 9 | + 3 | —56 | 839 | | 12 M. | — 8 | —54 | 267 |
| | 10 | + 2 | —53 | 865 | | 1 A. | — 8 | —54 | 265 |
| | 11 | + 2 | —56 | 876 | | 2 | — 8 | —54 | 242 |
| | 12 | + 1 | —57 | 885 | | 3 | — 8 | —54 | 247 |
| | 1 | + 1 | —53 | 893 | | 4 | — 8 | —54 | 242 |
| | 4 | + 1 | —56 | 895 | | 5 | — 8 | —54 | 238 |
| | 5 A. | + 1 | —56 | 895 | | 6 | — 8 | —54 | 238 |
| | 10 | + 1 | —56 | 907 | | 7 | — 7 | —53 | 237 |
| | 11 | + 1 | —56 | 910 | | 8 | — 7 | —53 | 236 |
| 25 | 9 M. | + 1 | —53 | 918 | | 9 | — 7 | —52 | 235 |
| | 10 | + 0 | —53 | 931 | | 10 | — 7 | —54 | 229 |
| | 1 A. | + 0 | —53 | 937 | | 11 | — 7 | —54 | 215 |
| | 2 | + 0 | —53 | 937 | 2 | 8 M | — 7 | —54 | 213 |
| | 7 | + 0 | —51 | 945 | | 9 | — 7 | —54 | 213 |
| | 8 | + 0 | —51 | 946 | | 10 | — 7 | —54 | 204 |
| | 9 | + 0 | —51 | 948 | | 11 | — 6 | —56 | 180 |
| | 10 | — 0 | —51 | 951 | | 12 | — 7 | —60 | 217 |
| | 11 | — 1 | —51 | 968 | | 1 A. | — 7 | —57 | 206 |
| 26 | 9 M. | — 4 | —53 | 30.087 | | 11 A. | — 5 | —53 | 144 |

| Day. Mar. | Hour | Corr. level. | Corr. temp. | Barom. correct. | Day. Mar. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| | 12 | —4 | —53 | 30.117 | 8 | 8 M. | —8 | —71 | 30. 241 |
| 3 | 8 M. | —4 | —59 | 113 | | 9 | —8 | —71 | 232 |
| | 9 | —4 | —59 | 112 | | 10 | —8 | —71 | 228 |
| | 10 | —4 | —59 | 111 | | 11 | —8 | —71 | 227 |
| | 11 | —4 | —62 | 094 | | 12 | —7 | —71 | 223 |
| | 12 | —4 | —65 | 085 | | 1 A. | —7 | —71 | 218 |
| | 1 A. | —4 | —70 | 074 | | 2 | —7 | —74 | 207 |
| | 9 | —3 | —62 | 071 | | 6 | —7 | —71 | 182 |
| | 10 | —3 | —62 | 059 | | 7 | —6 | —67 | 175 |
| | 11 | —3 | —62 | 059 | | 10 | —6 | —67 | 175 |
| 4 | 9 M. | —3 | —67 | 034 | | 11 | —6 | —67 | 165 |
| | 1 A. | —1 | —72 | 29.977 | 9 | 8 M. | —5 | —69 | 122 |
| | 2 | —1 | —77 | 948 | | 10 | —5 | —71 | 120 |
| | 6 | +1 | —75 | 876 | | 10 | —5 | —72 | 119 |
| | 7 | +1 | —72 | 879 | | 11 | —4 | —72 | 091 |
| | 8 | +1 | —71 | 874 | | 7. A | —3 | —72 | 035 |
| | 9 | +2 | —70 | 870 | | 8 | —3 | —72 | 031 |
| | 10 | +2 | —67 | 863 | | 9 | —3 | —72 | 027 |
| | 11 | +2 | —67 | 871 | | 10 A. | —2 | —72 | 022 |
| 5 | 8 M. | +1 | —70 | 874 | | 11 | —2 | —72 | 026 |
| | 9 | +1 | —70 | 883 | 10 | 9 M. | —2 | —72 | 29.996 |
| | 10 | +1 | —72 | 888 | | 10 | —1 | —72 | 985 |
| | 11 | +1 | —73 | 896 | | 11 | —1 | —72 | 987 |
| | 12 M. | +1 | —75 | 907 | | 12 | —1 | —73 | 976 |
| | 11 A. | —0 | —70 | 936 | | 1 A. | —1 | —75 | 964 |
| | 12 | —1 | —70 | 975 | | 2 | —0 | —75 | 953 |
| 6 | 8 M. | —2 | —70 | 30.028 | | 3 | —0 | —75 | 933 |
| | 9 | —3 | —67 | 052 | | 4 | +0 | —72 | 918 |
| | 6 A. | —4 | —70 | 076 | | 5 | +0 | —71 | 912 |
| | 7 | —4 | —70 | 086 | | 6 | +1 | —70 | 907 |
| | 8 | —4 | —70 | 096 | | 9 | +0 | —72 | 922 |
| | 9 | —4 | —70 | 106 | | 10 | +0 | —67 | 929 |
| | 10 | —5 | —72 | 121 | | 11 | —0 | —70 | 932 |
| | 11 | —5 | —70 | 127 | 11 | 8 M. | —3 | —72 | 30.945 |
| 7 | 8 M. | —6 | —70 | 164 | | 9 | —4 | —70 | 070 |
| | 9 | —6 | —68 | 175 | | 10 | —4 | —67 | 099 |
| | 10 | —6 | —68 | 184 | | 1 A. | —5 | —70 | 134 |
| | 11 | —7 | —68 | 187 | | 2 | —5 | —70 | 142 |
| | 2 A. | —7 | —71 | 198 | | 3 | —6 | —70 | 150 |
| | 6 | —7 | —71 | 198 | | 6 | —6 | —67 | 170 |
| | 7 | —7 | —71 | 198 | | 10 | —7 | —68 | 218 |
| | 8 | —7 | —71 | 218 | | 11 | —8 | —68 | 228 |
| | 9 | —7 | —71 | 222 | | 12 | —8 | —68 | 238 |
| | 10 | —8 | —68 | 236 | 12 | 7 M. | —8 | —71 | 261 |
| | 11 | —8 | —68 | 242 | | 8 | —8 | —68 | 269 |
| | 12 | —8 | —68 | 243 | | 9 | —9 | —65 | 276 |

| Day. Mar | Hour. | Corr. level. | Corr. temp. | Barom. correct. | Day. Apr. | Hour. | Corr. level. | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| 12 | 10 | —9 | —68 | 30.273 | 10 | 2 A. | — 6 | —80 | 30.153 |
|  | 11 | —9 | —68 | 273 |  | 3 | — 6 | —80 | 153 |
|  | 12 | —9 | —71 | 272 |  | 8 | — 6 | —75 | 145 |
|  | 1 A. | —9 | —73 | 277 |  | 9 | — 6 | —75 | 149 |
|  | 2 | —9 | —76 | 263 |  | 10 A. | — 6 | —72 | 142 |
|  | 5 | —8 | —74 | 238 |  | 11 | — 6 | —72 | 142 |
|  | 10 | —7 | —68 | 215 | 11 | 8 M. | — 5 | —75 | 140 |
|  | 11 | —7 | —68 | 199 |  | 9 | — 5 | —75 | 132 |
| 13 | 7 M. | —6 | —68 | 181 |  | 10 | — 5 | —75 | 124 |
| Apr. | 8 | —6 | —75 | 157 |  | 11 | — 5 | —75 | 119 |
| 7 | 9 A. | —4 | —53 | 105 |  | 2 A. | — 5 | —80 | 107 |
|  | 10 | —4 | —53 | 087 |  | 3 | — 5 | —80 | 107 |
|  | 11 | —3 | —53 | 068 |  | 4 | — 5 | —80 | 107 |
| 8 | 8 M. | —4 | —72 | 070 |  | 7 | — 5 | —75 | 115 |
|  | 9 | —4 | —75 | 079 |  | 8 | — 5 | —75 | 117 |
|  | 1 A. | —4 | —75 | 079 |  | 9 | — 5 | —75 | 120 |
|  | 2 | —4 | —75 | 079 |  | 10 | — 5 | —75 | 123 |
|  | 3 | —4 | —75 | 078 |  | 11 | — 5 | —72 | 127 |
|  | 4 | —4 | —75 | 077 | 12 | 8 M. | — 6 | —77 | 143 |
|  | 5 | —4 | —75 | 077 |  | 9 | — 6 | —77 | 147 |
|  | 6 | —4 | —75 | 083 |  | 10 | — 6 | —79 | 152 |
|  | 7 | —5 | —72 | 098 |  | 1 A. | — 7 | —85 | 173 |
|  | 8 | —5 | —72 | 107 |  | 2 | — 7 | —83 | 180 |
|  | 9 | —5 | —72 | 116 |  | 3 | — 7 | —89 | 187 |
|  | 10 | —6 | —72 | 127 |  | 10 | — 7 | —74 | 215 |
|  | 11 | —6 | —72 | 144 |  | 11 | — 8 | —76 | 221 |
|  | 12 | —6 | —72 | 149 | 13 | 10 M. | — 9 | —84 | 265 |
| 9 | 8 M. | —6 | —74 | 160 |  | 11 | —10 | —81 | 292 |
|  | 9 | —6 | —75 | 168 |  | 1 A | — 9 | —84 | 285 |
|  | 10 | —6 | —76 | 176 |  | 2 | — 9 | —84 | 286 |
|  | 11 | —6 | —81 | 171 |  | 3 | — 9 | —84 | 287 |
|  | 2 A. | —6 | —81 | 171 |  | 4 | — 9 | —84 | 285 |
|  | 3 | —6 | —81 | 171 |  | 7 | — 9 | —81 | 289 |
|  | 4 | —6 | —80 | 173 |  | 10 | — 9 | —79 | 290 |
|  | 5 | —6 | —78 | 174 |  | 11 | — 9 | —79 | 290 |
|  | 6 | —6 | —76 | 176 | 14 | 7 M. | — 9 | —71 | 280 |
|  | 7 | —6 | —76 | 175 |  | 8 | — 9 | —84 | 277 |
|  | 8 | —6 | —76 | 174 |  | 9 | — 9 | —83 | 274 |
|  | 9 | —6 | —76 | 174 |  | 10 | — 9 | —83 | 264 |
|  | 10 | —6 | —75 | 175 |  | 11 | — 9 | —81 | 264 |
|  | 11 | —6 | —74 | 176 |  | 12 | — 9 | —81 | 254 |
|  | 12 | —6 | —74 | 184 |  | 1 A. | — 9 | —82 | 251 |
| 10 | 8 M. | —6 | —74 | 176 |  | 2 | — 8 | —82 | 232 |
|  | 9 | —6 | —76 | 176 |  | 3 | — 7 | —82 | 221 |
|  | 10 | —6 | —79 | 173 |  | 4 | — 7 | —82 | 208 |
|  | 11 | —6 | —79 | 166 |  | 7 | — 7 | —82 | 189 |

| Day. Apr. | Hour. | Corr. level. | Corr. temp. | Barom. correct. | Day. Apr. | Hour. | Corr. level | Corr. temp. | Barom. correct. |
|---|---|---|---|---|---|---|---|---|---|
| 14 | 9 A. | —7 | —77 | 30.178 | 18 | 7 M. | —0 | —80 | 29.946 |
|  | 10 | —6 | —79 | 174 |  | 8 | —0 | —82 | 934 |
|  | 11 | —6 | —80 | 170 |  | 9 | —0 | —82 | 938 |
| 15 | 7 M. | —5 | —80 | 111 |  | 10 | —0 | —82 | 938 |
|  | 8 | —4 | —84 | 076 |  | 11 | —0 | —80 | 940 |
|  | 9 | —3 | —77 | 052 | 19 | 6 A. | —0 | —80 | 941 |
|  | 1 A. | —2 | —75 | 023 |  | 7 | —0 | —80 | 939 |
|  | 2 | —2 | —75 | 003 |  | 8 | —0 | —80 | 938 |
|  | 3 | —1 | —75 | 29.982 |  | 9 | —0 | —77 | 939 |
|  | 4 | —1 | —75 | 972 |  | 10 | —0 | —77 | 939 |
|  | 7 | —0 | —75 | 935 |  | 11 | —0 | —80 | 938 |
|  | 8 | —0 | —75 | 935 | 20 | 8 M. | —0 | —80 | 930 |
|  | 9 | —0 | —75 | 945 |  | 9 | —0 | —80 | 930 |
|  | 10 | —0 | —75 | 945 |  | 10 | —0 | —80 | 933 |
|  | 11 | —0 | —75 | 933 |  | 11 | —0 | —80 | 934 |
| 16 | 8 M. | +0 | —77 | 918 |  | 12 | —0 | —77 | 931 |
|  | 9 | +0 | —80 | 910 |  | 2 A. | —0 | —80 | 936 |
|  | 10 | +0 | —80 | 910 |  | 3 | 0 | —80 | 936 |
|  | 11 | +0 | —80 | 910 |  | 5 | 0 | —80 | 922 |
|  | 12 | +0 | —80 | 910 |  | 10 | +0 | —80 | 916 |
|  | 1 A. | +1 | —82 | 887 |  | 11 | +0 | —77 | 918 |
|  | 2 | +1 | —82 | 887 | 21 | 8 M. | +0 | —82 | 908 |
|  | 4 | +1 | —77 | 886 |  | 9 | +0 | —83 | 910 |
|  | 5 | +1 | —77 | 875 |  | 10 | +0 | —85 | 915 |
|  | 6 | +1 | —77 | 880 |  | 7 A. | +0 | —88 | 902 |
|  | 7 | +1 | —77 | 885 |  | 8 | +1 | —88 | 885 |
|  | 8 A. | +1 | —77 | 894 |  | 9 | +1 | —88 | 880 |
|  | 9 | +1 | —77 | 894 |  | 10 | +1 | —88 | 876 |
|  | 10 | +0 | —77 | 903 |  | 11 | +1 | —85 | 876 |
|  | 11 | +0 | —77 | 909 | 22 | 9 M. | +1 | —85 | 874 |
| 17 | 8 M. | +0 | —80 | 914 |  | 1 A. | +1 | —88 | 863 |
|  | 9 | +0 | —80 | 916 |  | 2 | +1 | —82 | 861 |
|  | 10 | +0 | —80 | 916 |  | 3 | +1 | —85 | 864 |
|  | 11 | —0 | —80 | 924 |  | 8 | +1 | —82 | 869 |
|  | 12 | —0 | —80 | 929 |  | 10 | +1 | —85 | 863 |
|  | 2 A. | —0 | —82 | 932 |  | 11 | +1 | —82 | 863 |
|  | 3 | —0 | —82 | 928 | 23 | 7 M. | +1 | —82 | 869 |
|  | 5 | —0 | —80 | 936 |  | 8 | +1 | —88 | 858 |
|  | 6 | —0 | —77 | 939 |  | 9 | +1 | —85 | 863 |
|  | 10 | —0 | —77 | 941 |  | 10 | +1 | —82 | 867 |
|  | 11 | —0 | —77 | 941 |  | 11 | +1 | —82 | 869 |
|  | 12 | —0 | —78 | 939 |  |  |  |  |  |

*(To be concluded in next Number.)*

## Art. XXI.—*On Footsteps before the Flood, in a specimen of Red Sandstone.* By Mr Grierson. *

It was obtained from the sandstone quarry of Corncockle Muir, about two miles to the north of the town of Lochmaben, in the county of Dumfries. The existence of specimens of this kind in that quarry has been known for a considerable time. Having lately spent a few days in that neighbourhood with Dr Duncan of Ruthwell, who is in possession of the finest specimens that have yet been procured, and who was anxious to obtain some others for Professor Buckland of Oxford, with whom he had been corresponding on the subject, I went with him to the quarry to see the original deposite, and, if possible, to procure a small slab for myself. The professor having received a cast of the most distinct impressions which Dr Duncan's specimens exhibit, together with a fragment of the sandstone itself, was so fully convinced by them that the rock, while in a soft state, had been traversed by living quadrupeds, though the fact was at variance with his general opinions respecting the geological formation, that he wrote to the doctor, earnestly requesting him to procure, at any expence, any specimens that could then, or that might in future be discovered.

On entering the quarry we found that the dip of the strata was towards the west, and at an angle of about 35 degrees. On the eastern side, therefore, it was the upper *surface* of the strata that was presented to us, and of this there was a great lateral extent. The upper edge of the strata, the face of which was there exposed, reached within about 15 feet of the surface of the ground. From this upper boundary down to the line where they disappeared under the rubbish, which, since the working had been carried on chiefly on the opposite side of the quarry, had accumulated at their base, there were fully 15 feet of their surface distinctly exhibited, and this for a range of not less than between 40 and 50 yards. On examining the whole range of this acclivity, we found no less

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* Read before the general meeting of the Literary and Antiquarian Society of Perth on the 22d November last.

than four separate tracks of as many different kinds of animals, and all of them different from *two* of the specimens at least which were already in Dr Duncan's possession. Three of these tracks were towards the south extremity of the range, on the surface of the same identical layer, and two of them within two or three yards of each other. The fourth one was towards the north extremity, and probably on the same layer as the others, but owing to some bendings in the direction of the strata, and to a quantity of earth, which at one place has rolled down and interrupted the view, this was what we did not fully ascertain. The simple inspection of the tracks themselves, however, made it impossible to doubt in what manner they had been produced. The great number of the impressions in uninterrupted continuity—the regular alternations of the right and left footsteps—their equidistance from each other—the outward direction of the toes—the grazing of the foot along the surface before it was firmly planted—the deeper impression made by the toe than by the heel—the forcing forward of the sandy matter of the rock by the downward and scarcely slanting direction in which it is remarkable that all the animals have traversed this singular acclivity—and in the largest specimen which Dr Duncan has, and which was found in a different part of the quarry—the sharp, and well-defined marks of the three claws of the animal's foot—are circumstances which immediately arrest the attention of the observer, and force him to acknowledge that they admit of only one explanation.

Of the four different tracks here mentioned, the one which was farthest to the south exhibited the deepest and most distinct impressions, and it was from it, therefore, that I wished to obtain a specimen. Having selected and marked off six prints of the foot, three on each side, it was found an easy process to detach them, as the layer which contained them did not exceed three quarters of an inch in thickness, while the one on which it rested was not less than a foot and half. The thinness of the slab, which rendered its separation so easy, rendered it at the same time so extremely fragile, that it went to pieces in the hands of the person who was removing it to the bottom of the quarry, and who was forced into a running motion by the steepness of the path in which he had to descend. Owing, however, to the comparative hardness of those parts which had been subjected to the pressure of the animal, the footmarks were but little injured by the fracture, and having collected and arranged on the spot as many of the fragments as we could clearly distinguish, they were afterwards put in a flat wooden case, and cemented with stucco, which, besides keeping them in their relative positions, served as a sort of compensation for those that were awanting. Mutilated as it is, the specimen is sufficient to show the size and shape of the footmarks, and the length of the stride or step, which is about 12 or 13 inches, and therefore of course a kind of index to the length of the animal's body. To what species the animal belonged I leave it to more skilful naturalists to determine. The impressions, of which a cast was sent to Dr Buckland, are thought by him to have been produced by the feet of a tortoise or crocodile.

The track next to the one from which this specimen was got, was that of an animal whose foot must have been about seven or eight inches in length, and fully four inches in breadth; and whose stride measured about twenty inches. The footmarks of this track were not so distinct as those of the preceding; and in some instances they had been filled up by a subsequent deposition of sandy matter, which was a little more elevated than the lip or edge of the impression—presenting exactly such an appearance as is sometimes exhibited on the sea-beach, where the tide has passed over and filled up the footsteps of a recent traveller. Of these impressions we eagerly set about obtaining a specimen, in order that Dr Duncan might meet the request of Professor Buckland; but we had the mortification of finding, that in the neighbourhood of this track, the thin superficial layer was, owing as it seemed to the pressure of the large animal which had walked over it, so closely compacted with the stratum beneath, that it was impossible to remove the specimen without quarrying an immense solid block. One or two footmarks, indeed, we did succeed in flaking or tearing off, but in a very imperfect state; and we had then an opportunity of observing, that in the centre of the part where the pressure had been greatest, the matter of the thin layer was less adhering to the one below; while the matter of this under one, escaping as it were from this pressure, had been forced up round the anterior margin of the foot, and produced a hollow impression on the under side of the incumbent layer.

A few yards to the north of the tracks already described, there was a third, in which the footmarks were all filled up and elevated rather than depressed, though the general outline was perfectly distinct. One row of them, indeed, was much more distinct than the rest; for it seemed as if at this place two or three animals of the same species had descended in succession, at some distance of time from each other. The shape of the footmarks was a blunt oval about 1½ inch in length, and those on each side were not more than 3½ inches asunder, while the distance of the one side from the other did not much exceed 1½ inch. Of these a very good specimen was obtained, the thickness of the containing layer being at this place nearly equal to that of thin pavement.

The separate track at the north extremity of the range was that of an animal still smaller than the one last mentioned, and whose foot was more circular. Here too more than one animal had passed along. The impressions were very numerous, and could be traced from the earthy belt on which we stood up to the very outgoing of the stratum; but besides being probably slight at first, they had all been so completely filled up with a sandy sediment, exactly similar to the rest of the rock, as not to afford any specimen that would have been of much value, when unconnected with others, or with the series to which it belonged.

It will be obvious, from the preceding description of the stratum containing these animal impressions, that though now lying bare and superficial as at the time when these impressions were made, it is really the one on which all the other strata of the quarry had been superimposed. It may be proper to state, too, that though the tracks here described are at the upper part of the acclivity, one of the specimens belonging to Dr Duncan, which contains the deepest and most distinct impressions that have yet been discovered, was found at the base of the stratum, in the lower part of the quarry, perhaps 60 or 70 feet beneath the surface of the earth. In what manner the facts and phenomena now described may affect some interesting questions in geology, I shall not presume to inquire; but I think I may be permitted to remark in conclusion, that we have now specimens of the new red sandstone, containing impressions of *quadrupeds*, impressions which, to say the least, may be denominated, Footsteps before the Flood.

## ART. XXII.—*On the Improvements in the Elements of the Moon's Orbit.* By M. LE CHEVALIER BURG,* Corresponding Member of the Academy of Sciences, F.R.S.E. &c. &c. In a Letter to Dr BREWSTER.

I AM glad to perceive from your letter that you have been interested in the communication which I sent you two years ago respecting my investigations into the elements of the lunar orbit. I have continued these researches without intermission, and I am resolved to occupy myself with them during the rest of my life. My principal object is to establish several epochs in order to decide the question, whether or not the mean motion of the moon is modified by an equation still unknown. I have, however, no intention of neglecting the correction of the other elements, and the more so as I am convinced that most of the coefficients of the equations of longitude may be deduced with certainty to *half a second*, and that the epochs determined will be as much more certain as the tables with which the observations are compared are exact. I have indeed already corrected almost the half of the equations of longitude, and as soon as I have done this with the rest, I shall calculate the select observations of Bradley in order to establish the epoch of 1755. If I live long enough to be able also to determine the epochs of 1802 and 1825, or 1830, we may consider the above mentioned question resolved. It is true that we can only arrive at this by employing much time and labour, but as analysis has not yet afforded the solution, and is not likely to do it

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* This distinguished astronomer obtained the prize offered by the Board of Longitude at Paris in 1800 for the best Lunar Tables, and since that time he has been incessantly occupied in the improvement of that great work. These Tables were published by Dr Vince in the Third Volume of his *Astronomy*.

soon, we have no other alternative but by comparison with observations.

I have succeeded in finding the first coefficient of the variation independently of the radius of the moon, by determining its value from the meridional passages of both kinds observed by Maskelyne at the full moon from 1765 to 1803. In general the result was not different from that which I had formerly found, by comparing the observations made at Greenwich between 1765 and 1794 before full moon, with those made after full moon. The result shows, that the radius of the moon adopted in my tables ought on no account to be diminished, as Burckhardt believes, but, on the contrary, increased by 1″4 from 1765 to the 11th July 1772, and by 0″3 after this period, in order to reduce exactly to the moon's centre the observed right ascensions of her limbs. From the first coefficient of the variation found in this manner we deduce the sun's parallax 8″62, and it appears to me that this value is not less probable than that found by M. Encke from the two transits of Venus in 1761 and 1769. The result given by the two equations, one of which depends on the longitude of the node, and the other on the true longitude of the moon, is equally satisfactory. The first gives for the flattening of the poles of the earth $\frac{1}{295}$, and the second, which is quite independent of the first, gives $\frac{1}{294}$.

With respect to the fundamental epochs, I have found for 1779, and for the meridian of Greenwich,

| | | | | |
|---|---|---|---|---|
| Mean longitude of the moon, - | $2^s$ | 12° | 45′ | 55″.73 |
| Mean anomaly, - | 5 | 11 | 50 | 33 0 |
| Supplement of the node, - | 9 | 10 | 34 | 50 |

These results include the secular equations. I have found also the

| | | | | |
|---|---|---|---|---|
| Annual motion in longitude, | $4^s$ | 9° | 23′ | 4″.8195 |
| ——————— in anomaly, | 2 | 28 | 43 | 18 1737 |
| ——————— Suppl. of node, | 0 | 19 | 19 | 41 03 |

As the observations on which these mean motions are founded embrace a period of only twenty-nine years, they will perhaps require ulterior corrections, but I consider them to be more correct than that which I have hitherto adopted. I have the honour to be, Sir, your most obedient servant,

WIESENAU, *October* 23, 1826. F. T. BÜRG.

## ART. XXIII.—*Excursory Remarks on Radiant Heat, with a short examination of Professor Leslie's Theory.* By WILLIAM RITCHIE, A. M. Rector of the Royal Academy at Tain. Communicated by the AUTHOR.

PROFESSOR LESLIE, in his ingenious works on heat, endeavours to account for the various phenomena of radiant heat, by supposing that caloric is carried from a heated body to another at a distance, by certain pulses excited in the ambient air. "By what process the several portions of heat thus delivered to the atmosphere shoot through the fluid mass, it seems more difficult to conceive. They are not transported by the streaming of the heated air, for they suffer no derangement from the most violent agitations in that medium. The air must therefore, without changing its place, disseminate the impressions that it receives by a sort of undulatory commotion, like those by which it transmits the impulse of sound. The portion of air next the hot surface suddenly acquiring heat from its vicinity, expands proportionally and begins the chain of pulsations. In again contracting, this aërial shell surrenders its surplus of heat to the one immediately before it, and which is now in the act of expansion; and thus the tide rolls onwards and spreads itself on all sides."* If air be the medium of communication, we may ask how it happens that caloric radiates more rapidly in the most complete Torricellian vacuum than in atmospheric air of any density whatever; or why it radiates more copiously in rarified than in condensed air? Sir Humphry Davy has proved, by a very simple and ingenious experiment, that in air exhausted to the 120th part of the whole, the effect of radiation was three times greater than in air of the common density. An explanation of his method may be seen in Dr Henry's *Elements of Chemistry*, vol. i. 83. The same fact

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* *Relations of Air to Heat and Moisture*, page 21.

was observed by the celebrated Lambert, though both he and Cullen seem to me to have given a false explanation of the cause; *Pyrometria*, sect. 492. Saussure notices the same fact, and remarks: "Le grand geomètre Lambert rapport cette même experience dans sa pyrométrie; et il ajoute, que l'experience réussit plus sûrement et donne un difference de chaleur plus grande lorsqu'on pompe l'air avec diligence, et que le récipient n'est pas trop petite." *Essais sur l'Hygrometrie*, p. 232. Now this fact, which by no means receives a satisfactory explanation from the theory of aerial pulsations, is easily accounted for by the idio-repulsive theory. If the exterior film of caloric be pressed towards the body by the ambient air, this pressure will evidently act as an antagonist force to the repulsive energy of the molecules of heat. If this process be diminished or removed, the atoms of heat will act on each other with a less restrained force, and a more copious radiation will be the necessary consequence. If this pressure be augmented by condensing the air there will not only be a greater number of aërial molecules, but they will also press with a greater force against the exterior film of heat. The atoms of caloric will therefore be much restrained in their mutual actions, and consequently the current of radiant heat will be much diminished. Were the air to be highly condensed, and the temperature of the body proportionably low, the two forces might become equal, and radiation completely prevented, as is the case with a heated body not visible in the dark when plunged into water. Dr Wells, in his elegant *Essay on the Formation of Dew*, has given a similar explanation of the process by which water is converted into ice, on the extensive plains of Hindostan, when the temperature of the air is many degrees above the freezing point. Evaporation he proves is insufficient to produce the effect. Radiation is also necessary to reduce the temperature of the water to the freezing point.*

In order to account for the striking difference between the radiating powers of different surfaces, Professor Leslie assumes that "air never comes into actual contact with any surface, but

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* *Essay on Dew*, from p. 261 to p. 279.

approaches nearer to glass or paper than to polished metal, from which it is separated by an interval of at least the 500th part of an inch. A vitreous surface, from its closer proximity to the recipient medium, must hence impart its heat more copiously and energetically than a surface of metal in the same condition." If air never comes into actual contact with any surface, by what power, we may ask, is caloric carried over the space between the surface of the body and the atmospheric boundary? Surely not by the pulses excited in the ambient air, since there is no air in which such pulses can be excited. Is this power, whatever it may be, so feeble as to lose its influence just at the atmospheric boundary, when it has delivered its charge to the wings of the ambient air? If a power, different from the ambient air, exist, which is capable of transporting caloric over the 500th part of an inch, why should not the same power carry it over the 100th part of an inch, or even a whole inch? The supposition which Mr Leslie has very ingeniously made, even if it were well-founded, could not, on the pulsatory system, account for the striking difference between the radiating powers of glass and polished metal. The true cause of this difference we have endeavoured to assign in one of the numbers of the *Edinburgh Philosophical Journal.*

The various contrivances to which the author had recourse in supporting his favourite theory are numerous and truly ingenious, though to us they appear to support with much greater force the opposite theory. "When a pellicle of gold-beater's skin," he observes, "was applied, the metallic surface immediately under it repelled partially the atmospheric boundary, and reduced the darting efflux of heat from ten, which would have been thrown by the skin alone, to about seven, or only six more than the efficacy of the naked metal. The repelling influence of the metallic plate was sensible even under four coats, or at the distance of the 750th part of an inch from the external face." The metals, as is well known, possess a powerful attraction for the matter of heat. This attraction will therefore be exerted at some distance from the surface of the metal. The calorific atoms ranged along the surface of the metal, and also in the interior of the pellicle of gold-beater's skin, will therefore be attracted with considerable force towards the metallic surface. This attraction will evidently act as an antagonist force to the tendency which the molecules of heat have to radiate from the surface. The flow of caloric will therefore be less than if no such counteracting force existed. By the addition of several coats the exterior film of heat is removed beyond the sphere of attraction of the metal, and hence an increase of radiant heat will be the necessary consequence. There is also another circumstance which must materially aid the rapid dispersion of heat, by the application of additional coats to the metallic surface. It is obvious that in soft or porous bodies radiation goes on not only from the surface, but also from some depth below it. In this observation I am supported by the high authority of M. Biot, who seldom risks an hypothesis that is not well founded. That accurate and profound philosopher concludes: "Car si, comme tout l'indique, le rayonnement n'émane pas seulement de la surface, mais aussi d'une petite profondeur dans l'exterieur des corps, cette profondeur devra augmenter à mesure que la temperature s'elevera, puisque la matière qui forme le corps deviendra plus permeable aux rayons calorifiques, et cette double circonstance devra produire un rayonnement plus abondant."* Now, if radiation takes place at a greater depth below the surface than the thickness of a single pellicle of gold-beater's skin, a much greater quantity of caloric will radiate from a metallic body having two or three such coatings than only one. The same thing will obviously take place by using coatings of oil or jelly of different degrees of thickness.

But the most formidable objection to the theory of aërial pulsation is derived from my experiments with thin liquid screens, published in the last volume of the *Philosophical Transactions.*† If heat be carried along on the wings of the ambient air, the aërial wave will be as completely stopped by the thinnest film of a viscous fluid as by an opaque screen of considerable thickness. It can only communicate its heat to the liquid film, which in its turn will act as a new source of radiant heat. But the effect on the thermometer was proved to be instantaneous, and such as could not possibly arise from

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* *Traité de Physique,* tome iv. 642.

† See this Journal, No. xiv. p. 348.

the screen acting as a secondary source of heat. Mr Leslie has proved, both by experiment and reasoning, that, if an opaque screen be placed between the heated body and the reflector, a striking difference of effect will be observed with *every remove of the screen from the heated body*. "At each remove," says he, "the impression upon the focal ball will regularly diminish; insomuch, that, when the screen has gained a position one foot advanced from the canister, and consequently two feet from the reflector, it will not exceed the thirtieth part of the full effect."* Now we have endeavoured to prove by numerous experiments, that the effect on the thermometer is nearly the same, whether the thin liquid screen be placed near the heated ball or the differential thermometer. If this experiment be correct, the theory of aerial pulsations cannot possibly be the true theory of radiant heat. I have requested Professor Leslie to examine the delicate experiments to which I have alluded; and I am convinced, that, should they be correct, he, from his love of philosophical truth, will be the very first to abandon a theory which, though no longer tenable, has in his hands been the means of advancing this department of physical science.

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## ART. XXIV.—*On the Effects of the Poisonous Gases on Vegetables.* By EDWARD TURNER, M. D. F. R. S. E. Professor of Chemistry in the University of London; and ROBERT CHRISTISON, M. D. Professor of Medical Jurisprudence and Police in the University of Edinburgh, &c.†

HAVING been called on last July to give evidence before the Jury Court, in the case of Hart against Taylor, relative to the effects of a black-ash manufactory on the vegetation in its neighbourhood, and having been unable to find any distinct facts recorded respecting the influence on vegetable life of the gases disengaged in the preparation of that article, we were induced to make some experiments on the subject, which were originally intended for our private satisfaction only. But we have since understood, that the case in which we were concern-

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* *Inquiry*, p. 30.

† *From the Edin. Med. and Surg. Journal*, No. 93.

ed is no less than the third or fourth instance in Scotland of the same kind of manufactory having subjected the proprietors to a prosecution on the ground of its destructiveness to vegetation, while nevertheless no data have hitherto been made public, except those derived from the very equivocal and contradictory testimony of unscientific witnesses as to the actual mischief done around the works. We have therefore conceived that a succinct account of our observations may be useful to others who may chance to be similarly circumstanced with ourselves.—Since the trial, besides repeating our original experiments, we have tried the effects of other gases; and we have annexed the results, not that we imagine them to be important in themselves, but for the purpose of drawing the attention of the botanist to this little tried, but probably valuable instrument for investigating the physiology of plants. The interesting experiments of M. Marcet on the effects of solid and liquid poisons on vegetable life,* and those related in the subsequent remarks regarding the effects of the gases will show, that the operation of poisons may furnish the attentive inquirer with as many useful facts in the case of vegetable as in that of animal physiology.

It was at first our intention to give an account of the leading facts brought out upon the several jury-trials alluded to. But on inquiry, we have found the evidence, as in most prosecutions for this description of nuisance, so opposite and irreconcilable, that we must rest contented with an abstract of our personal researches. The black-ash, we may simply observe, has been for many years a most important and extensive article of manufacture, being one of the substances formed in the course of the process for converting into soda the Glauber's salt, and more particularly the refuse in the making of bleaching powder. In the course of the process for preparing it, some chlorine and a good deal of sulphurous acid are evolved, and in those manufactories in which the black-ash is converted into carbonate of soda, an additional quantity of sulphurous acid is disengaged. It was to these gases, therefore, and more

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* *Ann. de Chim. et de Phys.* xxix. 200. See this Journal, No. vi. p. 293.

especially to the sulphurous acid, that our attention was drawn in the first instance.

The *Sulphurous acid gas* appears to be exceedingly deleterious to vegetables, even in very minute quantity and proportion. We first observed that when four, or even only two cubic inches were introduced along with a young mignonette plant, into the air of a glass jar of the capacity of 470 cubic inches, the leaves of the plant became greenish-gray, and drooped much in less than two hours and a half; and though then taken out and watered, it soon died altogether. We next found that when somewhat less than half a cubic inch was introduced into a jar of the capacity of 509 cubic inches, a mignonette plant introduced along with it began to lose its colour and to droop in three hours; and although taken out three hours after that it languished, and gradually died in the course of a few days.

But the peculiar effects of the gas, and its extraordinary destructiveness, are better shown when its quantity and proportion to the air are still less,—as, for example, in the following experiment. A wide-mouthed bottle, containing a mixture of six cubic inches of air and $\frac{23}{100}$ths of a cubic inch of sulphurous acid, was fixed, mouth uppermost, on a stand twenty inches high;—at the bottom stood a young mignonette plant, a young laburnum tree six inches tall, and a young larch, which had been all transplanted at least five days before, and had recently been well watered;—and over the whole was placed and carefully luted to the table a glass jar two feet high, and of the capacity of 2000 cubic inches, so that the proportion of sulphurous acid was nearly a 9000th part. The jar stood in a situation where it was exposed to a bright diffused light, but not to the sunshine. We had previously found in a similar experiment with a mignonette plant alone, that it became affected in less than twenty-four hours; and in a subsequent experiment with a laburnum visible effects were caused by the same quantity and proportion in nine hours. In the present instance, on account of the large surface of moist earth exposed, which would absorb some of the gas, the effect was slower and less complete. In forty-eight hours, however, all the plants were distinctly acted on. The tips of some of the mignonette leaves and larch leaves were grayish-coloured, shrivelled, and dry-looking, and the three lower leaves of the laburnum were speckled with irregular grayish-yellow dry-looking spots. The air was then renewed, together with the same proportion of gas, and it was allowed to act for forty-eight hours longer, during which the effects slowly extended towards the footstalks and over more of the leaves. The plants were then taken out. The earth continued moist. The middle leaves of the mignonette, but the lower leaves of both the larch and the laburnum had suffered most. The leaves of the mignonette were withered chiefly at the tips or edges;—most of those of the larch at the tips, in some, however, at the middle;—those of the laburnum were affected more uniformly over their whole disk, they drooped considerably, a gentle touch was sufficient to break the leaflets from the footstalks, and the footstalks from the stem,—nay, some of the leaflets had dropped off while the plant was in the jar. The bud-leaves were not injured in any of the plants.

The effect of this poison seemed to resemble considerably the ordinary decay of the leaves in autumn. It was invariably produced in several repetitions of the foregoing experiment.—The proportion of gas was sometimes a ten-thousandth only, the quantity a fifth of a cubic inch, and yet the whole unfolded leaves were nearly destroyed in forty-eight hours. We remarked that the withering and curling of the leaves always rapidly increased for an hour or two after the removal of the plants into the open air, so that some leaves which had been apparently but little affected in the jar died afterwards in the air quickly and completely. The whole plant, however, was never killed by these small proportions. Segments near the footstalks, particularly of the upper leaves, continued green and juicy, and the buds put forth fresh though generally stunted leaves. Even when the proportion of gas was larger, the plants were not killed altogether: the stem was not affected unless the proportion was considerable, and even then it was only the top which suffered.—It will be afterwards seen how different these phenomena are from the effects of deleterious gases not irritants.

It is particularly worthy of notice that the proportion of sulphurous acid which thus seems to be so deadly to plants, is hardly or not at all discoverable by the smell. When a ten-thousandth part of sulphurous acid gas was intimately mixed with air, we could not be confident that its odour was perceptible, although we have reason to think our sense of smell is acute; and when this proportion was mixed in the same jar, and in the same manner as in the experiments related above, but without either plant or moisture being present, we were certain that in eight hours no part of the air in the jar had the slightest odour of the gas. This fact, though simple, is an important one in regard to what has been stated in evidence on some prosecutions against chemical manufactories,—namely, that the emanations were not perceptible to the smell in the neighbourhood of the works, and therefore not likely to be in a state sufficiently concentrated to prove injurious.

We do not pretend to infer, as an absolute conclusion from these experiments, that manufactories from which sulphurous acid gas is disengaged even in large quantities must be injurious to surrounding vegetation. It is probable, nay certain, that, small as the proportion was which we have tried, the proportion contained in the air in the vicinity of the largest manufactories is a great deal less. But it seems certainly a fair presumption, that, when such extraordinary effects are produced in so short a time, by so minute a quantity, and notwithstanding so liberal an admixture of air, effects analogous, if not quite so fatal, will be produced by the lengthened application of a larger quantity, though inferior proportion of the same poison, in a state of constant renewal.

The next gas, whose effects we have particularly examined, is the *Hydrochloric*, or *Muriatic acid gas.*

Its effects have appeared to us not inferior, nay even superior to those of the sulphurous acid. In our first experiments with it we found that four cubic inches and a half mixed with a hundred times their volume of air, and two cubic inches mixed with four hundred volumes, began to turn the leaves of a mignonette plant grayish-yellow in ten minutes, then caused it to droop, and in five hours killed it altogether and irrecoverably; and that the leaves were wet and acid. We next remarked that half a cubic inch in a thousand times its volume of air began to affect another mignonette plant in an hour, and killed all the leaves in twenty hours; that the plant, though then taken out with its stem erect, soon died; but that the leaves were not damp or acid, as in the former instances. Various inferior proportions were tried with similar results, till at length the following experiment was made:

A fifth part of a cubic inch of hydrochloric acid gas was mixed with three inches of air in a long jar, and placed under a glass receiver of the same size and form, and with the same precautions to secure a gradual and thorough mixture, as in the experiments with the sulphurous acid: The plants chosen were a healthy laburnum tree five inches tall, and a little larch tree. In nine hours the edges of some of the laburnum leaves appeared to be curling inwards; in twelve hours this effect was unequivocal: As the latter examination was made by candle light, we could not say positively whether the colour had faded. In twenty-four hours the leaves had all acquired a dull-grayish green colour, and dry appearance, and their edges were crisped and curled. The crisping effect increased during the next twenty-four hours, after which the plants were removed into the open air of the room. The lower leaves were evidently most affected, and some of them even dropped their leaflets when the plant was shaken; none, however, had escaped, except a young half unfolded one at the top; all the rest seemed quite dead. As in the case of the sulphurous acid, so here the crisping and curling of the leaves increased rapidly after the removal of the plant from the jar; an effect which is probably to be ascribed to the more rapid evaporation of their moisture, no longer renewed from the leafstalks. The larch plant, whose changes could not be properly seen in the jar, on account of its colour being nearly the same in its natural, as in its withered state, was found, on close examination, to be wrinkled and dry, particularly on the lower leaves, and on the tips of them. Neither of these plants, however, died; the unfolded leaves were all destroyed, but the buds gradually expanded themselves, though nipped on the tops.

This gas must therefore be very injurious to vegetable life, since so small a quantity as a fifth of an inch, although diluted with 10,000 parts of air, destroyed the whole vegetation of a plant of considerable size in less than two days. Nay, we afterwards found that a *tenth part of a cubic inch in* 20,000 *volumes of air* had nearly the same effects. In twenty-four hours the leaves of a laburnum were all curled in on the edges, dry, and discoloured; and though it was then removed into the air, they gradually shrivelled and died. Like the sulphurous acid, the hydrochloric acid gas acts thus injuriously in a proportion which is not perceptible to the smell. Even a thousandth part of hydrochloric acid gas is not distinctly perceptible; a ten thousandth made no impression on the nostrils whatever, although great care was taken to dry thoroughly the vessels used in making the mixtures.

The other gases whose effects we have examined are chlorine, nitrous acid gas, sulphuretted hydrogen, ammonia, cyanogen, carbonic oxide, olefiant gas, and protoxide of azote. But our examination of these has been cursory.

*Chlorine* may be expected to have the effects of hydrochloric acid gas; and so indeed it has; but they appear to be developed more slowly. Two cubic inches in two hundred parts of air did not begin to affect a mignonette plant for three hours; half a cubic inch in a thousand parts of air did not injure another in twenty-four hours; but when the plants did become affected, the same drooping, bleaching, and desiccation were observed.

*Nitrous acid gas* is probably as deleterious as the sulphurous and hydrochloric acid gases. In the proportion of a hundred and eightieth it attacked the leaves of a mignonette plant in ten minutes; and half a cubic inch in 700 volumes of air caused a yellowish green discoloration in an hour, and drooping and withering in the course of twenty-four hours. The leaves were not acid on their surface.

The effects of *Sulphuretted hydrogen* are quite different from those of the acid gases. The latter attacked the leaves at the tips first, and gradually extended their operation towards the leaf-stalks; when in considerable proportion their effects began in a few minutes, and if the quantity was not great the parts not attacked generally survived if the plants were removed into the air. The sulphuretted hydrogen acts differently. Two cubic inches in 230 times their volume of air had no effect in twenty-four hours. Four inches and a half in eighty volumes of air caused no injury in twelve hours, but in twenty-four hours several of the leaves, without being injured in colour, were hanging down perpendicularly from the leaf-stalks and quite flaccid; and though the plant was then removed into the open air the stem itself soon began also to droop and bend, and the whole plant speedily fell over and died. When the effects of a large quantity, such as six inches in sixty times their volume, were carefully watched, it was remarked that the drooping began in ten hours at once from the leaf-stalks, and the leaves themselves, except that they were flaccid, did not look unhealthy. Not one plant recovered, any of whose leaves had drooped before it was removed into the air.

The effects of *Ammonia* were precisely similar to those of sulphuretted hydrogen just related, except that after the leaves drooped they became also somewhat shrivelled. The progressive flaccidity of the leaves,—the bending of them at their point of junction with the foot-stalk, and the subsequent bending of the stem,—the creeping, as it were, of the languor and exhaustion from leaf to leaf, and then down the stem, were very striking. Two inches of gas in 230 volumes of air began to operate in ten hours. A larger quantity and proportion seemed to operate more slowly.

These phenomena, when compared with what was observed in the instances of sulphurous and hydrochloric acid, would appear to establish, in relation to vegetable life, a distinction among the poisonous gases nearly equivalent to the difference existing between the effects of the Irritant and the Narcotic poisons on animals. The gases which rank as irritants in relation to animals seem to act locally on vegetables, destroying first the parts least plentifully supplied with moisture. The narcotic gases—including under that term those which act on the nervous system of animals, destroy vegetable life by attacking it throughout the whole plant at once. The former probably act by abstracting the moisture of the leaves, the latter by some unknown influence on their vitality. The former seem to have upon vegetables none of that sympathetic influence upon general life, which in animals follows so remarkably injuries inflicted by the purest local irritants.*

*Cyanogen* appears allied to the two last gases in property, but is more energetic. Two cubic inches diluted with 230 times their volume of air affected a mignonette plant in five hours; half a cubic inch in 700 volumes of air affected another in twelve hours; and a third of a cubic inch in 1700 volumes of air, affected another in twenty-four hours. The leaves drooped from the stem without losing colour, and removal into the air, after the drooping began, did not save the plants.

*Carbonic oxide* is also probably of the same class, but its power is much inferior. Four cubic inches and a-half diluted with 100 times their volume of air had no effect in twenty-four hours on a mignonette plant. Twenty-three cubic inches, with five times their volume of air, appeared to have as little effect

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* Other occupations prevent us making the requisite inquiries for examining such practical conclusions as our experiments seem to lead to. One, however, may be briefly mentioned. The differences described above show that the injury sustained by vegetation in the heart and vicinity of a great city must be caused by some irritant gas, if circumstances regarding the soil and exposure do not account for it, which they seldom or never will. The plants are rarely killed altogether; their vegetation is merely blighted for the season. In the spring it recommences with a luxuriance not surpassed in country situations; but when the leaves attain maturity, and have no longer the superabundant supply of moisture they received while young, they are blighted anew. How exactly do these phenomena concur with what we should expect from the influence of the irritating gases as ascertained in our experiments. Such a gas, it is well known, is disengaged in abundance from our coal-fires,—namely the sulphurous acid. There has long been a vulgar and very general notion, that coal smoke diffused and diluted in the atmosphere hurts vegetation; but we are not aware that it has rested till now on any solid reason. A curious fact, indeed, and the only one we have been able to find, is mentioned in Evelyn's *Fumifugium*,—namely, that one year, when Newcastle was besieged during the civil war at the Revolution, and coals were in consequence exceedingly scarce in London, in various gardens of the nobility in the metropolis fruit trees, which never bore fruit either before or after, were loaded with it. But the *Fumifugium* contains so many monstrous and incredible facts, and shows such an uncompromising determination to call in the aid of coal-smoke to account for everything wrong in London which could not be more easily explained, that the modern inquirer will naturally pause before he gives the lively and ingenious author credit even for what appears probable.

in the same time; but the plant began to droop when it was removed from the jar, and could not be revived.

*Olefiant gas* in the quantity of four cubic inches and a-half, and in the proportion of a hundredth part of the air, had no effect whatever in twenty-four hours.

The *Protoxide of nitrogen*, or intoxicating gas, the last we shall mention, is the least injurious of all those we have tried; indeed it appears hardly to injure vegetation at all. Seventy-two cubic inches were placed with a mignonette plant in a jar of the capacity of 509 cubic inches for forty-eight hours; but no perceptible change had taken place at the end of that time.

In all of the foregoing experiments, with the exception of those made with minute proportions of the sulphurous and hydrochloric acid gases, the gas was placed at the bottom of the jars, and the plant on a stage raised nearly to the top of them. It is hardly necessary to add, that comparative experiments were also made on plants in jars of pure air.

It is well know that plants are sometimes affected differently by the same agent. Some thrive in situations which are injurious to others, and where to all appearance the difference does not depend on the nature of the soil alone. Sir H. Davy found that while some plants grow in an atmosphere of hydrogen, others are speedily destroyed by that gas. We may hence anticipate that a variety of curious and interesting results would be obtained by experiments directed with this view; but circumstances have not permitted us to undertake the inquiry. We may observe, however, that of six different species of plants subjected to the action of sulphurous acid, all of them appeared to be affected by that gas nearly in an equal degree.

## ART. XXV.—ZOOLOGICAL COLLECTIONS.

### 1. *On the appearance of Locusts in the Doab.*[*] By G. PLAYFAIR, Esq.

ABOUT the 20th June 1812, a very large flight of locusts was observed hovering about Etawah, which at length settled in the fields east of the town, where they remained some time, and were seen copulating in vast

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[*] From the *Transactions of the Medical and Physical Society of Calcutta*, vol. i. p. 103.

numbers: they then took their departure, but continued to hover about the place for a month afterwards.

On the 18th July, while riding in that direction, I discovered an immense swarm of very small dark-coloured insects in the vicinity of a large pool of stagnant water: they were collected in heaps, and covered the ground to a considerable distance. These, on minute inspection, proved to be young locusts, but without wings. In this place they remained, hourly increasing in numbers for some days, when the great body moved off. Taking a direction towards the town of Etawah, they crept and hopped along at a slow rate, until they reached the town, where they divided into different bodies, still, however, keeping nearly the same direction, covering and destroying every thing green in their progress, and distributing themselves all over the neighbourhood. The devastation daily committed by them was almost incalculable. The farmers were under the necessity of collecting as many people as they could, in the vain hope that they might preserve the crop by sweeping the swarm backwards; but as often as they succeeded in repelling them in one quarter they approached in another. Fires were lighted all round the fields with the same view: this had the effect of keeping them off for a short time; but sufficient fuel could not be supplied, and the moment the fires became extinguished, the insects rushed in like a torrent. Multitudes were destroyed by the birds, and many more by branches of trees, used by the farmers for that purpose, as well as by their being swept into large heaps, and consumed by fire; yet their numbers seemed nothing diminished. They so completely covered some mango trees, and the hedges surrounding the gardens, that the colour of the leaves could not be distinguished. They had no wings, and at this time were about the size of small bees, their heads of a dark red colour, their bodies marked with black lines. They continued to creep along the ground, but hopped and leapt about when their progress was interrupted.

July 27th. They were increasing in size, and had overspread that part of the country in every direction. From the want of rain, and the overwhelming inroad of these insects, the farmers were nearly ruined. Nothing impeded their progress: they climbed up the highest trees, and scrambled over walls, and notwithstanding the exertions of several people with brooms, the verandah and outer walls of the hospital were completely covered with them. They no longer continued to move in one particular direction, but paraded backwards and forwards, wherever they could find food.

On the 28th July the rains set in with considerable violence: the locusts took shelter on trees and bushes, devouring every leaf within their reach; none seemed to suffer from the rain.

On the 29th it did not rain, and the young swarm again were on the move continuing their depredations; they were fast increasing in size, and equally lively as before the rain.

It rained on the 30th, and again the locusts took shelter on the trees and fences; several large flights of locusts passed over the cantonments, and I observed that the wings of the young ones began to appear. The head still retained the dark-red colour, but the black lines on the body had become much fainter.

Again, on the 31st, large flights continued to pass, driven by the wind to the southward; of course very few alighted. They caused little mischief within our view. The wings of the young tribe (the whole four being now formed) were about one-eighth of an inch in length. After this time, I made no particular observations on their progress, being otherwise engaged; but they disappeared in a few days.

## 2. *Destructive action of the Teredo navalis on vessels built of Teak Timber.*

By Mr C. Wilcox.

The following interesting observations on the œconomy of the *Teredo navalis* is taken from the Report of the Portsmouth and Portsea Philosophical Society. They form the report of a lecture by Mr C. Wilcox.

" The habits and economy of the *Teredo navalis,* the most destructive of the testacea, were described, and the irregular shape of the shell, description of the head, and formation of the hinge and valves noticed. A fine specimen was exhibited, and the statement of authors who affirm that it extends the whole length of the tube proved to be erroneous; since these tubes, which are formed by a peculiar secretion from the body of the animal, are often many feet in length and circuitous in their course. This was shown to be the fact, by a large piece of wood pierced in all directions. The manner in which it effects its passage, and the appearance of the interior of the tubes were described. The assertion that the *Teredo* does not attack teak timber was shown to be incorrect, and its destructive ravages on the bottom of ships exemplified, by a relation of the providential escape of His Majesty's ship Sceptre, which, having lost some copper from off her bows, the timbers were pierced through to such an extent as to render her incapable of pursuing her voyage without repair. The lecturer then exhibited the formation of the tubes (through an extent of several feet) in a plank of African timber. Hence the opinion, that the *Teredo* is attached to one end of the shelly tube was considered to be erroneous, as in this case it would have exceeded seven feet in length. The opinion that the animal revolved was also presumed to be unfounded, for then only one valve (from the peculiar construction of the head) would be effective; whereas by a semivolution both are called into action; while, from its very tender state, and the contorted direction of the tubes, it must of necessity be twisted up, if such revolutions took place. Mr Wilcox then noticed the habits and economy of the *Pholades,* exhibiting some specimens both in the living and dead state. Their manner of boring was explained, their phosphorescence shown, and their ravages described. The lecturer next adverted to an insect called the *Lepisma,* and concluding by stating that these minute depredators were frequently so numerous, that 300 will occasionally be found in the space of two inches square, and their attack commences the moment the timber is in the water, more particularly in the eastern part of the globe.

"An interesting debate followed as to the mode of action of the valves of the *Teredo;* in the course of which Mr Wilcox observed, that he thought Dr Turton, in his observations relative to Sir E. Home's opinion on the *modus operandi* of this animal, had mistaken the action of the double nosed auger, and had described it as a centre bit; but that their opinions of the method of boring admitted of being reconciled; the mode appearing to be, that, by a secretion from its body, the decomposition of the material is effected and reduced to a species of soft mud or pulp, which is mechanically removed, and a fine polished surface left. This idea, while it agrees with many of the statements, does not invalidate the experiments made on the charcoal produced by burning the excrementitious matter, and meets the difficulty which at first appears as to the possibility of such fragile animals piercing materials of so hard a texture.

"At the conclusion of this lecture, the curator of the museum drew a comparison between the recent *Teredines* and the fossil remains of that animal, as exhibited in specimens of wood from the London clay of Sheppy; showing, that, though the identity of these could not now be ascertained, yet such identity was very probable, as their operation and effects appear to have been the same. He also produced specimens of the *Mytilus lithophagus, M. Pholadis,* and *M. rugosus,* the two former penetrating madrepores, the latter limestone.

"Having pointed out the structure of the animals, and the formation of the valves, he concluded, that, possessing no apparent means of producing their perforations by a mechanical operation, this tribe at least might be considered as producing this effect by a chemical solvent, which, as the substances acted upon were calcareous, was probably an acid; although he admitted that the action of tests had not made the presence of such secretion satisfactorily apparent,—recommending a prosecution of observations and experiments, as the subject had excited much attention."

*Note.*—On the subject of boring marine animals, and their means of perforating wood and rocks, see this *Journal,* vol. v. p. 98, and vol. vi. p. 270. The assumption of a chemical solvent by Mr Wilcox is, in the present state of our knowledge, entirely gratuitous, as the most delicate tests have failed in detecting any such solvent or acid fluid. In supposing the *Lepismæ* also to burrow in submerged timber, we suspect Mr W. labours under a mistake. It is more probable that the animal he alludes to may be congenerous with the one which has committed similar depredations on the piles of the Chain Pier at Trinity near Edinburgh, and of which a notice follows.

### 3. *Destruction of the Piles at the Chain Pier by the Limnoria terebrans.*

As a sequel to the preceding observations the ravages of the *Limnoria terebrans* on the piles of the Chain Pier at Trinity may be noticed. These piles were on examination found to be perforated through a great part of their thickness by a marine animal, in a very short time, and thus rendered unserviceable. The extension of the eastern pier at Leith, which was proposed to be chiefly a wooden erection, induced Mr Day, one of the Dock

Commissioners, to turn his attention to the subject, and to make various experiments on different kinds of wood submerged at the same place, with the view of learning their mode of boring, and if possible to discover some means by which the contemplated erection might be secured from their depredations. We are not aware that any thing has been discovered, further than the necessity of covering that part of the piles under water by a casing of metal. Reports on the subject from three learned professors in this University were, it is understood, procured by Mr Day, which there is no doubt will have conveyed all the known information regarding the animal, its habits, and the best mode of securing submerged wooden work from its depredations; and it would be desirable that the results of their recommendation were generally known, as the animal seems to be pretty generally diffused.

The animal was ascertained by Mr Stark to be the *Limnoria terebrans* of Dr Leach, and which was first described by that gentleman from specimens sent him by Mr Stevenson in wood from the Bell Rock Light-House. It is a very small crustaceous animal, about three lines long, and makes the perforations which are so destructive to submerged wood-work merely as places of retreat. From the observation of the living animal by Professor Grant it does not appear to feed on the ligneous matter.

### 4. *On the means by which Spiders that produce Gossamer effect their aerial excursions.* By J. Blackwall, Esq.

The following interesting abstract of a paper on this subject read at the Linnæan Society, is given in the *Philosophical Magazine* for August.

" After noticing, that, in the absence of accurate observation, the ascent of gossamer spiders through the atmosphere had been conjecturally ascribed to several causes, such as the agency of winds, evaporation, electricity, or some peculiar physical powers of the insect, or from their webs being lighter than the air, Mr Blackwall states that the ascent of gossamers takes place only in serene bright weather, and is invariably preceded by gossamers on the ground. He then details the phenomena of a remarkable ascent of gossamers, October 1, 1826, when, a little before noon the ground was every where covered with it, the day being calm and sunny. A vast quantity of the fine shining lines were then seen in the act of ascending, and becoming attached to each other in various ways in their motions, and were evidently not formed in the air but on the earth, and carried up by the ascending current caused by the rarefaction near the heated ground; and when this had ceased in the afternoon they were perceived to fall. An account is added of two minute spiders that produced gossamer, and of their mode of spinning; and particularly when, impelled by the desire of traversing the air, they climb to the summits of various objects, and thence emit the viscous threads in such a manner as that it may be drawn out to a great length and fineness by the ascending current, until, feeling themselves sufficiently acted upon by it, they quit hold of the objects on which they stood, and commence their flight. Some of these insects, which were taken for the purpose of observation, when exposed to a slight current of air, always turned the thorax to the quarter from whence it came, and emitted a portion of glutinous matter, which was carried out into a line."

### 5. *On the Fascination of Snakes.* By Mr Nash.

"I have often heard stories about the power that snakes have to charm birds and animals, which, to say the least, I always treated with the coldness of scepticism, nor could I believe them until convinced by ocular demonstration. A case occurred in Williamsburgh, (Mass.) one mile south of the house of public worship, by the way side, in July last. As I was walking on the road at noon day, my attention was drawn to the fence by the fluttering and hopping of a robin red-breast, and of a cat bird, which upon my approach flew up and perched on a sapling two or three rods distant. At this instant a large black snake reared his head from the ground near the fence. I immediately stepped back a little, and sat down upon an eminence; the snake in a few minutes slunk again to the earth with a calm placid appearance, and the birds soon after returned and lighted upon the ground near the snake, first stretching their wings upon the ground and spreading their tails. They commenced fluttering round the snake, drawing nearer at almost every step, until they stepped near or across the snake, which would often move a little or throw himself into a different posture, apparently to seize his prey, which movements I noticed seemed to frighten the birds, and they would veer off a few feet, but return again as soon as the snake was motionless. All that was wanting for the snake to secure his victims seemed to be, that the birds should pass near his head, which they would probably have soon done, but at this moment a waggon drove up and stopped. This frightened the snake, and it crawled across the fence into the grass; notwithstanding, the birds flew over the fence into the grass also, and appeared to be bewitched to flutter around their charmer, and it was not until an attempt was made to kill the snake that the birds would avail themselves of their wings and fly to a forest one hundred rods distant.

"The movements of the birds while around the snake appeared to be voluntary, and without the least constraint; nor did they utter any distressing cries, or appear enraged, as when squirrels, hawks, and mischievous boys attempted to rob their nests, or to catch their young ones; but they seemed to be drawn by some allurement or enticement, (and not by any constraining or provoking power.) Indeed, I thoroughly searched all the fences and trees in the vicinity to find some nest or young birds, but could find none.

"What this fascinating power is, whether it be the look, or effluvium, or the singing by the vibrations of the tail of the snake, or anything else, I will not attempt to determine; possibly this power may be owing to different causes in different kinds of snakes. But so far as the black snake is concerned, it seems to be nothing more than an enticement or allurement, with which the snake is endowed to procure his food."

*Observations* by **Professor Silliman.**

"In the month of June 1823, in company with a friend, I had just crossed the Hudson River, from the town of Catskill, and was proceeding in a carriage, by the river along the road, which is here very narrow, with the water on one side, and a steep bank covered with bushes on the other.

"Our attention was at this place arrested by a number of small birds of different species flying across the road, and then back again, and turning and wheeling in manifold gyrations, and with much chirping, yet making no progress from the particular spot over which they fluttered. We were not left long in doubt, when we perceived a black snake of considerable size, partly coiled, and partly erect from the ground, with the appearance of great animation, and his tongue rapidly and incessantly brandished. This reptile we perceived to be the cause and the centre of the wild motions of the birds, which ceased as soon as the snake, alarmed by the approach of the carriage, retired into the bushes. The birds however, alighted upon the neighbouring branches, probably awaiting the reappearance of their tormentor and enemy. Our engagements did not permit us to wait to see the issue of this affair, which seems to have been similar to that observed by Mr Nash."—Silliman's *Journal*, June 1827.

6.—*Experiments on the reproduction of domestic animals.* By Mr Ch. Giron de Buzareurgues, Corresponding Member of the Royal Academy of Sciences.

The experiments alluded to, and of which a brief notice was read to the Academy on the 2d April 1827, had for their object to determine the means by which in sheep the number of male or female lambs could be diminished or increased, according to the wishes of the proprietor of the flock. The experiment is stated by its author in this manner: *to divide a flock of ewes into two equal parts, and to cause* to be produced by one half of the flock so divided a greater number of males or of females than in the other, according to the choice of the proprietor. This object seems to have been effected in the present instance by a selection of the ram or male; for it would appear, that, if the male be very young, there will be produced more females than males; and *vice versa,* that is, in order to obtain a greater proportion of male lambs to the females the ram must be four or five years of age.—*Annal. des. Sc. Nat.*

7.—*On the Esquimaux Dog.* By J. G. Children, Esq.

From this brief notice by Mr Children on the Esquimaux dog, accompanied by a very beautifully executed engraving, it would appear that the editors of the splendid work on Zoology now publishing in France, under the title of *L'Histoire Naturelle des Mammifères,* have inadvertently committed a very great error. They have caused to be represented, as a real specimen of the Esquimaux dog, a spurious issue, the product of a cross breed between a male Newfoundland dog and the female of the true Esquimaux race, which had been presented to the French naturalists by Dr Leach.

The error thus committed is stated to have been first pointed out by

Captain Sabine in his supplement to the appendix of Captain Parry's voyage in 1819-20. Under these circumstances Mr Children gladly embraced the opportunity afforded him by the kindness of Lieutenant Elliot Morris, R. N. of giving an accurate figure of an unquestionable genuine male Esquimaux dog, brought from the Polar Seas by Mr Richards, in Captain Parry's first voyage, and by him presented to his friend, Mr Morris, in whose possession the dog still remains. Mr Children, in his notice, has given the dimensions, colouring, &c. of the dog in question; but as the Esquimaux dogs are unquestionably domesticated, and must therefore be exposed to the powerful influence of this cause, we do not think it necessary to republish details which could be interesting only with reference to a wild or undomesticated species of animal.—*Zoological Journal*, No. ix. January 1827.

### 8.—*Elephant.*

The dismemberment of the genus *Elephas,* for the purpose of establishing a new one under the name of Loxodonta, has been attempted by Messrs Geoffroy St Hilaire, and F. Cuvier in the fifty-second and fifty-third *Livraisons* of the *L'Histoire Naturelle des Mammifères.* The following remarks by the editors of the *Zoological Journal* will put our readers in possession of the principal facts on this subject.

" M. G. Cuvier first pointed out to the satisfaction of modern zoologists the specific distinction existing between them, and employed to designate the former the name of *E. capensis,* while to the latter was assigned that of *E. Indicus.* M. F. Cuvier has now advanced still farther, and has regarded them as the types of two genera, differing from each other as much as Canis from Hyæna, or Lagomys from Lepus. For the elephant of Asia he retains the original generic name Elephas. The surfaces of its molar teeth present fasciæ of enamel irregularly festooned; while in those of the African elephant, the type of the new genus Loxodonta, the enamel is disposed in lozenges. In addition to this striking distinction derived from the dentary system, M. F. Cuvier also enumerates the other characters which have hitherto been regarded as specific,—the smaller, more elongated, and less irregular head of the African animal, when compared with the Asiatic; the rounded forehead of the former strongly contrasted with the deep depression in the middle of that of the latter; the ear of the former also twice the extent, while the tail is only half the length, &c.

" Since 1681 no African elephant has been seen in Europe, until the young female figured by M. Cuvier, which is now alive in Paris, having been sent as a present by the Pacha of Egypt. Its habits, so far as those of a very young animal can be relied on, exhibit none of the ferocity usually ascribed to it, and are indeed fully as mild, intelligent, and tractable as those of the elephant of Asia."

This novelty in the division of the genus Elephas will probably not be accepted by naturalists. The two species resemble each other far too closely to permit of their dislocation into separate *genera.* We can affirm from personal observation that the habits of the wild African elephant resemble entirely those which have been assigned to the Asiatic, and that the former generally are fully taller and larger than the latter.

## ART. XXVI.—HISTORY OF MECHANICAL INVENTIONS AND OF PROCESSES AND MATERIALS USED IN THE FINE AND USEFUL ARTS.

### 1. *Mr Farey's Improved Lamp.*

Our readers are doubtless well acquainted with the various contrivances both of a hydrostatic and a mechanical nature, by which oil is raised to supply the wick of a lamp, when it is required that the reservoir of oil shall not be placed above the flame. The most ingenious of these will be found described in the Article Lamp, in the *Edinburgh Encyclopædia*, which was written by Mr Farey, the inventor of the present improvement.

In place of raising the oil hydrostatically by the pressure of a column or water as in St Clair's and Keir's lamp, or by a piece of clock-work, which pumps up the oil, as in the beautiful contrivance of M. Carcel, Mr Farey puts the oil in a bladder, or other flexible vessel, which is prevented from collapsing by a helical wire spring. Above this bag is placed a disc with several ring-formed weights, which by their pressure force the oil up to the wick. Mr Farey founds his patent right on the idea of "applying the direct action of a descending weight, or the direct pressure of a spring to the raising up of oils, or other inflammable fluids in sufficient quantities, regulated by the smallness of the holes through which such oil or fluid has to pass in its ascent to the wick of his improved lamp." A drawing and more accurate description of this lamp will be found in Newton's *Journal*, November 1827, p. 128.

### 2. *Notice of the new Metallic Compound Artimomantico, resembling gold in colour and weight.*

This metallic compound is invented by a gentleman at Leghorn, a friend of T. Appleton, Esq. the American consul there, who has sent an account of it with specimens to Dr Mease of New York, where it has been examined by competent judges. It is of the same weight as gold of 18 carats, and can be made like that of 24. Mr Appleton's snuff box is made of it, and is always mistaken for pure gold. At a manufactory of it established at Bologna metal buttons are made of it at 50 cents per dozen; when new they resemble the most highly gilt buttons. The inventor sells the metal to the manufacturers at Bologna at two dollars and 60 cents per lb. of 12 oz. which makes 9 dozen of coat buttons. The editor of the Franklin Journal states that the *Artimomantico* is soft and bends, and founds its superiority to other gold-coloured metals on its not tarnishing. —*Franklin Journal.*

### 3. *Notice of a Metallic Alloy for plating Iron and protecting it from Rust.*

This invention is by the discoverer of the *Artimomantico,* and is communicated by the same gentleman. It is easily and cheaply applied, forms an amalgam with the iron, penetrates to some depth, and effectually protects it from rust. It derives this property from its refusing to unite with oxygen at common temperatures, or even when artificially heated. It is formed out of many metals. It does not increase the hardness of the article to which it is applied, nor does it efface the finest lines on the surface. It does not injure the temper of knives. Four ounces of this composition is sufficient to cover an iron bedstead; and twelve ounces are valued at a dollar and 50 cents.

A company is already formed at Bologna with a capital of 100,000 dollars for coating iron work, and they are now drawing out plates which can be united to one another by heat, without any injury to the coating.—*Franklin Journal.*

### 4. *Composition for washing in Sea Water.* By Edward Heard, Chemist, London.

This composition, which is secured by patent, is thus made. Take a highly concentrated solution of the alkalis, soda, or potash, with an equal weight of any earthy base, (China-clay or porcelain earth is best.) These materials being mixed together are to be ground in a mill in the same way as white lead is ground, and this will produce a thick paste, one pound of which is sufficient to soften four gallons of sea water.—See Newton's *Journal,* Nov. 1827, p. 151.

### 5. *Process for giving Statues and Medals the appearance of Bronze.*

Take two drachms of sal-ammoniac, half a drachm of salt of sorrel, and dissolve them in half a pint of white vinegar; after having well-cleaned the metal from verdigrease, moisten a brush by dipping it softly into this solution, then rub it continually on the same place till the colour becomes dry and assumes the tone or depth of shade desired. In order that the drying may be more rapid, this operation is to be performed in the sunshine, or by the heat of a stove. The oftener it is repeated on the same place the deeper proportionably will be the colour of the bronze. This process is used by M. Jacob of Paris.—*Journal des Connaiss. Utiles.*

### 6. *Account of an improvement in the construction of Bedsteads, Sofas, &c.*

This improvement, communicated to Mr Perkins by a foreigner, is very simple and effective. The object of it is to keep the canvass bottom or sacking of a bed always in a proper state of tension. This is effected by making the two horizontal bars or rails to which the canvass is nailed, turn a little round their axis by means of a lever. They are then held in this position, which of course stretches the canvass, by a click and ratchet wheel, which has also the effect of keeping the joints of the rails and posts firmly together.—See Newton's *Journal,* July 1827, p. 256.

### 7. *Account of new Bricks for building both cylindrical and curved Chimnies.* By Mr J. W. Hiort, Architect.

This contrivance is a very ingenious one, and at the same time highly useful. The patent bricks are of a wedge form, as their upper and lower surfaces are not parallel, and one of their sides has the curve of a quarter of an inch, so that four of them joined together make a complete circle. If two bricks were placed with their thickest sides exactly opposite, the upper and under surfaces of the two, when combined will be parallel, so that in this way a cylindrical chimney will be formed, but when it is necessary to bend the chimney, then two bricks are placed with their thick ends together, and when it is required to bend it back again, the thin ends of the bricks are placed on the same side as the thick ends were before. This will be understood from Plate III. Fig. 4. Fig. 5 is a horizontal plan of the flue.—See Newton's *Journal*, Aug. 1827, p. 325.

### 8. *Method of Mooring Ships in Roadsteads.* By Lieut. Col. Miller, F. R. S.

The method of mooring ships proposed by Col. Miller, consists in securing a large buoy by means of a block of cast iron, so that it cannot be moved by stress of weather, to which a vessel can make fast without letting go her anchor. Col. Miller proposes to make the buoy of the following dimensions,

| | |
|---|---|
| Length, | 16 feet. |
| Diameter at middle, | 9 |
| Do. at ends, | 7½ |
| Length of chain, | 36 |
| Diameter of cast iron block, | 3 |
| Do. at bottom, | 5½ |
| Height of do. | 2½ |
| Weight of do. | 7 tons. |

The buoy must be bound with iron, and coppered, and a strong iron hoop must pass round its centre, to which the chain and ring are attached. —*Ann. of Phil.* Aug. 1827, p. 110.

### 9. *On the adhesion of Screw Nails.* By B. Bevan, Esq. Civil Engineer.

The screws used in these experiments were about two inches long $\frac{22}{100}$ diameter at the exterior of the threads, $\frac{15}{100}$ diameter at the bottom, the depth of the worm or thread being $\frac{35}{1000}$, and the number of threads in one inch 12. They were passed through pieces of wood exactly half an inch in thickness, and drawn out by the weights given in the following table:

| | | | |
|---|---|---|---|
| Dry beech, | 460 lbs. | Dry mahogany, | 770 lbs. |
| Do. do. | 790 | Dry elm, | 655 |
| Dry sound ash, | 790 | Dry sycamore, | 830 |
| Dry oak, | 760 | | |

The force required to draw similar screws out of deal and the softer wood is about half the above.—*Phil. Mag.* Oct. 1827, p. 291.

### 10. *On the great Power and Duty of some new Steam Engines.*

Our mechanical readers are aware that the power of a steam engine is measured by the number of pounds of water that it will lift one foot high by each bushel of coals consumed. Hitherto the best engines have been able to raise only 40,000,000 lbs. of water one foot high by means of one bushel of coals. An improvement, however, has been made by Captain Samuel Grose, which increases their power without any additional complication or expence.

The first which he erected was at Wheal Hope with a sixty inch cylinder, working single as usual. The following was the work which it performed:

| | | | |
|---|---|---|---|
| April, | 42,101,739 lbs. | July, | 55,012,292 lbs. |
| May, | 42,241,650 | August, | 50,979,084 |
| June, | 54,725,716 | | |

Another engine subsequently erected at Wheal Towan by Captain Grose, having a cylinder of eighty inches, produced the following remarkable effects:

| | | | |
|---|---|---|---|
| April, | 61,877,545 lbs. | July, | 62,220,820 lbs. |
| May, | 60,632,179 | August, | 61,764,166 |
| June, | 61,762,210 | | |

*Phil. Mag.* Oct. 1827.

### 11. *Process for preparing Indelible Writing-ink.*

Make a saturated solution of indigo and madder in boiling water, and in such proportions as to give a purple tint; add to it from one-sixth to one-eighth of its weight of sulphuric acid, according to the thickness and strength of the paper to be used. This makes an ink which flows pretty freely from the pen;—and when writing which has been executed with it is exposed to a considerable but gradual heat from the fire it becomes completely black, the letters being burnt in and charred by the action of the sulphuric acid. If the acid has not been used in sufficient quantity to destroy the texture of the paper and reduce it to the state of tinder, the colour may be discharged by the oxymuriatic and oxalic acids and their compounds, though not without great difficulty. When the full proportion of acid has been employed, a little crumpling and rubbing of the paper reduces the carbonaceous matter of the letter to powder; but by putting a black ground behind them they may be preserved, and thus a species of indelible writing-ink is procured, (for the letters are in a manner shaped out of the paper) which might be useful for some purposes; perhaps for the signatures of bank notes.—Brande's *Journal.*

### 12. *Observations on the Explosion of Steam Boilers.* By Mr W. J. HENWOOD.

In the *Annals of Philosophy* for June 1827 Mr Henwood has published some interesting observations on Mr Taylor's opinions respecting the cause of the explosion of steam boilers, which were reprinted in our *Journal,* No. xii. p. 335.

"Mr Taylor," says he, "proposes several questions which I shall endeavour to answer.

"The Pen-y-frau engine," says Mr Taylor, "had been stopped a few minutes, and the workmen had opened the fire-doors of three of the boilers, and closed the dampers of two of them. The engineman observed a gust of flame from the fire-place, which was almost immediately succeeded by an explosion."—"In this case," asks Mr Taylor, "had the rush of the flame from the fire-place any thing to do with the subsequent explosion?" I think there can be little doubt that the rush of the flame was in consequence of some fracture having already taken place in the boiler; probably the fissure was not at first of very considerable size, as we know that wrought iron does not break at once, as cast iron, but rends. The rent being at first small it would have occasioned the rush; but as the fissure, once made, weakened the boiler, and the aperture not being sufficiently large to permit the escape of a very considerable quantity of water or steam, a moment between the gust of flame and the explosion would in all probability have elapsed. "And admitting that the steam was so far within the pressure that could, by mere expansive force regularly excited, injure such a boiler, might not the rupture be occasioned by the void that a vacuum suddenly created might produce?" That the expansive force of the steam, 30 lbs. on the inch, was not sufficient to injure the boiler, remains yet to be proved, as we do not know the strength of the boilers. Admitting the possibility of a vacuum, it might perhaps help us towards a real knowledge of the cause; but I am not aware of any circumstances to which the power of forming a vacuum can be ascribed.

"Does not the bursting of one boiler after another as at Polgooth seem to indicate that exterior causes operated? Is it possible to conceive,—supposing the pressure equal in two boilers as at Polgooth, both being connected to the same steam pipe,—that the relative strength of the two should be so exactly the same as that which would by mere expansive force burst the one should have the same effect upon the other?"

Mr Taylor informs us that the plates of which the interior tubes are made are ½ an inch thick, and those of the outer ⅜ths. Now, if we suppose each boiler to be made of 200 plates, would it not be truly surprising if in 400 plates there were not two of the same strength, the thickness being the same, and (as we suppose both boilers were made at the same manufactory) the quantity similar in each? Here then we have an expression of two known quantities only; whilst, if we refer the accident to the agency of an explosion of coal gas with atmospheric air, we must take into consideration the activity of the distillatory action, the facilities of escape afforded to the gas in either boiler, the intensity of combustion in the fire-place, the influx of air, &c. which leads us into a much more complicated calculation. The evidence then appears to preponderate in favour of the idea of its explosion originating in the expansive force of the steam, which it would seem was permitted to obtain too strong an elasticity.

"At the Pen-y-fras engine we see that the fire-door is thrown open, and then the current of air up the flue is stopped by closing the damper;

the interior is filled with atmospheric air, mixed to a certain extent with coal gas; the latter is increased by the distillatory action of the fire, until the proportion is attained which is explosive; it takes fire, producing the rush of flame which would be followed by a sudden vacuum in the tube, while the other side pressed by the steam gives way to this sudden impulse, and is destroyed by a force very much smaller than would be required if uniformly excited."

What Mr Taylor says may be very possible, with the exception of the formation of a vacuum. Motion only obtains when the resistance is inferior to the force applied, and ceases, except under particular circumstances, as soon as the two forces become equal. This then is the case in the phenomenon before us. The explosion may occasion a rush of air outwards through the fire-door, because the elastic force of the fluids within the tube exceeds that of the atmosphere, but as soon as that within has so expanded as to be reduced in elasticity equal to the pressure of the atmosphere, no farther emission of air from within the boiler can possibly ensue. Again, supposing the possibility of a diminution in volume of the gaseous matter within the boiler, the fire-door (say 1½ feet wide and 2½ feet long) in such boilers would afford an aperture quite sufficient to supply (at the moment of the diminution of volume) the void. Hence then it is evident, that no force at all varying from the atmospheric pressure, can, under any circumstances, be exerted on the part of the boiler exposed to the fire.

Mr Henwood is of opinion that hydrogen is not generated by the decomposition of water from leaks in the boiler. He conceives that the sudden bursts of flame from the chimneys of steam engines arise from gusts of air carrying the flame farther up the flue at some times than at others.

Those who take an interest in this very important discussion will find another paper in the *Phil. Magazine,* signed an Engineer, in which the author endeavours to show that the explosion of steam boilers is almost always owing to neglect, or to the originally bad construction of the boilers. Another correspondent, Mr J. Moore of Bristol states, that steam engines have often exploded on their being stopped, and he is of opinion that this arises from an additional strain on the boiler from within, occasioned by the steam which previously had a free passage being prevented from escaping anywhere but at the safety valve; the aperture of which, compared with the contents of the cylinder into which the steam passed before, is very small. Mr Moore suggests the application of a large valve on the tube adjacent to the part where the steam is prevented from passing to the engine.

### 13. *Account of the Collection and Preparation of the Fucus saccharinus, a sea-weed, for the Chinese market, and its uses.*

This vegetable, by the Malays termed Agar-Agar, and botanically *Fucus saccharinus,* abounds on the coral shoals in the vicinity of Singapore, and forms a bulky article of native import and export for the Chinese market, a very small portion only being reserved for the consumption of the settlement.

Those reefs and shoals exposed by the very low tides during the height of the north-east monsoon afford the most luxuriant crop of this weed, which appears in its native state very similar to a species of fern, the *Hamionitis* of Linnæus. The finest agar-agar known in the Archipelago is found on the coast of Billiton, where it grows to a great length, and fetches when prepared more than double the price of that which is collected elsewhere. On account of its superior quality it is called by the Malays *mayung agar-agar*. The whole produce of our vicinity is gathered by the followers and retainers of the Sultan of Johor, who repair to the banks for this purpose in the month of December, and remain till April and May, by which time the business is pretty well got through, and *gleaners* are allowed after this the pickings, until the departure of the Junks, which generally takes place by July, from which time until the next season the beds or fields are allowed to grow.

It is reported that this season presents the appearance of an extraordinarily abundant crop, and it is stated that the common harvest of 6000 peculs may probably be doubled.

The inhabitants of the islands of Sugi and Moro are the monopolizers of this commodity, the former of whom are divided into two parties, those living on the banks of Sungei Salet (about 400 persons) occupy the east, and the people of Sungei Sugi (about 500 in number) possess the west side.

The population of Moro is about 200 souls, and they collect in the Straits of Dryon or Salat Duri, from Red Island to the southward, along the west side only of Pulo Duri. The weed is here found scanty and poor, when compared to the produce of Sugi.

The grand field extending from the Buffaloe rock to the east side of Pulo Sugi, about fourteen miles in length, by a nearly similar breadth, belongs to the people of Sungei Salet, who, assisted by the Orang Laut from more distant parts, collect on Pulo Trong, and fish the extensive shoals about Pulo Dankan. The Sungei Sugi people are confined to their own shores. During the season, from 1500 to 2000 poor wretches are more or less engaged in the pursuit, subsisting themselves on their means during the whole time.

The weed is plucked by the hand very readily, stowed in small boats, and taken ashore, where it is exposed for two or three days to the sun, and then brought to Singapore, partly by the natives themselves, and partly by Chinese, who visit the spot, and by taking small investments of rice, &c. &c., by administering to the crying wants of the reapers, and bribing the agents of the Sultan, are enabled to make more advantageous contracts. The whole collection is, however, under the control of the Sultan, whose agents have the power of levying a duty, or allowing the labourers a sum for their trouble as they please, which never exceeds one-third of the value of the weed, when imported into Singapore, fetching generally in its then half-dry state, and very heavy, from twelve to eighteen Spanish dollars per bahar of twelve peculs.

The Chinese sailors belonging to the Junks are the next performers, for it falls to their lot to complete the drying, and prepare the article for exportation to China. For this purpose the streets, and every vacant spot in the town, are occupied with mats spread out and covered by the agar-agar in various stages of exsiccation. The first process is washing in salt water, and the picking out of all extraneous matter; after this, exposure merely dries it, and it requires but little attention to pick out parts which occasionally decompose as the process goes on, and to house it in case of rain, which is very prejudicial to its preservation.—Indeed that which, through neglect, has felt the effect of showers of rain seldom keeps to China.

The labour attending it is not very great, and is nearly the same as *kelp* undergoes in England previous to calcination.

In its dry state, when packed up ready for exportation, it is worth from three to four dollars per pecul, and fetches usually in China double that sum, but it must be remembered that the duty is very high. The article is known to the Chinese by the name of *Hy-Chy*, and is converted by them to various useful purposes, such as glue, paint, &c. The chief consumption of it is in the dressing and glazing of their cotton manufactures, and the preparation of sacrifice paper, and paintings for their temples. A small portion of the finest part is sometimes made into a firm jelly, which on being cut up, and preserved in syrup, makes a delicious sweetmeat.

We may here remark, that where the weed abounds, between Red Island, in the Straits of Dryon and Battam Point, so called in Horsburgh's charts, there is no passage for ships, the islands and shoals are extremely numerous, and called by the natives emphatically *Pulo sa Gantang*, meaning that there are as many islands and shoals as there are grains of rice in a *gantang*, a measure about the size of an English gallon.—*Calcutta Government Gazette*, October 26.

## Art. XXVII.—PROCEEDINGS OF THE ROYAL SOCIETY OF EDINBURGH.

*November 26th.*—At a general meeting of the Royal Society the foling Office-bearers were elected.

President.—Sir Walter Scott, Baronet.
Vice-Presidents.—Right Hon. Lord Chief-Baron. Lord Glenlee.
Dr T. C. Hope. Professor Russell.
Secretary.—Dr Brewster.
Treasurer.—Thomas Allan, Esq.
Curator of the Museum.—James Skene, Esq.
Physical Class.—Lord Newton, *President.*
John Robison, Esq. *Secretary*
Counsellors.—Sir William Forbes, Bart. Professor Wallace.
Dr Home. Dr Turner..

Sir T. Makdougall Brisbane. James Hunter, Esq.
Dr Graham. Dr W. P. Alison.

Literary Class.—Henry Mackenzie, Esq. *President.*
P. F. Tytler, Esq. *Secretary.*

Counsellors.—Right Hon. the Lord Advocate. Lord Meadowbank.
Sir Henry Jardine. Thomas Kinnear, Esq.
Sir John Hay, Bart. Dr Brunton.
Dr Hibbert. Sir W. Hamilton, Bart.

*Dec.* 3.—Dr Turner read the first part of a Paper, entitled "An Examination of the Ores of Manganese."

A letter from Captain Parry to Dr Brewster was read, accompanying two sets of hourly meteorological observations made on the ice and on board the Hecla on the 17th of July last. The first of these sets of observations were made in 82½° N. lat., the highest at which a meteorological instrument was ever used. The second set was made in lat. 79° 55′ in a harbour on the north-east of Spitzbergen. In this letter Captain Parry mentions the curious fact, that they experienced that season *at least twenty times as much rain* as in any other summer they passed in the arctic regions.

A Paper by Mr Thomas Graham, M. A. was read on the influence of the Air in determining the Crystallization of Saline Solutions.

The following, among many objects of natural history and the fine arts, were presented to the Society by George Swinton, Esq. Secretary to the Government, Calcutta, and F. R. S. E.

1. Three fine Marble Statues of Burmese gods.
2. Two Models, as large as life, of a Dwarf now in Calcutta.
3. Head of a Dugong.
4. Numerous Barrels and Bottles, containing Snakes from various parts of India.
5. An Armadillo.
6. Ship Fish from Arracan.
7. Head of a Horned Beetle.
8. Book of Natural History in the Talien language.
9. Two Dresses of Carian Women of Tavoy.
10. Bamboo joints containing Tabasheer.
11. Specimens of the Shola, in its natural state, and formed into sheets like paper.
12. Corals and Shells.
13. Specimens of Oils, Varnishes, Bhela or marking Nuts, Gums, Minerals, &c.
14. Stuffed Birds.
15. Large Sponge, or Neptune's Cup, from Singapore.
16. The Leaf Insect from Sylhet.
17. Skeleton of a Boa Constrictor.
18. Petrified Trunk of a Tree from the Irawaddy.
19. Large Chama gigas from the South Seas.

20. A pair of Elephant's Tusks.
21. Skeleton of the Iguana, &c. &c. &c.

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## ART. XXVIII.—SCIENTIFIC INTELLIGENCE.

### I. NATURAL PHILOSOPHY.

#### ASTRONOMY.

1. *Solar Eclipse of November* 1826 *observed at Naples.*—The eclipse of the sun was seen in the most beautiful manner under a true Italian sky on November 29, though the weather preceding and following was bad. As I had no proper instrument for observing it, I contented myself with throwing the sun's image through a pocket-glass on a sheet of paper, and measured the observation. I had previously by projection obtained the time of the eclipse, and during its continuance made several meteorological observations, not a single cloud appearing on the horizon to disturb their accuracy. The whole may be classed as follows:

Naples.

| App. Time. | | |
|---|---|---|
| 11h | 16′ | Eclipse begins (calculated.) |
| 12 | 0 | Temperature in the sun, 84½°. |
| 12 | 2 | Visible conjunction in AR. |
| 12 | 25 | Dig. eclipsed 5° 33′ (measured.) |
| 12 | 25½ | Middle. Digits calculated, 5° 42′. |
| 12 | 27 | Visible conjunction in Long. |
| 12 | 30 | Temp. sun 81½°, shade 55°. |
| 12 | 35 | nearly. Digits eclipsed 5° 15. |
| 12 | 40 | Temp. sun 82¾° shade 51½°. |
| 12 | 45 | Digits eclipsed 5° 2′. |
| 12 | 53 | Temp. sun 84° 51½° + in the shade. |
| 1 | 0 | Temp. sun 84½°, do. ——————— |
| 1 | 0 | Digits eclipsed 4° 12′. |
| 1 | 10 | Temp. sun 87° shade 52°— |
| 1 | 20 | ——— 89° —— 52° + |
| 1 | 26 | Digits eclipsed 0° 55′. |
| 1 | 35 | End calculated—Temp. sun 90°. |

As I had the means of making accurate observations, I resolved to try to what accuracy the end might be determined by the naked eye, merely screened by a smoked glass. At 1h. 32′, the eclipse was some way from being off, and I believe that half a minute after it would not have appeared to be gone, for at 1h. 33′ I judged it to be just gone to a very few seconds; and, on the whole, I think I may say, that, under such favourable circumstances, the end of a solar eclipse may be determined by the naked eye to a quarter of a minute on either side of the truth. Such is the accuracy of the human eye in completing precisely the periphery of an unfinished circle. The space described by the moon from the sun in the sum of the above specified limits did not amount to 15″. In the previous experiments on the thermometer, the one in the sun had its bulb wrapped in very thick soft black silk, and exposed above a bunch of white paper on a stone balcony fronting the south. The result from the one in the shade *ought uniformly* to be *diminished* one degree. The thermometer was not perhaps sufficiently sensible to denote the minute changes which may have taken place during the eclipse in the shade; but the instrument in the sun, which was both excellent and sensitive, shows the effect of the observation in diminishing, and even counteracting the natural increase of heat at this period of the day, and afterwards of accelerating it to a great degree as the shadow went off. As there were no clouds of any kind, adventitious alterations did not interfere. A.

2. *Opposition of Vesta to the Sun.*—This planet was in opposition to the sun on the 15th December, in R. ascension, $5^{h}$ 30′ 40″ and N. Declination, 19° 15′. The following are the places of this planet.

| | R. Asc. | | | Decl. N. | |
|---|---|---|---|---|---|
| 1828, June 1. | 5h | 12′ | 27″ | 19° | 47′ |
| 2. | 5 | 11 | 28 | 19 | 49 |
| 3. | 5 | 10 | 30 | 19 | 52 |

3. *Opposition of Juno to the Sun in March* 1828.—This planet will be in opposition to the sun on the 25th March in R. Asc. $12^{h}$ 27′ 52″ and Decl. N. 2° 15′. The following are the positions of this planet given by Mr Taylor for March and April.

| | | R. Asc. | | | Decl. | | |
|---|---|---|---|---|---|---|---|
| 1828, March | 5. | 12 | 42′ | 35″ | 0° | 38½ | S. |
| | 10. | 12 | 39 | 18 | 0 | 0½ | N. |
| | 15. | 12 | 35 | 42 | 0 | 45½ | N. |
| | 20. | 12 | 31 | 49 | 1 | 30 | N. |
| | 25. | Opposition. | | | | | |
| | 30. | 12 | 23 | 55 | 2 | 58 | N. |
| April | 1 | 12 | 22 | 21 | 3 | 14½ | N. |
| | 5. | 12 | 19 | 20 | 3 | 47 | N. |
| | 10. | 12 | 15 | 46 | 4 | 25 | N. |
| | 13. | 12 | 13 | 44 | 4 | 46 | N. |

*Ann. of Phil.*

4. *New Variable Star in the Serpent.*—Professor Harding of Gottingen has discovered a small variable star in the *Serpent.* Its position for 1800 is in right ascension 235° 22′ 3″ and in north declination 15° 44′ 48″. Its period seems to be about 11 months. When smallest it is entirely invisible.—*Phil. Mag.*

## OPTICS.

5. *On the Luminous Appearance of the Ocean.*[*] By J. HENDERSON, Esq. —On the 5th of March 1821, when on board the licensed ship Moffat, in N. latitude 2°, and W. longitude 21° 20′, a strange anomaly occurred in the phosphorescent appearance of the sea, and one which, as far as I am

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[*] From the *Transactions of the Medical and Physical Society of Calcutta*, vol. i. p. 107.

acquainted, has never hitherto been remarked. During a gentle breeze, the continuation of the north-east Trades, the sea appeared uncommonly luminous, and increased gradually in brightness, from a little after sunset until near midnight. The intensity was particularly great about nine o'clock; and every one who then kept his eyes fixed upon it but for a short time, was immediately seized with headach, giddiness, pain in the eyeballs, and slight sickness. Some on board certainly felt these symptoms more violently than others; but there was none who was not more or less affected by them. For my own part, the headach, &c. which immediately followed my looking at the water, was particularly severe; nor did it go off until morning. I cannot give a better idea of my sensations, than that the effects resembled those produced from having smoked an over quantity of tobacco. The brightness gradually decreased long before dawn, nor did it ever afterwards impress us with the same peculiar effects I have just described.

The luminous appearance of the sea seems as yet to have excited but little attention among philosophers, who are content with ascribing it to fish spawn, or animalcules. Of the two, I should rather be inclined to adopt the latter opinion, though their actual existence has not yet been ascertained. The following are my reasons for doing so.

1*st*, The luminous appearance is greatest where there are evidently fewest fishes.

2*d*, They are often seen in great masses, many fathoms from the surface. Now, as they do not give light without motion or agitations, it follows that these cannot be in the state of rest their position would lead us to suppose.

3*d*, They are of greater size, and more thinly spread in higher latitudes; whereas near the line they become more and more minute, and are seen in infinitely greater numbers.

4*th*, The luminous appearance varies according to the quarter from which the wind blows; and as fish spawn is, comparatively speaking, inanimate, it is improbable that so slight a cause should produce such a change upon it.

The shoals of them we observe below the surface appear to be owing to their attaching themselves to animal or vegetable matter, whose specific gravity being somewhat greater than water, it has sunk till it found an equilibrium. I have often observed them with a tolerably good microscope; but the motion of the vessel, and other circumstances, give me little confidence in the experiments I have made. The most interesting subject, however, is the principle in which their resplendent property resides. It is generally denominated phosphorescent; but phosphorus, in its most concentrated state, affords no effect such as I have described. I have witnessed it burning in oxygen gas, while its light almost rivalled that of noon day: its action then upon the eye was nothing more than would have been produced by looking for a few moments at the sun; while during the phenomenon I have described the slightest beam of that luminary would have rendered the whole invisible. If, therefore, we conclude, that the symptoms I have mentioned constitute a natural property inherent in the insect, and produced when its light and numbers are in a sufficient degree of intensity, we at the same time ascribe to it a power which no luminous animal or other substance possesses but itself. In conclusion, I have only to remark, that having made some experiments on the specific gravity of the sea, I found that it decreased, with slight exceptions, gradually from the line, so that, if these are correct, the animalcules are found smaller and more numerous where the specific gravity of the sea is the least, provided at the same time the temperature admits of their existence.

### MAGNETISM.

6. *Eaton's Proposed Improvement on Magnetic Needles.*—Professor Amos Eaton proposes that the needles of compasses should be tipped with silver, brass, &c. This not only preserves the points from rust, but withdraws the poles from any attractive power in the brass, whether it arises from hammering, or from any particle of steel or iron which may have been accidentally left in the brass.—Dr Silliman's *Journal,* No. xxv. p. 16.

7. *Professor Hansteen's Magnetic Tour to Siberia.*—We mentioned in our last Number that this eminent philosopher proposed to set out to Siberia, to examine the intensity of the earth's magnetism in that vast country. We are happy to inform our readers that the national assembly of Norway has voted the necessary funds for this purpose. Dr Erman Junior, the son of the celebrated Professor Erman of Berlin, has offered his services as the companion and assistant of Professor Hansteen, and from his knowledge of mineralogy and geology, we may expect much important information respecting Siberia. Professor Hansteen sets out in March, from Christiania for Stockholm and St Petersburgh, where he joins his companion from Berlin. We trust that Professor Hansteen will endeavour to obtain some information respecting the mean temperature of Siberia, which acquires a great interest from the proximity of the Asiatic Pole of maximum cold.—*Letter from Professor Hansteen.*

8. *On the Magnetic Actions excited in all Bodies by powerful Magnets.*—In a memoir on this subject read to the Academy of Sciences, on the 17th September, M. Becquerel points out the positions in relation to a powerful magnet, assumed by a small *cartouche* of paper filled with tritoxide of iron, or a needle of any substance whatever freely suspended, and the position of whose centre of suspension varies in relation to the nearest pole of the needle. When this centre is very near one of the extremities, and in a line parallel to the line of the poles, the needle will place itself in a direction perpendicular to this line, in place of taking the direction of the line which a magnetical needle would have done. If the centre of suspension is brought nearer the magnet, from 1 to 2 millimetres, the needle then deviates from the perpendicular direction. From numerous experiments, M. Becquerel has shown that the essential difference in the phenomena produced in a needle of iron, or steel, and needles of other substances is, that in the first, the *distribution of magnetism is constantly*

*in the direction of their length; whereas in the latter, it is in the direction of their breadth, particularly when a single bar magnet is used.*—*Le Globe*, September 20th 1827.

### ELECTRO-MAGNETISM.

9. *On the rotation of a magnet about its axis.*—M. Pouillet has succeeded in giving a magnet a motion of rotation by means of a metallic ring nearly encircling the magnet, which must be nearly cylindrical, and by placing on the ring a small quantity of mercury in contact with the magnet, and which the capillary force prevents from escaping out of the small interval which is left between the magnet and the ring.

By this means, the communication being made between one of the ends of the pile and the magnet, as in Ampere's apparatus, by a small cavity full of mercury hollowed in the upper end of the magnet, the communication with the other end of the pile takes place only at the points of the horizontal section of the needle or the point where the ring is placed. By this arrangement we may compare the velocities of rotation which correspond to each position of the ring along the magnet. M. Pouillet has shown that the velocity is a *maximum* when the ring is placed at the middle of the magnet; that it goes on diminishing, but remains always in the same direction whether the ring rises or falls; and that the magnet remains immoveable when the ring is placed very near one of its extremities beyond the pole.—*Le Globe*, Aug. 28, 1827.

### METEOROLOGY.

10. *Sound of the Aurora Borealis in Iceland, observed by Mr Henderson.*—"The most striking aerial phenomenon exhibited by an Icelandic winter is doubtless the Aurora Borealis or Northern Lights, which are here seen in all their brilliancy and grandeur. I had an opportunity of contemplating them almost every clear night the whole winter, sometimes shooting across the hemisphere in a straight line, and presenting to the view, for a whole evening, one vast steady stream of light; but more commonly they kept dancing and running about with amazing velocity, and a tremulous motion exhibiting as they advanced some of the most unrivalled appearances. On gaining one point of the hemisphere, they generally collected as if to muster their forces, and then began again to branch out into numerous ranks, which struck off to the greatest distance from each other as they passed the zenith, yet so as always to preserve the whole of the phenomenon in an oval shape; when they contracted nearly in the same way as they expanded, and after uniting in a common point, they either returned in the course of a few minutes, or were lost in a stream of light, which grew fainter and fainter the nearer it approached the opposite side of the heavens. They were mostly of a dimmish yellow, yet often assuming mixtures of red and green. When they are particularly quick and vivid, a crackling noise is heard, resembling that which accompanies the escape of the sparks from the electrical machine. They almost always took their rise from the summit of *Mount Esian*, which is about due north-east from *Reykiavick*, and proceeded to a south-west direction. When visible the whole length

of the hemisphere, they were uniformly strongest towards the north and north-east, and were always sure to be seen in that quarter, when they appeared nowhere else. Once or twice I observed them in the south, but they were very faint and stationary.

"In the days of superstition, these celestial wonders were received as portending certain destruction to nations and armies, and filled the minds even of the most enlightened with terror and dismay. At the present day, the Icelander is entirely free from such silly apprehensions, and only regards their uncommonly vivid appearance as predicting a hurricane or storm; an observation founded on experience, and which I frequently brought to the test, when it invariably turned out, that in less than twenty-four hours, after the Northern Lights were in a great commotion, we had either sudden squalls, or a heavy gale of wind from the north.

"It was scarcely ever possible for me to view this phenomenon without reflecting on Job, xxxvii. chap. 22. 'The golden splendour cometh out of the north;' and it seems extremely probable, that it is to these Elihu here alludes. The idea not only agrees with the light spoken of in the preceding verse, but is far more suitable to the latter clause of the same, 'With God is terrible Majesty.' In some parts of Asia, the northern lights are so terrible, that 'they strike the beholders with terror.' Every animal is struck with terror, even the dogs of the hunters are seized with such dread, that they will fall on the ground and remain immoveable, till the cause is over."—Henderson's *Iceland*, p. 277. Edinburgh, 1819.

11. *Auroræ Boreales observed in Roxburghshire in* 1827.—The following Auroræ were observed at Allerly, near Melrose, in Roxburghshire.

| | | |
|---|---|---|
| October 6, | - | Brilliant. |
| November 18, | - | Brilliant. |
| 19, | - | Faint. |

12. *Great Dryness in the Antilles in* 1827.—A distressing and singular dryness was this year experienced in the Antilles; during a period of *sixty six* days not a drop of rain fell. This dryness was succeeded by abundant rains, but the crops had been previously almost wholly destroyed. These rains were immediately preceded by an earthquake, which was felt at Martinique on the 3d of June at 8 o'clock in the morning.

As the yellow fever raged this year with great severity in the Antilles, M. Moreau de Jonnes considers this fact as an objection to the hypothesis that this disease is produced and kept up by a moist heat. These facts were communicated by M. Moreau de Jonnes to the Academy of Sciences on the 17th September last.—*Le Globe*, September 20, 1827.

13. *Meteoric Stone at Futtehpore.*—A communication was laid before the Medical Society of Calcutta from Dr Tytler, giving an account of a meteoric stone which fell at Futtehpore in the Doab, in November 1822. On the evening of that day, a short time after sunset, and before daylight had entirely faded, a meteor was distinctly seen, shooting with considerable velocity in a direction nearly north-west. This appearance was also observed by Europeans in the lines, and natives in the

city; and is described to have comprised a blaze of light, surrounding a red globe about the size of the *moon*, which impressed the spectators with the idea of that luminary descending from the skies. The same phenomenon, and at the same moment of time, it appeared from the newspapers, was likewise noticed at *Hazareebaug*, in Bengal, a distance of upwards of two hundred and fifty miles eastward from Allahabad. But, as the atmosphere was clouded when the ball was seen at the latter station, and the light was sufficiently strong to illuminate the horizon, the *meteor* appearing between the clouds and earth's surface, it is evident that at that particular moment its elevation could not have been greater than a few thousand feet from the ground. The *meteor* descended at *Rourpoor*, a village under the jurisdiction of Futtehpore, situated nearly seventy miles north-west from the station of Allahabad, immediately after it was seen at that place. The descent was accompanied with noises resembling the explosion of distant artillery, and a stone was seen falling, which, in the act of descending, is said to have emitted sparks similar to those proceeding from a blacksmith's forge. A strong sulphurous smell was also perceptible, and when first discovered the stone was hot to the touch. Besides the stone thus actually known to have fallen, several others of a similar description were picked up, at the distance of several coss from each other, whence it appears that a shower of stones in this instance took place,—or that several stones were enclosed in the body of the *meteoric* globe, which, analogous to balls emitted from a *Shraphell's* shell, were projected in various directions at the moment of explosion.

The *meteor* seen at *Hazareebaug* and *Allahabad* is identified with the shower of stones which fell near Futtehpore. The fragments amount to several pounds in weight. One weighs nearly one pound and six ounces avoirdupoise, and is heavy for its size. The external surface is of a deep black colour, the stone exactly resembling a body coated with black paint or pitch. In some places are also seen smooth black specks, darker than the rest of the covering, that looks as if it were cracking from the action of fire, to which it has evidently been exposed. The coat is likewise indented or rough, as if it originally possessed a softer consistence, which has been compressed by the action of some hard body, and in certain places is also covered with a yellowish-coloured substance. This black coating is not thicker than the finger nail, and encloses a whitish, or ash-coloured mass, which is very friable, contains a number of shining particles, and exhibits small brown specks, and streaks, or veins of the same colour. Upon examination with a magnifying glass of considerable power the shining particles are discovered to be evidently metallic, and to present an appearance exactly resembling the *Tutenague*, or white copper, named *pul* by the natives, that is commonly employed in the bazars for the formation of domestic utensils.

The three substances just mentioned are connected together by a fourth of an earthy consistence, and so soft that all the other substances may be easily separated by the point of a knife or the nail, and the stone itself crumbled to pieces between the fingers. This cement is of a grey colour.

The proportion and size of these different constituents vary considerably in different specimens; but all of them bear a striking resemblance to each other. The specific gravity varies from 3.352 to 4.281.

Dr Tytler then noticed the different theories that have been proposed to account for the appearance of these aerolites, and shows that none of them are free from objections. He then suggests their terrestrial origin, and that they have been emitted from volcanos upon the surface of the earth, for the following reasons:

*1st,* The stones in their appearance plainly bespeak a volcanic origin, and it is evident they have been subjected to the action of intense heat.

*2d,* Their descent is ascertained to be accompanied with a sulphurous smell, and the emission of fiery sparks, while the stone itself is constantly found hot.

*3d,* Stones of this description have descended in considerable numbers during eruptions of *Vesuvius,* and at a great distance from the volcano.

*4th,* Stones of the same kind are very frequently found on the sides of *Vesuvius.*

*5th,* These stones distinctly coincide with, or rather their substance is precisely the same, with that of *meteoric* stones.

*6th,* The *meteoric* phenomena attending the descent of the stones are also *volcanic.*

*7th,* And *lastly,* the meteors emitted from the craters of volcanos also upon their explosion eject stones. In proof of these assertions he quotes various recorded facts.

In connection with the volcanic origin of the stones in question, Dr Tytler refers to the occurrence of a remarkable volcano on Java in November 1822, and thinks it not improbable that they might have been thrown out on that occasion, being projected far beyond the elevation of the atmosphere, and falling to the westward of Java, conformably to the diurnal motion of the earth, the meteor having visibly passed in a direction from south-east to north-west.

## II. CHEMISTRY.

14. *M. Despretz on the Heat Developed in Combustion.*—On the 15th and 22d October last, M. Despretz read at the Academy of Sciences a memoir on the heat developed in combustion. By means of a new method of observation he found that *hydrogen* is the body which, under a given weight, disengages most heat, and that the metals disengage least. The result will be opposite if we refer the results to the same weight of oxygen. It is remarkable that carbon, which in burning does not change the volume of oxygen gas, produces three-fifths of the heat developed by the metals, (iron, zinc, and tin,) which reduce the oxygen gas to the solid state. Hence it is in the act of combination that we must seek for the principal cause of the developement of heat, and not in the approach of the particles.

In his second memoir M. Despretz has shown that the quantity of heat developed by a certain quantity of a body which burns without changing the volume of oxygen gas is the same, whatever be the density of the gas. —*Le Globe.*

15. *Karsten's Metallurgy of Iron.*—Dr Karsten, privy counsellor to the King of Prussia, Member of the Royal Academy of Sciences of Berlin, &c. a celebrated metallurgist, is engaged with the second edition of his classical *Metallurgy of Iron.* The first edition appeared in two volumes in the 1816, and was translated in the year 1824, by Captain Culman, into the French language. The new edition will be comprised in four volumes with sixteen copper-plates. The first volume, embracing the physical and chemical properties of iron, is already published. An English translation of this very useful work will be prepared in Germany.

16. *Iodine in Cadmium.*—Iodine is found in the great zinc foundry at Königshutte, in Upper Silesia, in the kadmium which accompanies the zinc-ores.

17. *Analysis of the Green Iron-ore.* According to Dr Karsten, (*Archiv fur Bergbau und Huttenwesen*, vol. xv. p. 241) a variety from the Hollerter mines near Siegen in Rhein-Prussia consists of

| | |
|---|---|
| Oxide of iron, | 63.450 |
| Phosphoric acid, | 27.717 |
| Water, | 8.560 |
| | 99.727 |

From this composition Dr Karsten deduced the formula $2\overset{\cdot\cdot\cdot}{F} + \overset{\cdot\cdot}{\overset{\cdot\cdot\cdot}{P}} + 2\frac{1}{2}$ Aq. the proportions of oxide of iron, phosphoric acid, and water, being as 62.51 : 28.59 : 8.90.

18. *Analysis of the Arseniate of Lead.*—According to Dr Karsten, (l. c. 255.) a variety from Herrhausen near Siegen, in Rhein-Prussia, consists of

| | |
|---|---|
| Oxide of lead, | 69.97 |
| Muriatic acid, | 0.81 |
| Arsenic acid, | 29.22 |
| | 100. |

The results of this analysis are not accordant with those obtained by Dr Wohler.—Poggendorff's *Annalen*, vol. iv. p. 161.

19. *On the Detection of Antimony in Mixed Fluids.* By EDWARD TURNER, M. D. *(From the Edinburgh Medical and Surgical Journal.)*—Having been recently engaged, along with Dr Christison, in examining some food supposed to contain tartar emetic, I was led to inquire into the comparative value of the tests recommended for detecting that substance; and as, on pursuing the investigation, I found reason to distrust the method described in our best works on toxicology, and at the same time succeeded in rendering it more secure, I am induced to believe that a short account of my experiments will not be unacceptable to the public.

Many reagents decompose tartar emetic, and cause precipitates in its solution. Of these the principal are alkaline substances, the stronger acids, such as the muriatic and sulphuric, the infusion of gall-nuts, and sulphuretted hydrogen. The value of these tests is very unequal. Pure potash, when cautiously added to a strong solution of tartar emetic, occasions a pretty copious flocculent white precipitate, which is readily and completely redissolved by an excess of the alkali. In a moderately dilute solution potash does not produce any change. Pure ammonia in a concentrated solution throws down a white, very fine, granular precipitate, which adheres firmly to the glass, and is only partially redissolved by an excess of the precipitant. Tartar emetic is not precipitated by carbonate of ammonia. The fixed alkaline carbonates and lime water act with considerable delicacy. In a solution containing a grain of tartar emetic to an ounce of distilled water, carbonate of potash and lime water yield distinct white precipitates, that from the former being the protoxide of antimony with a little carbonic acid, and that from the latter consisting of the tartrates of antimony and lime; whereas in the same liquid pure potash produces no change, and ammonia a cloudiness scarcely visible. When the tartar emetic is in the proportion of one grain to two ounces of water, lime-water has no effect, but the carbonate of potash still gives rise to a precipitate. If the proportion is a grain to four ounces of water, the action of the alkali can no longer be traced.

The delicacy of muriatic or sulphuric acid as a test of tartar emetic, is almost exactly the same as that of the carbonate of potash; but the acid must be added cautiously, as an excess of it redissolves the precipitate.

The recent infusion of gall-nuts produces a copious yellowish white precipitate in a concentrated solution of tartar emetic. The liquid is rendered turbid, when the proportion is two grains to an ounce; but it undergoes no change when the tartar emetic is in the ratio of one grain to an ounce of water.

Sulphuretted hydrogen acts with far greater delicacy and certainty than any of the others. On transmitting this gas through eight ounces of water containing one grain of tartar emetic, the solution instantly acquired an orange colour; and after saturating the liquid with the gas, and boiling in order to expel the excess of it, a considerable quantity of the sulphuret of antimony quickly separated. *

From these experiments it fully appears, that of all the tests of tartar emetic enumerated by toxicologists, sulphuretted hydrogen is the only one which is sufficiently delicate for being entitled to confidence. It is the only one, also, the indications of which as to the presence of antimony are precise. The orange tint of the precipitated sulphuret of antimony can scarcely be mistaken for any other metallic sulphuret by a person acquainted with its appearance. Its colour is quite different from that of orpiment

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* This precipitate is commonly, but I conceive incorrectly, regarded as a hydrosulphuret of the oxide of antimony. It appears rather to be a hydrated sulphuret of the metal.

or of the bisulphuret of tin; and from the sulphuret of cadmium, to which it bears a greater resemblance, it is distinguished by its ready solubility in a solution of pure potash. On the contrary, the other tests, taken singly, supply no proof whatever of the presence of tartar emetic; though, when they all agree in their indications, their evidence is not likely to be deceptive.

In describing sulphuretted hydrogen as a test of tartar emetic, it is almost unnecessary to state that this gas merely indicates the presence of antimony, without directly showing in what state it existed. But since tartar emetic is the only pharmaceutic preparation of antimony which is soluble in water, the detection of the metal itself, in judicial cases, leaves little doubt of its having been in the form of the double tartrate. This, however, is not a point of much importance, because all soluble antimonials are poisonous.

In order to ascertain if sulphuretted hydrogen may be relied on for discovering the presence of antimony in complex animal and vegetable fluids, tartar emetic, dissolved in water, was mixed with tea, broth, porter, and milk, in such quantity that each solution amounted to four ounces, and contained two grains of the compound. Through these solutions, after being acidulated with tartaric acid, boiled and filtered, a current of sulphuretted hydrogen gas was transmitted during fifteen or twenty minutes. In the three first liquids an abundant precipitation ensued immediately, and the same took place in the milk after boiling. The precipitate subsided easily from each, and the colour of that from the tea, broth, and milk, was quite characteristic. That procured from the porter was not so satisfactory at first; but on collecting and drying it upon a filter, the paper presented the distinct orange tint of the precipitated sulphuret of antimony.

In recommending the use of tartaric acid, I may observe that the employment of this substance should in no case be omitted. According to my observation, all the precipitates occasioned in tartar emetic by reagents, sulphuretted hydrogen excepted, as well as by animal or vegetable fluids, are readily dissolved by tartaric acid. Thus the precipitates occasioned by lime-water, or muriatic acid, disappear instantly on the addition of tartaric acid; and the compound of tannin and the oxide of antimony, whether formed by the infusion of gall-nuts, tea, or cinchona bark, may easily be rendered soluble by the same means. If milk is present, muriatic acid should likewise be employed, by which the coagulation of the caseous matter is more completely effected. In order, therefore, to form a rule applicable to every case, the following directions may be given: The fluid supposed to contain tartar emetic should be mixed with a drachm or two of muriatic and tartaric acids, boiled for a few minutes to separate any substance coagulable by heat, and then allowed to cool, and filtered. The liquid should next be exposed to the action of sulphuretted hydrogen, and boiled to expel the excess of the gas; after which the sulphuret will subside if tartar emetic had been present.

After procuring the sulphuret of antimony by the process above described, it is important to subject the compound to some operation by which the metal may be obtained in a separate state. Professor Orfila, in his work on *Toxicology*, (vol. i. p. 465, third edition,) states, that the precipitate in question, "dried on a filter, and mixed with charcoal and the potash of commerce, gives a button of metallic antimony by the action of heat. This reduction of the oxide of antimony by charcoal may be made in an earthen crucible, and is completed in the space of about ten or twelve minutes." It is chiefly to this part of the process for detecting antimony that I have found reason to object. I do not, indeed, deny that the process will succeed perfectly, when a considerable quantity of the materials is employed; but in operating on such quantities as are likely to be met with in medico-legal investigations, my attempts to procure the metal in this way have proved completely fruitless. Thus, four grains of the sulphuret, precipitated from tartar emetic by sulphuretted hydrogen, and well dried, were mixed with an equal weight of charcoal and dry carbonate of potash. The mixture, protected on all sides by charcoal, was placed in a Hessian crucible, carefully luted, and was then exposed to heat during fifteen minutes. The experiment was twice repeated; and on one occasion a full red, and on the other a commencing white heat was employed, but in neither case could I perceive any trace of the metal. On examining the residue chemically, I found that some particles of metallic antimony were diffused through the mass, though they could not be discovered by the eye; while another portion still remained as sulphuret, and was dissolved by the potash on the addition of water.* These experiments were varied by mixing the sulphuret with black flux, and heating the mixture in a glass tube by means of a spirit lamp; but a metallic globule was not procured, though the heat was augmented by aid of the blowpipe. It is worthy of remark, that in none of these trials was there any appearance of a metallic sublimate; so that, were colour insufficient for distinguishing orpiment from the sulphuret of antimony, the black flux would afford an easy mode of distinction.

Having failed in my attempts to procure the metal by the preceding process, I had recourse to another which proved successful. It is founded on the property hydrogen is known to possess, of separating sulphur from antimony at an elevated temperature,—a property, of which advantage has been taken for the purposes of analysis. In performing this operation, the dry sulphuret is placed in the middle of a glass tube about three inches long, and a quarter of an inch in diameter. One end of the tube is connected by means of a cork with a vessel, from which hydrogen gas is evolved; and to its other extremity is adapted a bent tube, which opens under water, so as to conduct away the hydrogen, and at the same time exclude atmospheric air. After the air within the apparatus has been expelled, heat is applied by means of a spirit lamp to the part of the tube on which the sulphuret is placed. The decomposition of the sulphuret commences

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* This, we apprehend, is owing to the formation of a double sulphuret of antimony and potassium.—E. T.

at a temperature by no means elevated; but in order to render it complete and fuse the antimony, the glass should be made red hot, and kept in that state for five or six minutes. The temperature at the close of the process may with advantage be increased to bright redness by the use of the blowpipe.

The appearance of the metal within the tube depends upon the manner of conducting the experiment. If the sulphuret had been placed in a heap, the metal is found partly in a spongy state, and partly in minute globules; but if it had been diffused over a considerable space, no globules appear, and the metallic lustre is indistinct. The metallic nature of the spongy mass may, in general, be brought distinctly into view by placing it on a piece of white paper, and pressing it with the nail or the blade of a penknife.

The result also depends on the velocity with which the hydrogen is transmitted through the tube. If the gas passes rapidly, some of the metal is hurried off at the moment of separation from the sulphur, and is deposited within the tube as a metallic film, which is sometimes very distinct. If, on the contrary, the passage of the gas is slow, this appearance does not take place.

By means of this process, I have succeeded in procuring from the tenth of a grain of the sulphuret metallic antimony, the lustre of which could be distinctly seen with the assistance of a lens. From half of the precipitates procured from the mixture of two grains of tartar emetic with broth and milk, I procured distinct metallic globules.

Should a considerable quantity of animal or vegetable matter subside with the sulphuret, the metallic antimony will then be so mixed with charcoal that its lustre cannot be seen distinctly. This occurred to me in decomposing the sulphuret obtained from porter. In a case of this kind the mixture should be placed in an open tube, and heated to redness by means of a spirit lamp. The antimony is then oxidized, and the oxide, which attaches itself to the cool parts of the tube in form of a white powder, may be recognized by its appearance and volatility.

20. *Ultimate analysis of several vegetable substances.*—By M. F. MARCET. (*An. de Ch. et de Ph.* vol. xxxv.) The mode of analysis employed by M. Marcet is that which was introduced by M. Gay-Lussac and Thenard. It consists in mixing the substances to be analyzed with peroxide of copper and heating the mixture to redness. Its composition is calculated from the loss of weight experienced by the oxide of copper, and the quantity of water and gas which are collected, the substance having been previously dried by exposure to the action of sulphuric acid under the exhausted receiver of the air-pump.

Starch in its common state, and modified by heat, (Amidine of Caventou) is thus constituted :—

| | Common starch. | Torrefied starch. | Starch from malt. |
|---|---|---|---|
| Carbon, | 43.7 | 35.7 | 41.6 |
| Oxygen, | 49.7 | 58.1 | 51.8 |
| Hydrogen, | 6.6 | 6.2 | 6.6 |

Torrefied starch contains more oxygen and less carbon and hydrogen than common starch. Though modified starch in some of its properties is analogous to gum, in its chemical constitution it differs more from that substance than common starch.

The hordein of Proust is composed, according to M. Marcet of 44.2 parts of carbon, 47.6 of oxygen, 6.4 of hydrogen, and 1.8 of nitrogen. It differs slightly, however, from starch in the proportion of carbon, oxygen, and hydrogen, and in containing nitrogen. It differs also from the fibrous matter of the potato, which consists, according to Marcet, of carbon 55.7, oxygen 22, hydrogen 7.8, and nitrogen 14.5. The zimome of M. Taddei was likewise analyzed, but appears similar in composition to common gluten. If this be true, it follows that the elements of gliadine must be in the same proportion as those of zimome.

Yeast was found to consist of carbon 30.5, oxygen 57.4, hydrogen 4.5, and nitrogen 7.6.

21. *On a chloride of Manganese, remarkable for its volatility.* By M. J. DUMAS, (*An. de Ch. et de Ph. v.* 35.)—This chloride corresponds to the manganesic acid, and is transformed by contact of water into muriatic and manganesic acids. It is readily formed by putting a solution of manganesic acid into strong sulphuric acid, and then adding fused sea-salt. The muriatic and manganesic acids mutually decompose each other; water and the chloride of manganese are generated, the former of which is retained by the sulphuric acid, and the latter assumes the gaseous form.

This chloride, however, does not constitute a permanent gas. When first formed, it appears as an elastic fluid either of a copper or greenish colour; but on traversing a glass tube cooled down to—15° or—20° C, it is condensed into a greenish-brown coloured liquid.

When generated in a capacious tube, its vapour gradually displaces the air, and soon fills the tube. If the vapour is then poured into a large flask, the sides of which are moist, the colour of the vapour changes suddenly on coming into contact with the moisture, a dense smoke of a pretty rose tint appears, and the sides of the vessel acquire a deep purple colour, which is occasioned by manganesic acid. In fact, water thus coloured yields a copious precipitate with nitrate of silver; and when heated with potash undergoes the same change as mineral chameleon.

The best mode of preparing this remarkable compound consists in forming the common green chameleon, and converting it into red by means of sulphuric acid. The solution, when evaporated, leaves a residue of sulphate and manganeseate of potash. This mixture, treated by strong sulphuric acid, yields a solution of manganesic acid, into which are added small fragments of sea salt, as long as coloured vapour continues to be evolved.

An analogous compound is formed when sea salt is replaced by a fluoride, but M. Dumas has not succeeded in collecting it so as to submit it to examination.

From the circumstances under which the new chloride is generated, it must obviously contain as many equivalents of chlorine as the manganesic acid does of oxygen. If, as Forchhammer supposes, this acid consists of one equivalent of metal, and four of oxygen, the new chloride will be composed of 28, or one equivalent of manganese, and 144, or four equivalents of chlorine, and hence contains four times as much chlorine as the common chloride.

22. *On the properties of Sulphur.*—By M. J. DUMAS, (Ibid.) M. Dumas, in verifying the well known fact that sulphur liquefied by a certain heat is rendered more tenacious by an increase of temperature, has ascertained the degree at which these changes take place. M. Dumas fixes the point of fusion of sulphur at 108° C. Between 110° C and 140° it possesses the greatest degree of fluidity, and is of an amber colour. It begins to thicken near 160° C. and acquires a reddish tint; and at the temperatures between 220° and 250° C. it is so tenacious that the vessel may be inverted without causing it to change its place. From 250° to its boiling point it becomes liquid again, but never to the same extent as when at 120° C.

It is also a familiar fact, that sulphur heated to a sufficient degree is rendered tenacious and soft if suddenly cooled by being poured into cold water. M. Dumas finds that the temperature required for this effect is 220° or above it. If the temperature is below 170° C. when the sulphur is put into cold water, it becomes brittle.

23. *On a new method of preparing the Deutoxide of Barium.* By M. QUESNEVILLE, Fils, (Ibid.)—The method proposed by M. Quesneville, which appears to us a great improvement, is to introduce nitrate of baryta into a luted retort of porcelain, to which a Welter's tube terminating under an inverted jar full of water is attached. Heat is then gradually applied to the retort, and a red heat is continued as long as there is any disengagement of nitrous gas or nitrogen. When these have ceased, and pure oxygen passes over, which is a proof that all the nitrate is decomposed, the process is discontinued. The peroxide of barium is then found in the retort, the baryta and oxygen having united in their nascent state.

## III. NATURAL HISTORY.

### MINERALOGY.

24. *Brachytypous Lime-Haloide of Mohs.*—Professor Stromeyer has analyzed the brachytypous lime-haloide of Mohs, and has found that the following varieties of this species consist of

| | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Magnesia, | 41.06 | 40.19 | 42.40 | 43.44 |
| Protoxide of iron, | 8.57 | 10.53 | 6.47 | 4.98 |
| Oxide of manganese, | 0.43 | 0.49 | 0.62 | 1.52 |
| Carbonic acid, | 48.94 | 48.48 | 49.67 | 49.93 |
| Carbon, | | | | 0.11 |

No. 1. is a crystallized wine-yellow variety, from the Zitterthal in Salzburg. No. 2. a crystallized pale yellowish-brown variety, in chlorite slate, from the Fassathal in Tyrol. No. 3. a granular straw-yellow variety, accompanied with bitterspar and talc, from St Gotthard mountain in Swit-

zerland. No. 4. a granular black variety, from Hall in Tyrol. As the mineral contains no lime, it cannot be placed under the genus lime-haloide. Professor Stromeyer called it Magnesite-spar.—*Göttinger gelehrte Anzeigen*, No. 158, 1827.

25. *Chrysolite in the Cavities of Obsidian.*—Professor Gustavus Rose of Berlin has found in the cavities of Obsidian, in the Jacal Rock near Real-del-Monte in Mexico, little crystals, greenish, and reddish-yellow, and transparent, which belong to the species of prismatic Chrysolite.—Poggendorff's *Annalen*, Vol. x. p. 323.

26. *New Minerals.*—Professor Breithaupt (Schweigger's *Journal der Chemie und Physik*, N. S. Vol. xx. p. 314, &c. gives a description of the following new mineral species:

I. *Karphosiderite.* Name derived from the straw-yellow colour. Reniform masses, rarely from granular composition, uneven; shining and glimmering in the streak, with resinous lustre. Colour and streak pale and high straw-yellow. Hardness = 4.0 ... 4.5. Sp. Gr. = 2.5. Feels greasy. Before the blowpipe upon the coal it becomes black and melts in a strong fire into a globule, which is attractible by the magnet. In glass of borax it is easily soluble, and with salt of phosphorus it melts into a black scoria. It contains oxide of iron, phosphoric acid, water, with small quantities of oxide of manganese and zinc. It has a great similarity to oxalite, yellow iron-ore, or iron-sinter. It occurs in Greenland.

II. *Mesitine-spar.* Name derived from μεσιτης, that is, what stands in the middle (of brachytypous lime-haloide, and brachytypous parachrose baryte.) Rhombohedral, $R - \infty$. $R = 107° 14'$ $R + \infty$. Cleavage distinct, parallel to R. Lustre vitreous. Colour dark-greyish, and yellowish-white...yellowish-grey. Streak white. Transparent...translucent. Hardness = 4. Sp. Gr. = 3.34...3.37. Before the blowpipe the mesitine-spar decrepitates. In muriatic and nitric acid a feeble effervescence takes place, but it is entirely soluble. It contains probably magnesia, lime, protoxide of iron, and oxide of manganese. It is found in little crystals, in rhombohedral quartz at Traversella in Piemont.

III. *Tautolite.* Prismatic. Fundamental form, scalene four-sided pyramid.

$$a : b : c = 1 : 1.9451 : 1.3648.$$

Observed combinations:

$$1,\ M = \infty a : b : c = 109° 46'.$$
$$g = 4\ a : b : \infty c = 51° 52'.$$
$h = \infty\ a : \infty\ b : c$ Fig. 9 of Mohs treatise, 2, $M$; $g$; $h$;
$$\left.\begin{array}{l} i = \infty\ a : \tfrac{3}{4}\ b : c = 56° 22'. \\ e = 2\ a : b : \infty c = 88° 25'. \end{array}\right\}\ \text{See Plate III. Fig. 6.}$$

Cleavage, only in traces and interrupted, parallel to *M* and *h*. Fracture conchoidal...uneven. Lustre vitreous. Colour velvet-black. Streak grey. Opaque. Hardness = 6.5...7.0. Sp. Gr. = 3.865. Before the blowpipe, upon charcoal, the tautolite melts to a blackish scoria, which is attracted by the magnet; with borax it melts to a clear green glass. These and other reactions show that the mineral consists of silica, black protoxide of iron, magnesia, and alumina. It is found in the volcanic feldspath-rocks, in the neighbourhood of the Lake Laach Sea in Rhein-Prussia. The tautolite seems to be related to the chrysolite, as the Ceylanite to the Spinelle.

27. *Mica from New Jersey.*—It is tetarto-prismatic, and blackish-green. The angles, in reference to Fig. 32 of Moh's *Treatise on Mineralogy,* are the following. M on T = 73° 40′, P on M = 110°, P on T = 118° 0′. Cleavage parallel to P.—(*Vide* Kobell, in Kastner's *Archiv. fur die gesammte Naturlehre*, Vol. x. p. 291.

28. *Dr Thomson's analysis of Pure Chromate of Iron.*—Hitherto the specimens of chromate of iron were mixed with octaedral iron and other extraneous matters. Dr Thomson however succeeded in finding octaedral grains nearly pure.

| | |
|---|---|
| Green oxide of chrome | 56.0 |
| Peroxide of iron, | 31.0 |
| Alumina, | 13.0 |
| Silex, | a trace |

Or when free of all mixture,

| | Atoms. | |
|---|---|---|
| Green oxide of chrome, | 2 | 57.1 |
| Peroxide of iron, | 1 | 28.6 |
| Alumina, | 1 | 14.3 |

*Ann. des. Mines,* 1827, p. 280.

## GEOLOGY.

29. *On the Boulder-stones in the North of Germany.*—Professor Hausmann, in a paper read before the Royal Society of Gottingen, at the meeting of the 25th August 1827, has shown that the numerous fragments of rocks and boulder-stones found in the sand-plains of Northern Germany, and in Denmark, originate from the mountain-formations in Sweden and Norway.

30. *Baron Von Buch on Volcanoes.*—Baron Leopold Von Buch had prepared in 1825 a physical description of the Canary Islands. This important work is not yet published, but a notice of a most interesting part of it, a treatise "on the nature of the volcanic phenomena in the Canary Islands, and their connection with other volcanoes of the earth," is given, with many new notices, in vol. x. of Poggendorff's *Annalen der Physik und Chemie."* Baron Von Buch, one of the most celebrated observers of volcanic phenomena, divides all volcanoes into *central* and *linear* (Reihen) volcanoes; the last appear to follow great fissures in the earth, and these again take the direction of the primitive rocks. Under the central volcanos this celebrated geologist ranks those of the Lipari Islands, Etna, the Phlegraean fields, Iceland, the Azores Islands, the Canary Islands, the Islands of Cape Verde, the Gallopagos, Sandwich, Marquesas, Society, and Friendly Islands, the Island of Bourbon, and many other volcanoes in the interior of several countries. All others are linear volcanoes.

31. *Greenstone and Porphyry of the Hartz.*—Careful observations in the

mines near Harzgerode, in the south-east part of that mountain, so interesting to the geologist, show that the greenstone and porphyry are raised from the interior of the earth. Baron Leopold Von Buch is of the same opinion, with regard to the granite of the Hartz and the porphyry in the neighbourhood of Ilfeld.

32. *Geological Map of Germany in 42 sections.*—This great map is published by Simon Shropp and Company in Berlin, under the direction of the Baron Leopold Von Buch. The twelve sections now published contain 1, the title-page; 2, the table of colours; 3, the review of the sections; 4, the country of Odensee; 5, of Copenhagen; 6. of Lincoln; 7, of London; 8, of Boulogne; 9, of Munich; 10, of Salzburgh; 11, of Milan; 12, of Triest.

## IV. GENERAL SCIENCE.

33. *Discovery of a remarkable structure in the knee-joint of the Echidna hystrix of Australasia.* By Mr F. J. KNOX.—We confine ourselves, at the request of Mr Knox, to a very brief notice of this remarkable structure which he has discovered to prevail in the knee-joint of the Echidna, and to a certain extent also in that of the *Ornithorynchus paradoxus*, Blumenbach; but the notice, though short, will be intelligible to all anatomists acquainted with the structure of the human knee-joint. That peculiar structure in the human knee-joint, usually known by the name of the *ligamentum adiposum*, constitutes, in the corresponding joint of the Echidna, a broad double membrane, dividing the joint into two perfectly distinct synovial cavities. In the superior of these cavities, the articular surfaces are the patella and a portion of the condyles of the femur; in the lower cavity the articular surfaces are the inferior half of the same condyles and the upper surface of the tibia.

A full account of this discovery, with explanatory drawings, has been transmitted some months ago to the Royal Society.

34. *Hydrogen Gas from Salt Mines employed for producing light, and for fuel.*—In the salt mine of Gottesgabe at Rheine, in the county of Tecklenbourg, there has issued for sixty years from one of the pits, which has on this account been called the *Pit of the Wind*, a continued current of inflammable gas. The same gas is produced in other parts of the mines. M. Roeders, the inspector of the salt mines, has used this gas for two years not only as a light but as fuel for all the purposes of cookery. He collects it in pits that are no longer worked, and conveys it in tubes to the house. It burns with a white and brilliant flame. Its density is about 0.66. It contains only traces of carbonic acid and sulphuretted hydrogen, and therefore should consist of carbonated hydrogen and olefiant gas.

35. *Natural Gas Lights at Fredonia.*—This village, on the shores of Lake Erie, is lighted every night by inflammable gas from the burning springs, as they are called, in its vicinity. Captain Hall has visited this village and will no doubt give us a good account of it on his return.

## Art. XXIX.—LIST OF PATENTS GRANTED IN SCOTLAND SINCE JUNE 14, 1827.

18. June 14. For certain Improved Machinery for Spinning Cotton. To Philip Jacob Heisch, London.

19. July 2. For certain Improvements in Machinery for the purpose of Spinning Wool, Cotton, &c. To Lambert Dexter, London.

20. June 30. For Improvements in Machinery for Hackling or Dressing and Cleaning Hemp, Flax, and Tow. To Solomon Robinson, county of York.

21. July 5. For certain Improvements on Locomotive or Steam Carriages To Timothy Burstall and John Hill, both of Leith.

22. July 17. For certain Processes for Rendering Distillery Refuse productive of Spirits. To Robert More, county of Stirling.

23. August 4. For certain Improvements in the process of preparing and cooling Worts or Wash from Vegetable Substances for the production of Spirits. To Robert More, county of Stirling.

24. August 8. For certain Improvements in apparatus for spinning Fibrous Substances. To William Church, of Birmingham.

25. August 23. For certain Improvements on Capstans. To Charles Phillips, Esq.county of Kent.

26. Sept. 5. For certain Improvements in Sizing, Glazing, or Beautifying the materials employed in the manufacturing of Paper, Pasteboard, &c. To Gabriel de Soras, county of Middlesex.

27. October 3. For an Improvement on Steam Engines. To Peter Burt, County of Middlesex.

28. October 24. For a New and improved method of forming and making of hollow Cylinders, Guns, Ordnance, Retorts, &c. To Joshua Horton, County of Stafford.

## Art. XXX.—CELESTIAL PHENOMENA,

*From January 1st, to April 1st, 1828. Adapted to the Meridian of Greenwich, Apparent Time, excepting the Eclipses of Jupiter's Satellites, which are given in Mean Time.*

N. B.—The day begins at noon, and the conjunctions of the Moon and Stars are given in Right Ascension.

### JANUARY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 17 | 50 | | ○ Full Moon. |
| 4 | 4 | | | ♂ ☌ ♃ ♂ 3½′ S. |
| 7 | 13 | 30 | | ♄ ☍ ☉ |
| 8 | 11 | | | ♂ ☌ 2 α ♎ |
| 9 | 1 | | | ♀ ☌ ϑ ♑ |
| 9 | 16 | 48 | 49 | Im. II. Sat. ♃ |
| 9 | 19 | 15 | | ☾ Last Quarter. |
| 9 | 22 | 44 | 22 | ☽ ☌ α ♍ ☽ 68′ N. |
| 10 | 17 | 3 | 32 | Im. I. Sat. ♃ |
| 11 | 11 | | | ☽ ☌ ♃ |
| 11 | 16 | | | ☽ ☌ ♀ |
| 12 | 22 | 29 | 46 | ☽ ☌ ν ♍ ☽ 54′ N. |
| 13 | 6 | | | ☿ ☌ 1 ν ♐ |
| 15 | 21 | | | ♄ ☌ δ ♊ ♄ 2¼′ S. |
| 15 | 22 | | | ♀ ☌ γ ♑ |
| 16 | 12 | 24 | | ● New Moon. |
| 17 | 7 | | | ♀ ☌ δ ♑ |
| 17 | 18 | 56 | 58 | Im. I. Sat. ♃ |
| 18 | 19 | | | ♅ ☌ ☉ |
| 20 | 11 | 56 | | ☉ enters ♒ |
| 23 | 8 | | | ☽ First Quarter. |
| 23 | 18 | | | ♃ ☌ 2 α ♎ |
| 25 | 22 | | | ♂ ☌ 4 ζ ♎ |
| 26 | 15 | 18 | 48 | Im. I. Sat. ♃ |

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 29 | 13 | | | ♂ ☌ κ ♎ |
| 31 | 6 | | | ♀ ☌ λ ♒ |
| 31 | 11 | 42 | 43 | ☽ ☌ 1 α ♋ ☽ 36′ N. |

## FEBRUARY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 2 | 15 | 30 | | ♃ □ ☉ |
| 2 | 17 | 12 | 13 | Im. I. Sat. ♃ |
| 2 | 19 | 15 | | ☿ Sup. ☌ ☉ |
| 3 | 7 | | | ♂ ☌ λ ♎ |
| 3 | 14 | 54 | 52 | Em. III. Sat. ♃ |
| 3 | 22 | 39 | 53 | ☽ ☌ ν ♌ ☽ 5′ N. |
| 4 | 23 | | | ♀ ☌ φ ♒ |
| 6 | 5 | | | ☿ ☌ γ ♑ |
| 7 | 5 | | | ☿ ☌ δ ♑ |
| 7 | 5 | 43 | 24 | ☽ ☌ λ ♍ ☽ 1′ N. |
| 7 | 19 | 57 | 45 | ☽ ☌ 2 α ♎ ☽ 53′ N. |
| 8 | 7 | 58 | | ☾ Last Quarter. |
| 8 | 14 | 11 | 12 | ☽ ☌ 4 ζ ♎ ☽ 11′ S. |
| 8 | 11 | | | ♂ ☌ 1 β ♍ |
| 8 | 12 | | | ♂ ☌ 2 β ♍ |
| 10 | 16 | 16 | 26 | Im. I. Sat. ♃ |
| 10 | 16 | 41 | 58 | Im. III. Sat. ♃ |
| 11 | 7 | | | ♂ ☌ ν ♍ |
| 11 | 13 | 33 | 57 | Im. I. Sat. ♃ |
| 14 | 22 | 45 | | ● New Moon. |
| 16 | 20 | | | ☿ ☌ λ ♒ |
| 18 | 9 | 6 | 30 | ☽ ☌ ι ♓ ☽ 1′ N. |
| 18 | 15 | 27 | 25 | Im. I. Sat. ♃ |
| 19 | 2 | 37 | | ☉ enters ♓ |
| 20 | 6 | | | ☿ ☌ φ ♒ |
| 22 | 2 | 38 | | First Quarter. |
| 25 | 17 | 20 | 54 | Im. I. Sat. ♃ |
| 27 | 19 | 47 | 20 | ☽ ☌ 2 α ♋ ☽ 8′ N. |
| 28 | | | | ♃ Stationary. |

## MARCH.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | | | | ☿ Greatest Elong. ☉ |
| 1 | 6 | 53 | | ○ Full Moon. |
| 2 | 19 | | | ♀ ☌ ζ ♓ |
| 5 | 1 | 18 | | ♂ □ ☉ |
| 5 | 13 | 42 | 50 | Im. I Sat. ♃ |
| 6 | 5 | | | ☽ ☌ ♃ |
| 6 | 13 | 11 | 25 | |
| 6 | 19 | 47 | 34 | ☽ ☌ 4 ζ ♎ ☽ 2′ N. |
| 8 | | | | ☿ Stationary. |
| 8 | 17 | 18 | | ☾ Last Quarter. |
| 11 | 17 | 28 | 52 | ☽ ☌ β ♍ ☽ 33′ N. |
| 12 | 15 | 36 | 29 | Im. I. } Sat. ♃ |
| 13 | 15 | 44 | 29 | II. } |
| 14 | | | | ♄ Stationary. |
| 14 | 8 | | | ♂ ☌ B. Oph. |
| 15 | 9 | 38 | | ● New Moon. |
| 16 | 19 | 24 | 25 | ☽ ☌ ι ♓ ☽ 5′ S. |
| 17 | 12 | 29 | 56 | Im. } III. Sat. ♃ |
| 17 | 14 | 38 | 42 | Em. } |
| 17 | 18 | 15 | | ☿ Inf. ☌ ☉ |
| 20 | 2 | 47 | | ☉ enters ♈ |
| 21 | 11 | 58 | 25 | Im. I. Sat. ♃ |
| 22 | 22 | 22 | | First Quarter. |
| 24 | 16 | 27 | 39 | Im. IV. Sat. ♃ |
| 26 | 2 | 19 | 7 | ☽ ☌ 1 α ♋ ☽ 25′ N. |
| 26 | 3 | 36 | 26 | ☽ ☌ 2 α ♋ ☽ 2′ N. |
| 28 | 13 | 52 | 9 | Im. I. Sat. ♃ |
| 28 | 19 | | | ☿ ☌ δ ♈ |
| 30 | 22 | 18 | | Full Moon. |
| 31 | | | | ☿ Stationary. |

### *Times of the Planets passing the Meridian.*

## JANUARY.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | h. | ′ | h | ′ | h | ′ | h | ′ | h | ′ | h | ′ |
| 1 | 10 | 42 M. | 1 | 31 A. | 7 | 38 M. | 7 | 43 | 12 | 29 A. | 1 | 13 A. |
| 7 | 10 | 54 | 1 | 36 | 7 | 26 | 7 | 20 | 12 | 0 | 1 | 37 |
| 13 | 11 | 7 | 1 | 40 | 7 | 14 | 6 | 57 | 11 | 32 | 0 | 24 |
| 19 | 11 | 23 | 1 | 49 | 7 | 3 | 6 | 34 | 11 | 4 | 11 | 52 |
| 25 | 11 | 40 | 1 | 47 | 6 | 52 | 6 | 11 | 10 | 37 | 11 | 40 |

## FEBRUARY.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 51 | 6 | 40 | 5 | 45 | 10 | 6 | 11 | 5 |
| 7 | 0 | 15 A. | 1 | 54 | 6 | 30 | 5 | 23 | 9 | 40 | 10 | 41 |
| 13 | 0 | 33 | 1 | 57 | 6 | 20 | 5 | 0 | 9 | 15 | 10 | 19 |
| 19 | 0 | 50 | 2 | 0 | 6 | 11 | 4 | 38 | 8 | 51 | 9 | 59 |
| 25 | 1 | 2 | 2 | 4 | 6 | 2 | 4 | 16 | 8 | 27 | 9 | 35 |

## MARCH.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 4 A. | 2 | 7 A. | 5 | 55 M. | 3 | 57 M. | 8 | 8 | 9 | 19 M. |
| 7 | | 52 | 2 | 11 | 5 | 46 | 3 | 35 | 7 | 45 | 8 | 58 |
| 13 | 0 | 23 | 2 | 16 | 5 | 38 | 3 | 12 | 7 | 23 | 8 | 37 |
| 19 | 11 | 37 M. | 2 | 21 | 5 | 29 | 2 | 49 | 7 | 1 | 8 | 16 |
| 25 | 11 | 2 | 2 | 26 | 5 | 20 | 2 | 25 | 6 | 40 | 7 | 55 |

*Declination of the Planets.*

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | ° | ' | ° | ' | ° | ' | ° | ' | ° | ' | ° | ' |
| JANUARY. | | | | | | | | | | | | |
| 1 | 22 | 29 S. | 21 | 25 S. | 13 | 10 S. | 13 | 35 S. | 22 | 4 N. | 21 | 15 S. |
| 7 | 23 | 49 | 19 | 39 | 14 | 20 | 13 | 51 | 22 | 8 | 21 | 10 |
| 13 | 24 | 8 | 17 | 34 | 15 | 26 | 14 | 6 | 22 | 12 | 21 | 6 |
| 19 | 23 | 40 | 15 | 11 | 16 | 29 | 14 | 18 | 22 | 16 | 21 | 2 |
| 25 | 22 | 20 | 12 | 34 | 17 | 27 | 14 | 29 | 22 | 20 | 20 | 58 |
| FEBRUARY. | | | | | | | | | | | | |
| 1 | 19 | 40 S. | 9 | 15 S. | 18 | 32 S. | 14 | 40 S. | 22 | 25 N. | 20 | 53 S. |
| 7 | 16 | 22 | 6 | 15 | 19 | 20 | 14 | 47 | 22 | 28 | 20 | 47 |
| 13 | 12 | 13 | 3 | 10 | 20 | | 14 | 58 | 22 | 31 | 20 | 43 |
| 19 | 7 | 23 | 0 | 1 S. | 20 | 4 | 14 | 55 | 22 | 33 | 20 | 40 |
| 25 | 2 | 23 | 3 | 8 N. | 21 | 21 | 14 | 56 | 22 | 36 | 20 | 36 |
| MARCH. | | | | | | | | | | | | |
| 1 | 1 | 11 N. | 5 | 43 N. | 21 | 48 S. | 14 | 55 S. | 22 | 37 N. | 20 | 34 S. |
| 7 | 3 | 44 | 8 | 46 | 22 | 15 | 14 | 53 | 22 | 38 | 20 | 30 |
| 13 | 3 | 36 | 11 | 42 | 22 | 39 | 14 | 49 | 22 | 40 | 20 | 26 |
| 19 | 0 | 10 N. | 14 | 28 | 22 | 59 | 14 | 42 | 22 | 40 | 20 | 24 |
| 25 | 1 | 53 S. | 17 | 2 | 23 | 15 | 14 | 34 | 22 | 40 | 20 | 22 |

The preceding numbers will enable any person to find the positions of the planets, to lay them down upon a globe, and to determine their risings and settings.

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## ART. XXXI.—*Summary of Meteorological Observations made at Kendal in September, October, and November,* 1827. By Mr SAMUEL MARSHALL. Communicated by the Author in a Letter to the EDITOR.

*State of the Barometer, Thermometer, &c. at Kendal for September* 1827.

| | Barometer. | Inches. |
|---|---|---|
| Maximum on the 1st, | - - - | 30.20 |
| Minimum on the 23d, | - - - | 29.14 |
| Mean height, | | 29.78 |
| | Thermometer. | |
| Maximum on the 16th, | - - - - | 68° |
| Minimum on the 24th, | - - - | 41° |
| Mean height, | - - - - | 55.55° |

Quantity of rain, 3.329 inches.
Number of rainy days, 16.
Prevalent wind, south west.

The atmosphere during this month has evinced frequent signs of electricity, particularly towards the latter part. On the 25th and several days previous we had lightning, but not much thunder was observable. On the evening of the 25th the aurora borealis was distinguishable by the unusual brightness in the northern part of the horizon, but from the cloudy state of the sky it was not conspicuous, excepting through occasional openings of the clouds. The thermometer has not been depressed to the freezing point, and the greater part of the month has been mild. On the whole, the weather has been particularly favourable for the harvest. The wind has been in the S. W. 12 days, in the N. W. 6, N. E. 4, S. 3, S. E. 2 W. 2, and in the N. 1 day.

*October* 1827.

| Barometer. | Inches. |
|---|---|
| Maximum on the 4th and 5th, | 30.18 |
| Minimum on the 11th, | 28.92 |
| Mean height, | 29.54 |
| Thermometer | |
| Maximum on the 3d, | 63° |
| Minimum on the 29th and 30th, | 34° |
| Mean Height, | 51.95° |

Quantity of rain, 3.009 inches.
Number of rainy days, 17.
Prevalent wind, south-west.

On the 19th and 20th there was a remarkably sultry wind from the E. and S. E., though the winds from these quarters are usually very cold. A similar circumstance took place on the 27th of last month. Though there have been many days on which we have had rain, yet no great quantity has fallen during the month; indeed less than usual in this month. The evaporation has been generally so slow, as to keep the ground in a very humid state. The barometer has mostly been very low. The thermometer has not been so low as the freezing point during the month, nor since the 26th April has it been below that point, in a period of more than six months. This circumstance shows the extraordinary mildness of the season.

November 1827.

| Barometer. | Inches. |
|---|---|
| Maximum on the 26th, | 30.05 |
| Minimum on the 29th, | 29.09 |
| Mean height, | 29.78 |
| Thermometer. | |
| Maximum on the 14th, | 55° |
| Minimum on the 22d, | 21° |
| Mean height, | 42.30° |

Quantity of rain, 2.615 inches.
Number of rainy days, 9.
Prevalent winds, W.

This month is, from the nature of evaporation, generally productive of fogs than any other in the year. They have prevailed through most of the month, and have been unusually thick. The quantity of rain is very trifling indeed, and forms a striking contrast to what fell in this month in 1825, which was upwards of 13 inches. The barometer has been very variable the latter part of the month. The thermometer fell below the freezing point on the 21st, a depression which had not been observed for upwards of six months. There were a few days of clear frosty weather, from the 20th to the 27th, the rest of the month generally mild.

## ART. XXXII.—REGISTER OF THE BAROMETER, THERMOMETER, AND RAIN-GAGE, *kept at Canaan Cottage.* By ALEX. ADIE, Esq. F.R.S. Edin.

THE Observations contained in the following Register were made at Canaan Cottage, the residence of Mr Adie, by means of very nice instruments, constructed by himself. Canaan Cottage is situated about 1½ mile to the south of Edinburgh Castle, about 3 miles from the sea at Leith, and about ¼ of a mile N. of the west end of Blackford Hill. The ridge of Braid Hills is about 1 mile to the south, and the Pentland Hills about 4 miles to the west of south. The height of the instruments is 300 feet above high water-mark at Leith. The morning and evening observations were made about 10 A.M. and 10 P.M.

### SEPTEMBER 1827.

| D. of Week. | Day of Month. | Thermometer. | | | Register Therm. | | | Barometer. | | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Morn. | Even. | Mean. | Min. | Max. | Mean. | Morn. | Even. | |
| S. | 1 | 60 | 51 | 55.5 | 46 | 60 | 53 | 30.25 | 30.19 | |
| S. | 2 | 65 | 55 | 60 | 43 | 69 | 56 | 30.22 | 30.22 | |
| M. | 3 | 61 | 54 | 57.5 | 51 | 65 | 57 | 30.27 | 30.28 | |
| T. | 4 | 54 | 52 | 53 | 50 | 59 | 54.5 | 30.28 | 30.26 | |
| W. | 5 | 55 | 51 | 53 | 49 | 58 | 53.5 | 30.24 | 30.24 | |
| T. | 6 | 57 | 52 | 54.5 | 44 | 61 | 52.5 | 30.22 | 30.22 | |
| F. | 7 | 59 | 54 | 56.5 | 47 | 60 | 53.5 | 30.18 | 30.15 | |
| S. | 8 | 57 | 49 | 53 | 49 | 60 | 54.5 | 30.07 | 29.81 | |
| S. | 9 | 59 | 57 | 58 | 44 | 64 | 54 | 29.42 | 29.43 | |
| M. | 10 | 63 | 55 | 59 | 53 | 68 | 60.5 | 29.51 | 29.51 | .08 |
| T. | 11 | 66 | 56 | 61 | 51 | 68 | 61 | 29.24 | 29.25 | |
| W. | 12 | 62 | 50 | 56 | 47 | 65 | 56 | 29.33 | 29.48 | |
| T. | 13 | 58 | 53 | 55.5 | 45 | 65 | 55 | 29.68 | 29.85 | |
| F. | 14 | 60 | 57 | 58.5 | 50 | 65 | 57.5 | 29.71 | 29.95 | |
| S. | 15 | 68 | 59 | 63.5 | 55 | 70 | 62.5 | 30.05 | 30.09 | |
| S. | 16 | 70 | 63 | 66.5 | 54 | 73 | 63.5 | 30.15 | 30.14 | |
| M. | 17 | 65 | 60 | 62.5 | 57 | 69 | 63 | 30.15 | 30.10 | |
| T. | 18 | 64 | 44 | 54 | 49 | 63 | 56 | 30.06 | 29.93 | .19 |
| W | 19 | 62 | 44 | 53 | 40 | 57 | 48.5 | 29.98 | 29.77 | |
| T. | 20 | 49 | 50 | 49.5 | 38 | 51 | 44.5 | 29.67 | 29.58 | .17 |
| F. | 21 | 50 | 48 | 49 | 45 | 59 | 52 | 29.10 | 29.05 | |
| S. | 22 | 51 | 47 | 49 | 45 | 58 | 51.5 | 28.97 | 28.97 | .02 |
| S. | 23 | 53 | 49 | 51 | 42 | 58 | 50 | 29.02 | 29.25 | .03 |
| M. | 24 | 57 | 48 | 52.5 | 48 | 64 | 56 | 29.35 | 29.26 | |
| T. | 25 | 58 | 54 | 56 | 44 | 61 | 52.5 | 29.20 | 29.26 | .04 |
| W. | 26 | 57 | 52 | 54.5 | 50 | 59 | 54.5 | 29.45 | 29.58 | .21 |
| T. | 27 | 55 | 54 | 54.5 | 50 | 56 | 53 | 29.60 | 29.61 | .05 |
| F. | 28 | 55 | 54 | 54.5 | 52 | 57 | 54.5 | 29.58 | 29.49 | .02 |
| S. | 29 | 55 | 52 | 53.5 | 50 | 64 | 57 | 29.58 | 29.65 | .10 |
| S. | 30 | 52 | 52 | 52 | 49 | 55 | 52 | 29.68 | 29.68 | .26 |
| | Sum, | 1757 | 1576 | 1666.5 | 1440 | 1859 | 1619.5 | 891.27 | 892.21 | 1.15 |
| | Mean. | 85.57 | 52.53 | 55.55 | 48. | 61.97 | 54.98 | 29.709 | 29.740 | |

### OCTOBER 1827.

| D. of Week. | D. of Mon. | Thermometer. | | | Register Therm. | | | Barometer, | | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Morn. | Even. | Mean. | Min. | Max. | Mean. | Morn. | Even. | |
| M. | 1 | 53 | 52 | 52.5 | 51 | 58 | 54.5 | 29.70 | 29.95 | |
| T. | 2 | 55 | 55 | 55 | 50 | 58 | 54 | 29.85 | 30.00 | .04 |
| W. | 3 | 58 | 50 | 54 | 51 | 59 | 55 | 30.09 | 30.18 | |
| T. | 4 | 58 | 50 | 54 | 42 | 61 | 51.5 | 30.21 | 30.20 | |
| F. | 5 | 57 | 50 | 53.5 | 43 | 62 | 52.5 | 30.15 | 30.05 | |
| S. | 6 | 58 | 48 | 53 | 44 | 63 | 53.5 | 29.95 | 29.81 | |
| S. | 7 | 56 | 47 | 51.5 | 43 | 62 | 52.5 | 29.69 | 29.57 | |
| M. | 8 | 57 | 45 | 51 | 43 | 57 | 50 | 29.45 | 29.31 | |
| T. | 9 | 50 | 44 | 57 | 42 | 52 | 47 | 29.15 | 29.58 | .19 |
| W. | 10 | 52 | 49 | 50.5 | 41 | 54 | 47.5 | 29.20 | 29.11 | .18 |
| T. | 11 | 49 | 49 | 49 | 41 | 52 | 46.5 | 28.80 | 28.79 | 1.66 |
| F. | 12 | 50 | 47 | 48.5 | 46 | 50 | 48 | 28.95 | 29.18 | .16 |
| S. | 13 | 52 | 44 | 48 | 42 | 54 | 48 | 29.21 | 29.34 | .03 |
| S. | 14 | 50 | 50 | 50 | 38 | 54 | 46 | 29.41 | 29.48 | |
| M. | 15 | 58 | 60 | 59 | 44 | 63 | 53.5 | 29.38 | 29.26 | |
| T. | 16 | 60 | 52 | 56 | 51 | 64 | 57.5 | 29.36 | 29.48 | .51 |
| W. | 17 | 58 | 50 | 54 | 49 | 59 | 54 | 29.50 | 29.61 | .05 |
| T. | 18 | 52 | 51 | 51.5 | 45 | 56 | 50.5 | 29.68 | 29.60 | .08 |
| F. | 19 | 55 | 53 | 54 | 47 | 56 | 51.5 | 29.64 | 29.62 | .16 |
| S. | 20 | 55 | 52 | 53.5 | 51 | 55 | 53 | 29.60 | 29.50 | .10 |
| S. | 21 | 53 | 50 | 51.5 | 50 | 55 | 52.5 | 29.42 | 29.35 | .21 |
| M. | 22 | 50 | 46 | 48 | 45 | 50 | 47.5 | 29.26 | 29.14 | .31 |
| T. | 23 | 49 | 49 | 49 | 45 | 50 | 47.5 | 29.10 | 29.24 | .36 |
| W. | 24 | 53 | 51 | 52 | 46 | 67 | 56.5 | 29.47 | 29.69 | |
| T. | 25 | 53 | 54 | 53.5 | 48 | 55 | 51.5 | 29.73 | 29.43 | .31 |
| F. | 26 | 56 | 52 | 54 | 52 | 56 | 54 | 29.72 | 29.68 | .04 |
| S. | 27 | 52 | 45 | 48.5 | 50 | 53 | 51.5 | 29.53 | 29.44 | .58 |
| S. | 28 | 43 | 36 | 39.5 | 40 | 46 | 43 | 29.51 | 29.70 | |
| M. | 29 | 45 | 45 | 45 | 31 | 46 | 38.5 | 29.75 | 29.76 | |
| T. | 30 | 50 | 44 | 47 | 35 | 51 | 43 | 29.62 | 29.58 | |
| W. | 31 | 45 | 36 | 40.5 | 35 | 49 | 42 | 29.57 | 29.78 | |
| | | 1642 | 1506 | 1574 | 1381 | 1727 | 1554 | 915.59 | 916.37 | 4.97 |
| | | 52.97 | 48.58 | 50.77 | 44.55 | 55.71 | 50.13 | 29.535 | 29.560 | |

### NOVEMBER 1827.

| D. of Week. | D. of Mon. | Thermometer. | | | Register Therm. | | | Barometer. | | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Morn. | Even. | Mean. | Min. | Max. | Mean. | Morn. | Even. | |
| T. | 1 | 40 | 48 | 44 | 30 | 49 | 39.5 | 29.76 | 29.52 | |
| F. | 2 | 44 | 47 | 45.5 | 40 | 49 | 44.5 | 29.80 | 29.84 | |
| S. | 3 | 52 | 45 | 48.5 | 41 | 54 | 47.5 | 29.67 | 29.75 | |
| S. | 4 | 49 | 47 | 48 | 41 | 52 | 46.5 | 29.80 | 29.83 | |
| M. | 5 | 48 | 45 | 46.5 | 45 | 52 | 18.5 | 30.00 | 30.07 | |
| T. | 6 | 41 | 41 | 41 | 39 | 47 | 43 | 30.07 | 30.05 | .29 |
| W. | 7 | 42 | 41 | 41.5 | 38 | 43 | 40.5 | 30.00 | 29.95 | |
| T. | 8 | 46 | 47 | 46.5 | 37 | 46 | 41.5 | 29.88 | 29.72 | |
| F. | 9 | 52 | 18 | 50 | 43 | 55 | 49 | 29.56 | 29.63 | |
| S. | 10 | 46 | 52 | 49 | 44 | 51 | 47.5 | 29.68 | 29.58 | .05 |
| S. | 11 | 47 | 42 | 44.5 | 44 | 52 | 48 | 29.67 | 29.82 | |
| M. | 12 | 52 | 54 | 53 | 37 | 54 | 45.5 | 29.86 | 29.89 | .09 |
| T. | 13 | 54 | 56 | 55 | 50 | 56 | 53 | 29.95 | 29.85 | |
| W. | 14 | 52 | 46 | 49 | 50 | 54 | 52 | 29.74 | 29.63 | .38 |
| T. | 15 | 45 | 39 | 42 | 35 | 52 | 43.5 | 29.41 | 29.38 | |
| F. | 16 | 45 | 44 | 44.5 | 37 | 46 | 41.5 | 29.40 | 29.56 | |
| S. | 17 | 42 | 35 | 38.5 | 40 | 45 | 42.5 | 29.63 | 29.74 | .11 |
| S. | 18 | 37 | 33 | 55 | 29 | 49 | 39 | 29.88 | 29.96 | |
| M. | 19 | 35 | 45 | 40 | 27 | 42 | 34.5 | 30.00 | 29.94 | |
| T. | 20 | 50 | 33 | 41.5 | 41 | 51 | 46 | 29.82 | 30.12 | |
| W. | 21 | 35 | 27 | 31 | 27 | 43 | 35 | 30.10 | 29.91 | |
| T. | 22 | 30 | 31 | 30.5 | 25 | 35 | 30 | 29.68 | 29.51 | |
| F. | 23 | 32 | 30 | 31 | 26 | 35 | 30.5 | 29.43 | 29.51 | |
| S. | 24 | 29 | 34 | 31.5 | 23 | 35 | 29 | 29.68 | 29.64 | .12 |
| S. | 25 | 43 | 43 | 43 | 28 | 43 | 35.5 | 29.64 | 29.82 | |
| M. | 26 | 43 | 46 | 44.5 | 35 | 48 | 41.5 | 30.03 | 30.03 | |
| T. | 27 | 48 | 48 | 48 | 44 | 51 | 47.5 | 29.93 | 29.68 | |
| W. | 28 | 50 | 49 | 43.5 | 45 | 53 | 49 | 29.50 | 28.96 | |
| T. | 29 | 48 | 48 | 48 | 45 | 50 | 47.5 | 28.93 | 29.12 | |
| F. | 30 | 47 | 45 | 46 | 40 | 50 | 45 | 29.12 | 28.73 | |
| | | 1324 | 1289 | 1306.5 | 1126 | 1442 | 1284 | 888.62 | 890.75 | 1.02 |
| | | 44.13 | 41.63 | 42.88 | 37.53 | 18.07 | 42.80 | 29.621 | 29.692 | |

THE

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## Art. I.—*On the supposed Influence of the Aurora Borealis upon the Magnetic Needle, in reply to the Observations of M. Arago, as communicated to the Academy of Sciences on the 22d January* 1828.

Nothing is more agreeable, and certainly nothing more useful to the progress of science, than the candid and temperate discussion of such scientific questions as admit of difference of opinion. Science is sure to gain by the collision of minds even of unequal strength,—by the scrupulous examination of statements often mutilated and partial, and by the fair and manly array of facts and arguments which either our prejudices or our ignorance have placed in apparent opposition. Compelled, therefore, as we are, to take up the gauntlet, which an eminent member of the Academy of Sciences has thrown down to us, we shall endeavour to discuss the subject with no other feelings but those which the interests of truth and of science demand.

At a meeting of the Royal Academy of Sciences, held at Paris on the 22d January 1828, " M. Arago* made a communication relative to a letter recently written by Mr Dalton, on several magnetic phenomena, and particularly on an observation of the Aurora Borealis. M. Arago prefaced this commu-

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* This passage is translated from an account of the proceedings of the Academy, published in *Le Globe* of the 26th January 1828, and an abstract of it has been printed in almost all the English and Scotch newspapers.

nication with some illustrations necessary to point out its importance.

"Since the commencement of the last century, several natural philosophers, among others Celsius and York, (a misprint, we presume, for Hiorter) had remarked that the appearance of the Auroræ Boreales *always* occasioned in the magnetic needle irregular and very sensible movements, *a certain proof that they attributed to magnetism the phenomena of these Auroræ.* At Paris, Father Cotte and Cassini *put it beyond a doubt* that the Auroræ Boreales exercise a magnetic influence even in our climate, whatever be the distance which separates us from the polar regions. *But M. Arago has gone much farther. He is the first person who has maintained that not only do the Auroræ Boreales impress movements on the needle* WHEREVER *they are visible,* and wherever also they might be seen if the clouds did not conceal them; but that this influence extends much farther, and that even where they are not visible from their not passing the horizon, they still manifest themselves in the motions of the magnetic needle.

"This assertion has been keenly controverted, chiefly in England, and particularly by Dr Brewster of Edinburgh; and our celebrated natural philosopher (M. Arago) in order to establish the truth of it, has for some years marked at Paris, where the Auroræ Boreales are no longer seen, *the days on which they ought to have been perceived in higher latitudes.* Hitherto *his predictions have been* ALWAYS *found exact,* but *a singular exception took place* about two years ago. On the 29th March 1826, between eight and ten o'clock P. M. in very clear weather, the magnetic needle in the observatory of Paris exhibited the most distinct movements, in consequence of which M. Arago *had announced that an Aurora Borealis had taken place in the north.* Hitherto this prediction had not been verified, and the English philosophers saw in this the ground of a grave objection. But Mr Dalton's letter actually contains the account of an Aurora Borealis which happened on the 29th March 1826, exactly between eight and ten o'clock in the evening. This Aurora, whose height was not very considerable, (three leagues if we rightly understood it), formed a very large arch (of three leagues extent and about as much in width) that is to say, it presented all the conditions necessary to agitate the magnetic needle."

In the preceding passage it is distinctly asserted as M. Arago's opinion,

1. That the Auroræ Boreales, *wherever* they are visible, impress motions on the magnetic needle.

2. That the Auroræ Boreales, wherever they are prevented from being visible by clouds, impress similar motions upon the magnetic needle.

3. That the Aurora Boreales impress the same motions upon the needle, even when the needle is observed at places where the Auroræ Boreales are never seen.

4. That all M. Arago's predictions of Auroræ Boreales from the movements of the magnetic needle at Paris have been fulfilled, with *one singular exception*, which Mr Dalton's letter has removed.

We shall now proceed to examine the truth of these *general* propositions; and if we do not entirely overturn them in their imposing generalities, we anticipate at least the thanks of our readers for having shown them the *other side* of the question, which is so completely concealed in the preceding communication to the Academy of Sciences.

There can be no doubt, as stated by M. Arago, that Celsius, Hiorter, Father Cotte, and Cassini, to whom we add Wargentin, and our celebrated countryman Canton, observed that the magnetic needle was often agitated *during* an Aurora Borealis; but we cannot agree with M. Arago, that such observations are a *certain proof that they attributed to magnetism the phenomena of these auroræ.* Two events may accompany one another even *always*, and yet they may not have to each other the relation of cause and effect. The agitation of the needle and the Aurora Borealis, may be the concomitant effects of a more general cause; and this general cause may produce the one effect without producing the other, or it may produce both of them, or it may itself exist without producing either of them. This, indeed, is the opinion of Mr Canton himself, who considers the Aurora as the light arising from the electricity of the heated air, and who attributes the disturbance of the needle, not to the Aurora, but to the effect of the same heat on the great terrestrial magnet,—a result which he has illustrated, by placing a needle under the influence of heated magnets. Mr Canton regards this opinion as strengthened by the fact, that the inhabitants of northern countries observe the Aurora to be remarkably strong when a sudden thaw happens after severe cold weather. This opinion is countenanced by the observation of Mr Winn, recorded in the *Phil. Trans.* for 1774.

"I believe the observation is new that the Aurora Borealis is *constantly* succeeded by hard southerly or south-west winds, (the warmest winds in this climate,) attended with hazy weather and small rain. I think I am warranted from experience to say *constantly;* for in twenty-three instances that have occurred since I first made the observation, it has invariably obtained. The gale generally commences between twenty-four and thirty hours after the first appearance of the Aurora."

The Reverend James Farquharson of Alford, in Aberdeenshire, who has observed the Aurora for many years, states the same opinion, that it *precedes* or *accompanies* westerly or south-easterly * gales. These views will receive a singular confirmation when we examine the observations of Colonel Beaufoy; and we have adduced them, not as our own opinion, but in order to show that very competent judges have believed, that the Aurora Borealis is the effect of a cause which may also produce agitations in the magnetic needle, and that the two phenomena may co-exist, either occasionally or constantly, without the one being the cause of the other.

We now come to a period when the variation of the magnetic needle became the subject of regular observation. Colonel Beaufoy, a name which will ever be venerated in the annals of English science, began at Hackney, near London, a regular series of observations, not only on the magnetical needle, but on the state of the atmosphere. He observed, with a delicate apparatus, the variation of the needle three times a-day. His

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* We suspect this to be a typographical error for *south-westerly,* as the author in the very next paragraph describes a fine Aurora during a *south-westerly gale.*

observations began in March 1813, and were, with the exception of 1816, continued till 1821, and the numerous agitations of the magnetic needle which he observed, were diligently compared with the state of the weather. All these observations have been given to the world, and by their means it is in the power of any philosopher to study the relation between the irregularities of the needle, and the meteorological or electrical phenomena of the atmosphere. He can compare these irregularities with the Auroræ which took place between Hackney, (near London,) and Thurso in the north of Scotland, a distance of *seven* degrees of latitude, in which a much greater number of Auroræ must have been observed than in the same distance of *seven* degrees which intervenes between Paris and Leith. As Auroræ are almost always recorded in the English and Scotch magazines and newspapers, it would be useful to science if M. Arago would enter upon this examination. If he does so, the general result will be this: He will find a certain number of the agitations of the needle accompanied with Auroræ Boreales: He will find a certain number of Auroræ which were not accompanied with any irregular indications of the needle; and he will find a great number of agitations of the needle which were not attended with Auroræ, but which, as Colonel Beaufoy has stated, were accompanied or followed by squalls and gales of wind, principally from the southern quarters of the horizon.

We come now to M. Arago's own observations. In the Royal Observatory of Paris there is a delicate magnetic needle, the variations of which have, we believe, been carefully observed for some years; but the series of observations which are made with it have never been published; and though M. Arago is the editor of a monthly journal, and prints regularly all the meteorological observations made in the observatory, yet *the far more important magnetic observations*, upon the authority of which he builds theories and utters prophecies, are withheld from the public eye. At particular times he observes agitations of this needle, and he predicts that an Aurora *has happened* in the north. At another time he reads in the English journals the account of Auroræ, and looking back to his magnetical observations, he finds that the needle was not "true to the pole." All this is very well so far as it goes; but as M. Arago has established a hypothesis on the authority of these observations, and as he maintains this hypothesis with so much keenness as to identify it with his own reputation, we humbly suggest to him, that it is his duty as a man of science to publish these observations without delay. Some philosophers will thus be indulged with the luxury of prediction which he now monopolizes, while others will enter upon the more useful occupation of drawing up a list of all the irregular agitations of the needle, and classing them according to their magnitude or their duration, and of comparing them with the Auroræ Boreales which they have become acquainted with either by reading or by observation, and with the more striking meteorological phenomena of the atmosphere. Until this is done, philosophers are entitled to regard M. Arago's deductions as little more than the special pleadings of a party interested in the establishment of a favourite hypothesis.

In order to illustrate the force of these observations, we shall give an example of M. Arago's mode of reasoning; 1st, when he has received information respecting an Aurora observed in Scotland; and, 2dly, when he predicts the existence of one from his magnetical observations.

1. Dr Coldstream and Mr Foggo of Leith observed on the 17th August 1825, at 10$^h$ P. M. a display of the Aurora Borealis, which was " neither vivid nor long-continued, and presented only the usual appearance of that meteor."

Upon examining his magnetical observations, M. Arago finds that there *was no agitation whatever in the needle that evening, and it had* then its ordinary position. But he finds that at half past eight o'clock in the morning, 13½ hours before the Aurora began, " the declination of the needle was 5′ greater than the mean of the month at the same hour. Here, then, the Aurora takes place at Leith on the 17th August, and it is admitted that during its existence the needle is still. This is no doubt a stubborn fact, but such is the ingenuity of hypothesis, that M. Arago " suspects that this was the termination of an Aurora Borealis of the day." If the suspicion were correct, why was not the Aurora seen from 7h till 10h? but even admitting that it was the termination of an Aurora of the day, why did the magnetic needle at Paris not feel its influence on the evening of the 17th?

Another case of exactly the same kind occurred on the 4th November. An Aurora *of great beauty, with numerous and very bright* rays, appeared at Leith in the evening; but the magnetical needle at Paris is then perfectly quiescent. From nine till two P. M. it was much agitated, and M. Arago again supposes that this "was most likely the remains of an Aurora of the day."

2. We next proceed to a prediction which is thus announced: "In this same month of August, on the night of the 21st, the morning of the 22d, *the night of the 26th*, and particularly on the night of the 29th, great anomalies were observed in the extent of the oscillations of the needle. On all these occasions the *sky was I believe clouded at Leith*. If not, and the observers there did not see the Aurora, for instance, on the night of the 29th of August, we will be obliged to admit that there exist other causes of which we are still ignorant, which excite considerable influence over the magnetic needle."

"In reply to this remark," says Dr Coldstream,* "I may observe, that the notes in our *Journal* of the state of the sky on the night of the 21st, and morning of the 22d, are not satisfactory; *that the night of the 26th was particularly clear*, with bright moonshine, and that much cloud prevailed on the 29th, and so that had an Aurora existed we could not have seen it." Here, then, we have an agitation of the magnetical needle at Paris on *four* days, the 21st, 22d, 26th, and 29th August 1825, and yet Auroræ, so far as we can find, were seen neither in Scotland or England. The night of the 26th was *particularly clear*, and though clouds prevailed on the 29th at Leith, yet the predicted Aurora, had it existed, might have been seen elsewhere, and must have been recorded. Before concluding this part of the subject, we may add, that an Aurora, "which played with considerable brilliancy," was seen at Leith at 10h P. M. on the 11th September, and we believe

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* See this *Journal*, No. x. p. 90.

that there was no corresponding agitation of the needle at Paris on that day.

We may now ask the candid inquirer after truth to compare these facts with the assertions made by M. Arago in his communication to the Academy of Sciences. Do they support the sweeping conclusions which are there deduced? or do they not rather entirely overturn them?

Before we quit this part of the subject, we must notice a very inexplicable passage in the communication to the Academy of Sciences. In speaking of the agitation of the magnetic needle on the 29th March 1826, between 8 and 10 P. M., and of his own prediction that an Aurora Borealis had taken place in the north, M. Arago says:

"*Hitherto this prediction had not been verified; and the English philosophers saw in this the ground of a grave objection.*"

Now, we do not scruple to characterize this statement as a philosophical dream. *The prediction was verified; and the English philosophers took no cognizance of the matter whatever.* The Aurora Borealis of the 29th March was as well known to every philosopher in England, as the battle of Navarino is to every politician. *A long and minute account of it was published in this Journal for April—June* 1826, by Messrs Coldstream and Foggo *; and as M. Arago uses this *Journal* in his editorial capacity, it is strange that he should have overlooked a meteorological paper by the two accomplished meteorologists whose labours for 1825 had given him such high satisfaction.

After M. Arago had uttered his prediction, might we not have supposed that he would have searched with avidity every English journal for the evidence of its truth; and might we not have expected his scrutiny to have been repeated with fresh diligence, when the English philosophers brought grave objections against his hypothesis from the want of an Aurora on the 29th of March. On the contrary, M. Arago remains nearly two years in the belief that his prediction was unverified, and he peacefully submits to the grave objections of the English

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* See *Meteorological Observations made at Leith, in* No. ix. p. 190.

philosophers till 1828, when Mr Dalton kindly relieves him from his dilemma, by sending him an account of an old, a well known, and now forgotten Aurora.

We now approach the period of sound inquiry, *when the magnetic needle and the Aurora Borealis are observed at the same time*, and on the same horizon, by men who had no hypothesis to support,—who possessed the finest instruments,—who lived among the very beams of the Northern Lights,—and whose attention had been especially directed to the subject now under discussion.

During the different voyages of Captain Parry to the Arctic Regions, the phenomena of the Aurora Borealis and of the magnetic needle were carefully observed; and it is a most singular circumstance, that neither the needle nor the electrometer were in the least degree affected by them, although they were often carefully watched, in order to ascertain this very fact.

In Captain Parry's third voyage, in 1824–5, a most splendid Aurora was seen, which *actually shot its beams between the observer and the land*, which *was then distant only* 3000 *yards*;—yet did this Aurora exercise no disturbing force on the magnetic needle!

"Our variation needles," says Captain Parry, "which were extremely light, suspended in the most delicate manner, and from the weak directive energy, susceptible of being acted upon by a very slight disturbing force, were *never in a single instance visibly affected by the Auroræ*, which could scarcely fail to have been observed at some time or other, had any such disturbance taken place, the needles being visited every hour for several months, and oftener when any thing occurred to make it desirable."

The observations themselves upon which Captain Parry founds his conclusions are the most numerous, and we hesitate not to say the most correct, that have ever been published. They occupy nearly 200 pages in the fourth part of the *Philosophical Transactions* for 1826. Lieutenant Foster has given an abstract of the daily variations of one of the needles for the months of *January*, *February*, *March*, *April*, and *May* 1825.

In one column is the amount of the daily variation, and in another column are placed all the Auroræ which were visible, so that we can compare the mean oscillation of the needles during a period when there were no Auroræ, with the mean oscillation during a period when there were many Auroræ, and thus obtain the united effects of groups of these motions.

The following table will put this in a clear light.

| 1825. | Number of Auroræ visible. | Mean Amount of Daily Variations. | Mean. |
|---|---|---|---|
| January, | 14 | 1° 37′½ | 1° 37′¾ |
| February, | 14 | 1 38 | |
| March, | 2 | 2 14½ | |
| April, | 0 | 2 52 44″ | 3 18 41″ |
| May, | 0 | 3 44 39 | |

These comparisons, which Lieutenant Foster seems to have overlooked, present a very curious result. *In place of exercising a disturbing influence, the Auroræ in the Arctic Regions would seem to exercise a sedative influence upon the needle.*

The observations from which this conclusion is deduced were made by seven different observers, Captain Parry, Lieut. Foster, Lieut. Sherer, Lieut. Ross, and Messrs Crozier, Richards and Head. "The needles were visited every hour during four successive months;" and as Lieut. Foster observes, "when any extraordinary change appeared to be going on, the needles were more closely watched; and every phenomenon, such as the *Aurora Borealis*, *meteors*, *clouds*, the kind and degree of *light*, the *moon's position*, and the *temperature* within and without, were *at all times* carefully noted;"[*] and he continues, "we have reason *to believe, that on no occasion were the needles in the slightest degree affected by the Auroræ, meteors,* or any other perceptible atmospheric phenomenon."[†]

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[*] *Phil. Trans.* 1826, Part iv. pp. 75, 76.

[†] In speaking of a motion of the needle on the 27th March, Lieutenant Foster states, that there was no appearance of an Aurora; and he adds in a note, "The Aurora generally appeared about N. by compass, extending in an arch from about N. E. to N. W., at an elevation from 10° to 20°,

That these observations and these results are deemed of the highest value, and worthy of the highest confidence, by philosophers of the first order, is proved by the fact, that the Royal Society of London have rewarded them with their Copley medal for 1827, and in those eloquent and admirable addresses which their distinguished President, Mr Davies Gilbert, delivered along with the medals, he has ranked among the most important contents of Lieutenant Foster's paper, the "*Refutation of the supposed connection between tremors of the Needle and Aurora Borealis.*" *

We may now be permitted to ask the philosophers of every country, if they are disposed to set aside, as of no value, the Herculean † labours of Lieutenant Foster and Captain Parry, and substitute in their place the responses which issue from the Royal Observatory of Paris, from a mysterious record which only one eye is allowed to see, and upon which only one judgment is allowed to be exercised? Will they prefer the sweeping conclusions presented to the Academy of Sciences on the 22d of January, to the cautious inductions of the English navigators?—and if they do, will their preference for these conclusions be increased, when they learn that M. Arago was long before in possession of the results of Captain Parry and Lieutenant Foster's observations?

It may be proper to state, that a very able observer, Professor Kuffner of Kasan, has observed a coincidence between agitations of the needle and Auroræ Boreales which appeared

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with streamers sometimes shooting towards the zenith. *At times when it was brightest,* though not very brilliant during any part of the winter, I have frequently watched this needle without ever being able to detect a change that could be ascribed to its influence."—*Phil. Trans.* 1826, Part iv. p. 175, note.

* *Addresses to the Royal Society, &c.* by Davies Gilbert, President, &c. Lond. 1828, p. 16. It is distinctly stated that the medal is awarded for the "observations and deductions" of Lieutenant Foster.

† The President of the Royal Society justly remarks, "One is utterly astonished at the magnitude of these labours, and *at the accuracy and care with which they were conducted* (as is manifest from internal evidence) in a situation where comfort and ease were unattainable, and where peculiar difficulties presented themselves at every step."—*Adresses*, p. 15.

in latitudes more northerly than his own, and this fact has been triumphantly submitted to the Academy of Sciences as a confirmation of the views that we have been controverting. The opinions, however, which we maintain are not in the slightest degree affected by any such observations, the truth of which we have no hesitation to admit; but even if a thousand observers on a thousand different meridians were to observe similar coincidences, they could only prove *that certain Auroræ are attended with agitations of the magnetic needle*,—a proposition of very different import from those which were submitted to the Academy of Sciences on the 22d of January.

In taking a general view of the different facts to which we have had occasion to refer, we may consider them in two points of view.

1. If we regard it as proved, and we think there is no fact in physical science better established, that Auroræ occur which have no influence on the magnetic needle; that agitations of the needle take place when no Auroræ are seen; and that these two phenomena sometimes appear simultaneously,—we must then view them as the separate though occasionally co-existent effects of some more general cause. But even if their coexistence were not occasional but constant, this could never prove that the one was the producing cause of the other; and it would still be as probable as before that they were both referable to a more general cause. What this cause is we do not pretend to know; but it has been and is the opinion of many eminent philosophers, that both the luminous meteor and the developement of magnetical action may have their origin in certain disturbances in the electrical equilibrium of the atmosphere.

2. Although we should have been disposed, previous to the voyage of Captain Parry, to adopt the preceding views, yet the observations of this distinguished navigator and of Lieutenant Foster seem to have embarrassed the question with a new difficulty. In the two months during which 28 Auroræ occurred, the mean monthly excursions of the magnetic needle on each side of its mean position was only 1° $37\frac{3}{4}'$; whereas during the two months when there were no Auroræ, it was

almost exactly double, viz. 3° 18′ 41″. If this difference, which is far too great to be accidental, shall be confirmed by future observation, it will prove that in the arctic latitudes, and in those periods which abound with Auroræ, the excursions of the magnetic needle are diminished; while in our own latitudes the causes which produce Auroræ increase the excursions of the magnetic needle.

In the present state of our knowledge, it would be idle to speculate respecting these apparently opposite effects. Numerous accurate observations, made in different points of the magnetic meridian, can alone furnish us with the data which such speculations require. On a subject involved in so much difficulty, and so far withdrawn from experimental research, it would be presumptuous to pronounce any rash opinion; and those who would fix us down to any dogmatical explanation, or shackle the freedom of discussion where every hypothesis must present so many vulnerable points, can neither be acquainted with the history nor imbued with the spirit of inductive science.

## ART. II.—*On the Elasticity and Change of Volume of Metallic Strings while in a state of Vibration.* By Baron CAGNIARD DE LA TOUR. *

IT is well known that if we draw out a plate of caoutchouc, it becomes thinner and narrower as its elongation is increased, so that in changing its form it does not seem to change its volume, since it loses in one dimension what it gains in another. The same effect might be expected in metallic strings; but M. Cagniard de la Tour has proved, that if we submit a metallic string to a moderate elongating force, the diminution of its diameter is less than it ought to be if its decrease of thickness were exactly compensated by its increase of length. Hence it follows, that in drawing a wire, a sensible vacuum is left between its molecules.

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* This abstract of Baron Cagniard de la Tour's paper is translated from *Le Globe*, Jan. 5th 1828.

M. Cagniard de la Tour is of opinion that the preceding result can only be observed in wires formed of substances sufficiently solid to support the weight of the atmosphere, which necessarily tends to fill up the vacuities.

In performing this experiment, our author took a metallic wire two metres (6½ feet long) and about one millimetre (1-25th of an inch) in diameter, and he immersed a portion of it, six millimetres long, in water which held a glass tube of a very small bore. This portion of the wire displaced the water, and raised it five millimetres in the tube. "Having then" says the Baron, "adjusted this little tube as a thermometric column on a large vertical tube of glass, and sufficiently long to contain two metres of the string, I filled with water the whole apparatus. The inferior end was closed by a cork beyond which the lower end of the cord projected. This end was fixed to a bit of wire driven into a piece of wood which supported the whole, and the lower extremity of the wire was rolled round a cylinder, by turning which the wire could be stretched at pleasure."

When the wire was lengthened, so as to be drawn six millimetres beyond the small tube, the descent of the column of water, in place of being *five* millimetres, as it should have been, had the diminution of its diameter compensated its increase of length, was only from 2¼ to 2½ millimetres. This experiment several times repeated always gave the same result.

Wishing however to know what would happen if he went beyond the elastic amplitude of the wire, he drew it out six millimetres beyond its primitive elongation; but in this case the descent of the water in the tube, which ought to have been a little less than in the first experiment, on account of the diminution of the diameter produced by its first extension, was, on the contrary, greater, and approached very nearly to *four* millimetres, because, says the author, "the wire having been in some degree forced to draw itself like a substance which is ductile but not elastic, there is in this case a greater compensation between its elongation and the diminution of this diameter.

Baron Cagniard de la Tour proposes to submit to similar trials rods of glass and other elastic substances, but by means of a process in which the extremities will not project beyond the apparatus.

It would doubtless be curious to demonstrate that sonorous bodies of hard substances, like glass, bell-metal, &c. not only change their form in vibrating, but very sensibly increase or diminish their volume, nearly in the same manner as if they were heated and cooled alternately, which would explain how these motions may produce molecular sounds analogous to those which liquid phosphorus emits when placed upon a bass, and in the act of becoming solid; and it might perhaps furnish some new data for explaining why the sonorous effect of solid bodies loses its intensity when the bodies are freed from the pressure of the atmosphere.

The same results might perhaps furnish also a new argument in favour of the theory by which our author explains how the sound of vibrating bodies arises principally from the shocks of the molecules propagated in the air like the noise of a musical hammer, rather than from their atmospheric excursions.

## ART. III.*—*On the singular Effects of two Strokes of Lightning upon the vessel called the New York, while sailing from London to New York.* By the Reverend WILLIAM SCORESBY. *

DURING the passage of the ship called the New York from London to New York, a voyage which she generally performed in twenty-five days, a stroke of lightning overturned all the partitions without exception, but no person was hurt. The vessel was deprived of its conductor.

The next day the Captain, dreading another storm, had placed a conductor upon the main-mast. The lightning struck the rod of the conductor, and melted it entirely; it also melted the iron conductor, which fell in drops into the sea. Almost all the passengers had observed the water of the sea sink down in a distinct manner, in a certain space round the

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* This is an abstract of a paper read to the Academy of Sciences on the 14th January.

point where the electrical current had entered the ocean. The rod of the conductor which was melted was four feet long by five inches and a-half in diameter, and the iron conductor was three-tenths of an inch in diameter. It was evidently too small, (in France they always make their conductors thicker.) An excellent chronometer, whose error never exceeded the tenth of a second in twenty-four hours, was so much deranged by the stroke of lightning, that it was accelerated thirty-four minutes.

The cause of this error was perceived in London, where it was ascertained that all the parts of the instrument had acquired a great degree of magnetism, in such a manner that its general motion depended very sensibly upon the position which was given it.

The second stroke of lightning, like the first, killed nobody; and it is a singular fact, that it even performed a very remarkable cure. A passenger, very old and overgrown with fat, was so much palsied in his limbs, that for three years he had never been able to walk altogether above half a mile; since he embarked, he had never been seen to stand up for a single instant. After the discharge, which took place near the bed where the poor cripple was sleeping, they observed him with astonishment rise and walk to the deck, where he continued to parade for a long time, as if he had never been ill. At first he lost his senses, but this mental affection did not last long, and the cure is complete. This person, who was formerly paralytic, having continued to walk with ease all the rest of the voyage, had the entire use of his limbs when he arrived, and he travelled on foot from the place where he disembarked to his own residence.

All the knives and forks of iron which were found melted in the ship had acquired magnetic power.

The effects produced upon the magnetic needles were very remarkable. Although they were all in the same room, the lightning produced upon them very different effects. In some the magnetic action was augmented, in others it was diminished, in some it was destroyed, and in others the poles were reversed.

## ART. III.—*On the Cold Caves of the Monte Testaccio at Rome.* By a CORRESPONDENT.

HAPPENING recently to notice in the tenth volume of the *Edinburgh Philosophical Journal*, some remarks on the causes of the remarkable coldness of the cellars in the Monte Testaccio at Rome, I was surprised to observe that the ingenious author of that paper denies the influence of evaporation in producing that cold,—an explanation which I have always understood to be deemed so generally satisfactory, that, during a late residence in Rome, I did not think of investigating minutely this remarkable phenomenon, which neglect I now extremely regret.

Some mistakes in the data and misconceptions of the localities shown by your correspondent, induce me to offer some imperfect remarks towards defending the theory of evaporation, and to lay before that gentleman a few hints for the correction of his observations, to which no one will be more able to apply the rigid mathematical investigations which he has elsewhere so successfully employed. Indeed, the science of hygrometry has lately received such an accession of accuracy, and such extension of limits, that I found my inquiries more difficult and minute than I at first anticipated; and I shall state my observations with greater brevity than I at first proposed, as I am not so familiar as I could wish with the modern refinements of this branch of meteorology.

Saussure found the temperature of one of the cellars, July 1, 1773, to be $44\frac{3}{4}$°, and of another 44°, while the external air was at 78°.1. Now, (says the author of the article in question,) as a cubic inch of air at 78° can contain .005878 of a grain of water in solution, and at 44° only .002032, the degree of dryness in the external air must have been $\frac{2032}{5878}$, or .346, (saturation being = unity,) = 23° Deluc's hygrometer; "a degree of dryness," he adds, "which is *seldom* observed except in high latitudes;" and a little before remarks, that a state of perfect dryness can *rarely* occur at Rome. On this I have to observe, 1*st*, That the present is a *very* extreme case; and we may assume the atmosphere to have been in a state which "seldom" and "rarely" occurs at Rome. That this was so, the following observations, taken from "*Lumsden's Antiquities of Rome*," which afford an uncommonly parallel instance, will easily show :

*August* 26, 1762.

| | Reau. | Fahr. |
|---|---|---|
| On the ground at the entrance of the cellar, | 12° | 59° |
| Four feet from the ground, | 13 | 61¼ |
| Top of the cellar, | 15 | 65½ |
| Half way from the door to the farther extremity, seven feet from the ground, | 15 | 65½ |
| On the ground, | 11 | 56¾ |
| Farthest extremity seven feet high, | 13 | 61¼ |
| On the ground, | 10 | 54½ |
| External air in the shade, | 21 | 79 |

The reputation of Saussure prevents us from a moment doubting his accuracy ; but the external temperature being almost exactly the same, and the internal so much higher, proves that his was an extreme case. But, *2d*, .346 is given as the required degree of dryness, (though we shall presently see that the author has not stated his argument in the strongest light,) and I by mere accident have the means of proving, that a much greater dryness does sometimes occur at *Rome*. Whilst examining the meteorological diary kept at the *Collegio Romano*, for the purpose of comparison, shown in my paper on the Horary Oscillations of the Barometer, I kept a note of several of the maximum and minimum results. For 1826, I found the maximum of the hygrometer, August 8th, 55°, and minimum, November 5th, 0°. For February 1827, the range 0°—48°. The head of the column for the hygrometer is entitled, "Igro. a Cap.," which, without the possibility of doubt, means "Igrometro a Capello," or Saussure's Hair Hygrometer. It is, however, evident, that the 0° or *zero* indicated perfect *dampness*, not *dryness*, as is usual ; but that this is sometimes done with common hygrometers, we have the testimony of the author himself, * after mentioning the common arrangement. "Some artists, however, reverse this order, and place the zero at extreme moisture,—a practice which cannot fail to

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* *Edinburgh Encyclopædia*, Art. HYGROMETRY.

lead to mistakes in recording the indication of the instrument." In this case, therefore, 55° indicates on the common scale 45° from dryness, and 48°, 52°. Now, 45° of Saussure is equivalent to .2413 parts of saturation, (see the above quoted article,) a degree of dryness very much greater than .346, which it was thought could not be counted upon. 3*d*, The influence of the localities, as well as of the latitude, in altering the hygrometric state of the atmosphere, does not seem to have been sufficiently considered. The writer of the article before us elsewhere observes, * that " the quantity of moisture mechanically combined with the air over different regions, must depend, in the *first* place, on the mean temperature; and, *secondly*, on the presence of a sufficient quantity of water at the surface of the earth, to afford an adequate supply of moisture to the atmosphere by evaporation." And though he observes that such dryness as .346 can seldom occur but in northern latitudes, he elsewhere remarks, † that the distressing effects of the Sirocco and Simoon arise from the power of their *extraordinary dryness* on the human frame. That this does not hold with regard to the Sirocco in Italy, my remarks, No. xiv. p. 263, sufficiently prove, which is evidently owing to the crossing of so large a portion of the Mediterranean. But an extremely dry cold wind comes from the northern quarters called the " Tramontana," which prevails in winter, and without doubt lowered the hygrometer in February to such a degree as was stated above. Besides, if we consider the situation of Rome, we shall not be surprised that in summer the wind should be excessively dry. Sterile arid deserts surround it on every side from twelve to at least eighteen miles distance; and towards the north particularly, whence the dry winds undoubtedly blow, the plains are extremely extensive, flat, and barren; abounding in every direction with small volcanic rising grounds, composed of ashes, breccia, tufa, and pozzulana, than which few substances show more avidity for moisture. Shall we then wonder that Rome frequently labours under excessive drought? The copious streams of delightful water which supply fountains in every street and square of the eternal city

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* *Edinburgh Encyclopædia*, Art. PHYSICAL GEOGRAPHY, p. 508.

† *Ubi supra*, p. 505.

are brought by aqueducts from distances of from fifteen and eighteen to twenty-four miles, all beyond the confines of the Arid Campagna.

Let us now turn to the little mountain itself, which has such a situation. It is no figure of speech to say that it is composed of broken pottery. It is literally and entirely so, without a particle of earth between the fragments; and in only a few spots on the outside is there a finger's breadth of soil deep to permit a stunted grass to grow, and a few coarse weeds which extend their roots into the fragments. Some excavations in the sides for mending the roads, permit us to see that its internal structure is exactly as I have described, and so loose, that, if you move a small morsel near the bottom, a whole *avalanche* of the necks, bottoms, and handles of *Amphoræ* descend upon you. The hill is about 160 feet high, and 590 paces, or nearly a third of a mile in circumference. It is evident that the weather must have complete access through the hill, and hence it follows: 1*st*, That the pots will imbibe and retain the rain water which falls in enormous torrents in winter; and, 2*d*, That the wind must have a pretty free access between the crevices of the fragments. With regard to the cellars themselves, the one which I entered extended, I suppose, above fifty feet into the hill, nor did I observe that the wind came from any particular funnel or chimney prepared for it, but rather appeared to proceed from the sides of the cavern on all hands, which were so loose and full of crevices as to require to be artificially supported. Saussure expresses himself of the same opinion: " Cet air vient lui-même des interstices, que laissent entre eux les debris d'urnes, d'amphores et d'autres vases de terre cuite, dont cette petite montagne paroit entiérement composée." Now, if we attribute the effect entirely to evaporation, the case seems to stand thus: The exterior air in a state of great dryness enters the mountain laterally, passing through it with perfect freedom, and at the same time acquiring with avidity the humidity presented to it by innumerable surfaces of baked clay, which have already been thoroughly wetted by the rain to the very centre of the mountain; hence the air must in *all* cases reach a state of perfect dampness before it reaches the caves; *therefore*, the depression of temperature depends *solely* on the dryness of the air when at the external temperature, and not when it is reduced to the mean temperature of the place in the interior of the hill, because *there* it will always be saturated. What the mean temperature is, has, by the errors both of the writer and the printer of the article before us, been most erroneously stated. "A quantity of loose materials," it is said, "whose mean temperature cannot be less than 46°." And in a note: "The mean temperature of Rome is, according to Humboldt, 45°.9 in winter, and 55°.2 in summer." Puzzled by such a mass of mistakes, I referred to the original passage in the *Edinburgh Encyclopædia*, Article PHYSICAL GEOGRAPHY, where I found the mean temperature still called 46°; but Humboldt's summer average, 75°.2 instead of 55°2, giving the real mean temperature 60°.6, which I know from experiment to be very exact; this, therefore, is the real mean temperature of the materials. In Saussure's most extreme example, the case is, that air of a certain degree of dryness, and at the temperature of 78°, moistened to humidity with moisture of the temperature of 60°, produced a cold air of 44°. This is a case too complex to be solved by the common hygrometric formulæ; I therefore undertook the following experiments, not with the hope of a complete solution of these delicate inquiries, but to obtain such general facts, as to give to the case in question an approximate estimation of the truth. The experiments themselves are in some measure similar to those of Saussure, (though I had not them in my eye at the time,) but are conducted upon more distinct principles, and by more precise data.

I. The room in which my first experiment was made had, at the beginning of my operations, a temperature of 59½, but at the end had risen nearly to 62°, and in both cases the temperature of a thermometer with a moistened bulb was 55°. The air was both hotter and drier, therefore, at the conclusion; but we shall take the temperature at 61 as an average. We then have for the dryness of the apartment, * $f' = ft - \frac{\frac{1}{6}\,B\,D}{180 - \frac{1}{2}\,D}$: in this case, supposing the barometer at 30 inches, as it was nearly; $f\,61 - \frac{\frac{1}{6} \times 30 \times 6}{180 - 3}$, we obtain .0021893 grains in a

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* *Ed. Ency.* Art. HYGROMETRY, 585.

cubic inch, and a degree of moisture (saturation being expressed by 1.000) of .626. I then caused the iron-pipe of a pair of bellows A, Plate IV. Fig. 1, to pass through an earthenware cylinder BB, to which it was firmly attached, and the interstice was filled up with sand. The muzzle of the bellows and its case was then heated, till the temperature of the air which issued from the mouth on working the bellows was 80°, and it was then placed touching the lower orifice of a large glass jar C, having a wide open neck D; in the bottom of the jar were placed fragments of pottery, moistened with water, at the temperature of the room. A thermometer E, was suspended among the pots, just at the lower tubulature of the jar, so that the bulb was only about three inches distant from the orifice of the bellows; these arrangements having taken some time, the heated stream of air was somewhat diminished in temperature. The bellows having been worked for some time, the thermometer (which had its bulb covered with paper and thoroughly moistened) was stationary at 59.5. When the experiment was finished, the stream of heated air was $74\frac{1}{2}$; the air at the top of the jar, shown by the thermometer F, was 66°, and among the pots 62°, to which the air of the apartment had now risen.

II. It then occurred to me that the experiment might be varied in a more just manner. The air of the room was 62°. A moistened thermometer fell to 55°; hence the grains of moisture in a cubic inch were .0022631, and the ratio to saturation .627, or almost the same as before. The stream of heated air produced in the same manner, but very equably, was $81\frac{1}{2}$°. Instead of using the jar, it was made to pass through a porcelain tube soaked with water, about eight inches long and half an inch in diameter, and at the farther end from the bellows was placed the thermometer, moistened with water, at 62°. When the bellows were worked, it fell to 60, or about half a degree higher than in the last experiment, the stream of air being at least 4° warmer.

III. To take the simplest, and perhaps the truest, view of the case, on an after occasion I caused a stream of air, heated to 80°, to fall directly on the moistened bulb, placed at the distance of only three inches from the muzzle of the bellows; and by a separate contrivance, drops of water at 64°, fell regularly at intervals upon the thermometer. The temperature of the room was 64°, and a moistened thermometer fell to 57°. The grains in cubic inch were .0025635, on the degree of dryness .668. The heated air was at first 81°; and, after a considerable time, had fallen only two degrees. The thermometer became stationary at 59°. By making the proper proportions, I find that the dryness of the *heated* stream of air in these three experiments, using the mean temperature of 77°, 81½°, and 80°, was respectively .482, .347, and .411.

Now, the results of these experiments go to prove, 1*st*, the circumstance which I have already insisted on, the small importance of the state of the air within the mountain, or at 60°. Although the temperature of the room varied from 59½ to 64, the final results are all within the limits of 59 and 60, because the condition of the surrounding air is always that of saturation; and a difference of 5° in the temperature of the humidity applied, (which is the most important agent,) gives no sensible alteration. The differences of result are solely owing to the change in condition of the hot stream of air applied. They cannot be ascribed to the different forms of the experiments; for it is sufficiently evident, that, whether the thermometer be simply applied to the direct blast of air heated to the high degree of 80°, and the reduction of temperature left to the simple coating of the moistened bulb; or whether the air reach the moistened bulb in a state of saturation, and surrounded by pots, which contribute to cool an atmosphere round it, as in the first experiment; or as in the second, whether the air reaches it already cooled down to the circumambient temperature, and loaded with moisture, the difference of result is wholly unimportant. In the *second* place, these experiments prove the influence of having the humidity which moistens the surfaces, over which the hot air passes, of a temperature considerably lower than that of the air itself, which is the sole effect which I am disposed to attribute to the comparatively low temperature, (that of 60°,) which undoubtedly exists within the mountain. For let us take the case of the third experiment, and find what coolness would have been produced by air of 80° impinging on a surface moistened with water at its own temperature; or rather in this case, what dryness was required in the air at $80^0$ to reduce the temperature to 59°, as it did in that experiment. This is solved by the formula above quoted, which in this case becomes $80f - \frac{\frac{1}{6}\,30 \times 21}{180 - 10.5}$, whence we have $1.0014 - .6195 = 3819$, and as $10014 : 6239 :: 3819 : 2379$, or .002379 grains in a cubic inch, and $\frac{2379}{6239} = .381$, the ratio to saturation or dryness the air would have required to have had, instead of .411, as we found above that it really had, which shows the smaller degree of dryness that was necessary in this case than in the simple one; and the difference would undoubtedly have been greater had the formulæ been applicable to both cases.

What the value of this reduction of temperature would be, owing to the coolness of the humid medium, when the resultant temperature is only 44°, as in Saussure's case, I do not feel myself able to pronounce; but my experiments show that it must have an effect probably of several degrees, suppose of four. In that case, the means of reducing the temperature to 48° would be all that was required by ordinary evaporation.

Having attained this point, it is still evident that we can hardly admit quite so great a stretch of evaporating force as this requires; but nature, I must observe, has extended methods of operation, like a great series, of which our experimental knowledge reaches only to a few terms. Though we may understand, in the main, the plan of any particular operation, yet all the combining minutiæ, the effects alternately augmenting and augmented, have only their proper scope in her great scale of action.

> "Mazes intricate,  
> Eccentric, intervolved, yet regular  
> Then most, when most irregular they seem."

One circumstance, the temperature of the moistening water is liable to be cooled to a much greater degree than we have yet considered, and in some respects, I may say, to an almost indefinite degree. Let us review the steps of the process. Air highly dried, and at the temperature of 78°, enters an enormous mass of aggregated materials,—a mass so large, that not only is it retained throughout at the mean temperature of the area of soil on which it is placed, 60°, but, being completely imbued with moisture, the air of the atmosphere being supposed at the dryness to saturation of .238, is instantly reduced to a state of saturation; and, in the *first* place, to a temperature of 54°, (by formula;) but also to a point several degrees lower, because the moisture contained in the pottery had a temperature of 60° instead of 78°. As the current forces itself inwards, and constantly reduces to 53° or 54° the tiles and fragments in the interior, which by and by assume the same temperature, and about the middle of summer may produce fresh evaporative force, as the heat of the sun may have prevented the full acquisition of humidity in passing through the outer stratum; and as we approach the centre of the mountain, these causes will always increase in rendering the moistening agent of a lower and lower temperature. It is the vast bulk of the hill which must necessarily produce more powerful and extended effects than our petty experiments and minute reasonings can enable us to judge of; and in some extreme cases may produce a cold of 44 or 45. Saussure, in his account of the Monte Testaccio, has treated the subject not very philosophically, particularly when he considers the evaporative force the same at all seasons, which arises from the obscurity of hygrometric science at that period; and I think it may be questioned how far even its present state can admit such extended mathematical formulæ as are now applied, and which I have so much employed in this paper. Be it ever remembered, that these *formulæ* are *founded* merely on experiments on a small scale, which must *ever* give more partial and incomplete results, (though they may agree well with one another when made under similar circumstances) than in the vast operations of the example before us. Saussure, however, states one important fact, that he considers the observations of the Abbe Nollet in 1739, and therefore by analogy those of Lumsden in 1762, as strictly comparable with his own. The former found the temperature, Sept. 9th, when the air was 72½°, to be 53½°; and the latter, Aug. 26th, with the air at 79°, to be 54½°. To account for this rise of temperature at the end of summer, he has an unsatisfactory theory of capacious, cool, and *dry* caverns; but we are able to account for it in an instant, either *generally* by the setting in of damp weather, or *particularly* by a simple change of wind. For were the wind to wheel from the N. E. to S. W., I have very little doubt that next day the temperature of the cellars would be found to have increased. So comparatively moderate a heat as 78° at Rome, in the middle of summer, may well be supposed to arise from the "Tramontana," after crossing the extent of the Campagna, which in winter blows such a *dry* chilling blast. We have already observed (p. 206) that in February 1827, Saussure's hygrometer stood at 52°, or in the ratio to saturation of .294. From my own Meteorological Journal, I find that in 13 days out of the 28, the wind was from the northern points, and on nine more it was variable; whereas in the 31 days of January it blew only eight days from those points, which may be considered a sufficient illustration of the fact. I have only farther to add on this point, that there is another and most legitimate source of coolness we have not yet noticed. Lumsden's observations sufficiently prove that a current of external air enters by the top of the door of the cellars; is cooled as it proceeds inwards; joins the cool air of the mountains; and comes out by the bottom of the door.* Now nothing can be more evident than that, as the interior of the caves are saturated with moisture in the coolest state, which all the circumstances we have before considered could reduce it to, that is, from 45° to 50°, a new quantity of dry external air comes upon it in that state, and must experience a great reduction by being moistened with such cool humidity. It is this new air which fills the caves, and which creates the currents. It is necessarily *it* which has its temperature taken; and it must necessarily be coolest at the bottom of the back of the cellar, as Lumsden found it, (see page 206.) This gives the concluding touch to the reduction of temperature, and is, I have no doubt, sufficient to produce even that cold which Saussure observed; and all the other cases on record will be easily solved by it.

In concluding these remarks, which have swelled so much beyond my original intention, I may be allowed to remark, that if it is thought by any that I have not made good the point I have proposed; that the certain determination is only what extensive experiments on the spot can give; and that I

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* See his work, pp. 172 and 173.

have endeavoured, as naturally as possible, to combine what hypothetical and even speculative reasoning was necessary, with those facts which a knowledge of the localities, an attentive consideration of the subject, and the results of several experiments enabled me to lay down; and though it may seem like a "*reductio ad absurdum*," that it seems impossible to explain the phenomenon in any other way, even the gentleman whose sentiments I have ventured to oppose, after conceiving he has proved, that to evaporation "no part of the effect can be ascribed," is compelled to come to the conclusion, that "it is difficult to conceive *in what other way* the temperature could be reduced so low as 44°." Allow me farther to add, that that philosopher's theory of ice caves is quite insufficient to explain the coolness observed by Saussure in Ischia and at Terni,[*] which he supposes to arise from crevices which descend from the higher regions of the mountains. The mean temperature of the latitude of Ischia is about 62°; and as the height of the very summit of the island is only between 1800 and 2000 feet, the reduction of mean temperature at the top will only be about 6° or 56°; whereas Saussure found the grotto 45½°, and was assured that it was still lower in summer, which, from the analogy of the Monte Testaccio, we may naturally suppose. Nearly the same remarks apply to the example at Terni.

The theory which ascribes the coolness of the Monte Testaccio to certain salts distilled from the pottery, may, I think, be set at rest by the following experiment:—I took 160 grains in powder, taken from a portion of an *Amphora* brought from the hill itself, and boiled it with three ounces of water for some time; I then threw it on a filter, and took a portion of the pure liquor, adding to it a decoction of litmus; but no change whatever on the colour of the litmus was produced. I then added a little sulphuric acid, but not the smallest symptoms of precipitation appeared. I next took another portion of the supernatant liquor, which I found had no taste, except a very slight one of clay, or earthy matter, which, of course, arose from a minute portion of the *terra cotta* remaining in mechanical mixture with the water. I evaporated it to dryness, but no saline residuum appeared. Something, however, being visible in the

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[*] Mentioned in the *Philosophical Journal*, viii. 13.

bottom of the small earthenware evaporating dish, I treated it with a small quantity of litmus, which appeared to have its tint extremely slightly reddened. To ascertain the presence of any of the stronger acids, I added a little carbonate of ammonia, which produced no action whatever. These rude trials render it probable that none of those saline matters usually employed to produce cold occur in the *terra cotta* of the Monte Testaccio in any sensible degree.

The coolness of the cellars renders the wine preserved in them extremely agreeable in such a hot climate as that of Rome; and many of the town's people go out to the Monte Testaccio to drink it in full perfection. The Abbate Venuti, in giving an account of the hill, seems as if he spoke *con amore* of its effect on his favourite beverage. "Ha questo monte una mirabile proprietà," says he, "ed è, che nell' estate esce da questi frammenti nella parte infima quando siano ben disposti, un vento freddissimo, e però vi si sono fatte d'intorno più sotto stanze e grotte al piano del terreno di fuori con capanne e Spartamenti, nelle quali *viene il vino notabilmente rinfrescato.*" Δ

## ART. IV.—*Observations on the Formation of Ice in India, in a Letter from* DAVID SCOTT, ESQ. to GEORGE SWINTON, ESQ. Calcutta.

I HAVE received your letter, with Dr Brewster's enclosures, at a time most opportune for giving you what information I possess on the various subjects which he mentions, having been for the last week enjoying the delightful climate and scenery of the Cossyn mountains. This part of the country is much higher than the Jyntah territory, I should think nearly 4000 feet above the plains; and the climate is proportionally colder. The thermometer is now, (10th November,) at noon, 63° in a small hut, and this morning the grass on the low grounds was covered with hoar frost; and ice one-third of an inch thick was produced in vessels placed upon straw. The subject of artificial congelation is one which seems to be more imperfectly understood by scientific men in Europe than almost any other. The old story of evaporation being at the bottom of the process, and *porous* pans being necessary for its success, is repeated by one author after another, although nothing can be more erroneous. In respect to the first, it seems sufficient to observe, that, when ice is produced in temperatures above the freezing point, a plentiful deposition of dew is always going on, which seems to be altogether inconsistent with the idea of the air being in a state capable of receiving fresh accessions of moisture. I have also found, by repeated experiments, that ice may be produced, although a thin film of oil be spread over the surface of the water; the latter being contained in *glazed* plates, which indeed answer much better than the *porous* pans of the country, the ice in them being invariably thicker, and the water, when it does not actually freeze, somewhat colder than the similar contents of porous pans placed in exactly the same situation. The fact is, that the natives use *porous* pans from necessity, there being no other description of crockery ware manufactured in the country; but so well are they aware that the *porosity* of the vessels is of no advantage, that they usually rub them with grease for the purpose, I was informed long ago, of more easily extracting the ice;—but also, I now fancy, because it must tend to facilitate the process, by keeping the straw, upon which they are placed, in a perfectly dry and non-conducting state. The only author that I have read, who has treated this subject properly, is Dr Wells in his *Treatise on Dew.* I have repeated many of his experiments, and sometimes with singular results. On one occasion, a turban being suspended across the ice pit, three feet above the pans, it, as it always does, prevented the formation of ice in those immediately under it; and in several which it only partially covered, ice was formed on the half of the water out of the perpendicular line, while that immediately under the turban was fluid. Two strings crossing each other, and placed at a less height above a pan, will also divide the ice into four quarters; but it is obvious that these results will not always be obtained; for if the temperature be rather lower than would be necessary to freeze the water, supposing no impediment to exist, the whole may be frozen although partially covered; and, on the other hand, if just sufficient to freeze the water under the most favourable circumstances, the contents of a vessel not fully exposed to the influence of the sky may remain fluid throughout. I have never found it practicable to make ice (operating, however, on a small scale) when the temperature exceeded 41° on the level of the pits; but on such occasions the temperature is much higher at some distance from the ground, and I have found a series of bottles filled with water, suspended from a mast of about seventy feet high, to show an increase of about 1° for every ten feet in height. Sir H. Davy is therefore right in saying that ice may be made when the thermometer is above 50°, if he allude to the upper regions of the air, or hills of moderate height; but, as I have already said, it cannot, according to my experience, be made when the thermometer, suspended at the distance of three feet from the ground, on the level plain, stands at above 41°. I wrote a letter on this subject to Mr Colebrooke some years ago, of which, I believe, I can still send you a copy. My experiments extend to the height of 3400 feet, at which elevation, on a *detached* mountain, the temperature of the air at sunrise is several degrees *higher* than it is in the plain of Bengal. I should like much to hear of this experiment being repeated, or of its having been already tried in some of the colder countries, where I suspect the same result will be obtained in the *winter* season with a *clear* sky, and at day-break.

NUNGKLOW, 10*th November*.

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## ART. V.—*Memoir on the Horary Oscillations of the Barometer at Rome.* Communicated by the AUTHOR. (Continued from p. 129.)

THE observations being reduced into the above table, it remained to be considered how the actual results would be most simply and accurately elicited. Had the observations been complete for every hour of each day the means for each hour in inches would have given the desired products; but as we find them unequally scattered through different days, they are so strongly affected by what the *positive* height of the mercury might be at different times, that the most erroneous results would have been obtained. For instance, suppose the mean of six observations at nine o'clock to be 30.000 on days when *no* observations at ten o'clock had been made; and again, that after a month I find the mean of six observations at ten to be 30.500, I would note *half an inch* for the horary variation, because the *radical height* was less at the former than the latter period. I therefore resolved to take the daily difference from some standard point, which, though liable in some degree to the same objection from the inequable fluctuations of the barometer, yet I expected that the combination of a sufficient number of observations would neutralize these irregularities. I resolved to employ 10 M. as the standard, the instrument being most regularly observed at that hour. I have since found that Captain Sabine uses the maximum for that purpose, but I rather prefer my own scheme, as it may often happen that the maximum of the day is not observed. Such is the ground-work of my third table. Part first contains the differences of each hour from 10 M., arranged in columns from 7 M. to 12 A. or eighteen hours out of the twenty-four, in which the observations have been most frequently made. As to part second, it is merely to give a wide guess of the state of the barometer during the night, as it only contains three sets of observations, and these not the most favourable. The first supplement contains the most useful observations selected from my ordinary diary in January, to find the difference between 10 M. and 10 A., since the reductions of the second supplement depends in a great degree upon that point, as it contains observations on those days on which 10 M. has not been observed and 10 A. is therefore substituted.

## TABLE III.—Part I.

N. B.—The sums in the several columns are the differences between the cor-

each column ; and these differences are

| Day. | 10 M. | 7 M. | 8 | 9 | 11 | 12 | 1 A. | 2 |
|---|---|---|---|---|---|---|---|---|
| Feb. 2 | 29.824 | | +5 | +3 | | | | |
| 4 | 894 | | | | +59 | +72 | +84 | |
| 5 | 30.172 | | —24 | —15 | +5 | +6 | | |
| 6 | 050 | | +74 | +27 | —27 | +68 | —96 | |
| 8 | 29.581 | | —31 | —16 | +18 | | | —8 |
| 9 | 935 | | | —54 | | | +12 | +41 |
| 10 | 30.017 | | +8 | +5 | —1 | —3 | | |
| 11 | 016 | | | | | | | —9 |
| 12 | 29.736 | | | +16 | +10 | | | —27 |
| 13 | 738 | | +8 | +8 | —2 | +8 | | |
| 14 | 804 | | | —56 | +7 | +20 | +32 | +38 |
| 15 | 833 | | +14 | +14 | —10 | —16 | —16 | —17 |
| 16 | 845 | | +7 | +7 | +3 | +3 | +2 | +2 |
| 17 | 845 | | —3 | 0 | 0 | 0 | +8 | |
| 18 | 967 | | | | | | | +37 |
| 19 | 30.063 | | +4 | +2 | | | —4 | |
| 20 | 29.987 | | | +21 | —14 | —24 | —31 | —43 |
| 21 | 858 | | | +1 | —6 | —12 | —21 | —45 |
| 22 | 730 | | | +12 | —2 | —30 | —44 | —59 |
| 23 | 569 | | | | 0 | 0 | | |
| 24 | 865 | —78 | —50 | —26 | +11 | +20 | +28 | |
| 25 | 931 | | | —13 | | | +6 | +6 |
| 26 | 30.113 | | | —26 | | +8 | +29 | |
| 27 | 222 | | | —26 | +14 | +21 | +23 | |
| March 1 | 274 | | +21 | 0 | 0 | —7 | —9 | —32 |
| 2 | 204 | | +9 | +9 | —24 | +18 | +2 | |
| 3 | 111 | | +2 | +1 | —17 | —26 | —37 | |
| 5 | 29.888 | | —14 | —5 | +8 | +19 | | |
| 7 | 30.184 | | —20 | —9 | +3 | | | +14 |
| 8 | 228 | | +13 | +4 | —1 | —5 | —10 | —21 |
| 9 | 119 | | +3 | +1 | —28 | | | |
| 10 | 29.985 | | | +9 | +2 | —9 | —21 | —32 |
| 11 | 30.095 | | —54 | —29 | | | +35 | +43 |
| 12 | 273 | —12 | —4 | +3 | 0 | —1 | +4 | —10 |
| April 9 | 176 | | —16 | —8 | —5 | | | —5 |
| 10 | 173 | | +3 | +3 | —7 | | | —20 |
| 11 | 124 | | +16 | +8 | —5 | | | —17 |
| 12 | 152 | | —9 | —5 | | | +21 | +28 |
| 13 | 265 | | | | +27 | | +20 | +21 |
| 14 | 269 | +11 | +8 | +5 | —5 | —11 | —18 | —37 |

Carried on

## *Final Reduction of Barometrical Observations.*

rected height of the Barometer at 10 A. M. and the hour marked at the head of expressed in thousandths of an inch.

| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | +164 | +209 | +217 | |
| +6 | —15 | —21 | —23 | —21 | —19 | —21 | —21 | —19 | |
| | | —119 | —144 | —175 | —202 | —239 | —256 | —276 | |
| | | +63 | +71 | +79 | +87 | +134 | +176 | +217 | |
| +52 | | | | | +85 | | | | +101 |
| | | +25 | | | | | +25 | +25 | +25 |
| | | | | —23 | —31 | —39 | —48 | —56 | —66 |
| | —36 | | | | | —8 | +15 | +15 | +11 |
| | | —16 | —17 | —17 | —18 | —21 | —24 | —27 | —29 |
| +43 | +46 | +55 | | | | | +61 | +63 | +63 |
| | | | | +9 | +12 | +18 | +18 | +18 | +18 |
| | | | | | —7 | +15 | +18 | +18 | +19 |
| | | | | +30 | +58 | +58 | +68 | +68 | |
| +45 | +53 | +60 | +70 | +80 | +90 | +95 | +100 | +102 | |
| | | | | —2 | +2 | +8 | +1 | —9 | |
| —50 | —74 | —79 | —83 | —83 | —87 | —91 | —94 | —95 | —95 |
| | | | —62 | —82 | —76 | | | | —97 |
| | | | | | —120 | —126 | —133 | —139 | —161 |
| | | +25 | +53 | +81 | +106 | +123 | +163 | +177 | |
| | +30 | +30 | | | | | +42 | +45 | |
| | | | | +14 | +15 | +17 | +20 | +33 | |
| +34 | | | +70 | | | +92 | +121 | +142 | |
| | | | | | | | +25 | +27 | +29 |
| —27 | —32 | —36 | —36 | —37 | —38 | —39 | —45 | —59 | |
| | | | | | | | | —60 | —87 |
| | | | | | | —40 | —52 | —52 | |
| | | | | | | | | +48 | +77 |
| | | | +14 | +14 | +34 | +38 | +52 | +58 | +59 |
| | | | —46 | —53 | | | —53 | —63 | |
| | | | | —93 | —97 | —101 | —106 | —102 | |
| —52 | —67 | —73 | 78 | | | —63 | —56 | —53 | |
| +51 | | | +71 | | | | +119 | +129 | +139 |
| | | —45 | | | | | —58 | —74 | |
| —5 | —3 | —2 | 0 | —1 | —2 | —2 | —1 | 0 | +8 |
| —20 | | | | | —28 | —24 | —31 | —31 | |
| —17 | —17 | | | —9 | —7 | —4 | —1 | +4 | |
| +36 | | | | | | | +68 | +69 | |
| +22 | +20 | | | +24 | | | +25 | +25 | |
| —48 | —61 | | | —80 | | —91 | —95 | —99 | |

to next page.

| Day. | 10M. | 7M. | 8 | 9 | 11 | 12 | 1A. | 2 |
|---|---|---|---|---|---|---|---|---|
| April 16 | 29.910 | | +3 | 0 | 0 | 0 | —23 | —23 |
| 17 | 916 | | —2 | 0 | +8 | +13 | | +16 |
| 18 | 938 | + 8 | —4 | 0 | +2 | | | |
| 20 | 933 | | —3 | —3 | +1 | —2 | | +3 |
| 21 | 915 | | —7 | —5 | | | | |
| 23 | 867 | +2 | —9 | —4 | +2 | | | |
| Jan. 12 | * 914 | +98 | +40 | +40 | | —2 | | |
| 15 | * 906 | +6 | —12 | —16 | —12 | —46 | —46 | —46 |
| Pos. sums | | 125 | 238 | 199 | 180 | 202 | 306 | 249 |
| Neg. do. | | 90 | 262 | 316 | 167 | 262 | 376 | 451 |
| (A) Truesums | 1439.518 | +35 | —24 | —117 | +13 | —60 | —70 | —202 |
| (B) Divisors,† | 48 | 7 | 33 | 43 | 37 | 29 | 28 | 28 |
| 1st Results, | 29.9900 | +0050 | —0007 | —0028 | +0003 | —0021 | —0025 | —0072 |
| (A) | 269.742 | +171 | +167 | +399 | CARRIED OVER FROM | | +157 | +175 |
| (B) | 9 | 1 | 4 | 7 | | | 4 | 5 |
| A + A | 1709.260 | +206 | +143 | +282 | +13 | —60 | +87 | —72 |
| B + B | 57 | 8 | 37 | 50 | 37 | 29 | 32 | 33 |
| 2d results, | 29.9870 | +0158 | +0039 | +0056 | +0003 | —0021 | +0027 | —0022 |

* Reduced to the probable mean temperature of 54° for these days.

† These divisors are the number of observations contained in the respective columns.

## TABLE III.—Part II.

| | 1 M. | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| January 12th……… | | +120 | +120 | +104 | +98 | +98 |
| ——— 15th ……… | +108 | +110 | +104 | +78 | +54 | +38 |
| February 22d……… | +25 | +17 | | | | |
| Results, | +0665 | +0823 | +1120 | +0910 | +0760 | +0680 |

| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|
|  | —24 | —35 | —30 | —25 | —16 | —16 | —7 | —1 |  |
| +12 |  | +20 | +23 |  |  |  | +25 | +25 | +23 |
| +3 |  | —11 |  |  |  |  | —17 | —15 |  |
|  |  |  |  | —13 | —30 | —35 | —39 | —39 |  |
| —52 | —62 | —48 | —26 | —18 | +2 | +28 | —2<br>+54 | +96 | +98 |
| 304 | 149 | 278 | 372 | 331 | 491 | 780 | 1350 | 1621 | 672 |
| 271 | 388 | 480 | 545 | 742 | 778 | 960 | 1139 | 1169 | 535 |
| +33 | —239 | —212 | —173 | —411 | —287 | —180 | +211 | +452 | +137 |
| 18 | 14 | 18 | 18 | 24 | 24 | 29 | 41 | 42 | 19 |
| +0018 | —0170 | —0118 | —0096 | —0171 | —0120 | —0062 | +0051 | +0108 | +0074 |
| THE SECOND SUPPLEMENT. |  |  |  |  |  |  |  |  |  |
| —13 | —30 | —49 | —46 | +11 | +9 | +37 | ‡ +64 | +30 | +16 |
| 3 | 2 | 2 | 5 | 6 | 7 | 8 | ‡ 14 | 9 | 3 |
| +20 | —269 | —261 | —219 | —400 | —278 | —143 | +275 | +482 | +153 |
| 21 | 16 | 20 | 23 | 30 | 31 | 37 | 55 | 51 | 22 |
| +0010 | —0168 | —130 | —0095 | —133 | —0090 | —0039 | +0050 | +0095 | +0070 |

‡ This is taken from the first supplement, and deserves confidence.

## TABLE III.—First Supplement,

*Containing the ratio of* 10A. *to* 10M. *in January.*

Jan. 4 10A.—182
5 - +56
Hence we have $\frac{64}{14}$ = .0046 in. 6 - +26
7 - +108
From tab. 3, pt. 1 + 211. div. 41 v. 8 - +96
Again, here + 64……14 9 - —2
10 - —2
Thence for the ratio of 11 - —36
10A. to 10M. $\frac{275}{55}$ = + 0050 inches. 16 - —60
x. 19 - +40
22 - —84
23 - +142
30 - —60
xiv. 31 - +22 sums +490——126 = +64

TABLE III.—*Second Supplement.—Differences from* 10A. *for the days when* 10M. *has not been observed.*

| | 7M. | 8 | 9 | 11 | 12 | 1 A. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 11 | 12 | 10A. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. 7 | | +193 | +171 | | | | +74 | | | | | +46 | +20 | +4 | 0 | 0 | 29.525 |
| 28 | | | +48 | | | | | | | +2 | +5 | | | 0 | 0 | —4 | 30 300 |
| March 4 | | | +161 | | | +114 | +85 | | | | +13 | +16 | +11 | +7 | +8 | | 29.863 |
| 6 | | —93 | —69 | | | | | | | | —45 | —35 | —25 | —15 | +6 | | 30.121 |
| April 7 | | | | | | | | | | | | | | +18 | —19 | | 087 |
| 8 | | —74 | —65 | | | —65 | —65 | —66 | —67 | —61 | —46 | —37 | —28 | —17 | +3 | +5 | 144 |
| 15 | +166 | +131 | +107 | | | +88 | +58 | +37 | +27 | | | —9 | —9 | 0 | —12 | | 29 945 |
| 19 | | | | | | | | | | | +2 | 0 | —1 | 0 | —1 | | 939 |
| 22 | | | +11 | | | 0 | —2 | +1 | | | | | +6 | | 0 | | 863 |
| Pos. sums | +166 | 324 | 498 | | | 202 | 217 | 38 | 27 | 2 | 20 | 62 | 37 | 29 | 17 | 5 | |
| Negative, | | 177 | 134 | | | 65 | 67 | 66 | 67 | 61 | 91 | 81 | 63 | 32 | 32 | 4 | |
| Results, | +166 | +147 | +364 | | | +137 | +150 | —28 | —40 | —59 | —71 | —19 | —26 | —3 | —15 | +1 | 269.787 |
| Reduced to 10 M. | +171 | +167 | +399 | | | +157 | +175 | —13 | —30 | —49 | —46 | +11 | +9 | +37 | +30 | +16 | 269.742 |
| Divisors, | 1 | 4 | 7 | | | 4 | 5 | 3 | 2 | 2 | 5 | 6 | 7 | 8 | 9 | 3 | 9 |

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*** These are reduced by applying the constant quantity —0050, derived from first supplement as many times as they are to be divided by, indicated in the last line.**

From a view of the two sets of results at the bottom of it, it is easily evident that those derived from the second supplement merely destroy the others, and they have only been inserted to show the complete execution of the *type*, for the numbers are too few to correct each other, and the difference of — 005 between 10 A. and 10 M. (of the same day) is utterly insufficient for correcting them. The morning observations are therefore quite destroyed, while the evening ones are less affected. Let us then notice the *first* results. The morning maximum occurs between 10 and 11, probably near the latter hour, as it differs from 10 *positively*, merely $\frac{5}{10000}$th of an inch. Whether the mercury is actually falling at 7 and 8 o'clock it is not so easy to decide. The observations at the former time, from their small number, *are* not much to be depended on, but they are abundant at the latter hour, and appear to indicate the conclusion of a fall, but it is probably inconsiderable, some fluctuation between the morning minimum and maximum. The mercury sinks regularly from 11 till 3. At that hour a temporary elevation is shown; but I am inclined to think it erroneous, and arising from an overplus of observations with the sign +, and an accidental deficiency of the others, which an inspection of the column will confirm. At 4 it decidedly attains the afternoon minimum (— 0170), and fluctuates till about 7, when the height is nearly the same, and then rises constantly for four hours. By 11 it has rapidly risen, and at that hour we have the evening maximum: at 12 it is lower. During the night I can give no account. Part second of this table shows all I know concerning it from three sets of observations, but *two* are so affected by irrelevant causes that I cannot pretend to discover the truth. They tend to indicate a maximum at 3 M., when we ought rather to have a minimum. I here give the mean results in inches of mercury found by applying the means in the columns to the height of 10 M. It only includes part first of the third table.

| | | D. |
|---|---|---|
| 7 M. | 29.9950 | |
| 8 | 9893 | — 57 |
| 9 | 9872 | — 21 |
| 10 | 9900 | + 28 |

| | | D. |
|---|---|---|
| 4 A. | 29.9730 | — 188 |
| 5 | 9782 | + 52 |
| 6 | 9804 | + 22 |
| 7 | 9729 | — 75 |

| | | |
|---|---|---|
| 11 | 9903 | + 3 |
| 12 | 9879 | — 24 |
| 1 A. | 9875 | — 4 |
| 2 | 9828 | — 47 |
| 3 | 9918 | + 90 |

269.9018

| | | |
|---|---|---|
| 8 | 9780 | + 51 |
| 9 | 9838 | + 58 |
| 10 | 9950 | + 112 |
| 11 | 30.0008 | + 58 |
| 12 | 29.9974 | — 34 |

269.8595
269.9018

18 )539.7613

**Mean,** 29.9867

Such is the precise statement; but we shall have a better idea of the general course of the mercury by taking out a few of the best observations and giving them to 1000ths of an inch, thus; 8 M. 29.989 — 10 and 11 M. 29.990 — 12.29.988 —2 A. 29.983.4.29.973—7.29.973—9—29.984—11.30.001 — 12.29.997. Hence we may safely infer, 1*st*, that the maxima occur very nearly at 11 both morning and evening; 2*d*, that the minimum is at 4 A., after which it remains for some time nearly stationary; 3*d*, that the falls are more gradual than the ascents; and, 4*th*, that the ranges between the morning and evening maximum is + 0105, and between the afternoon minimum and evening maximum ,0278, which is somewhat less than we should have reckoned by Humboldt's table. But there can be little doubt of its approaching the truth, and possibly, had the morning minimum been properly observed, it might have shown a greater range. It is to be remembered that in the northern latitudes the hours of variation change in summer and winter. These observations were made towards spring, and therefore probably represent very exactly the mean curve. Indeed they coincide remarkably with the hours found in the tables; and, notwithstanding any differences which exist between my observations and those of Humboldt's table, it will be there observed that different series of observations made for *several years* together do not coincide in the way that might have been looked for, in a path where certainty had been more attainable, and some allowance will therefore be made for these observations of mine, made during a very limited period, and under many unfavourable circumstances.[*] It remains only to be observed, that the mean height of the barometer at Rome appears to have been nearly 29.9867 inches, or when corrected for capillary action and reduced to the level of the sea 30.0807, and that this mean appears to occur about 7 M., between 1 and 2 A., and 9 and 10 A., which would therefore be the proper hours for observation. Δ

## ART. VI.—*Account of the Necropolis of Petra, a City in Palestine, excavated from the solid Rock.* By the Honourable CHARLES LEONARD IRBY and JAMES MANGLES, Commanders in the Royal Navy.[†]

SOME hundred yards below this spring begin the outskirts of the vast Necropolis of Petra. Many door-ways are visible upon different levels cut in the side of the mountain, which towards this part begins to assume a more rugged aspect. The most remarkable tombs stand near the road, which follows the course of the brook. The first of these is on the right hand, and is cut in a mass of whitish rock, which is in some measure insulated and detached from the general range. The centre presents the front of a square tower, with pilasters at the corner, and with several bands of frieze and entablature above; two low wings project from it at right angles, and present each of them a recess in the manner of a portico, which consists of two columns whose capitals have an affinity with the Doric order, between corresponding antæ; there are, however, no triglyphs above. Three sides of a square area are thus inclosed; the fourth has been shut in by a low wall and two colossal lions on either side of the entrance, all much decayed. The interior has been a place of sepulture for several bodies. On

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[*] Mr Daniell found the variation not far from *a-half* more than we should have estimated from Humboldt for London.

[†] The travels of these two able and enterprising officers having been printed only for private distribution; and the very interesting account which they have given of the famous city of Petra not having appeared in any periodical work, we have been induced to lay it before our readers with some slight abridgement.

the front are little niches and hollows, cut as if for the reception of votive offerings. Farther on upon the left is a wide façade of rather a low proportion, loaded with ornaments in the Roman manner, but in a bad taste, with an infinity of broken lines and unnecessary angles and projections, and multiplied pediments and half pediments, and pedestals, set upon columns that support nothing. It has more the air of a fantastical scene in a theatre than an architectural work in stone. What is observed of this front is applicable more or less to every specimen of Roman design at Petra. The door-way has triglyphs over the entablature, and flowers in the metopes. The chamber within is not so large as the exterior promises. It is a broad raised platform round three sides, on which bodies were probably disposed. Immediately over this front is another of almost equal extent, but so wholly distinct from it, that even the centres do not correspond. The door-way has the same ornaments. The rest of the body of the design is no more than a plain front, without any other decoration than a single moulding. Upon this are set in a recess four tall and taper pyramids. Their effect is singular and surprising, but combining too little with the rest of the elevation to be good. Our attention was the more attracted by this monument, as it presents perhaps the only existing example of pyramids so applied, though we read of them as placed in a similar manner on the summit of the tomb of the Maccabees and of the Queen of Adiabæne, both in the neighbouring province of Palestine. The interior of the mausoleum is of moderate size, with two sepulchral recesses upon each side, and one in form of an arched alcove at the upper end; a flight of steps leads up to the narrow terrace upon which it opens. Fig. 3, Plate III. given in last number, may convey an idea of some of these singular excavations.

The sides of the valley were now becoming precipitous and rugged to a high degree, and approaching nearer and nearer to each other, so that it might rather deserve the name of a ravine, with high detached masses of rock standing up here and there in the open space. Of these the architects had availed themselves. In some instances the large and lofty towers are represented in relievo on the lower part of the precipice, and the live rock is cut down on all sides, so as to make the resemblance complete. The greater number of them present themselves to the high road, but there are others which stand back in the wild nooks and recesses of the mountain. All seemed to have been sepulchral; and it was here that we first observed the features of a sort of architecture that was new to us, and is perhaps not elsewhere to be found.

To erect quadrangular towers for sepulchres seems to have been the fashion in several inland districts of the east. They abound at Palmyra, and are seen in the valley of Jehoshaphat near Jerusalem, &c.: but the details and ornaments of these universally betray an imitation of Roman architecture, whilst at Petra they bear all the marks of a peculiar and indigenous style. Their sides have generally a slight degree of that inclination towards each other, which is one of the characteristics of Egyptian edifices, and they are crowned with the Egyptian torus and concave frieze. A very remarkable superstructure rises above as a parapet. Two corresponding flights of steps represented in relievo, ascend in opposite directions from two points near the centre. They are connected together by a horizontal line drawn between the uppermost steps, and these are usually from four to six. At the angles are pilasters. In many instances they have a considerable diminution upwards. The capital is very peculiar, and appears like the rough draft of an unfinished Ionic capital as it comes from the quarry. It is, however, almost universal on these tombs, and may be called the *Arabian order* of architecture. An entablature and frieze, little differing from the Ionic or Corinthian, rests upon these pilasters. Above there is a blank space in the nature of a low attic, which is finished with the Egyptian torus and frieze, bearing the superstructure which I have described. There is one single example near the theatre of an upper door-way opening in this attic, to which there is no visible access. There may possibly, however, be some stairs in the interior. The lower door-way is unluckily choaked, so that we could not ascertain. In some instances the pilasters are multiplied to four in the front, and are rounded instead of being angular. What is the least peculiar in the details of these Arabian elevations is the decorations of the door-ways, which have in many instances a pediment not distinguishable from those of the Romans, and in others a plain horizontal architecture with the same character in the mouldings. It is remarkable that in very many instances the whole frame and ornament of the door has been of separate pieces, and grafted on upon the solid rock. Sometimes there are cavities for pegs or rivets, which would seem to have fastened these decorations in metal or in wood. In others they seem to have been of marble, or some finer sort of stone set into grooves, which show in the hollow their exact form. We were at a loss to account for the apparent conformity of this single member of the building to the rules of the Greeks and Romans. It seems too strong to be accidental; and if we suppose the imitation to have taken place so far back as the first Macedonian expedition into this country, it will still make the tombs by many ages more recent than it is probable that many of them really are; since, from the days of Rekem, king of the Midianites, who passes for the founder of Petra, to those of Alexander the Great, there must have been a long suite of kings, and these monarchs probably had tombs. Yet, if the form of the door-ways be judged decidedly posterior to that period, it is so general that few if any of the larger sort will remain for that early dynasty. If we bring them still later, and suppose them a Roman innovation, the difficulty is increased; because we must then believe a much greater lapse of ages to have passed in a flourishing kingdom without any considerable monuments, when architecture was not unknown. It is possible such of the door-frames as were not cut in the solid may have been added afterwards, but this does not appear very probable, nor does it entirely remove the difficulty; especially, as in some instances in the higher parts of the design, broad bands seem to have been attached in a similar manner, which very probably were charged with inscriptions.

It is surprising, amongst such a multitude of tombs, to find so few with any inscription to record for whom they were constructed. We only met with two instances. One was on the tomb which had a door in the attic already mentioned, as being near the theatre. It is much mutilated. The other which we copied is on the left hand side of the track leading towards Dibdebar, on a large front of pure Arabian design, with four attached columns; and in this monument the architect, from failure, or a defective vein in the sandstone, has been obliged to carry up the lower half in masonry, so as to meet the upper, which is sculptured on the face of the mountain, where also there were flaws, and here pieces have been let in to make up what was defective. These last remain, but the whole substructure has disappeared entirely, and the upper part is left hanging from the rock above without any base whatever. This is not the only proof that is to be found among the remains at Petra, that those who wrought on the live rock, contrary to the necessary practice of builders, began their work at the top. To return to the inscription; it is upon an oblong tablet without frame or relief, but is easily distinguished from the rest of the surface from being more delicately wrought. There projects, from each of its ends, those wings is in form of the blade of an axe, which are common both in the Roman and Greek tablets, and which would seem to have been in their origin, for the purpose of receiving screws or fastenings without encroaching on the part inscribed. This original purpose seems to have been particularly kept in view in the present instance, since, although the whole is in the solid, there is upon each side a chain of metal, which must be the effect of studs of bronze actually driven in, to give the whole tablet the appearance of a separate piece. The letters are well cut, and in a wonderful state of preservation, owing to the shelter which they receive from the projection of cornices and an eastern aspect. None of our party had ever seen these characters before, excepting Mr Banks, who, upon comparing them, found them to be exactly similar to those which he had seen scratched on the rocks in the Wady Makootub, and about the foot of Mount Sinai. He subsequently found a passage in Diodorus Siculus, wherein he speaks of a letter written by the Nabathæi of Petra to Antigonus, in the *Syriac character*; though this, perhaps, is no proof that the Syriac was in use with them, since they may have chosen that language only as more familiar to the court they were addressing. The tablet has five long lines, and immediately underneath a single figure on a larger scale, probably the date. The very same occurs at the bottom of the Hebrew characters on the tomb of Aaron. The interior of the tomb we have been describing has two chambers, with recesses for bodies, but no peculiarity worthy of notice. The front is crowned with a double flight of steps in the usual form. In many instances, in lieu of two flights diverging from each other, they are brought to meet in the form of pyramids, being reduced to a much smaller scale, and repeated in the manner of battlements to the number of three or five entire, with the half of one at each extremity.

We have preferred collecting into one view the most remarkable features of these tombs before we advance further, without confining ourselves strictly to those which are met with in the approach from Wady Mousa to the city, in order to generalize the description, and avoid interrupting the narrative by alluding to them as they present themselves, which is the case not only in every avenue to the city, and upon every precipice that surrounds it, but even intermixed almost promiscuously with its public and domestic edifices.

To return to the description of the eastern approach to Petra. As we advanced, the natural features of the defile grew more and more imposing at every step, and the excavation and sculpture more frequent on both sides, till it presented at last a continued street of tombs, beyond which the rocks, gradually approaching each other, seemed all at once to close without any outlet. There is, however, one frightful chasm for the passage of the stream, which furnishes, as it did anciently, the only avenue to Petra on this side. It is impossible to conceive any thing more awful or sublime than such an approach. The width is not more than just sufficient for the passage of two horsemen abreast; the sides are in all parts perpendicular, varying from 400 to 700 feet in height, and they often overhang to such a degree, that, without their absolutely meeting, the sky is intercepted and completely shut out for 100 yards together, and there is little more light than in a cavern.

The screaming of the eagles, hawks, and owls, who were soaring above our heads in considerable numbers, seemingly annoyed at any one approaching their lonely habitations, added much to the singularity of this scene. The tamarisk, the wild-fig, and the oleander, grow luxuriantly about the road, rendering the passages often difficult. In some places they hang down most beautifully from the cliffs and crevices where they had taken root. The caper plant was also in luxuriant growth, the continued shade furnishing them with moisture.

Very near the first entrance into this romantic pass a bold arch is thrown across at a great height, connecting the opposite sides of the cliff. Whether this was part of an upper road upon a summit of the mountain, or whether it be a portion of an aqueduct, which seems less probable, we had no opportunity of examining it; but as the traveller passes under it its appearance is most surprising, hanging thus above his head betwixt two rugged masses apparently inaccessible. Immediately under it are sculptured niches in the rock, destined probably for statues: and we suspect, that, by careful inspection, inscriptions might be found there; but the position in which they are viewed is disadvantageous, and the height so great, that it would require a good glass to distinguish them. Farther down, upon a much lower level, there is an object frequently repeated in sculpture along the road-side, which we were at a loss to explain. An altar is represented in a niche, upon which is set a mass of a lumpish form, sometimes square, and sometimes curved in its outline, or rising in other instances to a sharp or obtuse cone. In one instance three of them are coupled together in one niche. It might possibly be a representation of the god Terminus, or perhaps one of the stones which were objects of worship amongst the Arabs down to the time of the coming of Mahomed. The number of these representations on the face of the rock is very considerable. In some instances there are many almost contiguous with Greek inscriptions on them, all of which are too much defaced to be of use in explaining their object.

The ravine, without changing much its general direction, presents so many elbows and windings on its course, to which the track of necessity conforms, that the eye can seldom penetrate forward beyond a few paces, and is often puzzled to distinguish in what direction the passage will open, so completely does it appear obstructed. The exact spot was not pointed out to us, but it is somewhere amidst these natural horrors that upwards of sixty pilgrims from Barbary were murdered last year by the men of Wady Mousa on their return from Mecca. The wrapping cloak of one of them was afterwards offered to us for sale at Ipseyra, and one of their watches at Zaphoely. Salvator Rosa never conceived so savage and suitable a quarter for banditti. The brook has at this season disappeared beneath the soil, but the manner in which its occasional overflowings have broken up the antique pavement, and the slippery passes which the running of the waters have made by polishing the live rock where it had been cut away to form the road, sufficiently prove the necessity of providing another course for its waters. A trough, carried along near the foot of the precipice upon the left hand side, was destined to confine the water, and to convey it upon a higher than the natural level to the city. At a considerable distance down the ravine the water-course crosses over to the opposite side, and towards its extremity may be traced passing along at a great height in earthen pipes, bedded and secured with mortar, in horizontal groves cut in the face of the rock, and even across the architectural points of some of the tombs, which makes it probable that it is posterior to them.

We followed this sort of half subterraneous passage for the space of nearly two miles, the sides increasing in height as the path continually descended, while the tops of the precipices retained their former level.

When they are at the highest a beam of stronger light breaks in at the close of the dark perspective, and opens to view, half seen at first through the tall narrow opening, columns, statues, and cornices of a light and finished taste, as if fresh from the chisel, without the tints or weather stains of age, and executed in a stone of a pale rose colour, which was warmed at the moment we came in sight of them with the full light of the morning sun. The dark green of the shrubs that grow in this perpetual shade, and the sombre appearance of the passage from whence we were about to issue, formed a fine contrast with the glowing colour of the edifice. We know not with what to compare this scene. Perhaps there is nothing in the world that resembles it. Only a portion of a very extensive architectural elevation is seen at first, but it has been so contrived that a statue with expanded wings, perhaps of victory, just fills the centre of the aperture in front, which, being closed below by the sides of the rock folding over each other, gives to the figure the appearance of being suspended in the air at a considerable height, the ruggedness of the cliffs below setting off the sculpture to the highest advantage. The rest of the design opened gradually at every pace as we advanced, till the narrow defile, which had continued thus far without any increase of breadth, spreads on both sides into an open area of a moderate size, whose sides are by nature inaccessible, and present the same awful and romantic features as the avenues which lead to it. This opening gives admission to a great body of light from the eastward. The position is one of the most beautiful that could be imagined for the front of a great temple, the richnesss and exquisite finish of whose decorations offers a most remarkable contrast to the savage scenery which surrounds it.

It is of a very lofty proportion, the elevation comprising two stories. The taste is not exactly to be commended, but many of the details and ornaments, and the size and proportions of the great door-way especially, to which there are five steps of ascent from the portico, are very noble. No part is built, the whole being purely a work of excavation, and its minutest embellishments, wherever the hand of man has not purposely effaced and obliterated them, are so perfect that it may be doubted whether any work of the ancients, excepting perhaps some on the banks of the Nile, have come down to our time so little injured by the lapse of ages. There is, in fact, scarcely a building of forty years' standing in England so well preserved in the greater part of its architectural decorations. Of the larger members of the architecture nothing is deficient excepting a single column of the portico. The statues are numerous and colossal. Those on each side of the portico represent in groups, each of them, a centaur and a young man. This part of the work only is imperfect, having been mutilated probably by the fanaticism of early Christians or Musselmen, directed against idolatry, and particularly the human form. In the upper tier the figures are females, two are winged, and two appear to have been dancing or much in action, with some instruments lifted above their heads, of which that on the left hand seems to be the Amazonian bipennis. Unfortunately the centre figure, which was doubtless the principal one, is too much defaced for her attributes to be determined; nor is there any thing in the ornaments that could enable us to discover to what divinity the temple has been dedicated.

The principal chamber of the interior is large and remarkably lofty, but quite plain, with the exception of the door-frames and architraves, of which there are three, one at the further end, and one at each side, all opening into small and plain cells. There is also a lateral chamber on each side, opening from the portico, of a rude form. The centre of the superstructure, which comprises the second storey, is a circular elevation surrounded by columns, with a dome surmounted by an urn. This latter has not escaped or failed to excite the covetousness of the natives. We heard of it as the deposit of a vast treasure, "Hasnah-el-Faraoun," (treasure of Pharoah,) as far as Jerusalem; and that it has been repeatedly aimed at by musket shot there are evident proofs in the marks of bullets in the stone. None, however, seems to have succeeded in aiming at it by climbing, which would indeed be a difficult task. The green stains on either side would lead to the supposition that the handles had been of bronze. It is doubtful whether one of the perforations by a musket ball does not show that the urn is hollow. Above the monument the face of the rock is left overhanging, and it is to this that the excellent preservation of its details is to be ascribed. The half pediments, which terminate the wings of the building, are finished at the top with eagles, which, combined with the style of architecture differing little from the Roman, can leave no doubt that this great effort of art is posterior to the time of Trajan's conquest. Some of the heights whose steep sides inclose the area in front of the temple, are rendered accessible, though with great difficulty, by flights of steps cut in them. We found the ascent, in some instances, so steep and slippery that we were obliged to take off our shoes, and also to use our hands nearly as much as we did our feet.

Some small pyramids hewn out of the rock are on the summit of these heights, and we discovered a much higher conical point of mountain, to whose summit there is a regular spiral staircase of ascent, cut with great care and neatness, the same point possibly on which we could distinguish from another quarter a single pillar or obelisk. We first observed, also from the heights above the temple, the vase which crowned another monument to the N.W. The wide space which constitutes the area before the temple is about fifty yards in width, and about three times as long. It terminates to the south in a wild precipitous cliff, rendered accessible by the steps abovementioned to the N. N. W. The defile assumes, for about three hundred yards, the same features which characterize the eastern approach, with an infinite variety of tombs, both Arabian and Roman, on each side. This pass conducts to the theatre, and here the ruins of the city burst on the view in their full grandeur, shut in on the opposite side by barren craggy precipices, from which numerous ravines and valleys, like those we had passed, branch out in all directions. The sides of the mountains, covered with an endless variety of excavated tombs and private dwellings, presented altogether the most singular scene we ever beheld ; and we must despair to give the reader an idea of the singular effect of rocks, tinted with most extraordinary hues, whose summits present us with nature in her most savage and romantic form, whilst their bases are worked out in all the symmetry and regularity of art with colonnades and pediments, and ranges of corridors adhering to the perpendicular surface. The short notice of Petra by Pliny is as follows: "The Nabatæi inhabit a city called Petra, in a hollow somewhat less than two miles in circumference, surrounded by inaccessible mountains, with a stream running through it. It is distant from the town of Gaga on the coast six hundred miles, and from the Persian Gulf one hundred and twenty-two."—6th Book, c. 28. Strabo says, "The capital of the Nabatæi is called Petra. It lies in a spot which is in itself level and plain, but fortified all round with a barrier of rocks and precipices; within furnished with springs of excellent quality for the supply of water and the irrigation of gardens; without the circuit the country is in a great measure desert, and especially towards Judea. Jericho is at the distance of three or four days." He adds, that one of the royal lineage always resided at Petra, and had a sort of counsellor attached to him, who was entitled his brother. He premises their laws and customs.

It will be seen that these two ancient geographers, in characterizing the position of the city, not only agree with one another, but will be found sufficiently conformable to the reality, though strictly speaking the situation can neither be called a valley with Pliny, nor a plain with Strabo: yet it is certainly both low in position and level in surface, when compared with the crags and precipices that surround it. It is an area in the bosom of a mountain, swelling into mounds and intersected with gullies; but the whole ground is of such a nature as may be conveniently built upon, and has neither ascent nor descent inconveniently steep. Within the actual circuit of the city there are two mounds, which seem to have been entirely covered with buildings, being still strewed over with a prodigious quantity of loose stones, tiles, and fragments of ancient ware, of a very light and delicate fabric. The bed of the river, taking its course to the N.W., flows between these two spots. The water has now sunk beneath the surface, and perhaps creeps through the rubbish which ages have accumulated in its bed. Great part of it seems to have been arched over in the same manner as the stream at Philadelphia. In the low grounds on the left bank of the stream seem to have been some of the principal edifices; the first to the N.W. from the theatre, was an archway of a florid architecture, with pilasters having pannels enriched with foliage in the manner of Palmyra: the whole is much ruined. The arch was the introduction to a great pile of building standing nearly at right angles to it. This building had a door on one side; on the three others it was decorated with a frieze of triglyphs and large flowers in the metopes. Beams of wood are let in at intervals between the courses of masonry, and continue to this day a strong proof of the dryness of the climate. The front had a portico of four columns; this part is much fallen into ruins. The interior of the edifice was divided into three parallel chambers, and there seem to have been several stories. This interior economy made us suspect that it was not a temple, but rather a palace or private edifice. Whatever may have been its nature, it seems to have been destined to the same purpose as the ruined building at "Bait-el-Carm," which we afterwards saw from our camp above Dibdebar, and which is the only considerable work of masonry existing at Petra. Upon the summit of the other mound there is a mass of ruins of some solidity, but no very definite shape. The Nubian geographer, climate three, says that the houses of Petra were excavated in the rock. Now, that this was not universally true, is evident from the great quantity of stones employed in the lesser kinds of edifices which are scattered over the whole site. But it is also true that there are grottos in great numbers, which are certainly not sepulchral, especially near the palace. There is one in particular which presents a front of four windows with a large and lofty door-way in the centre. In the interior, one chamber of about sixty feet in length, and of a breadth proportioned, occupies three of the windows and the door; at the lower end, the fourth window seems allotted to a very small sleeping-chamber, which is not brought down to the level of the floor of the great apartment, but has a chamber below it of the same size, giving no light but from the entrance. This, which seems the best of all the excavated residences, has no ornament whatever on the exterior; and the same applies to all the other excavations of this nature.

The access to this house is by a shelf gained out of the side of the mountain; other inferior habitations open upon it, and more particularly an oven and some cisterns. These antique dwellings are close to an angle of the mountain, where the bed of the stream, after having traversed the city, passes again into a narrow defile, along whose steep sides a sort of excavated suburb is continued, of very small and mean chambers, set one above the other, without much regularity, like so many pigeon-holes in the rock, with flights of steps, or narrow inclined planes leading up to them. The main wall and ceiling only of some were in the solid; the fronts and partitions being built of very indifferent masonry with cement.

Following this defile farther down, the river reappears flowing with considerable rapidity; though the water is plentiful, it is with difficulty that its course can be followed, from the luxuriance of the shrubs that surround it, and obstruct every track. Besides the oleander, which is common to all the water-courses in this country, one may recognize among the plants which choke this valley, some which are probably the descendants of those that adorned the gardens and supplied the market of the capital of Arabia; the carob, fig, mulberry, vine, and pomegranate, line the river side; a very beautiful species of aloe also grows in this valley, bearing a flower of an orange hue, shaded to scarlet; in some instances it had upwards of 100 blossoms in a bunch.

Amongst the niches for votive offerings in the mountain's side, some of which are cut to the height of thirty feet, are pyramids and obelisks; and in one instance, there is an altar between two palm-trees. The position of the theatre has been mentioned. It is the first object which presents itself to the traveller on entering Petra from the eastward. It is entirely hewn out of the live rock. The diameter of the podium is 120 feet, the number of seats thirty-three, and of the cunii three. There was no break, and consequently no vomitories. The scene, unfortunately, was built, and not excavated; the whole is fallen, and the bases of four columns only remain on its interior face. The theatre is surrounded by sepulchres; every avenue leading to it is full of them; and one may safely say, that a hundred of the largest dimensions are visible from it. Indeed, throughout almost every quarter of this metropolis, the depositories of the dead must have presented themselves constantly to the eye of the inhabitants, and have almost outnumbered the habitations of the living. There is a long line of them not far from the theatre, at such an angle as not to be comprehended in the view from it, but which must have formed a principal object for the city itself. The largest of the sepulchres had originally three stories, of which the lowest presented four portals with large columns set between them, and the second and third a row of eighteen Ionic columns each attached to the facade; the live rock being insufficient for the total elevation, a part of the story was grafted on in masonry, and is for the most part fallen away. The four portals of the basement open into as many chambers, very dissimilar both in distribution and arrangements, but all sepulchral, and without any communication between them. In one were three recesses, which seem to have been ornamented with marble or some other extraneous material. Almost contiguous to this extensive front is another somewhat smaller, but equally rich, whose design has a great analogy, especially in the circumstance of the half pediment, and the circular lantern in the centre, to the beautiful temple of the eastern approach. Though a general symmetry pervades this species of architecture, yet there are irregularities observable in its doors and windows, which may be explained by the circumstance of their opening into apartments no way connected with each other, and intended apparently for different families. A little farther to the south-east, an area is gained upon the slope of the mountain by excavating it, so as to form three sides of a square. Two of these have been formed into Doric porticos; the third, which is the loftiest, as being that which abuts against the body of the mountain, is occupied by a lofty front, decorated with four engaged columns of the same order, but without triglyphs. A pediment surmounts the frieze, supporting an urn, in all respects similar to that on the temple of the eastern approach. A door-way with a window over it fills the centre, and there are three windows in the attic, the centre one of which exhibits two half-length figures in basso-relievo. In the approach to this tomb, there were arched substructions of great extent now fallen into ruins. It is surprising to reflect, that monuments of so vast a scale should be executed subsequent to the Roman conquest, since after that period we can look upon them as no more than the tombs of private individuals. Whence should come so much wealth, and with a taste for magnificence, after the country had lost its independence, it is difficult to conceive. It is possible, however, that a trade by the Red Sea with India, or even the caravan trade with the spice country, may have imported such riches into the place, as to give the inhabitants the same fondness for ostentation and ornament observable at Palmyra, which owed its wealth to the same source. Yet to consider a mausoleum of upwards of seventy or eighty feet high, with lateral porticos and flights of terraces upon arched work leading up to it, as the effect of the vanity of some obscure individual in a remote corner of the Roman empire, has something in it surprising and almost unaccountable. The interior was disposed of in one large and lofty chamber, having six recesses, with grooves in them at the further end.

On the establishment of Christianity, these six recesses have been converted into three for the reception of the altars, and the whole apartment has been made to serve as a church; the fastenings of the tapestry and pictures are still visible on all the walls, and near an angle is an inscription in red paint, recording the date of consecration. These were the only vestiges of a Christian establishment that we were enabled to discover throughout the remains of Petra, though it was a metropolitan see.

Diodorus Siculus has a long account of the expedition sent by Antigonus against the Nabataei. He mentions that their riches were very great in gold and spices, and that such of them as were feeble and infirm, were left *επι τινος Πετρας*, which he calls afterwards a place of prodigious natural strength, but without any walls; and distant two days' journey from any inhabited place. In the second expedition, it is said there was but one way of access to it, which was artificial. The loftiness of the post is afterwards mentioned. It is difficult to apply this description to Wady-Mousa. Upon some of the high points of rocks that rise about the skirts of the city, and tower above them, the remains of walled forts are visible from below; and as it is probable there was an acropolis, it must be looked for in some of these.

Two days were spent in these ruins from day break until dusk, and yet it will be seen by what has been said, that this time was very insufficient to complete an examination of them. It was impossible to remain any longer; for although Abou Raschid attended personally with us the whole time, yet having forced us to decline visiting Abou Zetoun in so abrupt a manner, and having but few attendants, he was never at his ease, and constantly urged us to depart. On the first afternoon, we undertook the ascent to the little edifice, which is visible to all the country round, upon the very highest and most rugged pinnacle of this range of mountains, and is called "the tomb of Aaron." The tomb of Moses has been so grossly misplaced by the Musselmen, who show it half a day's journey beyond Jordan to the westward, that we might look with some suspicion to one assigned to his brother, were it not that Josephus expressly says of the place of his decease, that it was near Petra. Compare also Mozera with Mousa, and it seems that the monument and the ruins mutually authenticate each other. We had no doubt, therefore, that the height which we were going to ascend, is the Mount Hor of Scripture. The base of the highest pinnacle of the mountain is a little removed from the skirts of the city to the westward; we rode to its foot over a rugged broken tract, passing in the way many sepulchres, similar to those which have been described. A singular monument presents itself upon the left hand; an obtuse cone, produced by the coils of a spiral, is represented as standing upon a vast square pedestal or altar, the whole being obtained out of one of the peaked summits of the rock. Not far from thence, close to the way side, is the same representation in relievo, within a niche, which we have remarked upon in the eastern approach, the form of the recess which surrounds the altar rising into the figure of a sugar loaf. Nowhere is the extraordinary colouring of these mountains more striking than in the tomb of Aaron which we followed, where the rocks sometimes presented a deep, sometimes a paler blue, and sometimes was occasionally streaked with red, and shaded off to lilac or purple; sometimes a salmon colour was veined in waved lines and circles, with crimson and crest scarlet, so as to resemble exactly the colour of raw meat; in other places there are livid stripes of yellow or bright orange, and in some parts all the different colours were ranged side by side in parallel strata. There are portions also with paler tints, and some quite white, but these last seem to be soft, and not good for preserving the sculpture. It is this wonderful variety of colours, observable throughout the whole range of mountains, that gives to Petra one of its most characteristic beauties. The façade of the tombs, tastefully as they are sculptured, owe much of their imposing appearance to this infinite diversity of hues in the stone.

We engaged an Arab shepherd as our guide; and leaving

Abou Raschid with our servants and horses where the steepness of the ascent commences, we began to mount the tract, which is extremely steep and toilsome, and affords but an indifferent footing. In most parts the pilgrim must pick his way as he can, and frequently on his hands and knees. Where by nature it would have been impassable, there are flights of rude steps or inclined planes, constructed of stones laid together, and here and there are niches to receive the footsteps cut in the live rock; the impression of pilgrims' feet are scratched in the rock in many places, but without inscriptions. Much juniper grows on the mountain, almost to the very summit, and many flowering plants which we had not observed elsewhere; some of these are very beautiful; most of them are thorny. On the top there is an overhanging shelf in the rock, which forms a sort of cavern. Here we found a skin of extremely bad water suspended for drinking, and a pallet of straw, with the pitcher and the other poor utensils of the shiekh who resides here. He is a decrepid old man, who has lived here during the space of forty years, and occasionally endured the fatigue of descending and reascending the mountain. The tomb itself is inclosed in a small building, differing not at all in external form and appearance from those of Mahomedan saints, common throughout every province of Turkey. It has probably been rebuilt at no remote period. Some small columns are bedded in the walls, and some fragments of grânite and slabs of white marble are lying about. The door is near the south-west angle, within which a constructed tomb, with a pall thrown over it, presents itself immediately upon entering; it is patched together out of fragments of stone and marble that have made part of other fabrics. Upon one of these are several short lines in the Hebrew character, cut in a slovenly manner. We had them interpreted at Acre, and they proved to be merely the names of a Jew and his family who had scratched this record. It is not probable that any professed Jew has visited this spot for ages past, perhaps not since the period of the Mahomedan conquest; it may lay claim, therefore, to some antiquity, and in any case it is a curious appendage to the testimony of Josephus on this subject. There are rags and shreds of yarn, with glass beads and paras, left as votive offerings by the Arabs. Not far from the north-west angle is a passage, descending by steps to a vault or grotto beneath, for we were uncertain which of the two to call it, being covered with so thick a coat of whitewash, that it is difficult to distinguish whether it is built or hollowed out. It appeared, in great part at least, a grotto. The roof is covered, but the whole is rude, ill-fashioned, and quite dark. The sheikh, who was not informed that we were Christians, a circumstance which our guide was not aware of, furnished us with a lump of butter. Towards the farther end of this dark vault lie the two corresponding leaves of an iron grating, which formerly prevented all nearer approach to the tomb of the prophet; they have, however, been thrown down, and we advanced so as to touch it; it was covered by a ragged pall. We were obliged to descend bare-footed, and were not without some apprehension of treading on scorpions or other reptiles in such a place.

The view from the summit of the edifice is extremely extensive in every direction, and the eye rests upon few objects which it can clearly distinguish and give a name to, though an excellent idea is obtained of the general face and features of the country. The chain of Idumean mountains which form the western shore of the Dead Sea, seem to run on to the southward, though losing considerably in their height; they appear in this point of view barren and desolate. Below them is spread out a white sandy plain, seamed with the beds of occasional torrents, and presenting much the same features as the most desert parts of the Ghor. Where this desert expanse approaches the foot of Mount Hor there arise out of it like islands, several lower peaks and ridges of a purple colour, probably composed of the same kind of sandstone as that of Mount Hor itself, which, variegated as it is in its hues, presents in the distance one uniform mass of dark purple. Towards the Egyptian side there is an expanse of country without features or limit, and lost in the distance. The lofty district which we had quitted in our descent to Wady Mousa shuts up the prospect on the S. E. side; but there is no part of the landscape which the eye wanders over with more curiosity and delight than the crags of Mount Hor itself, which stand up on every side in the most rugged and fantastic forms; sometimes strangely piled one on the other, and sometimes as strangely yawning in clefts of a frightful depth. In the midst of this chaos there rises into sight one finished work, distinguished by profuseness of ornament and richness of detail. It is the same which has been described as visible from other elevated points, but which we were never able to arrive at; it bears N.E. half N. from this spot; but the number and intricacy of the vallies and ravines which we supposed might have led us to it, baffled all our attempts. No guide was to be found. With the assistance of the glass we made out the façade to be larger to all appearance than that of the temple at the eastern approach, and nowise inferior to it in richness and beauty. It is hewn out of the rock, and seemed to be composed of two tiers of columns, of which the upper range is Ionic. The centre of the monument is crowned with a vase of gigantic proportion; the whole appeared to be in a high state of preservation. It may perhaps be an ornament to the northern approach to the city, similarly situated to that on the eastern side from Mount Hor. Petra is intercepted and concealed by the prominences of the mountains. An artist who would study rock scenery in all its wildest and most extravagant forms, and in colours which to one who has not seen them would scarcely appear to be in nature, would find himself rewarded should he resort to Mount Hor for that sole purpose.

## Art. VII.—*Notice of the Principal Meteorological Phenomena in the last eight months of* 1826 *at Patna and Futtehpore.* By Alexander F. Lind, Esq. of the Bengal Civil Service. Communicated by the Author.

ABSTRACT of a Meteorological Diary kept from the 1st May to the 24th July at Patna, Lat. 25° 37′ N. Long. 85° 15′ East; and from the 6th September to the 31st December at Futtehpore, Lat. 25° 56′ N. Long. 80° 45′ East; and during the intermediate period on the River Ganges, between Patna and Bitora, (Futtehpore.)

| 1826 | Mean of Far. Thermometer, in the shade, out of doors. | | | | | | | Far. Thermometer in the shade, out of doors. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mon. | Sunrise. | Ten A. M. | Noon. | Between 3 and 4 P. M. | Sunset. | Ten P. M. | Daily Range. | Least daily Range. | Greatest ditto. | Lowest Temperature. | Highest ditto. |
| May | 83°1 | 95°5 | 100°1 | 103°5 | 97°1 | 91°5 | 20 | 10°5 | 27° | 79° | 110° |
| June | 84 2 | 90 5 | 93 3 | 93 9 | 90 4 | 86 6 | 10 7 | 3 | 17 | 81 | 104 5 |
| July | 83 4 | 86 2 | 85 5 | 90 2 | 86 6 | 83 8 | 6 9 | 3 | 13 | 79 | 99 |
| Aug. | 83 4 | 86 6 | 88 7 | 89 6 | 86 8 | | 7 5 | 1 | 14 | 80 | 98 |
| Sept. | 83 | 88 | 90 | 90 7 | 87 3 | | 8 3 | 3 | 17 | 80 | 98 |
| Oct. | 72 6 | 87 | 92 3 | 93 9 | 87 7 | | 20 6 | 14 | 27 | 66 | 99 |
| Nov. | 60 6 | 74 7 | 79 7 | 80 7 | 75 8 | | 20 4 | 3 | 27 | 49 | 92 |
| Dec. | 48 4 | 65 2 | 70 7 | 73 9 | 66 3 | | 20 9 | 6 5 | 26 | 46 | 80 |

| 1826 | Prevailing Winds. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mon. | Direction. | | | | | Force. | | | | | |
| | West. | East. | North. | South. | Total Days. | Very Strong. | Strong. | Brisk. | Gentle. | Calm. | Total Days. |
| May | 10¼ | 19 | 1½ | ¼ | 31 | 5 | 3 | 18 | 5 | | 31 |
| June | 14¼ | 15½ | | ¼ | 30 | 5 | 3 | 3 | 16 | 3 | 30 |
| July | 5 | 25 | ¾ | ¼ | 31 | | 12 | 10 | 9 | | 31 |
| Aug. | 22½ | 7 | | 1½ | 31 | | 17 | | 12 | 2 | 31 |
| Sept. | 16 | 13½ | ½ | | 30 | | 1 | 22 | 7 | | 30 |
| Oct. | 25 | 6 | | | 31 | | 2 | 8 | 17 | 4 | 31 |
| Nov. | 22½ | 7½ | | | 30 | | 1 | 7 | 22 | | 30 |
| Dec. | 16½ | 11¼ | 3¼ | | 31 | | 1 | 6 | 24 | | 31 |

| 1826 | Weather. | | | | | Atmospheric Phenomena. | | | | Rain Gage |
|---|---|---|---|---|---|---|---|---|---|---|
| Mon. | A clear sky. | Fair with clouds. | Overcast. | Rainy. | Total Days. | Lightning. | Thunder. | Rainbows. | Falling Stars. | Falling Inches, &c. |
| May | 18½ | 9½ | 2½ | ½ | 31 | 9 | 4 | 2 | 6 | 1.244 |
| June | 3¼ | 13½ | 8½ | 4¾ | 30 | 18 | 12 | 2 | 6 | 3.232 |
| July | | 16½ | 8¾ | 5¾ | 31 | 14 | 10 | 6 | 3 | 8.201 |
| Aug. | 2½ | 12½ | 10¼ | 5¾ | 31 | 15 | 13 | 3 | 2 | 12.865 |
| Sept. | 11¼ | 13¼ | 1¾ | 3¾ | 30 | 13 | 10 | 4 | 2 | 4.471 |
| Oct. | 22 | 7½ | 1½ | | 31 | 4 | 2 | | 2 | 0.388 |
| Nov. | 22½ | 3¼ | 3½ | ¾ | 30 | | 1 | | 2 | 0.976 |
| Dec. | 17 | 10¼ | 3¼ | ½ | 31 | 2 | 1 | 1 | 10 | 0.485 |

May.—The first half of this month was distinguished by cloudless skies and excessive heat. The sun usually rose and set of a pale white colour. On the 21st May a total eclipse of the moon took place. It began about seven hours sixteen minutes P. M., and ended about ten hours forty-two minutes, and was distinctly visible throughout. At its commencement Fahrenheit's thermometer stood at 93°5, and towards the beginning of total darkness, the moon was apparently placed between the stars $\beta$ and $\delta$ Scorpio. The whole disc was visible of a dusky red colour, but here and there darkened with black clouds, and stars of the fifth magnitude became visible. When the total darkness ended, and the enlightened portion of the moon's disc was as large as the moon eight or nine days old, the entire disc was to be seen; but in a moment afterwards, the darkened portion disappeared, and a troubled corona environed the moon with a broken ring; and as the light increased, the corona often vanished and again formed. There were frequent flashes of lightning during the continuance of the eclipse, and a few cirri were observed floating through the sky after its termination. At two A. M. next morning, the weather began to blow, thunder, and lightning, and 1.003 inch of rain fell. On the 29th May, after sunset, a singular semicircular band coloured with a deeper blue than the surrounding sky was observed; its bases resting about as many degrees north of the real east and west as corresponded with the sun's amplitude. The breadth of this band was about 4°. Next morning, before sunrise, the Himalaya mountains were distinctly visible. The distance of some of these hills is as great as 160 miles in a direct line; of others somewhat less. When the sun rises they vanish.

June.—On the 7th, at seven hours ten minutes P. M. a fire-ball fell from the zenith in a south easterly direction. The ball was as large as Venus, and left a broken trail of light behind it. Next evening a beautiful fire-ball moved slowly from west to east over a distance of nearly 84°, leaving at intervals a trail of fire. On the nights of the 12th and 13th, the moon was surrounded with a discoid halo, tinged with a reddish brown colour. On the 20th the increase of water in the Ganges was very marked, and portions of the bed of the river left dry since the past year began to be covered with water, although since the 1st May only 2.246 inches of rain had fallen at Patna.

July.—At sunset of the 3d a large corona formed round the sun. The sky at sunset of the 6th presented a beautiful appearance, clouds of bright green (portending rain,) being surrounded with others coloured scarlet. At night, coronæ formed round the planets and large stars, and on the 8th, 2.249 inches of rain fell. From the 1st to the 14th rain fell daily.

August 30th.—While in a boat on the Ganges I observed a curious optical deception. A very violent shower of rain, attended with strong wind, swept from the opposite bank of the river, and the sky and the river became of one colour and indistinguishable the one from the other. The distant bank, with its trees, &c. appeared exactly like a picture depicted on the clouds. The appearance did not last long.

November 14th.—A total eclipse of the moon took place, but the clouded state of the sky prevented its being visible. The same cloudiness extended all along the Ganges as far as Calcutta, a distance of 3° 22′ of latitude, and perhaps farther.

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## ART. VIII.—*On the Assay of the Argillaceous Iron-Ore.* By HUGH COLQUHOUN, M. D. Communicated by the Author.

THE assay of an ore of iron is the process of subjecting a small portion of it, as an average specimen of the mass, to the test of chemical analysis, in order to discover the amount and value of metal which it may contain, together with the nature and relative proportions of those earthy ingredients with which the metal is associated. If this analysis be conducted by solution in acids, and then obtaining each ingredient in a separate form, so as to ascertain the constitution of the ore with scientific precision, it is styled the *humid assay.* But if the analysis be made by merely reducing the ore in a crucible, either *per se* or associated with a flux, and then examining the metallic and scoriaceous mass that results from this reduction, it is termed the *dry assay.*

Each of these processes has for its object the important purpose of estimating the metallic richness of any given mass of ore, and the expense in fuel and flux which it will cost to extricate the iron. Each method possesses certain advantages that are peculiar to itself, and each is also marked by its own inconveniences. For although the humid assay, or chemical analysis, affords the only sure method of ascertaining with precision the nature and relative proportions of the ingredients in any ore, yet it requires more delay, and perhaps more care than the smelter is willing to bestow; and it may also sometimes demand a greater acquaintance with the science of chemistry than he possesses. On the other hand, the dry assay, conducted by a man of practical experience, will seldom fail to give a tolerably accurate view of the amount of metal in an ore, and of the general character of its earthy ingredients. It is a process requiring no great exertion of patience or attention, and as being perhaps more congenial with his general habits, it is almost invariably preferred by the metallurgist.

We shall consider the two processes separately: and shall commence with the *dry assay*.

### § 1. *On the Dry Assay of Ironstones.*

In performing this assay, the leading object to be kept in view is to effect it accurately, in the most rapid manner, and on the smallest scale. It ought to be in all respects a miniature model of the process which is afterwards to be employed in smelting the ore in the blast furnace, and it is only when this point is pretty nearly attained that much reliance can be placed upon the conclusions deduced from the assay. In explaining therefore what is essential to the successful management of the dry assay, it seems of importance to keep in view, at the outset, the history of the smelting process. After a brief glance at this, the details which more exclusively belong to the assay will be better appreciated.

Metallic iron nowhere exists in a native state to any considerable extent. That metal must always be extracted from its combinations with oxygen and the admixture of certain earthy bodies, by fusing the earths, and by deoxidating the metal through the agency of carbonaceous matter. When the earthy constituents of the ore are brought into this state, the particles of metal which they include will subside through the fluid by their superior specific gravity, and unite at the bottom of the furnace in which the smelting takes place; so that when the whole is allowed to cool, the metal will be found collected in a solid lump at the bottom, while the earthy ingredients are lying above in the shape of a vitrified and homogeneous mass. In all cases of *assay*, the metal which is thus found below is called the metallic button, and the superincumbent vitrified earth is named the scoria.

There is no single earth of those which are usually found in ironstones, that can be brought into a state of fusion by the application of any heat of a furnace, however intense. But in some binary compounds of these bodies, and in many ternary compounds, the ingredients are found to act mutually on each other so as to yield to the heat of a furnace, and will soften into a porcelain, or melt into an enamel, or flow into a liquid glass, as the case may be. But as it rarely happens that these earths are associated with one another in iron ores, so adjusted in their nature and relative proportions as to form easily fusible compounds, it is necessary for the smelter to consider what are the earthy ingredients in any given ore, so that he may adapt thereto such a flux as will cause the whole mixed mass readily to melt in the furnace upon a due application of heat.

Thus it appears that it is of primary importance to attend both to the nature and to the proportions of the various earths which are brought together in the furnace. Now, as there is a considerable variety in the kinds of those earths with which iron is associated by nature, and as there is an endless changing in their relative proportions, it is essential that the smelter should possess some knowledge of the composition of any given ore which is to be assayed, in order that he may be enabled to prepare the most appropriate flux for it,—that flux which shall fuse it most perfectly, and produce as the result of the assay, the true amount of metal which the ore contains.

In selecting and adjusting his flux, the assayer ought always to have in view the following circumstances. First, the use of a substance which, while it is unexceptionable in other respects, is of such a nature as is best adapted to liquefy the ore at the lowest temperature. Second, the exhibition of this flux in sufficient quantity to fuse the whole of the ore; and third, the limiting of its amount within such bounds, that the whole of it may be engrossed in absorbing and liquefying the whole of the earthy ingredients of the ore. For if an excess of flux be employed, it has often the strongest tendency to form a new ore within the crucible, owing to the disposition of oxide of iron to unite, at a high temperature, with an earthy mixture and to vitrify it. So much indeed is this the case, that the most accurately adjusted fluxes always retain a certain portion of the metal unreduced; and the amount of this very rapidly augments when an excess of earthy matter is exhibited.

Nothing therefore can be more important to the successful operation of smelting, whether on the greatest or the smallest scale, than an accurate knowledge of the nature and relative proportions of the earthy constituents of an ore. This is the only sure means that the ironsmelter can possess for directing him in the compounding of his flux, so that he shall select substances of that kind, and in that quantity which are respectively the fittest to produce the fusion of the whole mass in the furnace. Nor is it possible to devise any formula for a flux of universal application, one which can be considered as, in all cases, a sure test of the quantity of metal contained in any ore. Our ores are, generally speaking, either siliceous, or calcareous, or argillaceous. Now a siliceous or sandy ore requires a flux in which pure lime is a predominating ingredient. A calcareous ore, on the contrary, naturally containing a considerable amount of the carbonate of lime, requires a highly siliceous flux. And an argillaceous ore, in order to solve its clay, will need either lime or a mixture of lime and silica. Indeed, some mixtures of silica and lime in an iron-ore may make it necessary to add a quantity of pure clay to the flux, before they will liquefy in the furnace. But since all these various kinds of ore often occur in the same coal-field, unless the composition of the flux be made to follow their alterations with corresponding changes on itself, it is plain that the smelting or assaying furnace will seldom or never make a fair return of metal. The only certain method, therefore, of trying the real value in metal of any given ore, is to obtain some information respecting its constitution, and then to compound a flux expressly adapted to it.

It is true, however, that there do exist various powerful solvents which will hardly fail to fuse any iron-ore in the furnace, and which, if judiciously compounded, may often be useful, especially when the smelter is left very much in the dark as to the constitution of any particular ore. This indeed is the only situation in which it becomes desirable to possess some uniform vitrifying material, which may be employed in assaying all kinds of ores, however different from one another in constitution. We would recommend for this purpose a mixture of from 15 to 20 parts of silica and 25 parts of quicklime (unslacked,) to every 100 parts of the (uncalcined) ironstone. This will be found upon trial to be of very general application, and will seldom fail to separate the ore into a metallic button and a scoria: and although the results of the assay will not possess the accuracy of those obtained with a flux selected according to more systematic principles, it will still afford a tolerable approximation. When the ore is unusually refractory, from poverty in metal or the predominance of one of its earthy ingredients over the others, it will be proper to increase the activity of the above mixture, by the addition of about 10 parts of fluor spar or calcined borax. *

Having thus stated the general nature of the operation which it is the object of the assayist to perform, we may next proceed to the details of this branch of the metallurgic art, in examining which we shall adopt the following order. We shall first consider what general rules have been established regarding the fusibility of the several earths which nature or art has associated with the oxide of iron in the smelting furnace. After determining what mixtures form the most fusible compounds, we shall next advert to the means of procuring in a state of purity any of those substances which the assayist's exigencies may require. We shall then consider the mode of subjecting the adjusted compound of ore and flux to

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* Many different recipes for compounding a general mixture for assaying iron-ores may be met with in chemical and metallurgic works; but we have seen few that are deserving of commendation. Bergman, for instance, mentions the following heterogeneous mixture for assaying iron-ores as having been long in use among the Swedish metallurgists, and as being held in high estimation.

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| To 100 parts of ore, | |
| 100 parts of sal ammoniac. | |
| 100 | tartar. |
| 100 | glassgall. |
| 50 | borax. |
| 50 | charcoal dust. |
| 200 | black flux. |

All these ingredients, after being well intermixed, to be put into an unprepared crucible, and covered with common salt.

Chaptal's general flux for assaying iron-ores consists of,

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| To 200 grains of ore, | |
| 400 | borax. |
| 40 | slacked lime. |
| 200 | nitre. |

The whole mixture to be heated intensely for half an hour in a crucible lined inside with charcoal powder. There can be little doubt that in most assays performed with either of these fluxes, a considerable portion of oxide of iron would be retained in a state of permanent combination by the scoria. But independently of this circumstance, the violent commotion into which the whole materials of the assay would be thrown in consequence of the copious extrication of elastic matter from the sal ammoniac, tartar, nitre, &c. would of itself seem sufficient to render every assay made with these fluxes unsatisfactory.

the action of the assay furnace, and shall conclude this part of the memoir by an examination of the metallic button and scoria, with a view not merely to determine the actual results of any assay which has been made, but also to discover how far it has been successfully conducted, or in what respects it may on a subsequent trial be amended.

In following out the method which has now been laid down, the first point is to state those principles which have been fixed by experience, regarding the fusible or fusifying nature of the ingredients which are usually found associated in the smelting furnace. Upon this subject the three following general rules will be found of universal application.

1. The earths which usually occur in the ores of iron are silica, alumina, lime, and magnesia. Each of these is infusible when exposed *per se* to the most elevated temperature of a furnace. The oxides of iron are fusible under the same circumstances.

2. Very few binary mixtures of these bodies afford compounds fusible at the temperature of the blast-furnace. The cases in which such compounds are produced are the following. Silica mixed with its own weight of lime melts under a strong heat, into a sort of enamel: it is fusible also with rather more than its own weight of oxide of iron or of oxide of manganese. Compounds possessed of considerable fusibility in very high temperatures are likewise afforded by oxide of iron, when mixed with less than its own weight of lime or of alumina; or with a quarter of its weight of magnesia.

3. A large proportion of the ternary mixtures of the earths and the oxides, and a still larger number of their quaternary mixtures, are fusible in the furnace. In these mixtures, if any one of the ingredients, excepting magnesia, predominates considerably over the others, the fusibility of the compound may be considered as almost certain. But magnesia, whenever its quantity exceeds that of the other ingredients of the mixture, has a remarkable effect in rendering it refractory.

It will be observed that in each of these complex mixtures, there is no single ingredient more conducive to fusibility than the oxide of iron or of manganese, and none more adverse to it than magnesia.

From these general rules regarding the fusibility of mixtures of silica, lime, magnesia, and alumina, it is plain that no compound of them, more simple than the ternary, is at present of any practical use in metallurgy. Upon these compounds, Mr Kirwan has instituted a series of valuable experiments, which lead to the following conclusions.

1. When lime, magnesia, and alumina are the component parts of the mixture.

If lime preponderate, and the proportions be 3 lime, 2 magnesia, and 1 alumina, the compound may be vitrified in the furnace. Whenever the whole mass is thus melted and run into a glass, the highest state of liquefaction is attained which the smelter can desire. If the proportions only approximate to those just mentioned, the mass may be softened under extreme heat, so as to form a porcelain or an enamel, but it will not vitrify.

If magnesia preponderate, the compound will be infusible in every degree of heat below 166° Wedgwood.

If alumina preponderate, and be equal to the larger of the two other ingredients, and at the same time is thrice as abundant as the smaller, the mixture may form a porcelain at 150° Wedgwood.

2. In a mixture of lime, magnesia, and silica.

If the lime preponderate, there are various proportions in which a fusible compound may be composed.

If the magnesia preponderate, the mixture is infusible.

If silica preponderate, few fusible compounds can be prepared.

3. In a mixture of alumina, magnesia, and silica.

If the alumina predominate, only a porcelain can be produced.

If the magnesia predominate, not even an imperfect fusion can be effected.

If the silica be the most abundant ingredient, there are various mixtures which will yield a porcelain, and one that will even vitrify. This occurs when the mass consists of 3 silica, 2 magnesia, and 1 alumina.

4. In a mixture of alumina, lime, and silica.

If the lime preponderate, the product will be a glass, a porcelain, or an infusible mass, according to the proportions of the mixture.

If the alumina predominate, many mixtures will yield a porcelain, but none will afford a glass.

If silica exceed, a porcelain or an enamel is frequently procured, and it is probable that even a glass may be attainable.*

From a due consideration of these experiments of Mr Kirwan, and of the preceding general rules, it will not be difficult for the assayist, with a little perseverance, to succeed in adapting an appropriate flux to his ore.

In doing this, he will find that the earthy ingredients which are most frequently present to excess in the common argillaceous ironstone, are clay and silica. Both of these substances will easily vitrify in the furnace with the addition of lime. Lime is therefore the principal flux which is employed for

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* *Elements of Mineralogy*, vol. i. p. 72. The fusibility of mixtures of the earths and metallic oxides has been made the subject of an elaborate course of investigation, by several other eminent chemists besides Mr Kirwan. Among these may be mentioned Achard, (*Memoirs of the Academy of Berlin*, 1779, 1780. *Journal de Physique*, xxii. 179, 300. xxiv. 280, xxv. 137.), Gerhard, (*Versuche einer Geschichte der Mineralreich*, vol. ii. *Journal de Physique*, xxviii. 34.), Klaproth, (*Beitrage zur chem. Kennt. der Mineralkörper*, i. 1.), and Lampadius, (*Handbuch der Allgemeine Hüttenkunde*, i. 127. *Journal des Mines*, xviii. 171.) It would be a highly interesting inquiry to examine in elevated temperatures the habitudes of similar mixtures of earths and metallic oxides, made in conformity with the prime equivalent proportions of these substances. Hitherto the only system of investigation pursued on this subject has been by subjecting to the action of heat an endless variety of binary, ternary, and quaternary mixtures. But when we consider the number of distinct substances and the infinity of their possible combinations whose reciprocal action in high temperatures it is of importance to know, it is almost a hopeless task to endeavour to subject each of these successively to the test of experiment. Now, however, that the combining proportions of bodies have been ascertained, the metallurgist is in possession of an infallible rule for his guidance in compounding earthy mixtures; and in every future prosecution of such an inquiry, he would, of course, systematically mix the substances to be experimented upon, in conformity with their prime equivalent weights. The number of the experiments which he would find it necessary to make, would be thus most materially abridged, while, at the same time, the attainment of important and decisive results would be rendered far more certain.

these ores. The amount of lime thus used will vary according to circumstances between 5 and 20 or even 30 per cent. of the ore, being increased or diminished according to the amount and the nature of the earthy matter which the ore contains.

In assaying ores which are overcharged with silica, and destitute of clay, it will often be found advantageous to employ, in conjunction with the lime, a portion of pure clay, varying in amount from 5 to 10 per cent. of the ironstone, according to the abundance of the silica.

In the same manner, in order to promote fusibility in any argillaceous ore which is more than usually destitute of silica, it will be proper to add a certain amount of that substance, varying from 8 to 12 per cent. of the ore, in order to form a flux along with the lime.

But before leaving this topic it is material to observe, that of all the ingredients which are associated with iron in the ore, clay is the most frequent and abundant, and that which requires the greatest delicacy in adjusting to it the due proportion of its counteracting flux. If the lime be exhibited in excess, the resulting scoria is difficultly fusible and viscous; and of course, obstructs the coalescence of the particles of reduced metal into a single mass; but if too small a portion of lime be employed, the consequence will be, either that vitrifaction will take place defectively in the furnace, or that the portion of the siliceous ingredient of the clay which is left unsaturated, will dissolve and unite with a portion of the oxide of iron, so as to shield it from reduction. It is therefore an object of primary importance to the assayist to determine the exact proportion of argillaceous matter contained in any ore, before he commences its assay; and as this may be easily done, even by those who have very little experience in chemical manipulations, it ought in all cases to be made the subject of a separate and preliminary experiment. This analysis may be conducted in the following manner.

Take 100 grains of the pulverized ore; put it into a wide-mouthed flask, and pour over it an ounce measure of muriatic acid, which has been previously diluted with two ounce measures of water. An effervescence will instantly take place occasioned by the muriatic acid attacking and dissolving the carbonate of iron, and any other carbonate, as of lime, magnesia or oxide of manganese, which may exist in the ore. When the whole muriatic acid has been added, expose the mixture to a moderately warm temperature, that of a sand-bath, for example, and agitate it frequently, so as to expose every particle of the ore to the direct action of the acid, and to prevent the undissolved portion from concreting into a mass. At the termination of about an hour, the whole of the oxide of iron, lime, magnesia, and oxide of manganese, will have been taken up by the acid; and the portion left undissolved will consist of clay, together with silica, if the ore has been of a siliceous nature, and of carbonaceous or coally matter. Let the whole be now transferred upon a small paper filter, and the insoluble residue washed, so long as the liquid which passes through has a perceptible taste of acidity. Then dry the filter, first between folds of blotting paper, and afterwards before a fire or upon a sand-bath: it should now be put together with its contents, into a platinum crucible, and calcined, either over the flame of a large spirit lamp or upon pieces of red hot wood charcoal, until the carbonaceous matter produced by the ignition of the paper and the coally matter originally contained by the ore, is entirely consumed. The residue will consist of the clay and silica of the ore in a state of separation from all the other ingredients; and its weight will of course indicate the proportion which the ore contains of argillaceous or siliceous matter.

After having thus ascertained the proportion of clay which is present in any ore that is to be assayed, the amount of lime which is to be employed as a flux will be carefully adjusted to it. In most cases a quantity amounting to three-eighths of the clay will be found the most efficacious adaptation. But if actual experiment should prove that a larger supply of lime is requisite, it may be inferred that the clay is unusually abundant in silica; and if, on the contrary, a smaller quantity of lime suffices, it is probable that the ore naturally contains a certain portion of the carbonate of lime.

We have now briefly considered the ores in which clay or silica is a preponderating ingredient. Those which are usually styled calcareous seldom contain a sufficient quantity of lime to flux their natural silica and clay, and it is necessary therefore in assaying them to add a certain amount of lime, ranging from 2 or 3 to 10 per cent. according to circumstances. If, however, the lime be superabundant, the flux to be chosen is silica, which should be exhibited in a proportion not under 6 and not exceeding 15 per cent., and varied within these limits according to the excess of the lime, and also according to the quantity of silica already present in the ore. Should the ore contain little natural clay, the flux will be improved by the addition of from 6 to 10 per cent. of pure clay.

It may be remarked upon the whole of the cases just considered, that, in whatever state the siliceous, calcareous, or argillaceous ore may occur naturally, it should be the aim of the smelter to prepare a mass for his furnace, the general proportions of which should be somewhat approximating to 1 part by weight of lime, 1 of clay, and 2 of silica. This is the mixture which will most easily run into a glass, and which will yield the most perfect and unreserved return of metal after fusion.

Magnesian ores generally prove the most refractory. If the excess of magnesia be considerable, the ore must be fluxed with a mixture of nearly equal parts of silica and lime, (from 6 to 12 per cent. of each,) together with a small amount of clay.

If an ore is extremely poor in metal, it may be inadviseable to supply its deficient earth as a flux for those other earthly ingredients which are already present in excess, on account of the inconveniences which arise from having the earthy scoria very abundant in proportion to the metallic product. In such a case as this, recourse should be had to a more powerful solvent, which, although used in small quantity only, may nevertheless flux the ore in the ordinary furnace heat. Fluor spar and calcined borax are the safest and the most efficacious substances for this purpose. If either be taken singly, an amount varying according to circumstances from 12 to 25 per cent. will form the flux; if they be taken jointly, each may be in the proportion of about 10 per cent. of the quantity of ironstone. Indeed it may be considered as a rule of general application, that whenever an ore is found to be more than ordinarily refractory, the flux may be very beneficially strengthened by the addition of a small quantity of either of these two substances. They both flux, with nearly equal vigour, either silica or lime, and as they have comparatively little tendency to retain the oxide of iron in a state of permanent combination, they are most valuable resources for the assayist in the case of a refractory or a barren ore. We cannot take leave of this subject, however, without clearly stating this caution, that neither these nor any saline fluxes whatever should be had recourse to by the assayist, except in those extreme cases where their use can scarcely be dispensed with. It is of the utmost importance to the practical metallurgist to maintain a strict analogy between the assay process and march of the blast furnace: but this analogy is evidently destroyed in the most essential point, when he introduces into the assay crucible substances which are never employed in the smelting of the iron-ore on the large scale.

Having now considered in what manner a flux should be adapted to each particular class of the argillaceous, the siliceous, and other most abundant of our ores, the next object which we have proposed is to point out in what manner the several ingredients which may be required to compose a flux may be obtained by the assayist in sufficient purity. In doing this, he will not encounter any difficulty, the substances in question being lime, silica, clay, borax, and fluor spar. We shall subjoin a simple mode of preparing each of them.

To prepare the lime, let a crucible be filled with pieces of pure white-coloured marble, and then exposed to the intense heat of a furnace for about an hour. Immediately after cooling, it should be pulverized, the powder should then be sifted with a fine sieve, and secured in a well-stoppered bottle. The reason why it is necessary to pulverize this, and all the other ingredients in an assay, is because it is essential to the success of the operation that all the materials should be exhibited in such a form as admits of their being thoroughly incorporated with each other.

The uncalcined carbonate of lime, as marble, or any pure common limestone, may be substituted in the assay with little inconvenience for quicklime. But in this latter case, the quantity of flux which is taken will of course require to be increased, as 100 parts of the carbonate are equivalent to only 56 parts of pure lime.

In preparing silica, it is only necessary to reduce colourless transparent quartz, or calcined flint, to an impalpable powder. The pulverization of the flint is materially facilitated by the previous calcination.

Pure white coloured pipe-clay, which is composed of little else than alumina and silica, the silica being almost always the preponderating ingredient, will be found a very useful material in any case where the presence of a small quantity of alumina is likely to promote vitrification in the furnace. It will be observed that all clays, however similar in appearance, if obtained from different localities, are liable to variation in the proportion of their constituents, and it is therefore proper, in the prosecution of a series of assays, to preserve a stock of the same clay in the laboratory, so as to make sure of always employing a reagent of the same description in each experiment. Without this precaution it is not always safe to compare the results of different assays with each other.

Fluor spar may be obtained by reducing to powder a transparent fragment of fluor or Derbyshire spar. This spar should be carefully selected, so as to be free from pyrites, a matter which requires the greater attention, as specimens often occur, through which minute crystals of pyrites are disseminated to a considerable amount.

Borax, before being used, should always be well calcined, to get rid of its water. Let it be first exposed to the moderate temperature of a sand-bath, until it ceases to swell up, and then let it be acted on by a dull-red heat. While yet hot, it should be pounded, sifted, and transferred into a stoppered bottle. Unless this be done before the borax has been allowed to become cold, or if the stopper do not accurately fit the neck of the bottle, the salt will speedily regain its water by absorbing the atmospheric humidity.

These seem to be all the substances which can be required to compose any flux in the assay of ironstones. We shall next consider in what manner the ore itself may be fitted for the crucible.

Upon this subject we cannot refrain from making one observation, which is of a nature so obvious, that were it not in many cases overlooked, we should hardly have considered it necessary to state it. The remark now referred to is this, that the first step to be taken in procuring any ore for an assay, is to select with care what is a fair average specimen of the quality of the ore. To do this with propriety, as it is only choosing a small sample from a large mass, requires a considerable share of discrimination and attention; and yet, to do it with accuracy is a matter of the very last importance, for if a mistake be committed here, no matter how carefully the other steps of the process may be performed, there still remains the greatest hazard that the result may either leave a mass of rich material undervalued, or perhaps the more fatal error, of causing too high an estimation to be placed on an ore of indifferent quality.

In most cases the ore may, without any material inconvenience, be subjected to the assay furnace, without having been previously calcined. This previous calcination, however, always has a sensible effect in facilitating the accurate performance of the assay. For if it have been omitted, an effervescence necessarily occurs at the commencement of the ignition, through the disengagement of carbonic acid from the carbonates of iron, lime, &c. and also through the escape of gas arising from the decomposition of the carbonaceous ingredient: the mixture, in consequence, is apt to be deranged, and a portion of it may even be thrown upwards out of the sphere of the flux altogether, so that though this may also be reduced, it is not absorbed by the scoria, and transmitted to the metallic button. Calcination becomes particularly important when the ore happens to contain an unusually large proportion of carbonaceous or coally matter, as is generally the case with the black-coloured varieties; for if the carbonaceous particles were allowed to remain diffused throughout the mixed mass, they would not fail to exercise a powerful influence in rendering it refractory, and in preventing the particles of reduced metal from meeting in a united mass.

The ore may be calcined in the following manner. Reduce from one to two hundred grains of it to a fine powder, and introduce this into a large platinum crucible, after which let it be ignited in a low red heat during the first five minutes, and then in a pretty strong red heat, in which it should be kept till the operation is finished. If the ore happens to be overcharged with carbonaceous matter, the calcination will be more complete if it be conducted in a shallower vessel than a common crucible; and it will be necessary to stir the powder frequently, so as to expose the whole of it during the course of the ignition, as much as possible, to the free and direct access of the atmospheric air. After complete calcination, the loss of weight sustained during the process will be found to indicate, with considerable accuracy, the proportion of carbonic acid and other volatilizable matter which had been contained by the ore.

The intermixture of charcoal powder with the flux has been frequently recommended as a useful auxiliary to it for the purpose of reducing the oxide of iron. But this practice is not only quite unnecessary, but it may often prove extremely prejudicial to the accuracy of the assay. A perfect reduction of the oxide may be always insured by simply keeping the whole materials of the assay surrounded externally with carbonaceous matter, as for example, by coating the inside of the assay crucible with a lining of charcoal powder. The presence of the carbonaceous particles necessarily adds also to the refractoriness of the mixture, and constitutes a strong mechanical barrier obstructing the aggregation of the globules of reduced iron. Besides this, it is well known to every one at all versant in the assaying of iron-ores, that iron, if imbedded in a state of minute division among charcoal powder and exposed to an intense heat, is liable to be converted into plumbago. This is a substance unattractible by the magnet; and as the assayist is always in the habit of searching his scoria with a magnet for the purpose of gathering up any small particles of iron which may not have made their way, during fusion, to the metallic button, he is deprived of all benefit from this resource in so far as such iron may have been formed into plumbago, and a proportionate disappearance of the metallic product is of course inevitably produced.

The practice of incorporating the ore and flux into a paste with oil is worthy of censure for a similar reason: the oil, when it is decomposed by the heat, leaving a quantity of an impalpable carbonaceous powder intimately diffused throughout the mixture. The best state in which the assay mixture can be introduced into the crucible is that of a fine, dry, and thoroughly blended powder, and the aid of any adventitious cementing matter is altogether unnecessary.

The crucibles that are to be employed in the assay obviously require to be highly refractory, and not easily susceptible of cracking, through exposure to any sudden change of temperature. The best are certainly those which are formed either of Stourbridge clay, or of a similarly constituted material. But the common Hessian crucibles, if they be genuine, will be found very suitable in all cases where the temperature of the assay furnace is not raised to an extreme degree of intensity. In the course of numerous experiments on the assaying of iron-ores, during which these Hessian crucibles were almost invariably employed, there did not occur a single failure in consequence of their either cracking or melting.

Before introducing the assay-mixture into the crucible, it is necessary to line it interiorly with a coating of charcoal, which in the high temperature of the furnace, deoxidates the oxide of iron and reduces it to the metallic state. This coating may be applied in the following manner.

Take a quantity of pulverized wood charcoal, and sift it pretty fine with a wire-cloth sieve. Then form a gum water, composed of 2 parts of gum arabic and 1 part of gum tragacanth, with 100 parts of water, and with this liquor make the charcoal powder into a thick dryish paste. Fill the crucibles with this paste, observing the precaution of introducing it into them in small successive quantities, so as to admit of its being more firmly rammed together into a solid, compact mass. Then reduce the crucibles and their contents to a state of thorough dryness, by keeping them in a warm situation for six or eight days.

It is not uncommon to diffuse a portion of clay through the gum water, with a view to increase the adhesion of the charcoal powder to the sides of the crucible. This practice ought not, however, to be imitated; for it is unnecessary, and will evidently cause a portion of clay to intermingle with the materials of the assay, so as to derange its composition and modify its results.

When the moisture is completely evaporated, a cavity for the reception of the assay-mixture is to be hollowed out in the centre of the carbonaceous mass, and of such a size that it shall be considerably larger than is strictly necessary for containing the mixture. A quantity of charcoal should be left to coat the sides of the crucible, not less than one-fourth of an inch in thickness, and as nearly as may be, of equal depth all around. Upon the bottom of the crucible, the charcoal should not be less than an inch in thickness. The cavity for receiving the assay should contain no angles or corners, and be well rounded off at the bottom; its interior should be smooth; and all the loosened charcoal must be carefully blown out before the assay is introduced.

When the crucible has been thus prepared, take 150 or 200 grains of the natural ore, or a proportionally smaller quantity of ore that has been previously calcined: let the ore and the flux be completely pulverized and thoroughly incorporated with each other; of course the weight of the flux which is employed in the assay must be ascertained with the same accuracy as the weight of the ore. Place the mixture in the cavity of the crucible, taking care to leave no detached portion of it sticking to any of the upper parts of the sides; because in that situation it would be left beyond the sphere of the scoria, and consequently, even although reduced, its metal would not be transmitted to the metallic button. Fill up the cavity to the top with charcoal powder, and then cover up the crucible with a well-adjusted lid; or, a similar crucible, somewhat smaller in size, may be inverted within it, instead of an ordinary flat lid. Then let all the joinings be accurately luted with fire-clay, leaving only a single small opening, for the purpose of furnishing a vent to the elastic fluids which are generated during the ignition.

The crucible, with its enclosed assay, is now ready for the furnace. It will be found advantageous to strew a little pounded glass over the seat on which the crucible rests within the furnace, in order that it may remain the more securely attached. It may be observed that, in most cases, for the sake of convenience, the assay furnace is made large enough to contain two or three crucibles at the same time. The fuel which is best fitted for the use of the assay furnace is coke, because it affords both the most equable and the most intense heat, and the crucibles should be kept completely buried in it during the whole process. It is proper to apply the fire at first in a very gradual manner, during the developement of the gaseous matter arising out of the decomposition of the gum, and the deoxidation of the ore, and therefore it should not be allowed to advance beyond a dull redness during the first half hour. By that time, the evolution of gaseous matter will have terminated, and the temperature may then be raised to its highest pitch, at which it should be permanently sustained for upwards of half an hour. The reduction will then be complete, so that the crucible may be withdrawn from the furnace. It should immediately be tapped, for several times, smartly against the floor, care being taken to preserve its perpendicular position, and this will have the effect of bringing down any globules of reduced iron which may not previously have descended to the metallic button. When this has been done, the crucible may be set aside till it cools.

When the flux is properly adjusted, the ordinary temperature of a good air furnace will be found sufficient for the reduction of the ore and the complete extrication of the reduced metal. In a pretty extensive series of assays conducted in a small portable furnace, in which no other fuel was employed than common pit-coal, a failure from deficiency of heat was rarely experienced, and in no instance where the flux had been adjusted to the ore with even very moderate accuracy.

If the assay has been successful, the original mixture of ore and flux will be found resolved into two separate bodies, the one consisting of metal, lying at the bottom of the crucible in the form of a flattened globule, and the other composed of all the unvolatilizable part of the earthy ingredients resting in a superincumbent mass above the metal, and termed the scoria. These bodies should be carefully separated from each other, and preserved for examination. The first step to be taken in this examination is an accurate determination of their respective weights. The upper surface of the scoria will frequently be observed to be studded with small globules or particles of iron. In order to separate these, let the whole be pulverized, then draw a small magnet repeatedly through the powder, which will gather up all the minute fragments of iron. The weight of these must of course be deducted from the total weight of the scoria, and added to that of the metallic button.

The assayist is now in a condition to fix some of the general results of his experiments. In the first place, the weight of the metallic button is in each case a direct measure of the amount of metal contained in the ore. In the second place, the weight of the flux, as originally introduced into the crucible deducted from the weight of the scoria, gives the amount of earthy matter contained in the portion of ore submitted to assay; and, in the third place, the sum of the weights of the metallic button and the scoria, deducted from the weight of the original mixture of ore and flux, will leave a quantity which measures the amount of volatilizable matter which has escaped during the operation of assaying. If the ore has been submitted to assay in its calcined state, this loss of weight in volatilizable matter will consist entirely of oxygen, which has been disengaged from the oxide of iron in the process of its reduction. But if the ore was not calcined previously to the assaying, this volatilized matter will, of course, consist of a mixture of oxygen and carbonic acid. It is obvious, however, that even in this instance the amount of oxygen which the oxide of iron loses during its reduction may be easily determined, by calcining a quantity of the crude ore *per se*, and deducting the loss of weight which it sustains in the calcination, from the gross weight of volatilizable matter which is separated from the ore in the process of assaying.

An examination of the scoria may now be made with much advantage, as its appearances will often be found to indicate in a pretty accurate manner both the nature and the relative proportions of the earthy substances contained by the ore.

If the scoria be found uncommonly transparent, and possessing most of the characters of a glass, such as brittleness, breaking into sharp-edged fragments and with a vitreous, conchoidal fracture, &c., it is certain that the assay has contained a superabundance of silica. Scoriæ thus constituted are always more or less deeply coloured, in consequence of the oxide of iron which the excess of silica holds in a state of combination.

If the scoria present the appearance of being completely melted, and has a vitreous and somewhat enamelly aspect; and if it is at the same time unusually free from colour, this is a proof that the lime has been adjusted in its due proportion to the other earthy ingredients of the assay. The colour by which such scoriæ are generally distinguished is a light shade of grey.

If the scoria be marked by a green colour, this indicates the presence of manganese. It is necessary to observe, however, that it would be unsafe to estimate the quantity of manganese solely from the degree of intensity of the green colour; for when the ignition in the assay furnace is violent and protracted, the oxide which the slag had originally held in solution undergoes reduction, and, coalescing with the iron, forms part of the metallic button.

But if, instead of obtaining the scoria fully and distinctly separated from the metallic product, the whole assay, on opening the crucible, be found to exhibit a scoriaceous mass, usually of a greyish or blackish colour, attractible strongly by the magnet, and containing particles of iron diffused throughout its entire substance, this result indicates, that although the oxide has been reduced in the furnace, yet some of the earths have been present to excess during the assay, and that the flux, either from its amount or its composition, has wanted the requisite degree of energy to liquefy the mass, and to unite the metallic particles into a button. Sometimes this product will present the appearance of having undergone a mere incipient fusion, and will be in the state of an incoherent and easily friable mass; or it may even have undergone a viscous semifusion, so as to be left in the shape of a solid opaque mass, very difficultly frangible, and breaking with a compact stony fracture.

Unfortunately, a scrutiny of the external characters of the metallic button cannot lead to any conclusions regarding the value of the metal to be obtained by smelting the ore, with the same degree of precision with which a similar investigation of the scoria indicates the nature of the earthy ingredients. The appearance and properties of the metallic product may be so much modified by a variety of circumstances, which may not only be extrinsic to the composition of the ore, but which cannot themselves be subjected to any certain rule, that it is always difficult to deduce from an examination of it any certain inference regarding the quality of the iron. Thus, the intensity and duration of the ignition, some apparently trivial modification of the nature of the fluxing material, or a change in the mode of cooling the crucible, will often produce remarkable differences in the nature and qualities of the metallic product. Indeed, in as far as the *metallic* ingredient of any ore is concerned, the *amount* of it seems almost the only property which can be certainly gathered from even the most careful assay. We may notice, however, a few of the most striking variations in the quality of the metallic button which will encounter the assayist in his experiments, and also, so far as possible, state the causes which produce them.

If the temperature of the assay furnace has been low, the metallic product never can present the appearance of black cast-iron, which is never produced without the application of an intense heat. Again, if the crucible be rapidly cooled, no matter from what intensity of heat, black cast-iron will not be formed; for even the most perfect specimen of this variety of carburetted iron may at once be converted into a body possessing all the external and physical characters of white cast-iron, by merely melting it, and cooling it suddenly. It is a singular fact, that by this simple variation in the mode of cooling, the same piece of metal, although it must obviously contain in either case the same quantity of carbon, will nevertheless have the most opposite properties communicated to it in colour, texture, and hardness. The white cast-iron is of a white colour, with a silvery aspect; it is excessively hard, and is composed of large crystalline laminæ irregularly superimposed upon each other. On the contrary, the black cast-iron is of a dark grey colour; it is soft, and exhibits a small crystalline or granular texture.

The flux may also exercise an equally remarkable influence over the properties of the metallic product of the assay.

Thus, if it happen to form along with the other ingredients of the ore a highly refractory compound, this will envelope the reduced particles of iron, and prevent them from becoming saturated with carbon. The metallic product, in such a case, has more resemblance to steel or malleable iron, than to cast-iron. In the same way, if the flux contain any compound from which carbon, at a high temperature precipitates a body that is capable of forming an alloy with iron, this circumstance will materially modify the metallic product of the assay. Among the most dangerous of these substances, are sulphur and the saline combinations in which it forms an ingredient, such as sulphate of soda, and sulphate of lime or gypsum, &c.; or phosphoric acid and its saline combinations, such as phosphate of soda, or phosphate of lime, which occurs in the earth of bones, in ivory black, or in animal charcoal. All of these ought to be most carefully excluded from the composition of the flux. The presence of any of them, even in a very minute degree, would infallibly contaminate the iron with sulphur or phosphorus, either of which is productive of the most injurious effects to the best properties of the metal. Indeed the use of borax in a flux is not altogether harmless in this respect, for it must cause the metal to be alloyed, to a certain extent, with boruret of iron.

Both sulphur and phosphorus possess in a remarkable degree, the power of augmenting the fusibility of iron. Both of them also are hostile to the formation of that state of the metal which is called black cast-iron. In this respect sulphur is a much more energetic agent than phosphorus. It not only seems to dispose the metal so strongly for fusion as to prevent it from remaining long enough in the higher and hotter part of the blast furnace, but also appears to destroy, to a certain extent, that peculiar state of combination between iron and carbon which constitutes black cast-iron. This latter fact seems to be established from the circumstance, that it is both extremely difficult to produce good black cast-iron from ores contaminated by pyrites, and that any piece of black cast-iron is readily converted into white by being fused along with a little sulphur. When metal that has been melted along with some sulphur is poured from the crucible, it consolidates almost instantaneously, in consequence of the lowness of the temperature which sufficed to produce liquefaction, and its colour also passes with more than the usual quickness to a dull red.

Every metallic oxide which is reducible in the temperature of the assay furnace, should be carefully rejected from the composition of the flux, as the reduced metal would inevitably form an alloy with the metallic button. The oxides against which it is chiefly necessary to be guarded, are those of manganese, copper, lead, and arsenic. In the assaying of iron-ores it is no uncommon practice to substitute pounded glass for silica; but, whenever this is done, it is necessary to avoid every species of glass whose composition is tainted with the oxides of manganese, arsenic, or lead.

With these precautions we are not aware that it is necessary to add any thing farther on the subject of the dry assay.

## § 2. *On the Humid Assay of Ironstones.*

We have now considered at some length the details of what seem to be the most advantageous methods of conducting the examination of an iron-ore by the *dry assay*. It has already been remarked that it is to this process that the metallurgist has by far the most frequent recourse when he wishes to prove an unknown ore. In convenience and dispatch it is so eminently preferable to the humid assay, that, although its results never can be relied on with the same degree of confidence, yet, as they are generally possessed of tolerable accuracy, it is very widely adopted in practice. By the dry method, if it has been judiciously followed out, a single operation enables the smelter to separate his ore into its two grand classes of constituent bodies, the earths on the one hand, and the metals on the other. He thereby obtains in miniature a pretty correct representation of the relative proportions in which the amount of metal and the amount of earth exist in the stratum of ore, and also of the general properties which the ore will be found to possess when treated in the smelting furnace.

In many cases, therefore, the dry assay is found to serve all the purposes of the practical metallurgist: but there are also many in which the humid assay or chemical analysis of the ore will be found highly useful, and some in which it is indispensable. The constitution of an ore can seldom be thoroughly explored by the dry assay. On the contrary, the conclusions at which the assayist arrives are of the most general nature. The number of the individual ingredients in the ore, the characteristic nature, and still more, the relative amount of each must always remain the subject of more or less doubtful conjecture. By the dry assay, the smelter possesses no test, to enable him to appreciate the true composition of a scoria, excepting its fusibility, and its external and physical characters. But as there are many earthy mixtures which, although very dissimilar in reality, are yet converted in the furnace into scoriæ which do not distinguishably differ from each other in any of the characters just mentioned, the assayist by fire, after all his resources are exhausted, may still be left in perplexity respecting the individual earthy constituents of his ore.

For these reasons the assay, *via humida*, is frequently indispensable, and, whenever sufficient time can be spared, it should be always resorted to, as affording, in every case, the most accurate and satisfactory exposition of the whole constitution of an ore. We shall therefore proceed to state in detail a general formula of analysis, *via humida*, by means of which the true nature and amount of the constituents of the mineral that is examined may be ascertained, even without employing any uncommon degree of caution, to within $\frac{1}{100}$th part of the whole mineral.

Take 100 grains* of the ore, either in powder or in small pieces not larger than a grain of wheat, and put it into a vessel of glass or platinum, containing a mixture of one ounce measure of concentrated muriatic acid, with two ounce measures of water. The mineral will immediately begin to pass into solution with effervescence. When the action in the cold appears to have terminated, digest the mixture upon a sand-bath, in a temperature scarcely exceeding 100°, for about four hours. It will now be found that, by this treatment, the whole of the metallic oxides and earths which existed in the

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* When it is the principal object of the analysis to determine the precise quantity of metal contained in the ore, and when the nature and amount of each of its extraneous ingredients are of minor importance, the assayist may obtain accurate results by operating with fifty or even with only twenty grains.

mineral in union with carbonic acid, have been dissolved. But the clay ingredient is scarcely changed in any respect, and remains mixed with the carbonaceous matter, in the form of a black-coloured powder. Let this insoluble portion be separated by a common paper filter, and then let it be thoroughly washed by repeated affusions of water. *

The liquid which passes through the filter contains all the oxide of iron which existed in the ore in a state of combination with carbonic acid; it may contain also lime, magnesia,

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* As some of my readers may probably have had very little practice in chemical manipulations, I trust that a few observations on the management of *filters* will not be deemed superfluous. After a precipitate has been collected upon a filter and dried, it cannot be again completely separated, because a certain quantity of it adheres so obstinately to the fibre of the paper, that it cannot be removed without bringing away with it a portion of the filter. Hence it would be impossible in this manner to determine the exact amount of a precipitate. The expedient usually resorted to for obviating this difficulty, is to weigh the filter beforehand: the increase of weight which it acquires in the process is held to indicate the weight of precipitate. But this method is liable to objection; for the weight of the filter is apt to be altered by the liquids filtrated through it. Besides this, unsized paper has a strong attraction for moisture, and the quantity of hygrometric water which it contains is constantly changing, according to the degree of humidity of the atmosphere: it is necessary, therefore, to take some peculiar precautions, in order to have the filter in exactly the same state of dryness both at the commencement and at the termination of the experiment. A much more accurate mode of filtering is to employ *two* filters. They ought to be in all particulars, such as thickness, fineness, size, &c. as nearly alike as possible; and they must be carefully counterpoised against one another on a balance, small portions being cut off from the heavier of the two, until they both possess exactly the same weight. One of these is then to be inserted *within* the other; and the precipitate is to be poured on this *double* filter, and washed in the usual manner. It is obvious, that whatever alteration one of these sustains in the course of the process, will in all probability be sustained by the other; and also, that, at the termination of the desiccation, the two filters will be in precisely the same state in regard to hygrometric humidity. The difference of weight between the inner and the outer filter will therefore indicate very accurately the weight of the precipitate. A very high degree of precision may be attained by this mode of manipulating.

When the precipitate requires to be heated to redness, its weight in the filter ought to be ascertained in the first instance; a determinate quantity of it is then to be ignited, and from the loss of weight which this sustains, it is easy to calculate the loss which would have been sustained had the whole been ignited.

and oxide of manganese, when these ingredients happen to be present in the ore in the form of carbonates. The solution has always more or less of a greenish tint, in consequence of the oxide of iron being chiefly in the state of black oxide. In the farther progress of the analysis, the first step to be taken is to convert the whole of this oxide into peroxide; without which, it would not be possible to make an accurate determination of its quantity, because the black oxide of iron cannot be collected in the form of a precipitate without its being partially converted, in the course of the operation, into the red oxide. This peroxidation may be conveniently effected by heating the solution nearly to a temperature of ebullition, and then gradually adding nitric acid, in small quantities, until the deep brown colour produced by the first portions of acid has disappeared, and is replaced by a clear reddish yellow. This is a proof that the metal is now entirely peroxidated.

Let this solution be diluted with water, and mixed with liquid caustic ammonia as long as a red-coloured precipitate continues to fall; and in doing this, some care should be taken to avoid adding an excess of ammonia. The precipitate thus produced consists solely of the peroxide of iron; for caustic ammonia does not precipitate lime from its solutions under any circumstances, nor does it readily precipitate magnesia or oxide of manganese, when their solutions contain a considerable excess of acid, even although it be added until the mixture acquires an alkaline reaction. The precipitate ought to be collected upon a filter, and thoroughly edulcorated; then it should be carefully dried, first in the open air between folds of common blotting paper, and afterwards in a moderate temperature, so as not to char the filter, between 200° and 250°; in fine, to complete the expulsion of the whole moisture, let the precipitate be exposed to a low red heat in a platinum crucible for about fifteen minutes. 100 parts of it, when thus freed from its water by ignition, represent 90 parts of protoxide of iron, and 145 parts of carbonate of protoxide of iron.* This

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* The ammonia is apt to attract carbonic acid from the atmosphere, and thus to acquire the property of decomposing solutions of lime. In consequence of this, it may be proper in all those cases in which it is of importance to determine the precise quantity of oxide of iron with extreme

oxide of iron generally contains a very small quantity of silica, but seldom or never any notable trace of alumina. Muriatic acid, assisted by heat, dissolves out the oxide of iron, and leaves behind the silica in the state of insoluble gelatinous flocks.

Should the presence of alumina be suspected, the oxide, previously to its desiccation, ought to be digested with some caustic potash or soda; and the earth may be subsequently precipitated by supersaturating the alkaline solution with an acid, and then decomposing it, in a boiling temperature, with an excess of carbonate of soda.

After having thus obtained the oxide of iron contained by the ore, the next step is to separate the lime which may also exist in it. It is necessary, for this purpose, that the alkaline liquid separated from the oxide of iron should be rendered exactly neutral: which may be done, either by adding to it dilute muriatic acid until it ceases to affect vegetable colours, or by supersaturating it slightly with the acid, evaporating to dryness, and redissolving the saline residue in water. Into this neutralized liquid pour a solution of oxalate of ammonia drop by drop so long as a precipitate continues to fall, and when this is done, set the mixture aside for six or eight hours, in a situation where it will be maintained at a temperature of about 100°. The whole of the lime will by that time be precipitated in the state of an oxalate. Let this be transferred upon a filter, washed and dried in a very gentle heat. 100 parts of it, dried in this manner, are equivalent to 38.36 parts of lime or to 68.49 parts of carbonate of lime. If this oxalate be cautiously calcined in a very low red heat, in a platinum crucible, it will be converted into pure carbonate of lime, 100 parts of which represent 56 parts of lime.

accuracy, to make the precipitation in a stoppered bottle, and to draw off the clear liquid with a syphon, after the oxide has had time to subside. The bottle should then be filled up with water, agitated, and set aside until the oxide has again subsided to the bottom, after which the liquid should be drawn off as before. In this manner the oxide should be washed several times, while it is kept from all access of the atmospheric air, until the greater portion of the soluble matter is separated. It may then, with sufficient safety, be collected upon a filter, and subjected to the treatment described above.

It is necessary to provide for that case, of very frequent occurrence, in which the liquid filtered from the oxalate of lime may contain magnesia and oxide of manganese. When this happens, let it be evaporated to dryness, then put the saline residue into a platinum crucible and calcine it in a temperature below a visible red heat, until the whole of the ammoniacal salts are expelled. It is necessary to do this, for unless these salts were previously got rid of, it would be impossible to effect a complete precipitation of the magnesia. Let the residue from the calcination be next dissolved in muriatic acid, and having neutralized the solution, either by evaporation or by the addition of an alkali, pour into it a few drops of hydrosulphuret of ammonia, in order to throw down the manganese. Calcination, under free access of the external air, converts this precipitate into an oxide of manganese, 100 parts of which are equivalent to 90 parts of protoxide, or to 145 parts of carbonate of protoxide of manganese. If it be inconvenient, from any cause, to calcine the precipitate, it may be dissolved in muriatic acid, and thrown down, at a boiling temperature, by carbonate of potash. This last precipitate will consist of carbonate of protoxide of manganese; 100 parts of which contain 62.07 parts of protoxide.

It now only remains to separate the magnesia. This will be effected most accurately by concentrating the solution from which the manganese had been precipitated by hydrosulphuret of ammonia, and then adding to it, while still nearly boiling, a slight excess of carbonate of potash, after which the mixture should be rapidly evaporated to dryness. On digesting the residue with water, the carbonate of magnesia will be obtained in a light pulverulent form. It may be collected upon a filter, washed, and dried; then let it be ignited strongly in a platinum crucible. The residue will consist of pure magnesia, 100 parts of which represent 210 parts of carbonate of magnesia.

It frequently happens that some of the magnesia either remains in the solution unprecipitated, or is redissolved from the filter by the edulcorating water. It will be necessary, therefore, to search for this portion also, when it is desired to determine the entire quantity of the earth with exactness. In this view, the liquid filtered from the carbonate of magnesia should be saturated with muriatic acid, then mixed with a little phosphate of soda and an excess of carbonate of ammonia, and next evaporated to dryness by the application of a very gentle heat. The whole of the magnesia combines, in this process, with phosphoric acid and ammonia, and forms with them a double subsalt; which, being insoluble or very nearly so, may be separated by treating the saline residue with water. By calcination in a low red heat, it is converted into neutral phosphate of magnesia, 100 parts of which contain about 35.7 parts of magnesia.

When the quantity of oxide of manganese contained by the ore is inconsiderable, it is a preferable system of manipulation to precipitate it along with the magnesia by carbonate of potash. Let the total weight of this mixed precipitate of magnesia and the oxide, after calcination, be determined: then redissolve it in muriatic acid, and precipitate the manganese in the usual manner by hydrosulphuret of ammonia. The weight of the oxide, deducted from that of the original precipitate, indicates accurately the quantity of the magnesia.

The portion of the ore which remains undissolved after digestion in muriatic acid is next to be examined: in general, it will be found to consist of a mixture of carbonaceous and earthy matter. To ascertain the quantity of the carbonaceous ingredient, the residue should be dried in a strong sand-bath heat, in a platinum crucible; then, after being weighed, it should be calcined under free access of the atmospheric air, until the whole of the combustible matter is burnt off. Its amount will of course be indicated by the loss of weight sustained in the calcination.

The residue is to be analyzed by the methods which are customarily employed in the examination of an earthy mineral. Thus, it may be decomposed by fusion in the furnace in a platinum crucible along with thrice its weight of dry carbonate of soda, the fused mass may then be dissolved in very dilute muriatic or nitric acid, the solution evaporated to dryness, and the residue digested in acidulated water, which will take up the earths in the state of saline combinations, while the silica will be left undissolved. Separate the solution from the silica by means of a filter, and mix it with a rather smaller quantity of carbonate of soda than would be necessary to precipitate the whole of its earthy contents; immediately afterwards digest it with a considerable excess of caustic potash or soda. The alkali will dissolve the alumina; but the lime and the magnesia, in the state of carbonates, and the iron and manganese, in that of oxides, will remain unacted upon. This mixture may be examined according to the rules which have been already laid down.

If the presence of any of those obnoxious ingredients, sulphur and phosphorus, be suspected in the ore, it will require a separate analysis to ascertain their respective quantities. Fortunately, however, the phosphorus, which is the most injurious constituent, is of rare occurrence; but it is otherwise with sulphur. This substance, whenever it is present in the ores, appears to exist in them in combination with iron, constituting iron pyrites. Its amount may be ascertained in the following manner. Into a small glass retort put 100 grains of the pulverized ore, and pour over it, in small quantities at a time, half an ounce measure of concentrated nitric acid. A receiver containing a small quantity of water should be attached to the beak of the retort, for the purpose of condensing any sulphuric acid which may be carried over with the evolved gases. A very violent effervescence will be produced by the first addition of acid, and there will be given off abundance both of carbonic acid gas and nitrous gas. When the whole acid has been gradually poured on, set the mixture aside for five or six hours, and agitate it occasionally: then add half an ounce measure of water, and 10 grains of nitre, in order to prevent any sulphuric acid from being volatilized, and digest this upon a sand-bath for a few hours. Throughout the whole process, the receiver, containing a little water, ought to be kept attached to the beak of the retort. The whole of the sulphur will now have become oxidized, and converted into sulphuric acid. Return the liquid contained by the receiver into the retort, then filter the clear solution from the insoluble portion, and by a very gradual addition of caustic ammonia, neutralize the excess of acid, as far as can be done without causing precipitation. A solution of nitrate of barytes, now poured into it will throw down the sulphuric acid in union with barytes. This precipitate is to be washed, dried, and ignited. 100 parts of it will prove equivalent to 13.56 parts of sulphur.

Phosphorus, on those rare occasions in which it exists in the ore, appears to be in the state of phosphoric acid, combined, probably, either with lime or with oxide of iron. In order to ascertain its amount, dissolve from 50 to 100 grains of the ore in nitric or muriatic acid, taking the necessary precautions to peroxidize the whole of the iron. Filter the clear liquid from the insoluble matter, and add a slight excess of ammonia to it. The oxide of iron which will, by this means, be precipitated, will carry down in combination with it the whole of the phosphoric acid. After this precipitate has been washed, mix it in a silver crucible, with a concentrated aqueous solution of twice or thrice its weight of caustic potash or soda, evaporate the mixture rapidly to dryness, and stir it constantly during the whole process to prevent any portion of it from being thrown out, after which, let the dry residue be ignited in a pretty strong red heat for half an hour. Digest the fused mass in water: the oxide of iron will remain untouched, but the phosphoric acid, now in combination with the alkali, will pass into solution. Neutralize the liquid with nitric acid, heat it, in order to expel all traces of carbonic acid, then render it alkaline by the addition of an excess of caustic ammonia, and lastly, pour in a solution of muriate or nitrate of lime. Phosphate of lime will fall down, in the form of a gelatinous precipitate: it may be collected upon a filter, washed, dried, and ignited. 100 parts of the phosphate, obtained in this manner, contain, according to Berzelius's analysis, about 48.4 parts of phosphoric acid.

The proportion of carbonic acid contained by any ore may be ascertained in an approximative manner by putting a determinate weight of it, (as, for example, 50 or 100 grains) previously broken down into fragments into a platinum crucible, and exposing it to a brisk red heat for fifteen minutes. The whole of the carbonic acid will be expelled by this treatment, and its amount will be represented by the loss of weight which the mineral sustains. When an ironstone is subjected to ignition, however, it is liable to undergo several other alterations in its composition besides the expulsion of carbonic acid. Thus if it contains any bituminous or coally matter, or iron pyrites, the volatilizable portion of these will be driven off by the heat. The small portion of water which the ore generally contains will also be expelled. All these circumstances tend to make the quantity of carbonic acid appear greater than it is in reality. On the other hand, it is necessary to remark, that these irregularities are counterbalanced to a certain extent by another decomposition which always takes place during the ignition of an ironstone, and whose tendency is to make the quantity of carbonic acid appear less than it is in reality. When the carbonate of protoxide of iron is ignited, a reaction always ensues between its constituents, the protoxide of iron, in consequence of its disposition to unite with an additional dose of oxygen, attracts that principle from a portion of the carbonic acid, reducing it to the state of carbonic oxide gas, and becoming itself converted partially into peroxide. This decomposition evidently introduces a double error into the results; for the ponderable matter that is abstracted from the carbonic acid is superadded to the oxide of iron. The decomposition of the carbonic acid, and the consequent peroxidation of the protoxide of iron take place to a much smaller extent in those cases where the ore is suddenly exposed to a pretty strong red heat, than in those where the ignition is brought on very gradually.

If it be desirable to ascertain by the most exact method, the amount of carbonic acid contained in any one ore, this is done by dissolving it in an acid. The process may be conducted in the following manner. Procure a globular-shaped glass bottle, having a cylindrical neck about an inch in length,* and adapt to it a stopper made by rolling up very loosely a bit of open textured woollen cloth, (flannel for example.) Fill the bottle half full with a dilute muriatic acid, prepared by mixing one part of the concentrated acid with one part and a half of water. The acid should be introduced by means of a small funnel, as it is of some consequence that the inside of the neck of the bottle should be kept quite dry. Then replace the

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* Any person accustomed to the management of a table-blowpipe, may easily form a bottle of this kind with a piece of barometer tube.

stopper, and counterpoise the bottle with its contents upon a balance. A determinate quantity of the ore (as from 50 to 100 grains) is next to be weighed out; it ought to be previously reduced to the form of small grains like coarse gunpowder, but none of it should be finely pulverized. Put a small portion of it into the bottle, then replace the stopper, and agitate the mixture occasionally. An effervescence will take place, occasioned by the disengagement of carbonic acid gas. The stopper will readily permit the escape of the gas, but will retain any particles of liquid which the gas may carry up with it mechanically. When solution is nearly accomplished, introduce an additional quantity of the ore into the bottle, and let this process of adding the ore in small successive portions be repeated, until the whole is used. When the solvent power of the acid begins to be weakened, towards the conclusion of the process, it may be assisted by heating the bottle very gently; the temperature must not exceed 90°, otherwise a portion of muriatic acid would be expelled along with the carbonic acid gas. When the action of the acid on the ore is completed, set the bottle aside for two hours, in order that it may recover the temperature of the atmosphere. Then remove the stopper, and having introduced into the bottle a narrow tube, draw out the carbonic acid gas that it contains, which will thus be replaced by atmospheric air. Nothing now remains except to place the bottle once more upon the balance, and ascertain the addition of weight which it has acquired. This increase indicates the weight of all the ingredients of the ore, with the exception of the carbonic acid; by subtracting it, therefore, from the original weight of the ore, the quantity of the carbonic acid may be ascertained.

By this method of analysis, the assayist may always be able to discover the true constitution of any of his iron-ores, and he will find that the result of his investigation determines, with extreme precision, the nature of each constituent of the mineral, and also its relative amount. When these are sufficiently known, he has only to attend to the affinities considered in page 255, in order to adapt the most appropriate flux to his ore, so that with the smallest expenditure of time and fuel, he may receive the largest return of metal for the furnace which the quality of the mineral is capable of yielding. Limestone is the only fluxing material which is in constant and systematic use with the iron smelter; but as the different specimens of this mineral vary extremely in the nature of their constituent parts, it may often be a matter of much moment for him to be able to make a correct assay of the composition of all those which are situated conveniently within his reach. For if he be in the dark regarding their true constitution, he may know well enough the sort of flux which his ore requires, and believe that he exhibits this in the furnace, at the same time that his ignorance of its composition may cause him to offer a different material from that which he intends to use. In order to ascertain the constituent parts of a limestone, nothing more is required than to follow out an analysis of precisely the same nature with that which has just been described for ores of iron. This arises from the circumstance, that limestones are of a composition extremely analogous to that of the argillaceous carbonates of iron. It is only necessary to remark, that even in those cases in which the amount of iron which is present in a limestone may be very inconsiderable, it is still advantageous to precipitate it with ammonia in the state of peroxide, before any of the other ingredients are separated. As solvents act more easily upon limestones than upon the iron-ores, the muriatic acid which is employed to dissolve the former should be diluted with at least thrice its volume of water.

Before leaving this subject, we are desirous of shortly adverting to the mode of analyzing another very important material which the smelter is obliged to employ in large quantities, we mean coal. The composition of this mineral varies so much in different strata, that it very much concerns his interest to be able in all cases to appreciate what proportion of a coal is combustible, and what proportion of it consists of earthy ingredients, and also what is the composition of these earthy ingredients.

In order to determine the first of these points, the amount of combustible matter contained in any coal, the following process will be found convenient and satisfactory. Reduce the coal to a very fine powder, and weigh out a determinate quantity of it, (say from forty to fifty grains.) Put about six or eight grains of this into a small shallow platinum capsule, and ignite them over the flame of a spirit lamp. As long as any smoke continues to be evolved, the heat must be applied with extreme caution, and the powder must be incessantly stirred. When all the bituminous portion of the coal has been volatilized, the temperature ought to be raised as high as possible; and in order to maintain it at this pitch, the lid of a platinum crucible may be placed over the capsule, so as to reflect the heat back upon the powder. At the end of about ten minutes, the whole of the carbonaceous matter will be consumed: an addition of six or eight new grains of the powdered coal is now therefore to be put into the capsule, and after having been mixed up with the earthy matter already formed, it is to be burnt with the same precautions as in the first calcination. Let this process be repeated several times in succession, until it appears that a sufficient quantity of the earthy residue has been obtained; after which, the weight of this residue deducted from the total weight of the original coal, will give the relative proportions of combustible and incombustible matter in the coal.

We have directed that the heat should always be applied very gradually at the commencement of the ignition. If the opposite course be followed, the smoke which is given off will speedily catch fire, and the pounded coal will be converted at the same time into a hard, spongy mass, with a semifused aspect, resembling coke. In this state, it is excessively incombustible; and indeed it would be found almost impossible to burn it over a spirit lamp, without pulverizing it anew. The intermixture of earthy matter with the pounded coal, which, of course, always takes place after the calcination of the first portion, has the beneficial effect of diminishing this tendency to concretion, and it also accelerates the combustion.

Upon examining the incombustible residue, which consists of the earthy ingredients of the coal, as there is frequently some sulphate of lime in it, this substance, which possesses a slight degree of solubility, may be dissolved out by boiling the ashes in distilled water; the clear liquid must then be separated and evaporated to dryness, and the weight of the residue ascertained. To determine the constituents of the portion which remains insoluble in water, the same method of analysis should be followed, which has been already recommended for examining the clay portion of the iron-ores.

The presence of sulphur in any coal, and its amount may be investigated according to the same process which is resorted to for determining the amount of that substance when it occurs in an ironstone.

We have now considered in detail both the processes of the dry and the humid assay. But we cannot conclude without again repeating that the humid assay is the only one which can be relied on with safety for the accuracy of its results. The mode by which this assay may be conducted, as stated on page 272, requires so little scientific skill, and so little nicety of manipulation, at the same time that it affords a very excellent analysis of the mineral, that we have no hesitation in strenuously recommending its adoption in every case where the smelter can afford the necessary delay. It is hardly necessary to add, that when we reflect upon the very large proportion of the charge in every smelting furnace, which is composed of limestone and of coal, it is of little less importance to examine the constitution of these minerals, than it is to analyze the ore itself.

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## ART. IX.—*On the Natural History and Properties of Tabasheer, the Siliceous concretion in the Bamboo.* By DAVID BREWSTER, LL.D., F. R. S. Lond., and Sec. R. S. Edin.

THERE is certainly no substance either in the vegetable or the mineral world so remarkable as Tabasheer. Its locality in the joints of the bamboo;—its derivation from the juices of that reed;—its occurrence only in particular situations and particular plants;—its chemical composition;—and its optical and physical properties, render it an object of very peculiar interest to the botanical as well as to the natural philosopher.

In the *Philosophical Transactions* for 1819, I have given an account of the optical and general physical properties of tabasheer, as determined from specimens which my late and respected friend Dr Kennedy procured for me from India. Since that time, I have the good fortune to obtain the finest collection of specimens that has ever been transmitted to Europe. I have received large portions of all the varieties that have yet been found, from the fine opalescent and transparent pieces, to the most opaque and coarse masses; and I have had the satisfaction of taking the specimens with my own hands from joints of the bamboo, that were sent unopened. This collection I owe to George Swinton, Esq., Secretary to the Government at Calcutta, whose liberality and unwearied ardour in the cause of science and the arts is well known to all the public institutions of his native country.

Along with these specimens, Mr Swinton has sent me also the following observations on Tabasheer, collected from the Sanscrit works on Medicine, by Dr Wilson, the learned secretary of the Asiatic Society of Calcutta.

" Bamboo-manna" (says Dr Wilson) " is known in the Materia Medica of the Hindus by a variety of appellations, implying simply its being the produce of the bamboo, or denominating it from some of its sensible properties, the *milk*, *sugar*, or *camphor* of bamboos. The name in ordinary use is *Bansa-rochunu*. The ornament of the bamboo, corrupted in the vernacular dialect to *Bunslochan*. The name in use amongst the Mahommedans of India is *Tabasheer*, an Arabic word, explained by Meninski, *liquor, specie sacchari concretus in arundine Indica majore, et quasi petrefactus; in India, saccar Bambu* (sugar of the Bamboo,) *dicitur, pro quo cineres nodorum aut radicum vulgo distrahi solent.*

" According to the Sanscrit works on medicine, such as the Bhava Prakas and Raja Nighant, the bunslochun is slightly austere, astringent, and sweetish to the taste. It possesses cooling and demulcent properties, allays thirst and fever, and relieves cough and difficult breathing. It sweetens the humours, and is serviceable in jaundice and leprosy. Its chief virtues, however, and those for which it is mostly esteemed, are supposed to be of a restorative nature, and it is highly apprized as an aphrodisiac.

" In the markets of Calcutta it is found in three states. The best is termed *Patnai*, being brought from Patna, and is in small compact pieces of a milky-white colour, having the lustre of enamel, and being semitransparent. It is termed *Nil-*

*kunthi*, from its bluish tinge, and *Paharika*, from its being brought from the *Pahar*, or hills to the westward of Behar. The second sort is of a dead white colour, without lustre or transparency, and much more friable than the preceding. It is termed *Chheluta*, the Bengali corruption of Sylhet apparently, whence it is well known that this substance is procured. The third and worst kind is termed *Desi* or country; it is white, with a yellowish tinge, less friable than the second sort, but without lustre or transparency. The last is said to be soluble in water; the two first are not. An artificial bunslochun is also manufactured from chalk.

" The following information respecting the Puharia or hill tabasheer, has been received from Captain Playfair, residing at Hazareebagh.

" Bunslochun is found at Zelda, Boondoo, sixty miles from Huzareebagh, at Luka Kole, 100 miles from thence, at Palamow and at Nagpore.

" It is found in the small hill bamboo. In a clump of fifty or sixty, only five or six contain the substance.

" From each bamboo one or two rutties (four or five grains) are usually obtainable. It very rarely happens that four anas (from forty to fifty grains,) are procured.

" It is found in the same bamboo of different qualities. The best sort is of a bluish white colour and glossy surface. An inferior kind is of a chalky white without lustre, and the worst sort is brown and even black.

" The raw material is sold at ten rupees a seer; but it is prepared for use, and in that state sells from forty to fifty rupees per seer.

" The only preparation, however, is its imperfect calcination.

" A quantity is placed in an open vessel of baked clay upon a fire of charcoal, which is urged with bellows till the vessel and its contents become of a red heat. The manna first becomes black, but when raised to a red heat, emits a fine diffusible aroma.

" It is kept red hot for some time, occasionally stirred with an iron spoon, and sometimes another vessel is inverted over that in which it is contained. The fire is then allowed to subside, and as it cools the bunslochun resumes its white colour.

"An ounce and a half, treated in this manner, was reduced to an ounce. The process lasted three quarters of an hour.

"The substance is sent to market in this state, and is taken in powder as a tonic, or chewed with betel, with a view to renovate the constitution."

From these observations of Dr Wilson, I shall now proceed to give an account of those which I have made upon Tabasheer, including in a very brief form such as I have already published.

As tabasheer is found only in a small number of bamboos, we cannot regard it as a secretion from the plant in a healthy state. An intelligent native of Vizagapatam, who had inspected several hundred bamboos, observed, that in every joint which contained the tabasheer there was a small perforation evidently made by an insect; and he conceives that the exterior juices of the plant find their way through this opening, and drying up form tabasheer. This observation, however, is by no means correct. I have found tabasheer in many joints where there was no perforation; and as the perforations are never lined with the siliceous matter, and have no accumulation of tabasheer at either end, they can have performed no part either in secreting or conveying the juices of the reed.

An examination of the joint or internode of the bamboo will probably lead us to a more satisfactory explanation. The culm or stalk of the bamboo represented in Plate IV. Fig. 2, by MN, consists of a number of concentric rings. The outer rings, AC, BH, shown in section, are continued through the length of the reed, notwithstanding the little annular protuberance which marks externally the place of the internode AB. The inner rings, DE, GF, however, the innermost of which is a delicate membrane, do not pass onwards, but are interrupted by the internode, and turning round at EF, they form the roof of the cavity DEFG, joining the similar membrane on the side FG. Between AE and FB, where the concentric rings diverge, the space left between them is filled up with a soft spongy mass, which forms the substance of the internode AB. As the sap ascends between AC and ED, it must be stopped partially at the internode between A and E, part of it passing A, and part of it being either absorbed by the spongy mass between AE, and remaining there, or passing through it to the opposite side of the stem.

But, however this may be, the juices of the plant are collected at the internode, and could not possibly penetrate into the inner tube while the inner ring and membrane are sound, as in the healthy plant. When this membrane, however, is destroyed or rent by disease, or when the whole internode is in a state of malconformation, as I have found it, the juice or milk at the joints is immediately extravasated, lines the roof EF, or the bottom DG of the inner tube, and forms tabasheer by its subsequent induration.

The quantity of tabasheer, therefore, does not depend on the size of the reed, but upon the diseased state of its joints; and it will be seen from those upon the table, that the greatest quantity is in one where the internode is completely disorganized. Captain Playfair has mentioned four or five grains as the usual quantity. In the bamboo now alluded to the quantity is fully twenty grains.

By the cutting down and transporting of the bamboo, the tabasheer encrusted upon the roof or bottom of the cavity is detached, and is always found in separate pieces of different sizes. Its existence in any individual bamboo may therefore be known by the rattling noise which takes place by shaking the reed. A portion of it, however, often adheres to the place of its formation, and we may sometimes detect it in the pores of the spongy mass from which it has exuded. The largest pieces of tabasheer are generally impressed with the inner membrane of the reed upon which it has been formed.

In opening different bamboos, the included tabasheer presents various appearances. When the tube has been perforated with holes, it has a brown and dirty aspect, arising no doubt from the admission of dust; and the perforating insects are often found among the fragments. When there are no perforations, the tabasheer is clean and pure, presenting a great variety of aspects, depending no doubt on the nature of the juices, on the manner in which they have been extravasated, and on the time in which their induration has been effected. The different varieties of tabasheer may be thus enumerated.

1. The finest variety, which is also the rarest, is of a delicate azure blue colour by reflected light, and of a faint yellow-

ish hue by transmitted light. It is easily crushed between the fingers, and it has an aërial and unsubstantial texture which we look for in vain in any other solid. It has its counterpart in the mineral kingdom in some of the finer semiopals, which approach to the precious varieties.

2. Another variety of tabasheer reflects a yellow tint like that of molybdate of lead, and transmits a light of a reddish yellow tinge. It resembles greatly some of the yellow semiopals.

3. A third variety is nearly white, with a slight tinge of blue, and is translucent at the edge like cacholong.

4. A fourth variety resembles chalk, and is perfectly opaque.

Although these are the forms in which tabasheer generally occurs, yet several peculiarities of structure present themselves in the examination of numerous specimens. In some I have observed a layer exactly like jasper, and in one specimen the surface is covered with a brilliant enamel possessing all the lustre of pure quartz.

The chemical composition of tabasheer is still involved in some uncertainty. That which Dr Russell brought from India in 1790, and which is similar to what is now on the table, consisted, according to Mr Smithson, of *pure silex;* but Fourcroy and Vauquelin, having examined a portion of what Baron Humboldt brought from South America in 1804, found it to consist of seventy parts of silex and thirty of potash.*

When we plunge any of the varieties of tabasheer in water, an effervescence takes place, owing to the rapid escape of air from its pores; and when this has ceased, the transparent and translucent varieties have their transparency and translucency greatly increased, but the chalky kind retains its opacity The quantity of water imbibed by the tabasheer exceeds in weight the tabasheer itself, and the space occupied by the pores is to that occupied by the solid particles nearly as 2½ to 1.

The chalky tabasheer which does not become transparent by the absorption either of oil of cassia or water, readily imbibes the fat oils, and with oil of beech-nut it becomes as transparent as glass, but it requires a considerable time to dis-

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* An analysis of Tabasheer by Dr Turner will be found in a subsequent article of this Number.

place the air from its pores. These results are perfectly analogous to those which we obtain with hydrophanous opal, and I have also succeeded in giving transparency to the chalky silex from the Giant's Causeway, by long immersion in oil of beech-nut.

If, instead of immersing the tabasheer in water, we place a small drop upon the most transparent variety, the drop is instantly absorbed, but the spot which it occupies becomes as white and opaque as if it had been covered with white lead. This extraordinary property, which is not possessed by any of the siliceous minerals, will be explained when we have treated of the optical properties of this substance.

The opaque tabasheer which has become transparent by absorbing oil exhibits a very curious phenomenon by change of temperature. If it is laid upon a piece of cold lead, it becomes suddenly opaque, and if it is restored to a warmer situation, its transparency as suddenly returns. These effects obviously arise from the great expansion and contraction of oil by heat. When the oil retreats from the surface of the specimen, the mutual attraction of its own particles accumulates them in one place, instead of permitting them to remain in a state of contraction in separate pores, as might have been expected. When the greater part of the oil has been expelled from these specimens by heat, the tabasheer exhibits a beautiful veined structure, the veins being sometimes parallel, as in the onyx, and sometimes curved, as in the agate. This effect arises from the different degrees of porosity in the different veins, in virtue of which some of them absorb more oil than others. The limits of each vein are thus rendered visible in the very same manner as the veins of burned chalcedony, which has absorbed oil from the lapidary's wheel, may be displayed in all their beautiful inflexions, although in its natural and transparent state it did not exhibit the slightest trace of such a structure. It is from the same property of some of the amorphous siliceous minerals that the lapidary is able to develope, and to colour, the veins of particular agates, and that the artist can execute the finest drawings, which actually lie beneath the surface of certain porous specimens of chalcedony.

The absorptive power of tabasheer is not confined to fluids. It draws into its pores solid bodies in a minute state of subdivision. If we wrap a piece of it in a bit of paper, and burn the paper, the tabasheer will come out of it of a glossy black colour, transmitting only red light like a piece of smoked glass. By repeating this operation twice or thrice it becomes so deeply black as not to admit a ray of the meridian sun. By exposing the specimen to a white heat the black matter is discharged, and the tabasheer is restored to its former appearances and properties. When the blackened tabasheer is plunged in water it disengages the included air, but with less rapidity than before, because there is less air to disengage; and when it is broken and pounded its fracture and its powder are black. If the black matter has not insinuated itself copiously into the heart of the specimen, this portion is of a bluish slate-colour. When slightly wetted in this place it becomes *white*, and when saturated with water it becomes *jet black*. This, however, is an illusion; for though it does appear absolutely black, yet it is in reality made translucent by the absorption of the water. This translucency allows the white light which the nucleus formerly reflected to pass on to the black coating, where it is absorbed,—an effect analogous to what takes place in a black inkstand, in which it is impossible to distinguish ink from water by looking at the surface of the fluid.*

One of the most remarkable properties of tabasheer is its low refractive power, which is lower than that of any other body, whether solid or fluid, as will be seen from the following table:

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* It is on the same principle that the false gems called *Doublets* form such admirable imitations of the precious stones. No light is allowed to reach the eye except that which is reflected from, or transmitted through an interposed coloured film; and hence we think that we are viewing the finest gem when we are only looking through a piece of glass. Having had occasion to examine a number of emeralds, which a skilful jeweller put into my hands, he pointed out one superior to all the rest; but upon exposing it to polarized light I found it to be a doublet. It is owing to the same cause that *octohedrite* appears almost *black* when lying upon its matrix. Its refractive power, which is equal to that of diamond, bends the incident light so much that it cannot escape from the opposite face of the prism: But when the light falls upon a parallel plate of the mineral, its transparency immediately appears.

| | | | |
|---|---|---|---|
| Air, | 1.000 | Flint glass, | 1.600 |
| Tabasheer, | 1.111 | Oil of cassia, | 1.641 |
| Water, | 1.336 | Diamond, | 2.470 |

Hence it appears that the refractive power of tabasheer is actually nearer that of air than that of water. The index of refraction given above is the lowest that I have obtained; but specimens of greater specific gravity have higher refractive powers, as will be seen from the following measures:

| | | | |
|---|---|---|---|
| Tabasheer, | 1.1114 | Tabasheer, | 1.1503 |
| do. | 1.1145 | do. | 1.1535 |
| do. | 1.1292 | do. | 1.1825 |
| do. | 1.1454 | | |

The specimen of tabasheer which I have described as covered with a brilliant enamel, possesses great hardness; and from the measure which I have taken of its angle of maximum polarization, I have no doubt that its refractive power approaches to that of the semiopals.

The determination of the low refractive power of tabasheer enables us to give a satisfactory explanation of the curious fact already mentioned, that a small drop of water produces white opacity, while a greater quantity renders it perfectly transparent.

If ABC, Plate IV. Fig. 3, is a prism or piece of tabasheer, we may suppose one of its pores, highly magnified, to be represented by $a\ b\ c\ d$. This space is filled with air, and when a ray of light MN, enters the separating surface AB at $e$, and quits it at $h$, it suffers so little refraction, that the tabasheer allows us to see objects distinctly through it. Let us now suppose that a small quantity of water is introduced into the pore $a\ b\ c\ d$, so as not to fill it, but merely to line its circumference with a film which terminates at $\alpha\ \beta\ \gamma\ \delta$. Then the light which passes from water into air at $f$, and again from air into water at $g$, will suffer a comparatively great refraction, and will be considerably scattered in all directions. Hence the tabasheer must appear opaque. If we now saturate it with water, so as to fill the pore $a\ b\ c\ d$, the refractions at $f$ and $g$ are removed, and the ray $e\,f$ will pass on to $h$ unobstructed, so as to experience no change of direction, except the small one which takes place at $e$ and $h$, where it enters and quits the fluid.

Before concluding these observations, it may be expected that I should attempt to answer a question which every person must have put to himself. Whence comes the silex which circulates so abundantly in the juices of the bamboo? If we consult on this subject our best systematic writers on chemistry and botany, we shall find it ranked as a "foreign ingredient," an intruding element which the plant had derived from the peculiar soil in which it vegetated. Those who examined the drawings and descriptions of the distribution of silex in the *Equisetum hiemale*, which I submitted to the Society some years ago, will concur with me in the opposite opinion, that the silex is an integral portion of the plant itself, and probably performs some important function in the processes of vegetable life.

## ART. X.—*On a new Acid of Selenium.*[*] By M. E. MITSCHERLICH, Professor of Chemistry in the University of Berlin, F. R. S. Ed. &c. &c.

THE existence of this very interesting compound, which we noticed briefly in a former number of this Journal, was originally observed by M. Nitzsch, who has long assisted M. Mitscherlich both in preparing for his lectures and in conducting his researches. M. Nitzsch, in order to prepare a seleniate of potash, decomposed the seleniuret of lead by fusion with nitre, dissolved the resulting seleniate of potash in water, evaporated the solution to dryness, and heated the residue with sal-ammoniac. As it was necessary to employ an excess of nitre, he endeavoured to separate that salt from the seleniate of potash by crystallization. After the separation of the greater part of the nitre, he obtained crystals which had the following characters. They had the form of sulphate of potash, and were analogous to that salt in relation to polarized light. They formed a neutral solution with water, were free from water of crystallization, deflagrated like nitre with red-hot charcoal, yielded an insoluble precipitate with the salts of baryta, gave rise to an evolution of chlorine when boiled with muriatic acid, and underwent no change by the action of sulphurous acid. After

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[*] Abstract from the *Annales de Chimie et de Physique*, xxxv. 100.

being heated with muriatic acid, the solution yielded a precipitate of selenium with sulphurous acid, and likewise retained its transparency when mixed with a salt of baryta. From these characters it results, that the crystals were a compound of potash and a new acid of selenium, isomorphous with sulphuric acid. As the new acid contains more oxygen than that discovered by Berzelius, it must be called *selenic acid*, while to the latter the term *selenious acid* is appropriate.

*Preparation of the new Acid.*—This acid is easily formed by fusing the nitrate of potash or soda with selenium, selenious acid, a metallic seleniuret, or a selenite. The seleniuret of lead, as the most common ore of selenium, is preferred; but it is very difficult to obtain pure selenic acid by means of this mineral, because it is generally associated with metallic sulphurets. The ore is first treated with muriatic acid to remove the carbonates; and the residue, which is about a third of the mass, is mixed with its own weight of the nitrate of soda, and thrown by successive portions into a red-hot crucible. The lead is thus oxidized, and the selenium converted into selenic acid, which unites with the soda. The fused mass is then treated with boiling water, which dissolves only the seleniate of soda, and the nitrate and nitrite of soda; while the insoluble matter, when well washed, is quite free from selenium. The solution is quickly made to boil. During the ebullition, anhydrous seleniate of soda is deposited, while, as the liquid cools, nitrate of soda crystallizes. On renewing the boiling and subsequent cooling, fresh portions of the seleniate and nitrate of soda are procured; and these successive operations are repeated until the seleniate of soda is entirely separated. This process is founded on the fact, that the seleniate of soda, like the sulphate of that base, is more soluble in water of about 91° Fahr. than at higher or lower temperatures. The nitrite of soda, formed during the fusion, is converted into the nitrate by means of nitric acid.

The seleniate of soda thus procured always contains a little sulphuric acid, derived from the metallic sulphurets of the ore; and it is not possible to separate this acid by crystallization. All the attempts to separate it by means of baryta were likewise fruitless; and the only method of effecting this object is by reducing the selenic acid into selenium. This is done by heating a mixture of the seleniate of soda and sal-ammoniac, when mutual decomposition ensues, and selenium, nitrogen, and water are evolved. The selenium thus obtained is quite free from sulphur. It is then dissolved in an excess of nitric acid, and any trace of sulphuric acid may be detected and removed by muriate of baryta, which, however, does not render it turbid. The acid solution is then neutralized by carbonate of soda, the selenite of soda converted into the seleniate by fusion with nitre in a crucible of porcelain, and the nitrate of soda removed by crystallization in the manner above described. The pure seleniate is dissolved in water, and obtained in crystals by spontaneous evaporation.

To procure the acid in a free state, the seleniate of soda is decomposed by the nitrate of lead. The seleniate of lead, which is as insoluble as the sulphate, after being well washed, is treated by a current of sulphuretted hydrogen gas, which does not decompose selenic acid. The excess of sulphuretted hydrogen is driven off by heat, and pure selenic acid remains diluted with water. The absence of fixed substances may be proved by its being volatilized by heat without residue; and if free from sulphuric acid, it gives no precipitate with the muriate of baryta after being boiled with muriatic acid. Any nitric acid which may be present is expelled by concentrating the solution.

*Composition of Selenic Acid and the Seleniates.*—Since the neutral salts of selenic acid are isomorphous with the sulphates, the composition of selenic acid and seleniates may be expected to obey the laws of isomorphism. Consequently, selenic acid should contain one-half more oxygen than selenious acid for the same quantity of selenium; and the oxygen contained in the base of the seleniates ought to be a third of the oxygen of the acid. Experiment fully confirms this supposition.

Of fused seleniate of potash, 2.6545 yielded 1.7655 of the chloride of potassium, equivalent to 1.117 of potash, and 3.3435 of the seleniate of baryta, indicating 1.5315 of selenic acid; because 1.812 of baryta is equivalent to 1.117 of potash. Accordingly, 100 parts of the seleniate of potash consist of

| | | | |
|---|---|---|---|
| Potash, | 42.16 | of which the oxygen is | = 7.15 |
| Selenic acid, | 57.84 | do. | = 21.79 |

The composition of selenic acid was ascertained by means of the seleniate of soda. The fused salt was boiled so long with muriatic acid, that on adding muriate of baryta no cloudiness ensued, a circumstance which proved both the absence of sulphuric acid, and the decomposition of all the selenic acid. After separating the baryta by sulphuric acid, the selenious acid was decomposed by means of the sulphite of soda; and 4.880 of the seleniate of soda thus yielded 2.020 of pure selenium. But since, according to the foregoing analysis, 100 parts of selenic acid, saturate 72.89 of potash, or 48.30 of soda, it follows that 4.880 of seleniate of soda must contain 3.29 of selenic acid. This acid must therefore be composed of 61.40 parts of selenium, and 38.60 of oxygen.

According to Berzelius, selenious acid is formed of 100 parts of selenium, and 40.33 of oxygen. Consequently, if the oxygen in selenic and selenious acids is in the ratio of 3 to 2, the former should be composed of 100 parts of selenium, and 60.495 of oxygen, or should contain 37.68 per cent. of oxygen. It appears from the numbers procured by this calculation, that the quantity of selenium, as obtained by analysis, is somewhat too small. This is owing to the loss of a similar quantity of that principle. To effect the entire decomposition of the seleniate of soda, it is necessary to boil it several times with muriatic acid, and during this operation a little selenious acid is volatilized. The precise composition of the selenic acid is best ascertained by the analysis of the seleniates, in which case the quantity of oxygen in the acid is inferred from that of the base.

According to the analysis of the seleniate of potash, the seleniates are so constituted that 100 parts of the acid saturate a quantity of base which contains 12.56 of oxygen.

*Properties of the Selenic Acid.*—This acid is a colourless liquid, which may be heated to 280° C. without appreciable decomposition; but above that point the decomposition commences, and it becomes rapid at 290° C. giving rise to oxygen and selenious acid. Heated to 165° C. its density is 2.524; at 267° it is 2.60, and at 285° it is 2.625, but a little selenious acid is then present. Obtained by the process above-mentioned, selenic acid always contains water, but it is very difficult to ascertain its precise proportion. Some acid which had been heated higher than 280° C, subtracting the quantity of selenious acid present, contained 84.21 of selenic acid, and 15.75 of water. If the oxygen in the water was to that in the acid as 1 to 3, the solution should contain 12.38 per cent. of water. It is certain that selenic acid is decomposed by heat before parting with all the water which it contained; and the composition of the solution at 280 C. is analogous to that of sulphuric acid which has been heated to 326.°

Selenic acid has a powerful affinity for water, and emits as much heat in uniting with it as sulphuric acid does. Like sulphuric acid it is not decomposed by sulphuretted hydrogen, and therefore this gas may be employed for decomposing the seleniate of lead or copper. With muriatic acid the change is peculiar; for on boiling the mixture chlorine is disengaged, and selenious acid is generated, so that the solution is capable of dissolving gold or platinum like *aqua regia.* Selenic acid dissolves zinc and iron with disengagement of hydrogen, and copper with formation of selenious acid. It dissolves gold also, but not platinum. Sulphurous acid has no action on selenic acid, whereas selenious acid is easily reduced by it. Consequently, when it is wished to precipitate selenium from selenic acid, it must be boiled with muriatic acid before sulphurous acid is added.

Selenic acid, in its affinity for alkaline bases, is little inferior to sulphuric acid; so much so, indeed, that the seleniate of baryta cannot be completely decomposed by sulphuric acid. It is therefore a very powerful acid. As its compounds are isomorphous with those of sulphuric acid, and possess both the same crystalline forms, and similar chemical properties, the history of the sulphates, with a few slight but very interesting modifications, is the same as that of the sulphates.

The great number of crystallized compounds which this acid produces, the different forms which they assume at different temperatures, the beauty of the crystals admitting of precise measurement, and the isomorphism of the seleniates with the sulphates, which with some chromates have supplied the most important facts towards that theory, induce M. Mitscherlich to collect in an essay, that will be published in a few months, the crystalline forms of the sulphates, seleniates, and chromates.

### Art. XI.—*Summary for the year* 1827 *of the state of the Barometer, Thermometer, &c. in Kendal.* By Mr Samuel Marshall. Communicated by the Author.

In comparing the following summary with that for 1826, it appears that the barometer has not reached the altitude which it then attained, 30.78; and the mean height for the year is one-tenth of an inch less. The heat of the summer months has not equalled that of 1826, the greatest being 74°, and the mean 48.°03, whilst in 1826 the maximum was 85°, and the mean 47.°81. The superior mean temperature for 1827 may be accounted for by the weather's being more uniformly mild. From 26th of April to 21st of November (or a period of nearly seven months) the thermometer was never so low as the freezing point, and from the former date to the end of the year, there have been but eleven days of frost. We have had thirty-two wet days more in this year than in 1826, and the quantity of rain is greater by 14.926 inches. The writer of these remarks has carefully registered observations on the weather in this town for upwards of five years. He subjoins a summary from 1823 to 1827, both years included. From observations made by the late John Gough, and by John Dalton of Manchester, he inferred the mean annual quantity of rain for Kendal to be 51.8 inches. The average for the five years alluded to will be found to be 57.310 inches. The difference may arise from two causes; one, the difference of altitude in the places where the observations were made above the level of the sea; but though that does not exceed many yards, yet even so small a difference will affect the amount of the mean in a series of years. The observations from which the former *mean* was calculated were taken from twenty different years, though not twenty successive years. Assuming all the observations to be equally correct, the mean deduced from the twenty years is most likely to be the correct one. There are few places where rain-gages are kept that have so great a quantity of rain as at Kendal, though it it is probable that in many places there are more rainy days within the same period. From a number of observations now in my possession, the annual mean quantity of rain which falls in England may be stated at 35.2 inches.

| Years. | Mean of Barometer. | Mean of Thermometer. | Inches of Rain. | No of Rainy Days. | Prevalent Wind. |
|---|---|---|---|---|---|
| 1822, | | | 62.726 | | |
| 1823, | 29.56 | 45.°00 | 62.749 | 198 | |
| 1824, | 29.76 | 46. 88 | 62.762 | 187 | S. W. |
| 1825, | 29.64 | 47. 49 | 59.973 | 169 | S. W. |
| 1826, | 29.73 | 47. 81 | 43.060 | 147 | S. W. |
| 1827, | 29.63 | 48. 03 | 58.006 | 179 | S. W. |
| Means, | 29.66 | 47. 04 | 57.310 | 176 | S. W. |

*Summary for the year* 1827 *of the State of the Barometer, &c. in Kendal.*

| 1827. | Barometer. | | | Thermometer. | | | Quantity of Rain in Inches. | Number of Rainy Days. | Prevalent Winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean. | Max. | Min. | Mean. | | | |
| Jan. | 30.08 | 28.89 | 29.61 | 49° | 9° | 34.°59 | 8.630 | 14 | S. W |
| Feb. | 30.40 | 28.89 | 29.51 | 53 | 14 | 33. 92 | 2.698 | 5 | N. |
| March, | 30.03 | 28.40 | 29.36 | 56 | 23 | 42. 93 | 8.676 | 22 | S. W. |
| April, | 30.13 | 29.42 | 29.77 | 70 | 30 | 47. 23 | 2.553 | 14 | S. W. |
| May, | 29.94 | 29.10 | 29.56 | 69 | 32 | 52. 87 | 3.483 | 15 | W. |
| June, | 30.14 | 29.27 | 29.69 | 74 | 45 | 56. 98 | 4.264 | 17 | W. & S. W. |
| July, | 30.15 | 29.39 | 29.79 | 74 | 42 | 59. 01 | 3.170 | 15 | W. |
| Aug. | 30.18 | 29.10 | 29.81 | 68 | 46 | 56. 61 | 5.214 | 12 | N. W. |
| Sept. | 30.20 | 29.14 | 29.78 | 68 | 41 | 55. 55 | 3.329 | 16 | S. W. |
| Oct. | 30.18 | 28.92 | 29.54 | 63 | 34 | 51. 95 | 3.009 | 17 | S. W. |
| Nov. | 30.05 | 29.09 | 29.78 | 55 | 21 | 42. 30 | 2.615 | 9 | W. |
| Dec. | 30.46 | 28.57 | 29.47 | 54 | 24 | 42. 53 | 10.365 | 23 | S. W. |
| | | | 29.63 | | | 48.°03 | 58.006 | 179 | |

## ART. XII.—*Account of an extraordinary Marine Animal or Sea Serpent.* By I. HARWOOD, M.D. F.R.S. Professor of Natural History in the Royal Institution. *

IN the autumn of 1826, whilst Captain Sawyer of the ship Harmony of Hull was in pursuit of the Bottle-nosed Porpoise in Davis's Straits, north latititude 62, and west longitude 57,

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* This paper is a popular abridgement of Dr Harwood's paper in the *Phil. Trans.* 1827, p. 49.

he observed a body floating on the surface of the water, which was at first mistaken by himself and his seamen for an inflated seal's skin, such as the Esquimaux employ in the destruction of large aquatic animals, by attaching it to the harpoon by which they are speared, and thus tiring them out by its floating property. On a nearer approach, however, the object which had excited attention proved to be a living marine animal. The creature is still in the possession of Captain Sawyer, who preserved it in rum soon after being taken. Its capture was occasioned by its being, when first observed, almost worn out by unavailing efforts to gorge a species of perch of about seven inches in circumference, with which it appeared to have been long contending, as it exhibited very feeble signs of life. The organs of motion being extremely small, and its body greatly elongated, this creature would on a cursory view be by all considered as an extraordinary kind of sea serpent, and this idea is supported by a more close examination.

Its body is one uniform purplish black, except the filamentous extremity of the tail, which is much lighter. The total length is four feet six inches. The enlarged, and extremely elastic pharynx, communicates with an enormous sac or air-vessel, extending in length from the extremity of the snout about twenty inches. When partially filled with air, this sac measured about nine inches in circumference below its union with the tail, and its greatest diameter, including the slender body to which it pertained, was four inches. The use of this enormous pouch Dr Harwood is not able to discover.

The skin all over the body of the Ophiognathus is particularly soft and slimy, yet it has a slight granular appearance. The spiracles, which are five and a-half inches from the snout, are large and of an irregular oval form. All the fins are extremely small, the pectorals being composed of an adipose disc, which is terminated and nearly surrounded by a narrow radiated membrane. The dorsal fin, which like the rest is very narrow and provided with simple rays, commences at about eighteen inches from the snout, and terminates insensibly upon that slender tape-like filament into which the tail becomes converted, and which is continued twenty and a-half inches in length beyond the posterior extremity of the dorsal fin. About this part of the dorsal fin, a few other minute filaments take their growth from it. The anal fin commences at the posterior union of the sac with the body, and ends at about fourteen inches from the extremity of the caudal filament. The body exhibits no apparent lateral line; but perhaps the most curious structures which the creature presents to our notice are connected with the head and jaws. The almost entire absence of a tongue might perhaps prove one of its most characteristic distinctions, were we as yet sufficiently acquainted with the condition of this organ in those nearest allied to it. The teeth are disposed in a single row above and below; above they exist only along the margins of the intermaxillary bones; below they extend almost the whole length of the maxilla; but the ossa palati are entirely destitute of teeth. Lastly, the jaw-bones are so long, and their articulation is such, that their capability of expansion exceeds what I have seen in any other animal, the rattlesnake not excepted; and as in snakes, when fully distended, the edges of the jaws describe a large circle, and then appear but as the hemming of an ample sac, the pharynx which usually occupies so small a space being an equal participant in this extensile property. When the jaws were gently opened, they measured two and a-half inches across, and three and a-half from the front teeth to those below; but while they possess this power of extension, their contractile power is no less remarkable.

A drawing of this singular animal is given in Plate IV. Fig. 4.

As this animal forms a new genus of serpentiform fishes, Dr Harwood has given it the name of OPHIOGNATHUS *ampullaceus*, with the following characters.

Corpus nudum, lubricum, colubriforme, compressum sacco amplo abdominali.

Caput anticé depressum, maxillo superiore (paulo) longiore.

Dentes in maxilla inferiore, et ossibus intermaxillaribus, subulati, retroflexi.

Maxillæ elongatæ, patulæ dilatabiles (serpentium instar.)

Lingua vix conspicua.

Spiracula ante et sub pinnas pectorales magna.

Pinnæ pectorales, dorsales, analesque radiis mollibus; ventrales nullæ.

Oculi minimi, prope extremitatem maxillæ superioris positi. Cauda elongata, in filamentum apterum producta.

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## ART. XIII.—*On the Mean Temperature &c. of various places in the State of New York for* 1826.

THE Legislature of the State of New York, with a laudable desire of promoting the progress of meteorological knowledge, has enjoined the Regents of the different universities within their bounds, to make annual returns of the state of the thermometer, rain-gage, and weather. The first annual report, which was made to the senate on the 13th April 1827, has been transmitted to us by a friend, and from it we are enabled to lay before our readers the following very valuable observations.

It is entitled *An Abstract of the Returns of Meteorological Observations made to the Regents of the University by sundry Academies in this State, in obedience to instructions* dated March 1, 1825.

The report unfortunately does not state the latitude and longitude of the places of observation, nor their height above the level of the sea. Of *Pompey Academy*, however, it is stated that it is "elevated 1000 feet above the long level of the Erie Canal, from which it is distant in a direct line about nine miles. Many estimate the elevation of this place to be from 1200 to 1500 feet.

At many of the academies observations have been made only during some months of the year: These, of course, we have omitted as of little value. The number of these imperfect reports is *twelve*. We trust, however, that in subsequent years the patriotic wishes of the Legislature will be more punctually executed; and that the longitude, latitude, altitude and peculiarities of situation of the different places of observation will be distinctly stated, even if approximate values only can be given.

The observations have been reduced by T. R. Beck and Joseph Henry, but they have omitted to state the hours at which the observations were made.

## TABLE I.

| Places of Observ. | Mean Temperature of each Month in 1826. | | | | | | | | | | | | Ann. Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | |
| Albany | 28°.25 | 30°.57 | 38°.60 | 45°.54 | 67°.01 | 70°.45 | 73°.66 | 72°.38 | 64°.93 | 52°.49 | 39°.88 | 29°.07 | 51°.07 |
| Eras. Hall | 34 .76 | 33 .29 | 40 .97 | 47 .35 | 71 .19 | 72 .31 | 75 .54 | 71 .99 | 67 .71 | 54 .05 | 44 .61 | 33 .77 | 53 .96 |
| Hartwick | 25 .36 | 28 .54 | 35 .36 | 38 .33 | 61 .30 | 64 .74 | 66 .32 | 66 .75 | 61 .04 | 48 .27 | 36 .42 | 26 .77 | 46 .60 |
| Un. Hall | 31 .61 | 34 .30 | 40 .22 | 44 .75 | 64 .62 | 68 .92 | 71 .77 | 71 .78 | 66 .66 | 54 .08 | 44 .19 | 33 .44 | 52 .19 |
| Utica | 26 .15 | 24 .64 | 34 .32 | 41 .38 | 65 .78 | 68 .90 | 72 .35 | 70 .52 | 63 .00 | 50 .80 | 37 .77 | 27 .26 | 48 .73 |
| Middleb. | 25 .45 | 29 .45 | 36 .41 | 39 .71 | 61 .12 | 67 .45 | 68 .24 | 64 .54 | 60 .59 | 51 .71 | 38 .35 | 29 .52 | 46 .87 |
| Greenv. | 30 .27 | 27 .48 | 33 .77 | 40 .18 | 62 .52 | 66 .77 | 68 .87 | 68 .72 | 61 .73 | 51 .26 | 36 .96 | 28 .13 | 48 .05 |
| Lausing. | 26 .29 | 29 .00 | 36 .00 | 43 .00 | 68 .00 | 73 .00 | 72 .00 | 66 .00 | 63 .33 | 52 .00 | 40 .00 | 27 .54 | 49 .68 |
| Onondaga | 25 .75 | 26 .27 | 36 .58 | 42 .34 | 65 .55 | 68 .73 | 71 .71 | 75 .69 | 70 .45 | 58 .40 | 40 .14 | 26 .88 | 50 .71 |
| Pompey | 40 .81 | 24 .36 | 31 .91 | 36 .13 | 60 .79 | 65 .16 | 67 .63 | 65 .02 | 57 .85 | 45 .48 | 32 .75 | 23 .83 | 45 .97 |

## TABLE II.

| 1826. | Highest Temp. | Lowest Temp. | Annual Range. | Total Fall of Rain and Snow. |
|---|---|---|---|---|
| Albany, | 93° | — 12° | 105° | 33.12 inch. |
| Erasmus Hall, | 92 | + 3 | 89 | 44.91 |
| Hartwick, | 96 | — 24 | 120 | 42.35 |
| Union Hall, | 93 | — 5 | 98 | 55.66 |
| Middlebury, | 100 | — 18 | 108 | 23.96 |
| Greenville, | 91 | — 17 | 118 | 30.69 |
| Lausingburgh, | 100 | — 18 | 118 | 33.00 |
| Onondaga, | 99 | — 22 | 121 | 36.69 |
| Utica, | 93 | — 18 | 111 | 26.67 |
| Pompey, | 90 | — 13 | 103 | |

The coldest day in the year at all the above places, excepting Pompey, was on the 1st of February. At Pompey it was on the 31st January. The hottest day was on the 15th and 16th of May at Albany, Erasmus Hall, Union Hall, and Greenville; and on the 10th, 11th, and 12th of July in all the other places.

The following are the only places whose position is given in the report.

| | West Long. | Lat. North. |
|---|---|---|
| Albany, - | 73°.47′ | 42°.39′ |
| Erasmus Hall, | 73 .58 | 40 .37 |
| Middlebury, | 78 .10 | 42 .49 |

According to Dr Brewster's general formula, applicable to the whole globe, the mean temperature of the middle of the State of New York is nearly - - - 49°.8

The mean temperature of all the *ten* places in the table is 49°.4

But as most of the places are elevated high above the sea, their mean temperature must be all increased; so that the formula will err in defect.

## Art. XIV.—*Account of the Tracts of Foot-Marks of Animals found impressed in Sandstone in the Quarry of Corncockle Muir, Dumfries-shire.** By the Reverend Henry Duncan, D. D. Minister at Ruthwell. Communicated by the Author.

The sandstone quarry of Corncockle Muir is situated between the rivers Annan and the Kinnell, about a mile and a half above their confluence, and not quite three miles from Lochmaben. It is near the top of a low round-backed hill, which stretches about half a mile in a westerly direction, almost in the line of the rivers.

The sandstone of which the quarry is composed is, like most other sandstone in the county, of a reddish brown colour, and is believed to be what is called in Britain the new red sandstone. Its texture is friable, and its strata of very unequal thickness. It lies in the direction of the greater part of the sandstone of the district, which is from west north-west to east south-east, with its dip southerly, inclining at an angle of 38°.

The remarkable phenomenon I am about to describe, as existing in this quarry, is that of numerous impressions, frequently distinct and well-defined, of the foot-prints of quadrupeds, which have been found by the workmen on the surface of certain strata, when the superincumbent layers have been removed in the process of quarrying. This fact, so extraordinary, and I believe *unique*, has not hitherto been noticed in any scientific work, though it is fifteen or sixteen years since the discovery was first made. It is not easy to convey an accurate idea of the nature of these impressions in words; but out of a considerable variety which have been observed,

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* The Editor has been indebted to Dr Duncan for this abridgement of his very interesting and valuable paper, which was read at the Royal Society of Edinburgh on the 8th of January last, and which will appear in vol. xi. part i. of their Transactions, now in the press.

differing in magnitude from the size of a hare's paw to that of the hoof of a pony, I shall give some account of one remarkable tract impressed on a slab, formerly in the possession of Mr Carruthers of Dormont, (who procured it from the quarry some years ago,) and now forming part of the wall of a summer-house in the garden belonging to the manse of Ruthwell. On this slab, which is five feet two inches in length, there are twenty-four impressions, which make twelve of the right feet, and as many of the left, being of course six repetitions of the mark of each foot. The marks of the fore-feet are a little more than two inches in diameter, both from claw to heel and across, and those made by the hind feet are of much the same size, but somewhat differently shaped. The appearance of five claws is discernible in each fore paw, the three in front being particularly distinct. The three front claws of the hind paws may also be plainly traced, and are placed nearer to each other than those of the fore feet. There has obviously been no division in the sole of the foot, as is the case in the canine and feline species; but a gentle concavity of surface may be observed, especially in the fore paws, occasioned partly perhaps by the act of sinking in the wet sand. The depth of the strongest impression is about half an inch; and it is observable that the fore feet have made somewhat deeper marks than those behind,—a fact which may either indicate a considerable length in the animal's neck, or the more than ordinary weight of its head and shoulders; for, had it not been for one or other of these circumstances, the chief pressure would have been thrown on its hinder paws, as is the case in some other specimens, because the surface up which it was moving, was of considerable steepness. The distance from the claw of the hind-foot, to the heel of the nearest impression of the fore foot on the same side, varies from an inch to an inch and half. This, however, merely marks the position of the two feet when the hinder one was brought forward in moving; and if we would ascertain the animal's step—or rather the distance between the hind and fore paw, when the former was thrown back and the latter advanced—we must measure from the hind foot forward, to the second impression of the fore foot on the same side. Now, this gives a distance of between thirteen and fourteen inches, which is considerably more, however, than would have been the case if the animal had not been moving. If we compare this with the distance between the line of the right and left feet, (which is, as to the fore-paws, nearly 6½ inches, and as to the hind paws something more than 7½ inches,) we shall see that an extraordinary thickness of the animal's body, in proportion to its length, is clearly indicated.

This description may be considered as applying, in its general features, to a considerable number of the impressions—I mean those of animals in the act of ascending. Not many tracts, however, have been found, of which the prints are so well defined, and several of them belong evidently to animals of different species. I am myself acquainted with five or six varieties which are clearly distinguishable—the largest of them indicating a quadruped of such considerable magnitude, that the distance between the impression of the hind foot and that of the corresponding fore foot, is more, if I am not greatly mistaken, than a yard and a half.

But there is another class of impressions which must be referred to the tracts of animals in the act of descending the steep face of the stratum. These are not less numerous than the other, but, for an obvious reason, they are not so easily recognized to be the prints of feet. The steep face of the stratum has caused the animals to slide in their descent, so that in most instances nothing is observable but the rut made by the heels of their fore paws, and sometimes also a slight mark of their hind paws, which must have rested lightly on the surface, while the animals were sliding their fore paws alternately downward, and sinking them in the sand to secure their footing.

Of both of those kinds of impressions, traces may at this moment be observed in the uncovered strata of the quarry, though there are none of a very striking character which have not been removed. The best specimens I have seen are in the summer-house at Ruthwell.

With regard to the species of animals whose tracts have been so wonderfully preserved, I am happy that as to three of them I can give the conjectures of a much more competent judge than myself, one of the first geologists of the age, Professor Buckland, with whom I have been in correspondence, having favoured me with his opinion on the subject. That eminent individual, supposing the sandstone to have been deposited at an era when, according to the received opinion, no animals existed on our earth of a higher order than reptiles, was induced to look to our present crocodiles or tortoises as the species most nearly resembling those of whose footsteps I sent him casts; and on making experiments with some live tortoises which he has in his possession, he has come to the conclusion, that to animals of this species the tracts belong. With regard to the sliding impressions in particular, he says that he fully adopts my theory of their origin, his tortoises, in going down a declivity over wet sand, having made "almost exactly the same impressions."

There are some curious facts connected with this phenomenon which have not yet been mentioned, and which the limits I must prescribe to myself will not allow me to do more than enumerate:—

1*st*, In most instances the counter impressions are distinctly marked in relief on the under surface of the layer covering the foot-prints, these projections corresponding to the cavities below as exactly as a cast to its mould.

2*d*, The impressions never occur but on what the workmen call a clay face, by which is meant a stratum, the outer coat of which has a slight admixture of clay, rendering it harder than the rest of the rock, accompanied sometimes with a thin layer of soft clay in the seam between the under and upper stratum.

3*d*, All the tracks are constantly in a direction either up or down, sometimes inclining a very little either to the right or left, but never running across the slope in any great degree.

4*th*, In most of the impressions there are marks of the matter being displaced by the foot-marks, and wherever such an appearance occurs, the matter is found to have been carried directly downwards, with reference to the present inclination of the quarry.

These two last circumstances, as well as that of the sliding tracts, prove that the strata must have been very much inclined, while in a soft state, and while in the act of forming, though this is contrary to the received opinion as to the formation of sandstone.

*5th,* The sand must have possessed very considerable tenacity, and have even been sometimes skinned over with a stiff coat, for in one of the specimens preserved at Ruthwell, the claws of the animal had evidently broken through the outer coat at every step, and in two others, where the hind paws have rested on the matter just displaced by the fore paws, their pressure, instead of obliterating the appearance of superadded matter, has merely caused an indentation of the part rested on.

*6th,* There are continuous strata of sandstone resting on those in which the impressions are found, for the distance of not less than a quarter of a mile, all of which must have been deposited subsequently to the period in which the tracks were left on the surface of the sand.

*7th,* As far down as the quarry has yet been worked, which is not less than forty-five feet perpendicularly from the top of the rock, similar impressions have been found, and these equally distinct and well-defined with such as are nearer the surface.

*8th,* The impressions are not confined to a single stratum, but have been found on many successive strata. Since the foot-marks were first discovered, about forty yards of sandstone have been removed in a direction perpendicular to the line of the strata, and throughout the whole of that extent, impressions have, at frequently recurring intervals, been uncovered, particularly in one part of the quarry, and still continue to be uncovered.

Hence it must be inferred that the process, whatever it may have been, by which the impressions were buried in the sand, that of drifting by storms for instance, has not been occasioned by any sudden or isolated convulsion of nature, but has been carried on through many successive years or rather ages. Nor has it been the result of tides on the shore of the sea, which can scarcely be supposed to have flowed to the height of between forty and fifty feet; and even if they had done so, would certainly have swept away or filled up any impressions which animals might have made at low water, by moving over the surface of the sands they were depositing.

In the midst of so much difficulty, it is not easy to form even a plausible conjecture as to the manner in which the sand composing the rock was originally accumulated. It might, however, be perhaps worth while to inquire whether or not this successive accumulation could be the effect of the drifting occasioned by violent winds from the south-west. Supposing a sand-hill to be thus formed, a period of rainy weather following the stormy season would soften and diffuse the particles of clay, which may easily be believed to have mingled with the sand-drift, and would not only prevent the sand from being again moved by the wind, but would form it into a substance of some tenacity, resembling mortar, well fitted for preserving any impression which it might receive. If, during or immediately after the rainy season, animals were to traverse a hill thus formed, their tracks would be either altogether obliterated, or partially filled up, of which latter state many traces are to be found in the quarry; but when the surface had begun to dry, the foot-marks impressed on it would remain a considerable time quite distinct and well defined. Now, supposing the stormy monsoon again to commence, the neighbouring sands, which had not yet been fixed by any mixture of clay, and which happened, from their situation, to be easily dried by a few days of favourable weather, would be suddenly drifted on the hill in question, forming a layer which may easily have covered over the half-indurated surface, without being incorporated with it, and without in any way injuring the form of the footsteps imprinted on it. Let the monsoon be now supposed to continue during the whole course of a dry summer: Fresh layers of sand would be drifted, pure at first, but mingled again towards the close of the season with the clayey dust swept from an arid soil, which mixture would form the materials of what the quarrymen know in its present state by the name of a *clay-face*, and would once more, when subjected to the operation of the returning period of rain, both fix the sand, and prepare it for the reception of permanent impressions of the tracks of wandering animals. Thus from year to year the same round would be continued, and the same appearances would take place, till, after the revolution of many ages, what was originally sand would be converted, by a common process of nature, into sandstone, and being exposed, in common with the rest of our globe, to those mighty but mysterious convulsions of which there are every where such incontrovertible proofs, would at last, by the submersion of the universal deluge, be buried under its present covering of soil.

## Art. XV.—*On the supposed changes in the Meteorological Constitution of the different parts of the Earth during the Historical Period.*[*] By M. Schow, Professor of Botany in the University of Copenhagen.

This paper forms part of a large work, which comprises not only the climate of the earth during the existence of man upon its surface, but treats likewise of the question of the change of climate in the antediluvian world, as far as it can be ascertained by fossils.

It is hardly possible to draw a distinct line between the ante-historical period and that which is to be treated in this paper. The different strata bear no marks on them by which we can ascertain the exact period of their formation; and in the earlier period of history, truth is so involved in, and mingled with, fable, that no distinct limits can be traced. Although no real meteorological observations were made in the earlier part of this period, and though we want a direct measure of heat and moisture, as well as information about the other relations of the atmosphere, yet the relicts of antiquity are able to furnish on these points a much greater certainty than that which would be obtained for any earlier period. Although no artificial thermometer and hygrometer did exist, yet a number of relations and phenomena are known, which, like a kind of natural thermometer and hygrometer, lead more or less to ascertain the climateric relations. The most important questions in this respect are undoubtedly,

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[*] This interesting paper, read at the Royal Society of Copenhagen, has been translated from the original Swedish, and kindly communicated to us by Dr Forchhammer.—Ed.

1. What animals lived, and what plants grew in the country spoken of; have they been the same that now live there, or have they been such as require a more or less warm, a more or less moist atmosphere, than those that now live in these spots?

2. At what time of the year have the inhabitants in former times begun and finished their crops of hay, corn, or other cultivated plants.

3. Have the effects of meteors upon inorganic nature, which suppose a rather fixed temperature, as for example the freezing of lakes and rivers, the fall of snow, changed? Are the masses of snow and ice on the mountains now greater or smaller than they were formerly?

4. Have the customs and business which more or less are dependent upon the climate changed, for example the use of artificial heat, dress, navigation, &c.?

It is evident that the most rigorous criticism is required in such an inquiry, in order that we may not be led into errors. The ancients are not very careful in their description of plants and animals, and many of the smaller parts, which now are considered essential in determining the species, were utterly unknown to them. Their descriptions are, besides, not free from fabulous admixtures. Representations by drawing, engraving, &c. &c. which now so powerfully enlarge our information of such animals and plants as we have not before our eyes, are not found in any number among the relicts of antiquity; and those which still exist are not much to be depended upon, since they were not made for purposes of natural history. Yet some remains of that kind occur on coins and gems; and a considerable collection of representations of objects of natural history, from antiquity, are found in Herculaneum and Pompeii. Some of the sculptures in the Vatican, representing animals and plants are excellent. The grottos at Elytheia in Egypt contain similar representations. But to all these objects very little attention has been paid, although it might not be altogether fruitless.

If the plants and animals, however, of which the authors of former times speak, as productions of certain countries, are identified, great caution is still required in drawing conclusions from them about climate. If we find them speak of plants and animals, which now only occur in colder climates, the conclusion that the climate had been changed would not be directly warranted. Thus it is certainly not a higher temperature which has driven the beaver from the greater part of Europe, and which in North America compels it more and more to retire into the interior; but it was the increasing population and the cultivation of the soil which did not allow the animal to remain in that undisturbed state which is required for its existence. And it may be owing more to a bad management of the wood than to any change in the climate, that in some places of Switzerland no wood is now growing although stems and roots of trees are found on the very plains. With respect to cultivated plants it is not enough to know that a plant was not cultivated by the ancients; but we must ascertain whether they knew it, and whether they, without success, attempted its cultivation. The conclusion, too, that the climate has become colder, because plants formerly cultivated there are not so now, is not directly to be justified, for want of industry or other changes in the state of man may have occasioned it.

Only such plants or animals can be of great use in the inquiry into the supposed changes of climate, which have either their polar or their equatorial limits in the country of which the climate is doubtful. Thus it proves nothing, if it is ascertained that wheat in former times, as well as now, was cultivated in upper Italy under 45° of latitude; because that species of corn has its northernmost limit at about 60° of latitude, and its southermost at about 20°. If, on the contrary, it could be ascertained that a plant, which now has its polar limit in the said country, also was found there in former times, it is proved thereby that the climate has not become warmer; and the former existence of a plant which now has its equatorial limit in the same place would prove that the climate has not become colder. If, in the same country, two plants were found, of which the one had its polar, the other its equatorial limit there, the proof of the unchanged state of the atmosphere would be complete; and knowing the mean temperature for this limit, we should be able to ascertain almost with certainty the mean temperature which that region had about 2000 years ago. By such inquiries the geography of plants and animals which ascertains the present limits for these beings, and the relations of the temperature on these limits, may lead to conclusions concerning the former climate; and it is only to be regretted that the geography of plants is still in its infancy, and that a geography of animals hardly exists.

Great care is likewise required in drawing conclusions from the time of harvest in antiquity, which partly depended upon varieties of corn, which we hardly will be able to ascertain, and partly upon the tillage; besides it is different in different years, of which the mean time is to be taken.

With respect to such phenomena as seem to depend upon changes in the climate, such as the freezing of the sea, the protrusion of ice from higher places, a great difference must be made between that which is usual and that which is extraordinary; and great allowance must be made for the weakness of human memory, which recollects much better the exception than the general rule of things. Similar uncertainty is found with respect to the customs of the inhabitants, depending so much upon the tribe which inhabits the country, their state of culture, &c. &c.

Criticism must be applied in studying the authors from which we draw our knowledge of the produce of former times. The richest and best harvest will evidently be obtained from writers on natural philosophy and natural history; but historical and geographical writers are not to be neglected, and even poets may furnish some important facts. But of course the greatest care and caution is here principally required.

The author divides the historical time into two great periods, of which one, comprising all history until the time when real meteorological observations began, is again subdivided into two smaller periods, the one of which ends about the year 400 *p. c n.*, and has its best authorities in the Greek and Roman writers; the other, which comprises the latter half of that great period, has the Arabian writers, the chronicles of that time, and the newer historians for its best authorities.

### I. Part of the I. period. *Antiquity.*

It will be convenient to begin with Palestine, the Bible being the oldest, or one of the oldest books; and although great uncertainty exists about the determination of the plants which are mentioned in it, yet two of them do not admit of any doubt, and these are sufficient for the determination of the climate of Palestine in former times, viz. the date-tree and the vine.

The date-tree was frequent, and principally in the southernmost part of the country. Jericho was called Palmtown. The people had palm branches in their hands. Deborah's palm-tree is mentioned between Rana and Bethel. Pliny mentions the palm-tree as being frequent in Judea, and principally about Jericho, in the neighbourhood of which he speaks of palm-trees. Tacitus and Josephus speak likewise of woods of palm-trees, as well as Strabo, Diodorus Siculus, and Theophrastus. Among the Hebrew coins, those with date-trees are by no means rare, and the tree is easily recognized, as it is figured with its fruit.

The vine also was one of the plants most cultivated in Palestine, and not merely for the grapes, but really for the preparation of wine. The spies which Moses sent out into Canaan brought back a grape which required two men to carry. The feast of the tabernacle of the Jews was a feast on account of the wine harvest. In many places vineyards are spoken of, and Moses, the prophets, and Christ, took frequently their similes from the vine-grapes and wine. From a passage where the cultivation of the vine is mentioned in the valley of Engeddy, it is evident that the vine did not only grow in the northernmost mountainous part of the country, but also in its southern lower part. Strabo and Diodorus also speak frequently of the cultivation of the vine in Palestine; and grapes are as frequent a symbol even for the whole country on Hebrew coins as the palm-tree is. They occur even together on the same coin.

The date-tree, in order to bring its fruit to perfection, requires a mean temperature of 21° centigrade. Near Palermo, which has a mean temperature a little above 17°, the date-tree grows, but its fruit is not eatable. At Catania, where the mean temperature is 18—19°, the dates want sweetness, and do not germinate when laid into the earth. On the north coast of Africa, near Algiers, whose mean temperature is 21°, the dates ripen perfectly; but the best are brought from the interior. Since dates, therefore, ripened perfectly, and occurred plentifully in Palestine, this country, or at least its further provinces about Jerusalem, cannot have had a lower temperature than 21°.

Von Buch places the equatorial limit of the vine on the island of Ferro, 27½° latitude, where the mean temperature is probably between 21° and 22°; which, according to the same author, is the mean temperature on the coast of Teneriffe. In Barbary, the vine succeeds only on the coast, and even there the north of the hills is chosen for its cultivation. The mean temperature of Algiers is 21°, as has been mentioned. In Egypt the cultivation of wine is insignificant. Cairo, at 30° latitude, has 22° centigrade of mean temperature. At Abusheer, in Persia, at 29° latitude, and a mean temperature probably of 23°, they plant vines, according to Niebuhr, in ditches, to protect the plant against the heat of the sun. Thus the cultivation of the vine being of importance in Palestine, its mean temperature cannot have been above 22°, probably not above 21°. Thus, from the successful cultivation of these two plants, we obtain the result, that the mean temperature of Jerusalem in antiquity has been 21°, and certainly has not deviated more than one degree from that temperature.

We have no direct observation on the present mean temperature of Jerusalem; but Cairo has 22°, and Jerusalem, being 2° farther north, has probably 21° mean temperature. Algiers, in about 5° latitude more to the north, has that mean temperature. The highest mean temperature of the north coast of Africa arises doubtless from the sandy deserts in the interior of that continent; while Asia Minor has cold mountainous plains. If, therefore, there has been any difference at all between the mean temperature of Jerusalem in ancient and modern times, it can hardly amount to one degree, a difference similar to that between Copenhagen and Berlin.

The frequent cultivation of wheat in Palestine proves that its mean temperature cannot have been above 24°—25°. The growth of the balsam tree near Jericho proves that it has not been below 21°—22°; and among all the other determinable plants and animals of ancient Palestine, the author could not find a single one which was contrary to the assumed mean temperature of 21°.

The time of harvest in Palestine was formerly from the middle of April until the end of May. Travellers of our days mention, that in the south of Palestine barley was quite yellow in the middle of April. Near Acre wheat was ripe on the 13th of May; and, according to Russel, the harvest of Aleppo, which has a colder climate, is from the beginning to the 20th of May. In Egypt, the climate of which is warmer, the harvest of wheat is now at the end of April or the beginning of May. In the south of Sicily, the wheat harvest is at the end of May or the beginning of June. The feast of the tabernacle, or the feast of the wine-harvest of ancient Palestine, was in October; now the wine-harvest is, according to travellers, at the end of September or the beginning of October. It may be seen from many passages in the Bible, that snow and ice were known in former times in Palestine, although of rare occurrence. It is the same now. It is likewise evident from several passages, that they used artificial heat to warm themselves, and travellers mention that even now the nights are very cold.

The ancient authors in geography and history, principally Theophrastus, give a tolerably clear idea of the plants of Egypt. Most of the trees, and some other plants that have still their northernmost limits in Egypt, are mentioned by him as not occurring farther to the north, such as *Mimosa Nilotica*, *Ficus sycamorus*, *Cordia Myxa*, *Hyperanthera Moringa*, and *Nymphæa lotus*. The list might be easily increased, but only such are given, about which, as mentioned by the ancients, not the least doubt can exist. The polar limit of *Nymphæa lotus* has been placed in Egypt, although Waldstein and Kitaibel describe the plant as growing in the hot springs of Hungary; but by this peculiarity it belongs to another mean temperature than that of the country. A palm-tree, different from the date-tree, the *Cucifera Thebaicà*, grows now in Upper, but not in Lower Egypt. Theophrastus, who describes it exactly, speaks of it only as a plant of Upper Egypt. It follows, from the observations of Theophrastus and Pliny, that the olive-tree was cultivated in Upper Egypt; that the climate could not have been more warm; for the tree does not bear a great heat, its equatorial limit being on this side of the tropic.

The animals also seem to be the same. They had then, as now, the *Crocodile*, *Ichneumon*, *Ibis*; and that the *Hippopotamus* does not now occur there, but only in Abyssinia, seems to be no proof of a changed climate.

There are, however, some passages in the ancients which seem to prove a change of temperature, and therefore deserve a closer inquiry.

Herodotus says, that formerly the Egyptians had no wine in their country; they made wine from barley, from which it might perhaps be inferred, that at that time the climate was too warm for the vine; but it is not very clear from that passage, whether Herodotus really meant all Egyptians, or only such as cultivated corn. But he speaks in another passage about a great consumption of wine. Besides, Theophrastus speaks of vines growing near Elephantina, and Strabo of wine from the Lacus Mareotis. Athenæus speaks of wine from the same place, or Alexandria, which he says is excellent, and is cultivated in great quantities in that country, adding, that vines grow on the banks of the Nile, and even mentions wine from Thebes.

Lastly, among the representations of the grotto at Elytheia a wine harvest is seen. It could not be inferred from the passages of Athenæus and Theophrastus, that the climate had been colder, because the vine grew as far to the south as upper Egypt; for it is pretty evident from them that the vine was rare. Theophrastus speaks only of the plant but not of wine; and Athenæus, who was an Egyptian, makes an apology even in this very passage, because he praises his native country and its produce. Strabo says that the date-tree in Egypt, near the Delta and Alexandria, is sterile, or bears no eatable fruit, while the palms of Thebes are the best of all. In our times the date-tree bears eatable fruits in lower Egypt also. But this passage is not altogether clear; and all the other authors speak of the date-tree being frequent throughout Egypt, which would hardly have been the case if the tree did not bear any or not eatable fruit. It might be concluded that the climate of Egypt had been warmer, since the *Nelumbium speciosum* is not now found in the Nile, although the plant described by Theophrastus, Herodotus, Strabo, Pliny, Diodorus Siculus, Athenæus, and

Dioscorides, is evidently that which now bear that name. Theophrastus adds even that it grows in Syria, Cilicia, and Torone in Chalcidia, still farther to the north than Egypt; and even there it has been songht for in vain by recent botanists. *Nelumbium speciosum*, however, has been found by Thunberg in Japan, and by Fisher at the mouth of the Volga, in climates much colder than that of Egypt. The plant from Japan is evidently the same; and although Fisher considers the plant from the Volga as different, and calls it *Nelumbium Caspicum*, yet Decandolle considers it only as a variety.

It thus appears that the temperature of Egypt, like that of Palestine, has not undergone changes since the time of the ancients, a result which might have been expected from the two countries being so near to each other.

The moisture also does not seem to be different. The ancients speak much about the scarcity of rain in Egypt. It is the same now; from the month of May till November 1799, not a drop of rain fell at Cairo, according to the French observer, and in the other months it rained only three times Herodotus mentions that the Nile begins to increase at the summer solstice In the *Description de l'Egypte*, it is mentioned that above the cataracts the water is observed to rise at the summer solstice, and at Cairo in the first days of July. It results from these observations that the rainy season formerly began in the tropical part of Africa at the same time as it does now.

The ancients knew too little about the countries within the tropics to enable us, from their observations, to derive any sufficient proof of the stability of their climate. There occurs in their writings, however, nothing which could prove a change, except the report that these countries were uninhabitable on account of the heat, which those authors only mention who had no information respecting these lands. Among the products of India, Theophrastus, Pliny, and Diodorus Siculus mention *Bambusa arundinacea*, *Amomum cardamomum*, *Laurus cinnamomum*, *Ficus Indica*, *Gossipium arboreum*, *Oriza sativa*, *Piper nigrum*, besides many others, which being less certain, have been passed over. Theophrastus says, that the vine grows only in the mountainous parts of India, and that in general India hardly produces any of those plants which grow in Greece. It was, according to Theophrastus, only with difficulty that Harpalus could bring the lime and box-tree to grow at Babylon, but the ivy would not grow there at all.

Among the products of Arabia, myrrh and balm are mentioned, which still grow there. Although some speak of cinnamon as a product of Arabia, yet Herodotus says the Arabs do not know where it grows, but some are of opinion that it comes from the land of Iacchus (India.) At present it does not grow in Arabia.

We have a number of facts that allow us to form an opinion what the climate of Italy and Greece has been, and as both have almost the same climate and vegetation, they will be treated under one head. There is in the present time a great and general difference between the vegetation of those parts of Europe that lie to the South of the Pyrennees, the Alps, and the Greek mountains, and those to the north of them. That part of France, however, which is adjacent to the Mediterranean belongs to the first division. In this case there is not a question about some new species, but about several thousands of plants which are not found in the North of Europe, and on that account our author has thought himself entitled to treat the South of Europe as a system of vegetation quite different from the North of that continent, an idea which he has further explained in the map to his geography of plants. Since the limit between the northern and southern vegetation is very sharp and distinct, except in the plains of Lombardy, where both forms are mixed, a comparison between the present plants and those mentioned by the ancient authors will furnish data enough for the determination of the climate. Theophrastus, Dioscorides, and Pliny speak of a number of trees and shrubs, such as the different evergreen oaks, which are wanting in the North of Europe. *Quercus Suber*, *Ascalus coccifera*, *Agelops*, the bay and myrtle tree are repeatedly mentioned, and these bear only with great difficulty a climate colder than that of Italy and Greece is at present. There occur besides *Pistacia lentiscus*, *Erica arborea*, *Ficus Carica*, *Arbutus unedo*, *Nerium oleander*, *Viburnum tinus*, the species of *Phillyrea*, *Rhus cotinus*, *Juniperus sabina*, *J. Oxycedrus*, *J. Lycia*, *Mespilus pyracantha*; to which might be added the *Pinus* *pinea* and *Cupressus sempervirens*, which, however, are considered as cultivated plants. Theophrastus mentions that the *Chamærops humilis* is frequent in Sicily; and that even there and in Calabria it begins at present to cover large tracts of ground.

At a certain height above the level of the sea occur, both in the Apennines and in Greece, a number of trees which do not bear the high temperature of the plains, and which partly are the same that in the north of Europe belong to the lower countries. Theophrastus mentions among the plants which require cold places *Pinus picea and abies*, *Taxus baccata*, *Sorbus aucuparia*, *Betula alba*, *Juniperus communis*, *Corylus avellana*; even *Buxus sempervirens*, *Quercus ilex*, *Castanea vesca*, and *Arbutus unedo*, are mentioned among them, although they belong to the middle region. About *Pinus picea*, Pliny says, "situs in excelso montium;" and Virgil, "abies in montibus altis." Pliny, in another passage, "gaudet frigidis sorbus et magis etiam betula." Pliny reports, that the bay and myrtle grow somewhat upon the mountains, and this may be a farther proof that the climate has not been colder, because now they grow in the middle of Italy only to the height of from 1000 to 1200 feet.

From the beech-tree some objection, not to be neglected, might be derived. It is now the most common tree in the higher regions of the Apennines and in the Sicilian mountains, but it is absolutely wanting in the lower hills and in the plains. In upper Italy the lower limit of the beech is 2000 feet above the level of the sea; in middle Italy about Rome it occurs only at 3000 feet; in Sicily only at a height of 4000; in Greece, according to Sibthorp, likewise on mountains. There are some passages in the ancients, which lead to the conclusion, that the beech in former times has grown on the plains of Italy and Greece. Theophrastus says respecting οξυα (the beech) that the plains in the country of the Latins are covered with it, and bay and myrtle. Pliny mentions the beech as a tree which, although it grows on the mountains, yet descends into the plains, and says that a place in Rome is called Fagutal, because there was before the foundation of the town a beech wood on that spot. As to Theophrastus, some doubts may be raised that his οξυα is the beech, for he describes it like a fir-tree with a thorn on the end of the leaves, and very flat roots; but, according to Sibthorp, the new Greeks call the beech still οξυα. Thus it seems most probable that Theophrastus has not known the beech, and has in his description confounded two trees; which appears still more probable from his mentioning it together with bay and myrtle as growing in the plains of Latium. The highest mean temperature in which the beech grows is 9° to 10° C., while the lowest in which the myrtle thrives is 13° to 14° C., except where mild winters are combined with an equally low mean temperature. Much more important is the testimony of Pliny. His Fagus is evidently the beech, but he may have meant mountain plains, and seems to have copied Theophrastus also in this place, and perhaps has confounded the Greek φηγος *(Quercus Esculus)* with the Latin Fagus. The derivation of the word Fagutal depends entirely upon a report, and cannot serve as a proof. The passages of Virgil are taken from his description of pastoral life, which certainly could only take place in the mountains, since in the lower plains there is not sufficient grass on account of the heat. Myrtle and bay have grown near Rome since the earliest times; myrtle branches were made use of when the peace was concluded between the Sabines and Romans, and bay crowns were used in the time of the kings. Even if at that time the beech has grown now and then in the plains, for its real place is the mountains, yet the climate could not be much colder than now, since myrtle and bay grow there.

Of cultivated fruit-trees several are mentioned, such as the olive-tree, the almond-tree, the *Punica granatum*, among which the olive-tree is the most interesting, its polar limit falling on the boundary of the South European Flora. Strabo says that Gallia Narbonnensis has the same fruits as Italy, but that in going farther north to the Cevennes mountains, the olive-tree and fig-tree disappear. In comparing Decandolle's map to his *Flore Française* with this, we find the limit for the olive-tree at the same place. At all events, it proves that the climate has not been colder. That the climate of the south of Europe has not been more warm, is proved by an account which Theophrastus gives about the date-tree in Persia, *(Cordia Myxa,)* which, when brought to Greece, does not bear fruit, or at least no eatable fruit, but on the island of Cypera, the fruit, although it remains unripe, is yet eatable. Thus, if any change has really taken place, we might incline, both from the reasons already expressed, and from some to be added, to assume that in former times the temperature has been lower than it is at present, which is contrary to the general opinion.

As to the time of harvest, Columella says, that it must be the 18th of May, and Palladius says, speaking generally, in the month of May. According to a mean number of several years, it begins now in Rome on the 14th of May. Varro fixed it in general from the solstice to the dog-days, which is from the 21st of June to the 20th of July. Columella says, that the harvest of barley is finished the 28th of June, and in temperate places, the harvest of wheat the 29th of July. Palladius allows the harvest of barley to begin with the beginning of June, and that of wheat for warm places near the coast at the conclusion of June, and for temperate countries in the month of July. According to the mean of several years, they now begin the harvest around Rome on the 15th of June, therefore, somewhat earlier than even the earliest of the times mentioned. It must, however, be remembered, that this is the beginning of harvest, while in the report from former times, they spoke of the end of the harvest, and where nothing is mentioned probably the middle of the harvest is meant. It is, however, difficult to determine the mean times of harvest in a country of so great extent, but I think that of Rome may pretty well serve for it. Besides, the time of harvest depends much upon the varieties of corn which the Romans cultivated.

The time of the wine harvest agrees better. Varro says it happens between the autumnal equinox and the setting of the Pleiades, which he himself supposes to happen thirty-two days after; and it is thus fixed between the 21st of September and the 23d of October. Columella says, that the wine harvest happens in Bœtica near the coast, as well as in Africa, the 31st of August; in other warm places on the 11th of September, but in most countries on the 28th of September. Palladius mentions September as the month of the wine harvest for warm situations, and October for temperate ones. According to a mean number, the wine harvest now begins in Rome on the 2d of October.

The author thinks himself entitled to assume, that the climate in Greece and Italy, like that of Palestine and Egypt, has undergone no important change since ancient times. But if, on account of the later harvest, and the possible growth of the beech trees in the Roman plains, we might be led to the opinion, that formerly the climate had been a little colder than now, the difference will hardly come up to one or two degrees, and will not be greater than might be occasioned by the cultivation of the north of Europe.

From Greece and Italy the author passes to the countries on the Black and Caspian Sea; (the Euxine Sea, and Palus Mæotis of the ancients.) Here it has been pretended that the change of climate has been most extraordinary. The Abbé Mann, who collected the accounts of the ancient writers about it, says, that they " all concur in asserting, that the climate there was such as is now hardly found in Sweden and Norway, but must be sought for in Lapland, Siberia, or in America, to the north of Hudson's Bay." At present there grow, according to the accounts of travellers, olive-trees, fig-trees, bay-trees, and most of those which are peculiar to the south of Europe. This seems to be a most extraordinary change; but our author has done away with a great deal of these pretended changes, as he is of opinion, that a severer criticism than that of Mann, the use of accounts which he has not taken into consideration, and, lastly, an inquiry into the climateric relations of the present day, both in general, and such as they are modified by local influence, will annihilate the opinion of the learned Abbé and his followers, and either prove that the climate has not changed at all, or at least has changed only very little to the better.

Herodotus mentions the European Scythia, the countries to the north of the Euxine Sea, and the Palus Mæotis, and says that the winter lasts eight months, and the summer four, that the sea freezes as well as the whole Cymbrian Bosphorus, over which the Scythians led their armies and waggons. In summer, he continues, it rains constantly, and there are even thunder-storms in that season; horses may live there but not asses and mules. It had been reported, that in the interior of Scythia the air was full of feathers, which Herodotus explains by the falling of snow, and adds that such winters make the northern countries uninhabitable. But Herodotus had not been in these regions, and the inhabitants of the south are seldom very correct in their descriptions of the climate of northern countries. It is only to an inhabitant of the shores of the Mediterranean that it could be a very remarkable matter, that it rained around the Euxine Sea more in summer than in winter, and that thunder-storms occur in summer. The only fact we learn from Herodotus is the freezing of the sound which unites the Assyrian Sea and the Black Sea. Strabo mentions the same thing, and says that it is possible to drive over the sound between Phenagoras and Ponticapæum, where there is at that time a general road, and, he adds, that it is reported that Neoptolemus, the ambassador of Mithridates, fought a battle with cavalry in winter, where in summer he had fought a sea battle. But Pallas says that the Bosphorus, even in moderately severe winters, is now covered with ice, as well as a great part of the Assowian Sea, principally from drift-ice from the river Don; that in severe winters loaded waggons are carried over it; and that in spring the drift-ice remains generally until the month of May. It is thus at present the same as in former times. According to Strabo, the heat was very powerful, either, he says, because they are not accustomed to it, or because there does not blow any wind. This also agrees very well with the climateric relations of the present day, for it is very surprising how great the difference of the seasons becomes in the north of Europe at greater distances from the Atlantic Ocean. Thus the difference between the mean temperature of winter and summer is at Moscow 32° Cent., at Copenhagen 17°, at Edinburgh 11°, all three lying under the same latitude.

Herodotus speaks of people to the north of the Euxine Sea who carried on agricultural operations, and Strabo mentions that the vine in the winter time was dug into the earth, in order to protect it against frost. Theophrastus gives an account of fruitless trials to plant myrtle and bay; but there grew, although covered in the winter, large fig trees and pomegranate trees, besides pears and apples of excellent quality, which very ill agrees with the Lapponic climate. At present the myrtle does not thrive there, nor the bay-fig; and olive trees succeed only in those valleys of the Krimea which open to the south. According to Theophrastus bay and myrtle grew also on the south end of the Euxine Sea. The author proves, lastly, that the descriptions of Virgil and Ovid by no means serve to confirm the idea of such a cold climate, seeing that their descriptions are filled with contradictions.

*(To be Continued.)*

## ART. XVI.—*Experiments on the Absorption of Vapours by Liquids.*[*] By THOMAS GRAHAM, A. M. Communicated by the Author.

FROM theoretical considerations I was led to institute the following experiment:—Into a deep cylindrical jar as much water was poured as covered the bottom of it to the depth of half an inch. Within the jar, and an inch above the surface of the water, a porcelain basin, three inches in diameter, was supported, containing 500 grains of a saturated solution of chloride of sodium of the temperature 57°, which was observed to be also the temperature of the water below and of the air without. The mouth of the jar was finally covered over by a glass plate, and made nearly air-tight by means of lard. It was intended by this arrangement to preserve the solution of chloride of sodium in an atmosphere, saturated or nearly so with aqueous vapour, to be supplied by the water at the bottom of the jar. For comparison another arrangement of a similar nature was made at the same time, with the only difference, that the porcelain basin contained 500 grains pure water instead of a saline solution. The two jars were set aside in a quiet place, not subject to great variations in temperature, and a specimen of the dry chloride of sodium made use of, was exposed freely to the air in their neighbourhood. At the expiration of six days the whole were examined: the salt ex-

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[*] Read before the Royal Society of Edinburgh, March 3, 1828.

posed to the air did not present the slightest appearance of deliquescence. The basin of pure water in the second jar had lost three grains in weight, but the solution of chloride of sodium had increased in weight by 63 grains. This solution possessed no power to absorb and condense vapour from a temperature originally lower than that of the water near it ; while the circumstance of a loss, rather than an increase of weight, occurring in the other case, renders it improbable that any inequality of temperature took place during the continuance of the experiment, and operated in this way. The plain inference from the experiment was, that the chloride of sodium employed, although by itself not deliquescent, or incapable of absorbing vapour, yet possessed that property in a considerable degree when in solution, seeing that in six days it had absorbed nearly half its weight of water, the quantity of salt in solution being 143 grains, and the increase of weight 63 grains.

In a second preliminary experiment there were two cases similar to the preceding, and besides, the same quantities of saturated solutions of muriate of ammonia and of sulphate of magnesia were inclosed in jars containing a little water in a similar manner. The temperature on closing the jars was about 58°, and very equable during the experiment. In four days the basin of pure water was found to have lost 2.5 grains, but the solution of muriate of ammonia had increased 34 grains, of chloride of sodium 37 grains, and of sulphate of magnesia 8 grains. The increase in the case of sulphate of magnesia was the least, although it contained most saline matter.

In the farther investigation of this subject, instead of separate jars, low tin-canisters were employed, in which several vessels with solutions might be arranged at the same time. The vessels rested on a support of wire-cloth an inch from the bottom of the canister, the lowest part of the canister being occupied with water to the depth of half an inch. The canisters were provided with lids, which could be made air-tight. It had been found that Wedgewood porcelain basins unfailingly absorbed a portion of the water or of the saline solution which they contained, varying from one to twelve grains.

The use of them was therefore discontinued, and hemispheres or capsules of glass three inches in diameter, and blown as like each other as possible, were employed in their place.

1. Solutions were formed of one part chloride of sodium in four parts water, and of anhydrous carbonate of potash and water in the same proportions. The carbonate of potash, which is deliquescent, was obtained by keeping the sesquicarbonate in a red heat till the excess of acid and the water which it contains were wholly expelled. Three of the glass capsules were placed in contact on the wire-cloth support of a small tin canister, with water below, but not in contact with them. These capsules contained respectively, 500 grains water, 500 grains of the solution of chloride of sodium, and 500 grains of the solution of carbonate of potash. They were less than half full. The observation being made that no inequality of temperature existed within the canister, its lid was applied, and the joinings made air-tight with lard. Upon examination at the expiration of six days, the capsule of water was found to have lost 23 grains; that of the solution of chloride of sodium to have gained 39 grains; and the solution of carbonate of potash was found to have gained only 6.5 grains. Here it is evident that the solution of chloride of sodium had drawn vapour not only from the water below, but likewise to a large extent from the adjoining capsule of water, and most probably to a small extent from the solution of carbonate of potash, likewise in contact with it. The solution of chloride of sodium appears, therefore, to possess a manifest superiority in absorbing power over a similar solution of the deliquescent carbonate of potash.

2. In a large tin-canister or box, eighteen inches long, nine broad, and four deep, with a wire-cloth support and water under it, precisely as in the foregoing case, ten capsules containing various solutions were arranged at the same time. To prevent the liquids from influencing each other, they were separated by temporary screens of pasteboard, so that each capsule was contained in a cell by itself; but all communicated equally, through the apertures of the wire-cloth, with the reservoir of water below. The results of this experiment are thrown into the form of a table. In the first

column the composition of the solutions is given, of which 700 grains were always employed. When the proportion of salt in the solution is not expressed, it is to be understood that the solution was a saturated one at the temperature of the atmosphere, which varied during the experiment from 55° to 42°. In the second column the increase or loss of weight undergone by the different solutions, after being inclosed for six days, is expressed; and in the third column the additional increase or loss of weight, after farther confinement for fourteen days. In a fourth column the boiling points of the solutions are subjoined, for a purpose which shall be presently explained.

| Solutions. | Gain in 6 Days. | Gain in 14 Days. | |
|---|---|---|---|
| 1. Chloride of sodium, - | 35 grs. | 66 grs | 224° |
| 2. Sulphate of magnesia, - | 7 | 16 | 214.5 |
| 3. Sulphate of soda, - - | 0 | 2 | 213 |
| 4. Carbonate of soda, - - | 2 | 7 | 214 |
| 5. Nitrate of potash, - - | 2 | 8 | 214 |
| 6. Muriate of ammonia, - | 29 | 39 | 221 |
| 7. 1 carbonate of potash, 2 water, | 22 | 45 | 221 |
| 8. 1 chloride of calcium, 2 water, | 53 | 105 | 230.5 |
| 9. 1 chloride of calcium, 5 water, | 17 | 33 | 216.5 |
| 10. Water, - - | –5 | —3 | 212 |

From the experiments of this table, and from other experiments yet to be detailed, it is evident that not only the solutions of salts, which are deliquescent, but that the solutions of salts which are persistent in the air, and even of efflorescent salts, are capable of absorbing vapour in an atmosphere nearly saturated with it. Some of the results are curious. It appears from the table that a saturated solution of common salt, which contains less than a third of its weight of a saline substance, which is not deliquescent, absorbs vapour much more powerfully than a solution of the deliquescent carbonate of potash in twice its weight of water. In fact, it appears that *all* saline solutions just as readily inhale as exhale vapour, according to the state of the atmosphere in which they exist. It is this proposition in all its generality which I wish to establish. As the powers to absorb and to emit vapour appear to be necessarily conjoined and of equal importance, it may be allowed us to say, that liquids *in*vaporate when they take in their vapour, as they are said to evaporate when they give it out.

The column of boiling points is an index of the invaporating powers of the solutions. The superior invaporating power of chloride of sodium is distinctly connected with the high temperature at which it boils. We see that the power of water to emit vapour at these high temperatures is diminished in various degrees by the saline matter in solution. At low temperatures it is probably diminished according to the same rate; and saline solutions, unable to give out vapour of the tension of that in the atmosphere around them, necessarily become absorbents of that vapour, as is proved by these experiments.

3. The following table exhibits the weight acquired by solutions of the same salt, viz. chloride of sodium, in various proportions, and also by sea-water, by enclosure for five days. 500 grains of each solution were employed. The boiling points of the solutions are likewise subjoined.

| | Gain in 5 Days. | Boiling Points. |
|---|---|---|
| 1. Saturated solution, chloride of sodium, | 33 grs. | 224° |
| 2. 2 do. + 1 water, - - | 23 | 220 |
| 3. 2 do. + 2 water, - - | 17 | 217.5 |
| 4. 2 do. + 4 water, - - | 10 | 216 |
| 5. Sea-water, - - | 3 | 213 |

A capsule of pure water inclosed at the same time, instead of increasing in weight, lost 4 grains. The curious inference is deducible from this experiment, that sea-water is capable of absorbing moisture from air, perfectly saturated with it at the same temperature. The experiment with sea-water was several times repeated, and it always exhibited a slight invaporating power, while a capsule of pure water placed beside it lost weight.

4. Several saline solutions and acid liquors were formed, all of which boiled at one temperature, viz. 224°. 700 grains of each were employed, and they were retained for five days in the tin-vessel. In the second column the weight is expressed

which each liquid acquired during that period. These liquids were afterwards withdrawn from the tin-vessel and freely exposed to the air, that they might evaporate, in order that the connection between their evaporating and invaporating power might be observed. The loss of each liquid by evaporation during twenty-four hours is placed against it in a third column.

| Solutions. | Gain by Invaporation in 5 days. | Loss by Evaporation in 24 hours. |
|---|---|---|
| 1. Chloride of sodium, | + 32 grs. | — 8.5 grs. |
| 2. Chloride of calcium, | + 34 | — 8.0 |
| 3. Carbonate of potash, | + 30 | — 8.6 |
| 4. Tartaric acid, | + 31 | — 8.4 |
| 5. Sulphuric acid, (1.221) | + 34 | — 8.1 |
| 6. Muriatic acid, (1.125) | + 113 | + 2.1 |
| 7. Muriatic acid, (1.089) | + 61 | — 2.3 |
| 8. Nitric acid, (1.206) | + 59 | — 2.9 |

A capsule of pure water was allowed to evaporate spontaneously for the same time as the cases in the table. It lost 13.9 grains. The temperature of the air did not exceed 45°. The similarity of the point of ebullition seems to be attended with an analogous increase from invaporation and loss by evaporation in the saline solutions and in tartaric and sulphuric acids. The difference of the results in these cases is so small that it might depend on slight variations of the form of the capsules, or other accidental circumstances. But the absorbing power of the two cases of muriatic acid and of nitric acid, which boil at the same temperature, are exceedingly different. The stronger muriatic acid also actually gained weight when exposed to the air, instead of sustaining loss by evaporation, like the other cases. The weaker muriatic acid and the nitric acid likewise lost less by evaporation, as they gained more by invaporation than the saline solutions. The invaporating powers of liquids appear to be reciprocally proportional to their evaporating powers, as might be expected. This was observed very distinctly on exposing to the air various saline solutions of dissimilar absorbing power, when those which invaporated in the least degree evaporated most rapidly, and *vice versa*.

It has not, I believe, hitherto been noticed, that muriatic acid is ever capable of increasing in weight when exposed to the air, as sulphuric and nitric acids are known to do, and as occurred in the case of the stronger muriatic acid in the foregoing experiment. But I have frequently observed muriatic acid, of all degrees of strength, intermediate between 1.190 and 1.100, to increase in weight by the absorption of hygrometric moisture, when the weather was damp, and the temperature not above 55°. When the acid is strong it emits muriatic acid gas at the same time that it absorbs aqueous vapour, till it becomes of specific gravity 1.0960. But when acid, diluted to any degree below that strength, is exposed in a dry atmosphere, no material quantity of the acid gas is emitted, but the acid concentrates by the emission of aqueous vapour, till its specific weight rises to 1.0960. The boiling point of muriatic acid is at a maximum when of that strength, as was observed by Mr Dalton; and it consists of exactly one atom acid and sixteen atoms water, as Dr Thomson remarked.

As evidence of the power of muriatic acid to absorb moisture from an atmosphere not particularly dry, and to increase in weight, I may be allowed to state one experiment, made lately in the month of January. Three small porcelain basins, each containing 200 grains of liquid, were exposed together, with paper covers, in a room in which there was no fire. The liquid in No. 1 was muriatic acid of specific gravity 1.185. In No. 2 the same, diluted with half its weight of water. In No. 3 pure water. It had been previously ascertained that the muriatic acid contained no sulphuric acid. The basins were weighed every twenty-four hours, and the following results obtained :—

| Weight in Grains. | | |
|---|---|---|
| No. 1. | No. 2. | No. 3. |
| 200 | 200 | 200 |
| 209 | 204 | 194 |
| 219 | 216 | 187 |
| 227 | 224 | 160 |
| 235 | 220 | 133 |
| 242 | 223 | 105 |
| 247 | 221 | 93 |
| 245 | 210 | 70 |
| 244 | 200 | 50 |

5. The capacity of liquids of dissimilar composition to absorb the vapours of each other is also exceedingly general. We may always presume with safety, that if two liquids are miscible in all proportions, the more fixed liquid is capable of absorbing the vapour of the more volatile liquid. Yet the only instances of such absorption which have been attended to are the absorption of aqueous vapour by sulphuric acid, and of the same vapour by nitric acid.

6. Alcohol and water are miscible liquids, of which water is the more fixed; and I find water to absorb the vapour of alcohol at the temperature of the atmosphere with considerable avidity.

Sulphuric acid also absorbs alcohol vapour with avidity, as was stated in a former communication. The following experiment was performed, with the view of ascertaining the relative intensity with which water absorbs the vapour of alcohol, and sulphuric acid the vapours of water and of alcohol.

(1.) A small Wedgewood basin, one inch and a half in diameter, containing 200 grains water, was supported over sulphuric acid in a cylindrical vessel, and closed in. Upon opening the jar after twelve hours, the water was found to have lost eleven grains. (2.) The acid was stirred up, and instead of the water 200 grains absolute alcohol were introduced into the basin, and the whole closed in as before. In twelve hours the alcohol was found to have lost sixty grains, and the sulphuric acid had acquired a reddish tinge. (3.) The sulphuric acid was now withdrawn from the jar, and pure water substituted as the absorbing liquid. The quantity of absolute alcohol in the basin being again increased to 200 grains, and the lid carefully luted down, in twelve hours the alcohol lost 45 grains, and the water below had acquired the taste of alcohol very sensibly. The vapour of sulphuric ether is absorbed with great avidity by alcohol, and with much less force by water.

The vapour of alcohol is likewise absorbed by castor oil, especially after some alcohol has been previously mixed with it, although with a very feeble force. Retained over alcohol for ten days 200 grains castor oil became 273 grains. Bichloride of mercury deliquesces in alcohol vapour, although slowly when in hard crystals. Twenty grains of the crystals (not reduced to powder,) suspended in a capsule over alcohol became in six days 29 grains, a portion being dissolved by the alcohol absorbed. A solution of bichloride of mercury in alcohol likewise exhibits an invaporating power when in an atmosphere of alcohol vapour.

It would be curious to know whether alcohol is capable of absorbing the vapour of water, as well as water is capable of absorbing the vapour of alcohol. It is difficult to determine the point directly, as the quantity of water absorbed might be very minute; but I am inclined to believe, from an indirect experiment, that alcohol does not possess such an absorbing power. A crystal of sulphate of soda was suspended over a small quantity of absolute alcohol very carefully prepared, by a thread, which was attached to the cork of the phial, for a period of six months, without undergoing the slightest alteration in appearance. Now, if alcohol had possessed the power to absorb aqueous vapour, and to keep the atmosphere above it in a dry state, so far as aqueous vapour is concerned, the crystal would certainly have effloresced and fallen into powder.

The phenomena presented when pieces of camphor are placed at a little distance from alcohol are very remarkable. A number of small pieces in a gauze bag were suspended within a glass jar which contained a little alcohol. In a few hours the camphor began to run into a liquid, which fell in drops, and in twenty-four hours the whole camphor had left the bag in that manner. It is evident, therefore, that solid camphor with relation to alcohol vapour is deliquescent. Forty grains camphor were suspended over alcohol, as in the previous case, with the difference, that the camphor was contained in a little glass capsule. Five days afterwards the capsule contained a solution of camphor in alcohol weighing 105 grains. A little camphor, however, had passed down to the alcohol below, to which it communicated its taste and smell; but the quantity was so small that the alcohol, on being diluted with water, became only slightly opalescent. The temperature of the atmosphere during these experiments averaged about 55°.

The salt subcarbonate of ammonia is known to be possessed of considerable volatility, and also to be soluble in water. Inclosed with water in separate vessels it quickly passes over into the water. Thirty grains of dry subcarbonate reduced to powder were suspended in a glass capsule over a considerable quantity of cold water, the whole being contained in a close vessel as usual. Upon examination after five days, the capsule, instead of 30 grains of the dry salt, was found to contain 12 grains of a solution of it, the greater part of the salt having passed over into the reservoir of water below, to which it had imparted its taste and properties. The habitudes of subcarbonate of ammonia in an atmosphere saturated with aqueous vapour are therefore exceedingly different from those of any other salt, as, instead of attracting water or remaining unaffected, it is itself attracted by water and dissolved.

Such are the principal facts which have presented themselves in the investigation of the absorption of vapours by liquids.

## ART. XVII.—*Chemical Examination of Tabasheer.* By EDWARD TURNER, M. D., F. R. S. E. Professor of Chemistry in the University of London.[*] Communicated by the Author.

HAVING completed an analysis of tabasheer, for a supply of which I am indebted to the kindness of Dr Brewster, I conceive that a short account of the chemical examination, as connected with the interesting paper lately communicated by that gentleman, will not be unacceptable to the Society. A further appeal to analysis for illustrating the chemical constitution of tabasheer seems the more necessary, since the results of the two analyses of it which have been published differ considerably from each other. For according to the experiments of Mr Macie, detailed in the Philosophical Transactions for 1791, p. 368, the tabasheer brought from India by Dr Russell consists of pure siliceous earth; while the specimen brought from South America by Messrs Humboldt and Bonpland was found by Fourcroy and Vauquelin to contain only 70 per cent. of silica, the other 30 consisting of potash, lime, water, and a small quantity of vegetable matter.[†] This difference is both considerable and important. The siliceous concretions in the joints of the bamboo must surely have existed in the sap in a state of solution; and from the large proportion of silica contained in the epidermis of the bamboo, it may also be inferred

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[*] Read at the Royal Society on March 3d.

[†] *Memoires de l'Institut.* tom. vi. p. 382. (1806.)

that this earth must exist in the fluids of the plant, not as an accidental, but as an essential ingredient. In what manner a substance of so insoluble a nature is taken up by the roots of the plant has not yet been investigated; but it is probable that considerable light would be thrown on the subject by a chemical examination of the soil in which the bamboo grows, and of the fluids which circulate in its vessels. In attempting any explanation on chemical principles two views may be suggested. It may be supposed either that silica at the moment of being set free by the decomposition of siliceous compounds, may be dissolved in common spring-water; or that siliceous earth, in its ordinary state, is rendered soluble in water through the medium of an alkali. It would be an argument of considerable weight in favour of the latter view should potash always be contained in tabasheer; but, at the same time, the former supposition is by no means impossible. The researches of Berzelius have demonstrated, that when silica in the nascent state is acted on by water, it is dissolved in considerable quantity; and hence it is not improbable, that when in the act of separation from substances with which it was previously combined, it may also, under favourable circumstances, be dissolved by water.

When tabasheer is put into water, numerous small air-bubbles rapidly escape, the quantity of which is fully equal in bulk to the specimen employed, and is even somewhat greater in the finer varieties. The weight of the dry tabasheer compared to that of the water which it is capable of absorbing is as 1 to 2 in the chalky variety, 1 to 2.32 in the translucent, and 1 to 2.24 in the transparent tabasheer. The specific gravity of these different kinds, taken at the temperature of 56 Fahr. is shown by the following table. In finding the numbers contained in the first row, the air was displaced by soaking the specimen for several hours in cold water; in those of the second, the air was more completely expelled by boiling for a few minutes in water.

| | 1st Row. | 2d Row. |
|---|---|---|
| Chalky tabasheer, | 2.161 | 2.189 |
| Translucent tabasheer, | 2.143 | 2.167 |
| Transparent tabasheer, | 2.133 | 2.160 |

The density falls below the number observed by Mr Jardine, but agrees closely with the observations of Mr Macie and Mr Cavendish.

Tabasheer is very slightly affected by heat. When heated to 212° Fahr. it gives out both air and water, and the latter has neither an acid nor alkaline reaction. The loss in weight is small, and differs slightly in the different specimens. Thus the chalky tabasheer loses 0.838 per cent., the translucent 1.62, and the transparent variety 2.411 per cent. On exposure to the atmosphere it absorbs both air and moisture, and speedily recovers its original weight. At a red heat all the varieties become dark in a slight degree, but almost instantly recover their former appearance; a minute quantity of smoke accompanied with an empyreumatic odour rises at the same time, and the moisture which is expelled has an acid reaction. These phenomena are owing to the decomposition of a trace of vegetable matter. By being thus heated to redness the chalky variety loses 1.277, the translucent tabasheer 3.84, and the transparent tabasheer 4.518 per cent. The whole loss occasioned by a red heat is not recovered by exposure to the air.

Tabasheer feels gritty in the mouth, and causes a sensation very like magnesia, but with a rather nauseous taste. It is brittle and easily reduced to powder. When boiled in distilled water it yields to that menstruum only a trace of vegetable matter. Digested with muriatic acid, moderately diluted with water, the solution on being evaporated left a minute residue, which deliquesced on exposure to the air, and proved to be muriate of lime. The chalky tabasheer by this treatment lost 0.4, and the translucent tabasheer 0.3 per cent. of lime. The transparent variety yielded barely a trace of any thing to muriatic acid.

Tabasheer dissolves readily in a solution of pure potash, even after being heated to redness. The alkaline solution of the chalky kind is slightly turbid, but that of the other varieties is quite transparent. On neutralizing with muriatic acid, and evaporating to dryness to render the silica insoluble, a quantity of that earth is left almost exactly equal to the quantity originally employed. The filtered liquid contained nothing but muriate of potash and the minute quantity of lime above-mentioned.

A portion of tabasheer in fine powder was intimately mixed with five times its weight of carbonate of barytes, and exposed for an hour and a half to a white heat. On dissolving the mass in muriatic acid, and separating the silica and barytes in the usual manner, the soluble parts were evaporated to dryness and ignited, but not a trace of alkaline matter was detected.

It hence appears from the foregoing analysis, that the tabasheer of India consists of silica containing a minute quantity of lime and vegetable matter.

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## ART. XVIII.—ZOOLOGICAL COLLECTIONS.

### 1. *Bears of India.*

THE three bears which have been ascertained to be natives of India form part of the collection in the menagerie at Barrackpore Park. The first, or *Ursus labiatus*, the ursine sloth of Shaw and others, has long been known. The second, or *Ursus Malayanus* of Dr Horsfield, has been described by that gentleman and by Sir Stamford Raffles; and the third, or *Ursus Thibetanus*, was first ascertained by M. Duvaucel to be a separate species. "As his description, however, does not entirely accord (says a writer in an Indian Journal) with the observations which we have made on the specimen of this animal at Barrackpore, it may be serviceable to add a supplementary one.

"*Description.*—The general colour of the animal is coal-black. The hair is thick and glossy, but harsh; on the back it is about an inch and a half long; but is neither so long nor so harsh as the hair of the *Ursus labiatus*. Head conical; viewed laterally it appears gradually attenuated, the nose being nearly in a continuous line with the forehead, so as to present very definitely the form of a truncated cone. The ears are round, large, and very distinct from the long hair in which they are situated. This hair passes down from the ear on each side of the head, giving the appearance of a ruff, but does not pass entirely round the throat, as it leaves a large interval under the chin. Between the ears and on the back of the head the hair is much shorter. The muzzle, in shape like that of a dog, is of a rusty-gray colour; under the chin is a white triangular spot. A white semilunar mark occupies the chest. The paws of the animal are very broad; each has five toes of unequal length. Its claws are short and weak.

"*Remarks.*—The form of the animal is expressive of great strength. The limbs are more strikingly muscular than those of any other individual in the park collection. The observation of M. Duvaucel that its apparent "force supérieure ne s'accorde pas avec la foiblesse de ses ongles," is very just; but the supposition that he thinks may be drawn from it "que celui ci n'est pas grimpeur," is contradicted by the habits of the Park individual, who is a distinguished climber. His remark that "son museau supérieur est noir à tout age" is also at variance with the fact in respect to two specimens in the Park, in both of which the upper part of the muzzle is of a rusty-gray colour. With regard to the pectoral mark this naturalist observes, that it has "la forme d'une fourche dont les deux branches, tres ècartées, occupent toute la poitrine, et dont la queue se prolonge jusqu' au milieu du ventre." This is not an invariable character. It was present in an individual which was lately removed from the park, but in two specimens now there, one above three years old, the other not quite one, it is a curved, rather narrow stripe, which passes across the chest between the fore legs; but has no prolongation down the belly of the animal.

"Of the disposition of this animal we know scarcely any thing, but have no reason to believe that it is more fierce than its congeners. All the different species in the park have been rendered tame. If there be any difference between them, it is rather in favour of the *Ursus Thibetanus*; for of two young specimens of the *Ursus labiatus*, and of the *Ursus Thibetanus*, the former is more pugnacious than the latter."

## 2. *On the Crocodiles of the Ganges.* By C. Abel, M. D., F. R. S.

On Tuesday, March 23d, 1824, I received at Barrackpore, through the kindness of my friend, Dr Wallich, a large crocodile, measuring eighteen feet from the extremity of the nose to the end of the tail, which had been brought to him at the botanic garden by some fishermen, who had taken it in the river. It had been dead several days when it reached me, and had apparently been destroyed by a spear driven into its neck at the junction of its head with the cervical vertebræ, so as to separate the brain from the spinal marrow, This animal proved to be the Cummeer of the natives. In consequence of its very putrid state, I was unable to examine its internal structure, but made such observations on its external characters, as enabled me to compare it with its described congeners.

M. Cuvier divides the genus *Crocodilus* into three subgenera, which he names—1st *Les Gavials*:—2d *Les Crocodiles proprement dits*:—3d *Les Caimans* (Alligator.) Of these the *gavial*, or *gurryal*, of the natives,—the *Lacerta Gangetica* of Gmelin, has been long known as the inhabitant of the rivers of India, and is distinguished by its elongated head. Of the true crocodiles the *Crocodilus biporcatus*, is said by Cuvier to be the inhabitant of the islands and probably of the two peninsulas of India. The *caiman*, or alligator, has not, according to Cuvier, been found except in America. The *Crocodilus biporcatus* is described by Cuvier as having "eight ranges of oval plates along the back, and two prominent projections on the top of its muzzle." In the cummeer brought to Barrackpore, the arrangement of the principal plates were in four rows, or rather two double rows, occupying the middle of the back, with two other less prominent than these, one on each side; two more traces of rows were also visible, but only traceable, in small scattered prominences. Of the projections on the top of the nose or muzzle (deux aretes saillantes sur le haut du museau) there was no other appearance than two not very striking elevations, or knobs above the eyes, although between these and the end of the upper jaw the surface of the nose was rough with mammillated prominences. The slight differences which I have here pointed out would not of themselves, perhaps, suffice to make any specific distinction between the cummeer and *Crocodilus biporcatus*, but I have also to mention a character which affects even the genus of the crocodile as characterized by Cuvier. This naturalist states that the whole family of crocodiles have five toes before, and four behind, of which the three internal ones alone on each foot are armed with claws. Thus far the cummeer agrees with his description. But he further adds, that all the toes of crocodiles are more or less united by membranes or webs, as has also been stated by Lacepede and others; and adds that the crocodile, properly so called, in this respect has the character of the *gavial*, in which, he says, the hind feet are palmated to the extremity of the toes. This character is wanting in the cummeer, in which the inner toe of the hind and two inner toes of the fore feet are perfectly free, not being connected by any membrane. If this peculiarity be of constant occurrence, it makes the cummeer not only a new and undescribed species, but it also vitiates the description of the family and of the genus of crocodiles heretofore given. It would be premature, however, to decide on this question, till other opportunities of examining the animal shall have occurred, and it will have been sufficient to have pointed out the peculiarity to observers in this country.

It should be observed of the cummeer, however, that its teeth correspond with those of the true crocodiles, in the mode in which those of the under are received into the upper jaw. "The teeth," says Cuvier, "of the crocodiles, properly so called, are unequal, the fourth tooth on each side passes into a fissure, and not into a hole of the upper jaw. In the gavials the teeth are nearly equal, although in other respects they agree with those of the crocodile. In the *caimans* or alligator, on the contrary, the teeth are unequal, but the fourth tooth of the lower jaw on each side is received into a hole, and not into a fissure."

In the cummeer there are thirty-six teeth in the upper jaw, and thirty in the lower. These are all in the form of blunt cones, excepting the fourth in the lower jaw, which are rather more pointed, and might be compared to the canine teeth of large carnivorous animals. The two front teeth of the lower jaw pass into holes which perforate the upper jaw; the second and third are received into small holes, and the fourth into deep fissures visible on each side when the mouth is closed; all the other teeth of the lower jaw enter small holes. The upper teeth, on the contrary, are all received into fissures on the outside of the lower jaw, with the exception of the four hindmost, which are very small, and received into indentations of the lower jaw.

Although the putrescency of the body of the animal prevented any deliberate examination of its internal structure, the contents of its stomach were exposed and found to consist of the remains of a woman, of a whole cat, of the remains of a dog and sheep, of several rings, and of the separated parts of the common bangles worn by the native women.

## 3. *Account of the White Elephant of Siam.* By George Finlayson, Esq.

We were first conducted to the stables of the white elephants, which, being held in great veneration by the Siamese, are kept within the inner enclosure of the palace, and have habitations allotted to them quite close to those of the King himself.

Of white elephants there are at the present time no fewer than five in the possession of the King, whence we may infer that this variety is far less rare than we are accustomed to believe, at least that is so in the farther Peninsula of India. It has, however, seldom happened that so many have been collected at one period, and the present is regarded as auspicious, in consequence of an event so unexpected, and so much desired. A white elephant is still reckoned as beyond all value. Every effort is made to take them, when they are by chance discovered; and the subjects of the King can perform no more gratifying service than that of securing them. They, and indeed all elephants, are the property of the King only.

The appellation white, as applied to the elephants, must be received with some degree of limitation. The animal is in fact an occasional variety, of less frequent occurrence indeed, but in every respect analogous to what occurs in other orders of animals, and, amongst the rest, in the human species. They are, correctly speaking, albinos, and are possessed of all the peculiarities of that abnormal production; but of these *white* elephants, it was remarkable that the organ of sight was to all appearance natural and sound, in no way intolerant of light, readily accommodating itself to the degrees of light and shade, and capable of being steadily directed to objects at the will of the animal. In short, similar in all respects to that of the common elephant, with the exception of the iris, which was of a pure white colour. In this respect they resembled all the quadrupedal albinos that I had hitherto seen, as those among horses, cows, rabbits. This circumstance I should scarce have thought worth the noticing, were it not that I shall have occasion to mention in the sequel an instance of an animal of the albino kind, possessed of the peculiar eye of the human albino. In one or two of the elephants, the colour was strictly white, and in all of them the iris was of that colour as well as the margins of the eyelids. In the rest the colour had a cast of pink in it. The hairs upon the body were for the most part yellowish, but much more scanty, finer, and shorter than in other elephants; the strong hairs of the tail were darker, but still of a yellowish colour. In none did the colour and texture of the skin appear entirely healthy. In some the cuticular texture of the legs was interspersed with glandular knots, which gave a deformed appearance to these members. In others the skin of the body was uncommonly dry, while the natural wrinkles were unusually large, secreted an acid-like fluid, and seemed ready to burst out into disease. These beasts were all of a small size, but in excellent condition, and one of them was even handsome. They were treated with the greatest attention, each having several keepers attached to him. Fresh cut grass was placed in abundance by their side. They stood on a large boarded platform, kept clean; a white cloth was spread before them, and while we were present, they were fed with sliced sugar cane and branches of plantains.

In the same place we observed rather a fine-looking elephant, but a small one, which appeared to me to be a greater object of curiosity than any of the others. This animal was covered all over with black spots, about the size of a pea, upon a white base. It is not unusual to observe a partial degree of this spotted appearance in the elephant of Bengal, as on the forehead and trunk of the animal, but in this instance the skin was entirely covered with them.

The greatest regard is entertained in Siam for the white elephant. He who discovers one is regarded as the most fortunate of mortals. The event is of that importance, that it may be said to form an era in the annals of the nation. The fortunate discoverer is rewarded with a silver crown, and with a grant of land equal in extent to the space of country at which the elephants cry can be heard. He and his family to the third generation are exempted from all sorts of servitude, and their land from taxation.—*Mission to Siam and Hue, &c.* 1821-2. London, 1826. pp. 151-154.

### 4. *Account of a Fight between a Tiger and an Elephant.* By George Finlayson, Esq.

In the midst of a grassy plain, about half a mile long, and nearly as much in breadth, about sixty or seventy fine elephants were drawn up in several ranks, each animal being provided with a mahawat and a hauda, which was empty. On one side were placed convenient seats; the governor, mandarins, and a numerous train of soldiers being also present at the spectacle. A crowd of spectators occupied the side opposite. The tiger was bound to a stake placed in the centre of the plain, by means of a stout rope fastened round his loins. We soon perceived how unequal was the combat. The claws of the poor animal had been torn out, and a strong stitch bound the lips together, and prevented him from opening his mouth. On being turned loose from the cage he attempted to bound over the plain, but, finding all attempts to extricate himself useless, he threw himself at length upon the grass, till, seeing a large elephant with long tusks approach, he got up and faced the coming danger. The elephant was by this attitude and the horrid growl of the tiger too much intimidated, and turned aside, while the tiger pursued him heavily, and struck him with his fore-paw upon the hind quarter, quickening his pace not a little.

The mahawat succeeded in bringing the elephant to the charge again before he had gone far, and this time he rushed on furiously, driving his tusks into the earth under the tiger, and, lifting him up fairly, gave him a clear cast to the distance of about thirty feet. This was an interesting point in the combat. The tiger lay along on the ground as if he were dead, yet it appeared that he had sustained no material injury, for on the next attack he threw himself into an attitude of defence, and, as the elephant was again about to take him up, he sprung upon his forehead, fixing his hind-feet upon the trunk of the former.

The elephant was wounded in this attack, and so much frightened, that nothing could prevent him from breaking through every obstacle, and fairly running off. The mahawat was considered to have failed in his duty, and soon after was brought up to the governor with his hands bound behind his back, and on the spot received a hundred lashes of the rattan.

Another elephant was now brought, but the tiger made less resistance on each successive attack. It was evident that the tosses he received must soon occasion his death.

All the elephants were furnished with tusks, and the mode of attack in every instance, for several others were called forward, was that of rushing upon the tiger, thrusting their tusks under him, raising him, and throwing him to a distance. Of their trunks they evidently were very careful, rolling them cautiously up under the chin. When the tiger was perfectly dead, an elephant was brought up, who, instead of raising the tiger in his tusks, seized him with his trunk, and in general cast him to the distance of thirty feet.—*Mission to Siam and Hue,* p. 321–323.

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## ART. XIX.—HISTORY OF MECHANICAL INVENTIONS AND OF PROCESSES AND MATERIALS USED IN THE FINE AND USEFUL ARTS.

### 1. *Account of the Makleua, a Siamese Black Dye.*

THIS is a berry growing on a large forest tree at Bankok, and used most extensively by the Siamese as a vegetable black dye. It is merely bruised in water when a fermentation takes place, and the article to be dyed is steeped in the whole and then spread out in the sun to dry. This operation is repeated, and in two or three times the cotton or silk receives an excellent and durable black colour. If the article to be dyed is previously of a red or white colour, it receives the black dye much more easily. But a piece of English green camlet was dyed black in four applications. Captain Burney could not procure any of the flower or seed of this plant, but the Portuguese consul at Bankok has promised to send him some of the seed at the proper season. Ten or twelve young plants were brought away from Siam, only one survived to Penang, where it was left, as it looked sickly. The Siamese said that the tree is not to be found in any part of the Siamese territory lying to the southward of Bankok. All the crape scarfs worn by the common people at Bankok are dyed black with this makleua berry, which is remarkably cheap, being sold at the rate of twenty or thirty large cups-full for a rupee. The berry when fresh is of a fine green colour, but after being gathered for two or three days it becomes quite black and shrivelled like pepper. It must be used fresh, and whilst its mixture with water produces a fermentation.

CALCUTTA, 1*st February* 1827. W. BURNEY.

### 2. *Account of a new kind of Cloth fabricated by Insects.*

M. Habenstreet of Munich has obtained this curious fabric by directing the efforts of the larvæ of a butterfly called *Finea punctata* or *Finea padilla.* As these caterpillars construct over themselves a tent of extreme fineness, and impervious to air, M. H. contrived to make the insects work on a paper model suspended from the ceiling, to which he gave any form and dimensions he pleased. He thus obtained square shawls an ell wide, and some two ells long by one broad, an air balloon four feet high, and a woman's complete robe with the sleeves, but without seams. In order to give the tissue a regular form, the caterpillars are limited in their motions, and interdicted from particular parts by oil, which they dislike, and upon which they will never work. Hence he made them fabricate a stuff which appeared as if regularly stitched. One or two insects can weave a square inch of cloth.

This cloth exceeds in fineness the lightest gauze, and a specimen of it sent by M. Paret of Stockholm was exhibited by M. Lenormand to the Academy of Sciences of Paris.

The air balloon above-mentioned weighed only five grains, and yet it was impervious to air. The heat of the hand instantly inflated it; and the flame of a single match held for some seconds beneath it caused it to rise to a considerable height in the air, where it remained for half an hour.

A shawl an ell square was, when extended, blown into the air by a slight puff, when it was like a light vapour gently agitated by the wind.

M. Habenstreet offered a shawl to M. Paret, on condition that the latter would cause it to fall from the air upon his head, but this was impossible, for, as the shawl approached his body, the heat which rose from it repelled the shawl into the air.

A complete robe of this stuff was worn by the Queen of Bavaria over her dress on court days.

The fibres of this fabric, of which the caterpillars form their coccoons, are not interlaced, but merely superposed, and this act takes place the moment the insect secretes the matter of the fibre. M. H. gives it increased solidity by compelling the insects to labour several times over the same surface. A shawl an ell square costs at Munich only eight francs.

M. Lenormand, from whose memoir the preceding facts are taken, suggests, that, as the caterpillar which forms the fusain (*Euonymus Europæus*) and which is common in France, spins its threads and forms its tent in a similar manner, its labour might be employed for the same purpose.—Abridged from Newton's *Journal of the Arts*, December 1827, p. 214.

### 3. *Radii of the surfaces of a Double Achromatic Object-Glass.* By M. LITTROW.

The index of refraction of the crown glass being 1.53, and that of the flint glass 1.60; their dispersive ratio 0.25, the thickness of the crown lens 0.01, and that of the flint 0, and the lenses being supposed in contact, the best radii will be

| | |
|---|---|
| Crown lens equally convex, radius of each surface, | 10.6 |
| Flint glass lens double concave, radius of 1st surface, | 1.04394 |
| 2d surface, | 3.296512 |
| Focal length, - - - - | 3.702231 |
| Aperture, - - = Focal length, × | 0.09973 |

That is, the aperture will be 1-10th of the focal length, which is a much larger proportional aperture than it is usual to give to achromatic telescopes.

### 4. *Exhibition of the National Industry of France.*

This great exhibition of the production of the arts, sciences, and manufactures of France took place on the 3d October 1827, was honoured with the approbation of his Majesty Charles X.

This munificent sovereign, whose patronage of the arts and sciences is not equalled by any of the Princes of Europe, conferred the decorations of the Legion of Honour on twelve of the most distinguished artizans, and adjudged *twenty-two* gold medals, *seventy-one* silver medals, and *sixty-nine* medals in bronze, for improvements connected with the manufacture of silken, woollen, cotton and linen fabrics. For works performed in metals, 10 gold, 27 silver, and 58 bronze medals.

For improvements in machinery, 2 gold, 8 silver, and 11 bronze medals. For mathematical and musical instruments, 7 gold, 5 silver, and 20 bronze medals.

For discoveries in chemistry, 4 gold, 11 silver, and 24 bronze medals.

For productions in the fine arts, 2 gold, 11 silver, and 12 bronze medals.

For china and pottery-ware, 2 silver and 6 bronze medals. And

For various arts, including printing, 2 gold and 4 silver medals.

The total medals adjudged were—

| | | |
|---|---|---|
| Gold medals, | - | 48 |
| Silver medals, | - | 139 |
| Bronze medals, | - | 217 |
| | Total, | 404 |

The Editor of the *Journal of Arts*, from whose pages we take the preceding statement, asks, What would be the effect of such an exhibition in London? We extend the question by asking, What would be the effects of such an exhibition in London, Dublin, and Edinburgh? and we venture to answer it.

The artists of France and of all foreign countries have, within the last ten years, not only been rivalling those of Great Britain, but in many points they have greatly surpassed them, and the consequence is, that Great Britain is rapidly sinking from the prominent position which it formerly held in the practical, and even in the scientific arts. This is owing to the neglect of the arts and sciences by every successive government by which we are ruled. The concerns of faction, and the urgencies of political, financial, and commercial transactions, occupy all the time and all the anxieties of our Ministers. No applications, however disinterested,—no remonstrances, however eloquent, can make the slightest impression in favour of science and the arts. Even those who devote their time and their money to introduce new arts and new materials of art, without any view to their own advantage, are checked and harassed by the oppressive regulations of our excise laws and our custom-house regulations, and are driven in utter despair from their patriotic position.

In other countries no such obstructions exist. Public boards, whose objects are of a scientific nature, are there composed of scientific and practical men, whereas here scientific and practical men are entirely excluded; and the consequence of this is, that the concerns of these boards are conducted at a most inordinate expence, and all improvements, and all inventions which are brought forward to promote their objects, are overlooked or rejected.

To draw public attention to such a state of things,—to give to the useful and scientific arts the same fashion which the fine arts have so long enjoyed,—to collect from every corner of the island into its three metropolitan cities its unseen and its unhonoured inventions,—and to draw genius from its obscure retreats, would be a few of the effects of a biennial exhibition of British industry. The Society of Arts for Scotland has been struggling to accomplish this by their own means and exertions, but public aid and royal patronage are absolutely necessary to its success; and unless the plan is laid at the foot of the throne by some influential individuals, it will never be effected; and we must continue to brook the mortification, bitter as it is, of witnessing the triumphs of the arts in every land but the land which we love.

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## ART. XX.—ANALYSIS OF SCIENTIFIC BOOKS AND MEMOIRS.

### 1. *A new System of Chemical Philosophy*. Part First of Vol. ii. By JOHN DALTON, F. R. S. &c. Manchester, 1827.

THE author informs us that about the half of this volume was printed ten years ago, and that the rest was sent scrap by scrap to the printer till the time it appeared. Owing to this unhappy arrangement, many of the results, which would have been important, had they been published some years ago, have now, in consequence of improved modes of analysis and more refined manipulation, been superseded by experiments of greater accuracy. The present volume, nevertheless, contains various interesting observations, and bears the stamp of that original mind for which Mr Dalton is distinguished. A short review of it, therefore, cannot fail to prove acceptable to our chemical readers.

Mr Dalton in the volume before us treats of *compounds of two elements*, and he divides it into six sections; the first on oxides; the second on sulphurets; the third on phosphurets; the fourth on carburets; the fifth on alloys; and the sixth on triple alloys. The volume is concluded by an appendix, containing corrections on his former volumes in consequence of new discoveries; and some remarks on recent investigations on heat. We intend to take such a review of these several parts of Mr Dalton's work as will enable the reader to judge of the merits and interest of its contents.

*Section on the Oxides.*—Mr Dalton enumerates six methods for ascertaining the proportion in which oxygen combines with a metal; first, by combustion in air or in oxygen; second, by solution in an acid and subsequent precipitation by an earth or alkali; third, by precipitating one metal by another, whereby oxygen is thus said to be transferred from the one to the other; fourth, by the hydrogen evolved in solution by an acid; fifth, by transferring a lower oxide into a higher by means of a solution of oxymuriate of lime (bleaching powder;) and sixth, by the nitrous gas evolved during solution in nitric acid. "The first four methods have been used by chemists for several years past; the two last I have added from my own experience, having found them very useful assistants in various instances.

The last method by nitrous gas, has indeed been proposed before, and labour bestowed on it both by others and myself, but without reducing the results to any certainty, till lately; the principal cause of this want of success has arisen from misunderstanding the nature and constitution of nitric acid." (Page 4.) "It sometimes happens that the nitrous gas is partly or wholly retained by the residue of nitric acid; but in this case the oxymuriate of lime may be applied to convert the nitrous gas into nitric acid." (Page 5.)

Accordingly this method of ascertaining the proportion of oxygen which enters into combination with a metal is the one adopted by Mr Dalton. The method, we should apprehend, is one not likely to be approved by practical chemists; for though assuredly it must be possible in some instances to ascertain the combining oxygen by this method; yet there is hardly an instance where other methods equally easy and more susceptible of accuracy could not be adopted. Besides, the method rests on a somewhat remote deduction from an assumption that the sole product is a nitrate. Now we know that ammonia results in some cases from the action of nitric acid; and its production ought perhaps to be suspected in other cases where it has not yet been ascertained. Accordingly we find Mr Dalton stating (page 31) that his experiments on the nitric oxide evolved by iron and nitric acid did not afford "satisfactory" data for deducing the oxygen which combines with iron. Part of the nitric oxide was retained by the iron solution; and when in order to convert this into nitric acid he added a solution of bleaching powder, a pungent gas was evolved, which he supposes to be a compound containing more oxygen than nitric acid. We have no doubt that this "pungent gas" is the same again mentioned by Mr Dalton (Appendix, page 336,) as an accompaniment to the azote evolved when an ammoniacal salt is mixed with a solution of bleaching powder—"exciting sneezing, and inducing catarrh." The offensive vapour which produces these effects is chloride of azote derived probably in the case of the iron solution from the action of dissolved bleaching powder or nitrate of ammonia. Since we are upon the subject, we may observe that it is by no means easy to obtain azote quite free from all smell of chloride of azote, by decomposing ammonia by means of chlorine; and if we should attempt to free the azote of chloride by washing, we run equal risk of contaminating the azote with other gases separated from the water. Messrs Berzelius and Dulong (*Annales de Chimie et de Physique*, vol. xv. page 390) procured the azote of which they took the specific gravity by decomposing ammonia by chlorine; and the reason that they obtained the specific gravity .976 which Messrs Biot and Arago before then got .968 probably was that their azote retained a trace of chloride of azote. At least we are certain that either their specific gravity of oxygen or of azote must be too much or that of air too little; for, taking the air to consist of .21 of oxygen by bulk and .79 of azote, 1. of air by bulk, yields by computation a specific gravity of 1.0026 instead of 1. Admitting the specific gravity of oxygen to be as they state it, we would have to reduce that of azote to .9727, in order to make that of air 1. Besides oxygen and azote, Messrs Berzelius and Dulong took the specific gravity of hydrogen and of carbonic acid; and from their specific gravities of these four gases, continental chemists have deduced their atomic weights, and have been content to *calculate* the specific gravities of other gases consisting of oxygen, azote, carbon or hydrogen. This is a deference to which we humbly apprehend the experiments are not entitled. The atomic weight of hydrogen, carbon, azote, and oxygen are light compared with those of other undecompounded substances; and we need hardly remind our chemical readers that the lighter the atomic weight of an undecompounded substance is, the more likely is it to be found afterwards the constituent of another heavier undecompounded substance now assumed to be simple; and conversely the heavier the atom of an undecompounded substance, the more likely is it to prove compound. Thus, according to Dr Thomson, the atomic weight of fluorine is 2.25, that of chlorine 4.5, and that of iodine 15.5. Iodine being the heaviest atom is most likely to be compound. So far as weight is concerned, iodine *may* contain chlorine, and chlorine *may* contain fluorine. If the question is put, may iodine be a compound of one atom of fluorine (2.25) and three atoms of chlorine ($4.5 \times 3 = 13.5$;) we answer it by adding them together ($2.25 + 13.5$) and we get the sum 15.75 instead of 15.5. We can therefore be certain that iodine does not consist of one atom of fluorine and three atoms of chlorine; provided always that we are sure the atomic weights of fluorine, chlorine, and iodine are, as we have stated, 2.25, 4.5, and 13.5. The day is coming when the art of analysis being exhausted in attempts to resolve into others, substances which resist decomposition, aid will be derived from the indirect light afforded by such considerations as these. We attach, therefore, much importance to the accurate determination of the atomic weights of such substances as hydrogen, carbon, azote, and oxygen; and probably, on the whole, the atomic weights of these substances may be best determined by ascertaining their specific gravities. But we shall be loth to admit the specific gravities of hydrogen, carbon, azote, and oxygen, as determined by any experiments which are not confirmed by similar ones on carbonic oxide (as well as carbonic acid,) on cyanogen, on nitrous and nitric oxides, and on ammonia. If the experiments of Messrs Berzelius and Dulong had extended to these compounds, we would have had *proof*, which they themselves have not, of the accuracy of their results; and the want of such proof must ever in our eyes depreciate the value of their experiments considered as fundamental.

Mr Dalton gives experiments on most of the metals, calculating generally from the nitric oxide evolved during their solution in nitric acid. These experiments may be regarded in two points of view; *first*, as they afford new quantitive determinations; *second*, as they add to our knowledge of chemical combinations. Viewed as quantitive determinations, we can hardly regard them as of much interest. Most of the oxides he examines had been examined by other chemists before him, or at least have been examined since his experiments were made; and though doubtlessly repetitions of quantitive experiments are of value in as far as they enable us to approximate to accuracy, we cannot regard Mr Dalton's methods of experimenting to be of that character which would warrant us in employing them for this purpose. Indeed we cannot help regretting that the author of the most important discovery which has ever enriched chemistry should not have partaken of the feeling of the illustrious author of the *Novum Organon*, who complained that "he, who deserveth to be an architect in this building, should be forced to be a workman and a labourer, and to dig the clay and burn the brick; and to gather the straw and the stubble all over the fields to burn the bricks withal." Mr Dalton could not indeed, like Bacon, complain that there were no workmen, and that, "unless he do it, nothing will be done;" for all in all the labourers are not few; and we cannot but feel, that, if he had employed himself (which obviously he has not) in overlooking their labours, he would have stood more in his place; and he, who ranks low among workmen, might, as an architect, have continued to add beauty and stability to the edifice of which he was the projector. With regard to new facts, Mr Dalton's work does not furnish many; yet various statements scattered up and down will repay an attentive perusal. We shall take notice of one or two of these, which, however, are not absolutely new.

In dissolving mercury in aquafortis, Mr Dalton says that no gas is evolved in the cold. Without having experimented on the subject personally, we may remark that it is quite possible that by this means a mixture or compound of one atom nitrate and of one atom hyponitrite of mercury may be produced. Thus two atoms nitric acid 13.5 (= 3.5 of axote + 10 oxygen, according to Dr Thomson) may resolve themselves into 6.75 (one atom) of nitric acid + 1. (one atom) of oxygen = 7.75, and into 4.75 (one atom) of hyponitrous acid + 1. (one atom) of oxygen = 5.75 which, added to 7.75 gives 13.5, the two atoms of nitric acid. From Mr Dalton's highly valuable paper on the action of nitric oxide on oxygen over mercury,* it is easy to gather that two volumes of nitric oxide form with one volume of oxygen one volume of nitrous acid; which volume of nitrous acid is absorbed by the mercury producing hyponitrite of mercury.

The effect of heat on the solution of mercury formed in the cold was singular. To simplify the explanation, we shall suppose that exactly fifty grains had been used, which, according to Dr Thomson, should take up two grains of oxygen to form the black oxide and four grains to form the red oxide. Now a *boiling* heat being employed, nitric oxide was evolved and collected, equivalent to two grains of oxygen. "This would have led me to suppose I had obtained the black oxide in solution; it was, however, entirely the *red*, as it gave no precipitate by common salt and exhibited the red oxide by lime water; but it required as much oxymuriate of lime as contained two of oxygen to saturate the *nitrous gas* in the solution before any oxymuriatic acid was liberated." It surely is more probable that the "oxymuriate of lime" acted on hyponitrous acid than on nitrous gas, since Mr Dalton says he employed a boiling heat, and that only one-tenth excess of acid remained in solution (p. 22.) The nitrate containing the red oxide of mercury consists of 12.5 metal + 1 oxygen + 6.75 of acid = 20.25. Now we conceive that out of the 50 of mercury, twenty-five produced

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* *Annals of Philosophy*, x. p. 43.

twice this quantity of nitrate of red oxide, that is 40.5; in doing which, it is evident, that nitrous gas would be evolved equivalent to two of oxygen as Mr Dalton found; and the remaining 25 of mercury may have divided into two parts, forming with two atoms of nitric acid (13.5) *first,* nitrate of red oxide (12.5 metal + 1 oxygen + 6.75 acid = 20.25) and *second,* hyponitrite of red oxide (12.5 metal + 1 oxygen + 4.75 acid = 18.25,) and this 18.25 of hyponitrite would evidently decompose oxymuriate of lime equivalent to two of oxygen, as Mr Dalton also found. One-fourth of the mercury would thus produce hyponitrite of red oxide, and three-fourths nitrate of red oxide. This is a result which may have eluded any other mode of investigation than that employed by Mr Dalton; for we learn from his paper alluded to, that the hyponitrite of mercury readily absorbs oxygen from the air, becoming a nitrate.

Red oxide of lead seems to us a compound, the nature of which requires further investigation. Doctors Berzelius and Thomson agree in the statement, that after being treated with vinegar, 27 parts dissolved in nitric acid leave nearly 14 of brown oxide. But before being treated with vinegar, Mr Dalton (p. 46) says that nitric acid leaves only one part of brown oxide out of five of red lead. M. Longchamp found only one left out of six; and M. Houton-Labillardière found one left out of four of a *crystallized* specimen, (*Ann. de Chim. et Phys.* vol. xxxiv and xxxvi.) Even allowing for the accidental presence of litharge (though 50 or 60 in the 100 appear excessive) there is reason to suspect that an oxide of lead may exist consisting of three atoms of metal and four atoms of oxygen.

The red oxide of iron is considered by Mr Dalton as a compound of one atom of oxygen with two atoms of black oxide of iron. In the present state of chemistry this view is probably the simplest and the most plausible that has been proposed. Other statements respecting the oxides occur not devoid of interest; but having dwelt thus long on this part of the work, we must beg to refer our chemical readers to the volume itself. The next section treats of the *sulphurets.* We do not dwell upon this subject, because the interest of Mr Dalton's statements is now superseded by the subsequent discoveries of Berzelius and Berthier.

The next section treats of phosphurets. The most interesting part of this section consists of some corrected statements respecting phosphuretted hydrogen. This is the most unfortunate of all compounds. It has been successively investigated by Davy, Dalton, Thomson, Dumas, and Rose; and all disagree. Much as has been done, new experiments are still required. Probably the paper of Dumas would be the best starting point. That of Rose proceeds too much on deduction, and includes too many assumptions to inspire us with confidence.

Under the section of the carburets, Mr Dalton's opinion of the nature of steel merits grave consideration.

"From the above account of steel, it is evident there is an essential difference between it and pure iron. That difference consists, according to the common opinion, in steel being a *carburet* of iron, or carbon and iron united. The fact of the union of carbon and iron in the formation of steel does not seem to me satisfactorily proved. Mr Collier asserts that iron gains about 1-180th of its weight by being converted into steel.[*] But Mr Mushet found that though steel gains weight upon the iron when copiously imbedded in charcoal, yet it loses weight if the charcoal is only 1-90 or 1-100 of the weight of the iron.[†] The same ingenious gentleman seems to estimate the carbon in cast steel, from synthetic experiments, to be 1-100th of its weight.

"From analytic experiments, however, there does not appear reason to believe that steel contains so much, if any charcoal. Pure steel dissolved in dilute sulphuric acid gives hydrogen gas containing no carbonic acid nor oxide, neither is there any appreciable residuum of any kind in general.

"On considering all the circumstances, I am inclined to believe, that the properties which distinguish steel from iron are rather owing to a peculiar crystallization or arrangement of the ultimate particles of iron, than to their combination with carbon or any other substance. In all cases where steel is formed, the mass is brought into a liquid form, or nearly approaching to it,—a circumstance which allows the particles to be subject to the law of crystallization. We see that great change is made in steel by the mere *tempering* of it, which cannot be ascribed to the loss or gain of any substance, but to some modification of the internal arrangement of its particles. Why then may not its differences from iron be ascribed to the same cause?" Pp. 216,-218.

In the *addenda* to the volume Mr Dalton says: "Since writing the article at page 214, I have had an opportunity of analyzing the crystalline steel, formed by Mr Macintosh's process of cementation by means of coal gas. I dissolved twenty-one grains of this steel in sulphuric acid, with only a very slight excess of acid. The whole was dissolved except about one-tenth of a grain of silvery-like particles. The gas obtained amounted to 29.6 cubic inches. It yielded no trace of carbonic acid. When fired with oxygen it yielded 3 per cent. upon the volume of hydrogen of carbonic acid; and this arose, as I ascertained, from the hydrogen containing 3 per cent. of carburetted hydrogen gas: it contained no carbonic oxide. Supposing the carbon to have been combined with the iron, it would amount only to about 5-8ths of a grain, to 100 grains of iron. Whether such a quantity can be deemed an essential or an accidental ingredient of steel, may be a subject of consideration." P. 354.

To us it appears, that whether carbon should or should not turn out to be essential to the manufacture of steel, the iron can never be said to be in combination with carbon, in the same sense that it is said to be in combination with sulphur in its sulphurets. A difference in the *structure* of iron and steel exists; but such a difference does not imply necessarily a chemical change; as we know water to be chemically the same as ice, and as steam; and as we know common sulphur, which is very brittle, to be chemically the same as that of flexible sulphur, which is obtained by melting common sulphur, raising it to a high temperature, and dropping it into cold water. With regard to steel, the question is, whether carbon is essential to its change in structure? or whether heat alone is adequate to this change?

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[*] *Manchester Memoirs*, vol. v. p. 120. [†] *Philos. Mag.* vol. xiii.

The next section treats of *alloys*. These Mr Dalton considers to be chemical compounds. One striking instance of a true chemical compound occurs in the alloy called speculum metal. This alloy is formed out of tin and copper. The smallest deviation from the true proportions, it is well known, will spoil the alloy as a reflector. These proportions were, by laborious experiment, ascertained by Mudge to be 32 of copper to 14¼ of tin. Now, dividing each of these quantities by 2, we get 16 of copper = 4 atoms according to Dr Thomson, and 7.25 of tin = 1 atom. This, be it observed, is the result of experiments made forty years ago, when atomic weights had as yet been unheard of.

To show that chemical investigations on the alloys are likely to afford light on some points long known in practice, we shall quote, with a comment of our own, Mr Dalton's table of the alloys of tin with lead.

| Atoms. | | Weights. | | Sp. Gr. by calculation. | Sp. Gr. by Experim. | Fusing Point. |
|---|---|---|---|---|---|---|
| Tin. | Lead. | Tin. | Lead. | | | |
| 1 + | | .58 + | 1 | 9.32 | 9.17 | 430° |
| 2 + | 1 | 1.16 + | 1 | 8.64 | 8.79 | 350 |
| 3 + | 1 | 1.73 + | 1 | 8.25 | 8.49 | 340 |
| 4 + | 1 | 2. 3 + | 1 | 8.00 | 8.10 | 345 |
| 5 + | 1 | 2. 9 + | 1 | 7.93 | 8.00 | 350 |
| 6 + | 1 | 3.47 + | 1 | 7.81 | 7.90 | 360 |

The most fusible alloy, our readers will perceive, is that of 1 atom of lead and 3 atoms of tin. Excluding the alloy of 1 atom of each metal, it will be perceived, that the remaining five alloys taken successively, differ in their smelting points only 10° or 5°. But the alloy of 1 atom of lead with 1 atom of tin, differs in its melting point no less than 80° from that of the alloy of 1 atom of lead with 2 atoms of tin. What, then, would be the consequence, if a pot containing a mixture of these two alloys, both perfectly liquid, should be cooled down to 400°? 430° being the melting point of the alloy, 1 atom tin + 1 atom lead, we should expect that the whole of this alloy in the pot should become solid; and 350° being the melting point of the alloy, 1 atom lead + 2 atoms tin, we should expect that this alloy would remain liquid. Part would be solid, part liquid; and the mass should be in a sort of intermediate state, resembling that of moist clay. Now the solder used by plumbers consists of a mixture of the two alloys we are considering; and it is well known that this solder preserves a pasty-form long before it perfectly solidifies, so as to admit of being moulded and pressed about a joint, somewhat like a lute.

But though we agree with Mr Dalton in considering many alloys as chemical compounds, we by no means would take for granted, that all alloys are compounds. Thus an alloy of silver and steel was formed by Messrs Stodart and Faraday, by melting these two metals together. When this alloy was forged into a bar, and then dissected by means of dilute sulphuric acid, the silver was discovered, not in combination with the steel, but disseminated in threads throughout the mass. These threads of silver may give toughness to the mass, just as hair imparts strength to common mortar; but the silver is as distinctly in a state of mechanical mixture as hair is in common mortar. In like manner small quantities of other metals or alloys are often added, for the purpose, as it strikes us, of imparting mechanical properties, by mixture rather than by combination. But besides combined and mixed alloys, we should regard it quite possible, that some alloys in the solid state, are in fact *frozen solutions*. Mercury, there is no doubt, is capable of holding some amalgams in solution; and till experiment shall contradict the supposition, we shall regard it as conceivable and probable, that some melted masses of metal will prove to be *solutions* of one metal or alloy in another metal or alloy; and that the solid masses derived from such liquids are congealed solutions.

In their present state of ignorance, chemists will regard Mr Dalton's contributions to our knowledge of alloys as an acquisition. But it appears to us, that Mr Dalton has been too scantily furnished with information by practical persons, to render his views available in the arts.

Under the last section, Mr Dalton gives some useful experiments on the *triple alloys* of lead, tin, and bismuth.

The *appendix* contains a number of remarks which will interest the studious chemist. We were very well pleased with the following judicious strictures on a table of the specific heat of thirteen metals published by Messrs Dulong and Petit. We need not quote this table; because it has already obtained a place in almost every elementary chemical book; and we need hardly remind the reader that they profess to have discovered that the atomic weight of a substance multiplied by its specific heat should give a constant product.

" The Essay of MM. Dulong and Petit, in the tenth volume of the *An. de Chimie* (see *An. of Philosophy*, vol. 14th, 1819) manifests great ingenuity. It does not appear, however, so fortunate either in theory or experiment as the former one. It would be difficult to convince any one, either by reasoning or by experience, that a number of particles of mercury at the temperature of — 40°, whether in the solid, liquid, or elastic state, have all the same capacity for heat. Indeed the experiments of De la Roche and Berard, if they are to be credited, demonstrate the inferior capacity of condensed air to rarefied air; and if the same body changes its capacity in the elastic form, it may well be concluded that all the three forms have not the same capacity. *MM. Dulong and Petit have themselves shown, in their former essay*, (see page 276) *that solid bodies vary in their capacities for heat, and that scarcely any two bodies vary alike; hence it is impossible that the product of the weight of the atom and specific heat of the body should be a constant quantity.* Their specific heat of certain metals differ greatly from what is found by others. For instance, they make the specific heat of lead .0293; the lowest authority I have seen is Crawford, .0352, and the highest Kirwan .050; from repeated trials I have lately found it, upon an average, .032. The weights of some of the atoms in their table differ materially from what are commonly received; for instance, bismuth is 13.3 instead of 9; also copper, silver, and cobalt, are only half the weights of some authors. The gases too are unfortunate examples. Oxygen gas gives a product of .236 instead of .375; azotic gas gives a product .1967, if oxygen be to azote as 7 to 5, but a product of .393 if oxygen be to azote as 7 to 10: by Dr Thomson's ratio of oxygen to azote, 4 to 7, the product will be .482, very different from .375. Hydrogen will give a product of .47 or .41 instead of .375. All these differences, it may be said, are occasioned by errors in the specific heats of the gases; but if errors of this magnitude can still subsist after all the care that has been taken, we shall scarcely know what to trust in experimental philosophy." Pp. 293, 294.

Independent of these inconsistencies, we have grave reason for not admitting the accuracy of Messrs Dulong and Petit's table; and our reason is simply, that this table consists merely of results (sufficiently different from former ones) without the authors having given any details of their experiments even yet nine years after their publication; so that, forsooth, we are left to pin our faith not merely to the honour but to the immaculate accuracy of Messrs Dulong and Petit; for they have taken effectual measures of preventing the repetition of their experiments by others to confirm or to disprove them. Do we doubt their experiments? We are without evidence; and therefore we do not doubt them: We are without evidence; and therefore we do not believe them. But we protest against regarding the experiments as ever made, till the authors enable others to repeat them. We cannot help wondering at Dr Berzelius having allowed himself recently to be carried away by this flimsy table, so far as to assign three times the atomic weight to bismuth that he otherwise would, especially when he admits the atomic weight of cobalt to be a-half more than that assigned by Messrs Dulong and Petit; and the atomic weight of silver to be twice as much.

Having thus endeavoured to give some idea of the nature and merits of the volume before us, we take leave of it, recommending it to the attention of our chemical readers. The work is one which will not be read as an introduction to chemistry; but it will be perused with interest by all who have made some progress in the science, and who make its doctrines a subject of habitual reflection. Of almost any other chemist than Mr Dalton, we would have complained of the ignorance in which, it is evident, he has kept himself of the researches of other chemists. But we cannot speak in the language of complaint of Mr Dalton, known to the world as a very apostle of science—leaving all worldly advantage behind to follow it, and proceeding on cheerfully, without scrip, or purse, or staff. We know not how to express the feelings with which we glance over the last three pages of this volume, containing a list of the scientific papers which Mr Dalton has published during a period of thirty-five years. One discovery of his gives a glory to the scientific character of the nation; independent of other discoveries which alone would rank him high as a philosopher. And for whose good? We cannot look to this list without believing that Mr Dalton is more likely to have lost money than to have gained by all his publications. In other countries, less happily constituted governments than our own would not have hesitated to put into the hands of such a man the means of prosecuting with independence those discoveries which in all after ages were to render his native land illustrious among civilized nations. Almost the only means of profit held out to scientific men in this country is lecturing,—an occupation not always adapted to individuals who are yet well qualified for the prosecution of scientific research. Assuredly it does become the scientific journalist to complain loudly that even this precarious encouragement to science is about to be taken away; for a system has begun of publishing lectures taken for this purpose by professional reporters, who, by attending the same course twice, may copy a lecturer's manuscript, as accurately as if it were before them; and the law has in due solemnity pronounced that this description of robbers, who prey upon the vitals of science, are not to be molested in their lawful calling in this free country. We have no fears for the progress of science; but, looking to the shameful neglect of their rights in this country, and to the munificent patronage which is extended to scientific men in other countries, we have fears for the share of glory that will fall to Britain. Amidst these complaints, however, it would be unjust in us to forget that in the case of Mr Dalton, the neglect upon which we animadvert was alleviated by his being presented, through the hands of Sir Humphry Davy, with a royal medal, when his own genius had established a fame, which envy could no longer tarnish, and to which royalty could add no lustre.

## II.—*A History of British Animals, exhibiting the Descriptive Characters and Systematical Arrangement of the genera and species of Quadrupeds, Birds, Reptiles, Fishes, Mollusca, and Radiata, of the United Kingdom; including the indigenous, extirpated, and extinct kinds, together with periodical and occasional visitants.* By JOHN FLEMING, D.D. F.R.S E. &c. 8vo. Edinburgh, 1828.

WE are happy to announce a work on British Zoology by a naturalist so learned and acute as Dr Fleming; and are so much more pleased with its appearance, that it affords a practical proof of the progress of the study of Natural History in this quarter of the island. Till lately, notwithstanding the Zoological, Botanical, and Mineralogical riches of Scotland, it is rather a singular circumstance that the published works connected with these subjects have been chiefly written by temporary visitors or tourists, whose means of investigation must have been limited in point of time, and their attention distracted by a multiplicity of other objects. With the exception of Sir Robert Sibbald and the first superintendent of the Edinburgh Botanic Garden, James Sutherland, upwards of a century ago, and afterwards the Reverend George Low, a clergyman in a remote district, we scarcely recollect a name belonging to Scotland which is worthy of record as having contributed to the investigation of indigenous Natural History. The first Flora of Scotland was by an ingenious Englishman, the fellow traveller of Pennant; and the second, much later in point of time, by a Scottish professor, though from the sister kingdom—Dr Hooker, a most able and zealous botanist. In Zoology, *Pennant's British Zoology*, however incomplete as a scientific catalogue, long stood without a rival. This was followed by the useful *Synopsis* of Dr Berkenhout, of which two editions were printed; and in 1807 by the *British Fauna* of Dr Turton.

The systems of British Zoology prior to Dr Fleming's work have been chiefly arranged on the Linnæan model. In the present work, however, the author classes the British animals according to a method of his own. This method, which seems to have been suggested to him by the tables of Ray, he terms the *Dichotomous*, or binary arrangement, the principles of which are detailed in a former work, the *Philosophy of Zoology*. The quinary and circular arrangement proposed by Mr Macleay, and illustrated by Mr Vigors in the class of birds, Dr Fleming conceives "to have originated in metaphysical prejudices," without suspecting that the same objection may be made to his own binary or any other numerical combination. With regard to both, to use the Doctor's own words, "in the various organs and their numerous modifications, belonging to each species, there are characters which enable the physiologist to trace resemblances in structure and function with the organs of many other species; so that the same animal may occupy a place in many different physiological groups."

We observe, besides, that Dr Fleming does not give, as is the usual custom, in addition to his generic terms, the names of the authors who first instituted or used them. Different writers have applied the same generic name so variously, according to their peculiar views, that without this indication it is impossible, amidst their conflicting arrangements, to ascertain the identity of an individual species; and in Dr Fleming's work, which has added not a few to the number, even the divisions instituted by himself are left to be discovered by the previous knowledge or sagacity of the reader.

But, waiving altogether these considerations, Dr Fleming, from the talent and industry he has brought to the task, leaves far behind all his predecessors in the walk of British Zoology. We have received his work too late to be able to state, by comparison with former writers, the new species he has added to the British Fauna, and the corrections he has made on the statements of his predecessors. "He has long (as he states in his preface) been a practical observer of British Animals, or what a friend of the Honourable Daines Barrington used to term an out-door naturalist. This circumstance has enabled him to correct the specific characters of several animals, and to point out with greater accuracy their habits and distribution, to suppress several spurious species, and to give to the synonymes, in many cases, a greater degree of precision." Besides this, and which no previous writer on British Animals has attempted in the same degree, the extirpated and extinct species have been enumerated with a precision of detail, which leaves little to be desired in this most important part of the work. The following are the heads under which the species are classed.

"The *resident animals* are such as can accommodate themselves to all the changes of this variable climate. They are the only species which strictly merit the epithet *indigenous*.

"The *periodical visitants* chiefly belong to the class of Birds. Some of these come from more southern latitudes, to spend the summer and bring forth their young; while others arrive from more northern latitudes, to escape the rigours of an arctic winter. The vernal shifting, the author has denominated *Equatorial Migration*, the autumnal shifting the *Polar*

*Migration.* All the species of these groups, though intimately connected with the country by the regularity of their visits, enjoy a right of citizenship less perfect than the resident animals.

"*Stragglers*, or irregular visitants, have hitherto occupied a higher rank in every British Fauna, than they seem entitled to possess. Driven from their native haunts to this country by some temporary calamity, the persecution of foes, or the fury of a storm, they have been recorded inconsiderately as indigenous species. Their occurrence, as serving to illustrate the distribution of species, should be recorded; but not in such a manner as to assimilate them with the resident kinds, and periodical visitants. Acting upon this principle, the author has been compelled to degrade to the rank of stragglers several birds and fishes which have long occupied a more distinguished place.

"The *extirpated animals* are such species as still maintain their ground in other regions, but have been destroyed in this country by the long-continued persecutions of man.

"The *extinct animals* are such as once dwelt in this country, but which have disappeared, and, from various causes, seem to have perished from off the earth." (P. xiv.)

"In the enumeration of British Animals contained in this volume, the author has referred to the extinct or fossil species so frequently, as probably to have excited surprise in those accustomed to consult the more modern of the British Faunas. He was led to adopt this course, not for the purpose of filling up the chasms in the fancied laws of continuity, but that the attention of zoologists may be directed to an examination of the extinct races, and that the geologist may connect with his studies a knowledge of the character and distribution of existing species." (P. xix.)

Such is the plan upon which the work of Dr Fleming is constructed. The number of existing Mammalia described is 60; of Birds 237; of Reptiles 12; of Fishes 170: of Mollusca 597; of Radiata 67; and of Zoophyta 209. The other tribes of invertebrated animals, such as the Crustacea, Insects, &c. are to form a future volume.

A work of this nature forbids any attempt at conveying a knowledge of its contents by analysis. Of the appropriate and useful remarks distributed throughout the book, the following extract, regarding a most important class of animals, may serve as an example.

"The *migrations* of fishes, in compliance with the arrangements of their reproductive system, exhibit the most singular movements, often complex, but always useful to man. Those which inhabit the inaccessible depths of the sea, in ordinary cases, approach the shores, towards the season of spawning; and, after depositing their eggs in suitable situations, again retire to their inaccessible haunts. The fry occupy for a time their littoral birth-place, and then follow the course of the older individuals, though in several cases the young seem to execute movements different from the full grown fish. Not a few species, as the salmon, which have their ordinary residence in the sea, approach, towards the spawning season, the shores, enter estuaries and ascend rivers, where, having selected a suitable place, they deposite their eggs, and again return to the sea. The fry, after a certain period, likewise leave the fresh waters and betake themselves to the sea. Similar movements are executed by the fish which inhabits lakes. As the spawning season approaches, several species, as the Gwiniad, leave the deep water, and approach the margin; while others, as the Roach, not only approach the margin of the lake, but ascend the neighbouring streams.—With a few other species, as the Eel, for example, these movements are reversed; the spawning fish leave the fresh-water lakes and rivers, and retire to the sea to give birth to their progeny.

" But there are other movements executed by fishes of a more anomalous character, the necessary conditions of which remain to be investigated. The Herring, Pilchard, and Haddock, for example, after frequenting certain parts of the coast for many years, at stated intervals, suddenly withdraw themselves to other stations, to which they had not been accustomed to resort. It is probable that these shiftings of fish may depend on the movements of those animals on which they subsist, or on the changes in the quantity of food occasioned by excessive consumption.

" The *fisheries* of this kingdom are objects of vast importance, yet though they have frequently occupied the attention of Parliament, a great deal remains to be done before they be placed in that state of improvement of which they are susceptible. In point of importance, our fisheries probably rank in the following order: 1. *Gadusidæ,* or fisheries having for their object the capture of Cod, Coal-fish, Haddock, Ling, Hake, Tusk. 2. *Salmonidæ,* including Salmon, Trout, Char, and Smelts. 3. *Clupeadæ,* including Herring, Pilchard, Shad. 4. *Pleuronectidæ,* including Turbot, Holibut, Flounder, and Sole. 5. *Scomberoidæ,* or Mackerel. 6. *Raiadæ,* including Rays and Skates. 7. *Cyprinidæ,* including Carp, Bream, Tench, &c. 8. *Anguillidæ,* including the Eel and Conger.

" To those interested in the improvement of these fisheries, the following remarks may not be deemed out of place. 1. The fisheries sustain much injury in consequence of the capture of fish ready to spawn. No one can witness the exhibition of the large *roes* of the Cod, Ling, or Haddock, on the stalls of our fish-markets, without being convinced of the propriety of some legislative enactment (capable of application) to prevent this prodigal waste of our stores, by prohibiting the fishery of each species for a certain time, at the ordinary spawning season. 2. The fisheries are injured by the destruction which takes place in the *fry,* in consequence of the operations being carried on at improper seasons, or with improper engines. The injury done to the salmon fishery by the destruction of the fry has been frequently stated to the public, but few seem to be aware of the vast extent of injury to the fry of many kinds of fish, from the use of improper nets, by the trawlers of the Channel Fisheries. On this subject the reader will find some important remarks in Mr Cornish's *View of the present State of the Salmon and Channel Fisheries,* Lond. 1824. 3. The fisheries might be extended and rendered more valuable by enlarging the system of *bounties,* or rather, perhaps, by directing them to new objects. The Turbot and Eel fisheries are neglected in many places where they might be prosecuted to advantage; and hundreds of our fresh-water lakes, which at present are useless and waste, might be rendered productive of much wholesome food. It becomes a question of great national importance, whether these, and other obvious improvements in our fisheries, might be most effectually promoted, by public *statutes*, or by Boards furnished with suitable powers." Pp. 221, 222.

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## ART. XXI.—PROCEEDINGS OF SOCIETIES.

### 1. *Royal Society of Edinburgh.*

*December 17th.*—Conclusion of a Chemical Examination of the Oxides of Manganese. By Dr E. TURNER.

A Notice on the formation of Alcoates, definite compounds of Alcohol and Salts, analogous to the Hydrates. By T. GRAHAM, M. A.

*Jan.* 7, 1828.—Francis Walker Drummond, Esq. and Sir W. G. Gordon Cumming, Bart. were elected Ordinary Members.

The Vice-President announced to the meeting that the Council had adjudged the biennial Keith prize to Dr BREWSTER, for his communications regarding his discovery of two new immiscible fluids in the cavities of certain minerals.

The following papers were read :—

1. Account of a remarkable peculiarity in the Structure of Glauberite. By Dr BREWSTER.

2. On the Chloro-ferro-cyanic Acid and its Compounds. By J. JOHNSTONE, A. M.

3. An Account of the Tracks and Foot-marks found impressed on Sandstone in a Quarry in Dumfries-shire. By the REV. DR DUNCAN. See this Number, p. 305.

Specimens were exhibited.

4. Demonstrations of propositions published by Dr M. Stewart in 1746, at the end of his general theorems. By A. GALLOWAY.

5. A letter from the Right Honourable the Countess of Morton, to Sir Walter Scott, accompanying a donation of models and plans, &c. connected with the erection of the Eddystone Light House, and which had belonged to the late MR SMEATON, Civil Engineer.

6. Experimental inquiries concerning the Laws of Magnetic Forces. By W. S. HARRIS, Esq. of Plymouth.

*January* 21.—1. Determination of the Longitude of the Observatory of Edinburgh, from observations of the moon and moon-culminating stars. By PROFESSOR WALLACE.

2. On the Earliest Maritime Regulations of Modern Europe. By JOHN REDDIE, LL. D.

*February* 4.—Erskine D. Sandford, Esq. Dr D. Maclagan, James Crawford Gregory, M. D., Sir Alexander Keith, Knight Marischal, and John Frost, Esq. were elected Ordinary Members.

1. A Notice regarding a Mass of Metallic Iron (supposed to be meteoric) from South America. By T. ALLAN, Esq.

2. On the Natural History and properties of Tabasheer, the siliceous concretion found in the joints of the Bamboo. By Dr BREWSTER.

*February* 18.—1. Notice regarding a compendious and easy method of performing the operation of Multiplication in Arithmetic. By PROFESSOR WALLACE.

2. Part 1st of a Memoir on the Geographical position of Ecbatana the ancient capital of Media. By the REVEREND J. WILLIAMS.

*March* 3.—CAPTAIN MAXWELL, K. D. G. was admitted an Ordinary Member.

1. A Notice of some experiments on the Absorption of Vapours by Liquids. By T. GRAHAM, A. M. Printed in this Number, p. 326.

2. Chemical examination of Tabasheer. By Dr E. TURNER. Printed in this Number, p. 335.

## 2.—*Proceedings of the Society for Promoting the Useful Arts in Scotland.*

*December* 4, 1827.—A Notice by Dr BREWSTER on the Varnishes from the Varnish Trees of India was read, and specimens of articles varnished with them, and sent home by GEORGE SWINTON, Esq. of Calcutta, were exhibited. See Number xv. p. 96.

An Account of the poisonous qualities of the Indian Varnishes, by Dr BREWSTER, was also read. See Number xv. p. 100.

An Account of the method of blasting rocks in Assam, communicated by GEORGE SWINTON, Esq. of Calcutta. See Number xv. p. 111.

There was also read an Account of the Black Dye of Siam, by CAPTAIN BURNEY. Communicated by GEORGE SWINTON, Esq. See this No. p. 343.

*December* 19.—There was read a Description of a New Latch Lock, by the Reverend Mr BRODIE. The model of the Lock was exhibited.

A Pendulum Chronometer belonging to ANDREW WADDELL, Esq. executed by Mr DAVID WHITELAW, Edinburgh, was described and exhibited.

Specimens of Screws made by Mr CLARK were exhibited.

There were read Observations on the Low Temperature of Steam escaping from under High Pressure. Communicated by THOMAS GRAHAM, A. M.

An improved Air Pump was described and exhibited, by Mr DUNN.

The following gentlemen were elected Honorary Members:

CAPTAIN PARRY, R. N. JOHN OLDHAM, Esq. of the Bank of Ireland.

Mr JOHN P. BERTRAM, Clyde Street, was elected an Ordinary Member.

Dr HUGH COLQUHOUN, Glasgow, and Mr THOMAS CLARK, Glasgow, were elected Associate Members.

*January* 9, 1828.—There was read a Notice of a method of manufacturing the Nepaul Paper, Communicated by GEORGE SWINTON Esq.

Mr J. W. JOHNSTON of Durham was elected an Associate Member.

*January* 23.—An Account of a New process for obtaining Absolute Alcohol, by THOMAS GRAHAM, A. M. was read.

A Farther account, by Dr WALLICH, of the manufacture of the Nepaul Paper was read. Specimens of this paper in its natural state and as remanufactured at Calcutta were exhibited.

There were exhibited to the Society impressions of Drawings executed on Talc. Communicated by GEORGE SWINTON, Esq.

An account of an Engine for cutting the tools for grinding Lenses, by the Right Honourable Lord OXMANTOWN, was read.

The RIGHT HONOURABLE LORD OXMANTOWN was elected an Honorary Member;—and THOMAS GRAHAM, A. M., and Mr DUNN, Optician, were elected Ordinary Members.

*Feb.* 6.—The following gentlemen were elected Honorary Members:—S. P. Rigaud, Esq. A. M. F. R. S. Savilian Professor of Astronomy, Oxford. —G. B. Airy, Esq. Lucasian Professor of Mathematics, Cambridge.—Rev. W. Whewell, M. A. Trinity College, Cambridge.

The following papers were read. Observations on the formation of Ice in India. By David Scott, Esq. See this Number, p. 216.

Notice respecting a powerful Aromatic Oil obtained from Malwa in India, from a particular species of grass.

Mr Lizars exhibited impressions of Engraving on different kinds of paper, including the Nepaul Paper exhibited at last meeting of the Society. Mr L. reported that the coarser kind of Nepaul Paper is well adapted for the purposes of Engraving.

*Feb.* 20.—Observations on Street Railways. By Mr Alexander Scott, Ormiston, were read.

A Description of a Method of cutting leading Screws, exhibited at a former meeting, was read. Drawings of the Apparatus employed were exhibited. By Mr J. Clark.

The Working Model of a Hydraulic Engine by Mr Ruthven was exhibited.

A Notice regarding the proper forms of Taps and Dies for cutting metal Screws. By John Robison, Esq. F. R. S. was read.

Sir John Seppings was elected an Honorary Member.

Robert Aytoun, Esq. and James Tod, Esq. were elected joint Secretaries of the Society, in room of Dr Turner and Professor Wallace, who retired.

*March* 5.—There was read a Notice of the qualities and adaptation of a species of Stone brought from Caithness. Communicated by Sir John Sinclair, Bart. Specimens of the Stone were exhibited.

The masses of stuff from Nepaul for making paper having now arrived, were exhibited.

Mr Edward Sacy, Teacher of Mathematics, was elected an Ordinary Member.

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## Art. XXII.—SCIENTIFIC INTELLIGENCE.

### I. NATURAL PHILOSOPHY.

### ASTRONOMY.

1. *Eclipses of Jupiter's Satellites observed at Wilna.* By M. Slawinski. —The longitude of Wilna is $1^h\ 41'\ 12''$ east of Greenwich.

| | | Sidereal time. | |
|---|---|---|---|
| 1825, Jan. 17, | Im. I. | $4^h\ 0'\ 23''.7$ | good observation. |
| March 22, | Em. II. | 8 51 51 .9 | very good. |
| April 23, | Em. I. | 10 44 23 | good enough. |
| May 5, | Em. I. | 12 29 38 .7 | very good. |
| 1826, May 8, | Em. I. | 15 31 56 .1 | middling. |
| June 2, | Em. II. | 16 46 0 .1 | middling. |
| 1827, March 18, | Im. I. | 16 1 14 .9 | a little doubtful. |
| April 18, | Im. I. | 16 46 15 .2 | passable. |

2. *Occultations of Stars observed at Wilna.* By M. Slawinski.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1825, April 1, | *e* Leonis, | Im. | $10^{h}$ | $8'$ | $55''.2$ | very precise. |
| | | Em. | 11 | 15 | 14 .2 | a little doubtful. |
| 23, | Star (Mag. 8, 9,) | Im. | 11 | 22 | 29 | exact. |
| 1826, Feb. 15, | 208 Tauri, | Im. | 6 | 55 | 58.8 | good. |
| 1827, March 18, | λ Libræ, | Im. | 17 | 4 | 55.9 | good enough. |

3. *Occultation of Saturn observed at Wilna.* By M. Slawinski.

| | | | | | |
|---|---|---|---|---|---|
| 1826, Feb. 16, | Saturn, 1st Ansa, | $3^{h}$ | $11'$ | $58''.8$ | Sidereal time, Observation good. |
| | 1st Limb, Im. | 3 | 12 | 8 .8 | |
| | 2d Ansa, | 3 | 14 | 48 .3 | |

4. *Occultation of the small star of the double star of β Scorpii, observed by* Mr Riddle.—At Greenwich Hospital, in longitude 8″ west of Greenwich Observatory, and in latitude 51° 28′ 53″ north, the small star of β Scorpii was eclipsed by the southern dark limb of the moon, on the 25th September 1827, at $6^{h}$ P. M., but the larger star *was not eclipsed at all.—Ann. of Phil. June* 1828, p. 26.

5. *Comet of June* 1827.—The elements of this comet computed by M. Benj. Walz of Nismes are,

| | |
|---|---|
| | D. |
| Passage of Perihelion 1827, Mean time for Midnight at Paris, | June 8. 336 |
| Perihelion Distance, | 0.808 |
| Long. of Perihelion, | 297° 34′ 18″ |
| Long. of Node, | 318 14 48 |
| Inclination of Orbit, | 43 37 48 |
| Motion, retrograde. | |

6. *Comet of September* 1827 *similar to that of* 1780.—M. Walz has given the following elements of this comet.

| | Sept. 1827. | Sept. 1780. |
|---|---|---|
| Passage of Perihelion, | D. | D. |
| Mean time from Midnight at Paris, | 11.565 | 30.2589 |
| Perihelion Distance, | 0.157 | 0.099256 |
| Long. of Perihelion, | 254° 15′ 52″ | 246° 21′ 18″ |
| Long. of Node, | 150 26 25 | 124 9 19 |
| Inclination of Orbit, | 54 53 30 | 53 18 15 |
| Motion, retrograde. | | |

### OPTICS.

7. *Luminous Appearance of the Sea near Prince of Wales' Island.*—Nothing is more singular in these seas than their phosphorescent appearance by night, the ocean showing, like a vast lake of liquid fire, melted sulphur or phosphorus. In many bays, such as the harbour at Prince of Wales' Island, the bodies which emit this singular light exist in such vast quantity that a boat may readily be distinguished at the distance of several miles by the brilliant light, resembling that of a torch, proceeding from the water, agitated by her bow and oars. We have seen the sea rendered of a

green colour and slimy appearance by day, so that it might have been mistaken for the green vegetable matter common on stagnant pools. We have taken up a quantity of this green-coloured water, and by keeping it till night, have ascertained that the green colour by day, and the phosphorescent appearance by night, were occasioned by the same substance.

The causes of this luminous appearance in the sea are doubtless various in different parts of the ocean. We know that fish, when dead, afford similar light, and experiments have shown that dead fish immersed in sea water, after a time, afford it also. The spawn of fishes is said to afford it, and putrefaction is considered as a very common cause of this appearance. In the present instance it appeared unequivocally to proceed from innumerable granular gelatinous bodies, about the size of a pin's head. These, when taken upon the hand, moved about with great agility for a second or two, when they ceased to be luminous and remained immoveable.—*Finlayson's Account of Siam.*

8. *Magnificent achromatic Telescope executed in Paris.*—We have lately been informed by one of our scientific countrymen now in Paris, that M. Lerebours, an eminent French optician, has executed *an achromatic telescope with an aperture of twenty-four inches, and a focal length of twenty-five feet.* The object glass is made of M. Guinand's glass. The telescope cost 40,000 francs (about L. 1670,) and the stand about 10,000 francs (L. 415) making in all about L. 2080. It has been now above three months in the Observatory, but no good opportunities for observing with it have occurred. Whether this grand instrument turn out well or ill, its execution does honour to the spirit and genius of the French nation, and to the monarch in whose reign it has been made.

## METEOROLOGY.

9. *Red Rain, supposed to arise from Butterflies.*—The following narrative seems curious and important in connection with the various accounts of red rain. It is extracted from *Gassendi's Life of Peiresc*, p. 110-113. "Through the whole of this year (1608) nothing gave M. Peiresc greater pleasure than his observations upon the *bloody rain*, said to have fallen about the beginning of July. Large drops were seen both in Paris itself upon the walls of the cemetery of the greater church, which is near the walls of the city, upon the walls of the city, and likewise upon the walls of villas, hamlets, and towns for some miles round the city. In the first place, M. Peiresc went to examine the drops themselves, with which the stones were reddened, and spared no pains to obtain the means of conversing with some husbandmen beyond Lambesc, who were reported to have been so astonished at the shower, as to leave their labour and fly for safety into the neighbouring houses. This story he ascertained to be without foundation. To the explanation offered by the philosophers, who said that the rain might have come from vapours, which had been raised out of *red* earth, he objected that evaporated fluids do not retain their former hues, as is plainly exemplified in the colourless water distilled from red roses. Nor was he better satisfied with the opinion of the vulgar, countenanced by some of the theologians, who maintained that the appearance

was produced by demons, or witches, shedding the blood of innocent babes. This he thought was a mere conjecture, scarcely reconcileable with the goodness and providence of God. In the meantime an accident happened, which discovered to him, as he thought, the true cause of the phenomenon. He had found some months before a chrysalis of a remarkable size and form, which he enclosed in a box. He thought no more of it, until, hearing a buzz within the box, he opened it, and perceived that the chrysalis had been changed into a most beautiful butterfly, which immediately flew away, leaving at the bottom of the box a red drop of the size of a shilling. As this happened about the time when the shower was supposed to have fallen, and when a vast multitude of those insects was observed fluttering through the air in every direction, he concluded that the drops in question were some kind of excrementitious matter emitted by them, when they alighted upon the walls. He therefore examined the drops again, and remarked, that they were not upon the upper surfaces of stones and buildings, as they would have been, if a shower of blood had fallen from the sky, but rather in cavities and holes, where insects might nestle. Besides this, he took notice that they were to be seen upon the walls of those houses only, which were near the fields, and not upon the more elevated parts of them, but only up to the same moderate height at which the butterflies were accustomed to flutter. In this way he explained the story, told by Gregory of Tours, of a bloody shower seen at Paris in the time of Childebert, at different places, and upon a house in the vicinity of Senlis; and another said to have fallen in the time of King Robert about the end of June, the drops of which could not be washed out by means of water, when they had fallen upon flesh, garments, or stones, but might be washed out from wood; for the time here stated was the season for the butterflies; and he showed that no water could wash out these red marks from stones. After discussing these and similar arguments in the presence of much company at the house of his friend Varius, they determined to inspect the appearance together, and, as they wandered through the fields, they saw many drops upon stones and rocks, but only in hollows or upon sloping surfaces, and not upon those which were presented to the sky." The butterfly observed by Peiresc was probably the *Papilio C. album,* or common butterfly. It has been observed to deposit the same red fluid in England.

10. *Waterspout seen on the Lake of Geneva,* 11*th August* 1827.—This meteor was seen by Professor Mercanton at 6$^h$ 52′. A portion of a dark cloud suspended below the summit of the Savoy mountains, suddenly took a vertical direction, and being gilded with the deep orange tint of the setting sun, it attracted universal attention, and enabled the spectators to trace all its movements. Its form was that of an inverted cone, the summit of which was about 200 feet from the surface of the lake, to which it precipitated itself in less than two minutes. This elongation of the cone took place by an oscillatory motion. This part of the spout appeared cylindrical, and its diameter was about ten or twelve feet. The moment it reached the lake a great mass of the water was briskly agitated as if it had been boiling, the boiling foam *rising to a height of more than fifty feet.*

This large column of water was inflected like a riband exposed to the wind. In eight minutes it reached the mouth of the Rhone, and as long as it was above the river, the boiling continued and the column was unbroken. When it quitted the river the boiling ceased, and the whole soon disappeared, the base of the cone continuing longest visible.—*Bibl. Univers.* October 1827, p. 142.

### ELECTRICITY.

11. *Different effects of an electric discharge in Magnetising different needles.*—M. Savary, whose electrical discoveries we have already noticed in No. x. p. 369, has recently found, that when a number of needles are electrified by a single discharge, some of them are rendered slightly magnetic, some highly so, and others not at all. For any discharge of determinate strength, the distance performs the principal part. The magnetic virtue goes on decreasing to a certain distance, then it disappears at a given distance;—it then increases progressively, is again extinguished, and again increases. The distance requisite to produce the maximum and minimum degree of magnetism depends on the strength of the discharge. M. Savary has likewise determined the effects produced by the interposition of screens. —*Le Globe, 26th January* 1828.

12. *On the variable conducting powers of bodies for Electricity.*—Professor Delarive of Geneva has found that the degree of conductibility of bodies for electricity *depends on the quantity of electricity which traverses them,* so that of two conducting bodies, that which is the best for one electric current may be the worst for either a stronger or a weaker current.

13. *M. Becquerel on the Pyro-electricity of the Tourmaline.*—On the 22d January 1828, M. Arago communicated to the Academy of Sciences the following fact respecting the Tourmaline discovered by M. Becquerel.

"While the tourmaline is of a certain length it is electrical by heating and cooling; in a greater length it ceases to be so by heating. In taking crystals of different lengths, the phenomena diminish in intensity, and those crystals which are eight centimetres (three inches and 1-9th) are neither electrical by heating nor cooling.

If this law is inversely true, that is for very small lengths, *the atoms of the tourmaline ought to acquire a considerable electrical polarity by the smallest changes of temperature.*"

The powerful pyro-electricity of Tourmaline in the state of the *finest dust* has been long ago described by Dr Brewster, who has pointed out the singular contrast between this unexpected property and those of magnetical and doubly refracting structures.—See this *Journal*, No. ii. p. 212.

## II. CHEMISTRY.

14. *Analysis of the Gas obtained from the Body of a Cow, inflated in consequence of feeding too freely on Green Food.* By M. PLUGER.—According to the observations of M. Pluger, the gas derived from this source had the following properties:—

1. It was colourless, and of a very disagreeable odour.
2. It burned slowly with a feeble bluish flame. On plunging a lighted

taper into a jar of the gas, the light was extinguished; but the gas itself was set on fire, and the taper might be rekindled by passing through the flame of the burning gas.

3. On agitation with lime water, the solution became turbid, and the gas lost three-fifths of its original volume. By the action of ammonia it underwent the same diminution.

4. The gas remaining after the action of lime water or ammonia burned slowly with a blue flame, and extinguished a lighted taper as before.

5. With atmospheric air it formed a mixture, which was not explosive, but burned tranquilly with a blue flame. Mixed with oxygen gas, it is said to have afforded a similar result, and that the product of the combustion rendered lime water very turbid.

6. A mixture of 100 measures of the gas and fifty of oxygen, fired by the electric spark, yielded 100 measures of carbonic acid gas.

From these experiments it is inferred by M. Pluger, that the gas extracted from the cow consisted of three-fifths of carbonic acid, and two-fifths of carbonic oxide gas. The air procured from another cow similarly affected, was found to contain four-fifths of carbonic oxide, and one-fifth of carbonic acid gas.

The Editors of the Annals from which this note is taken remark, that the results of M. Pluger differ entirely from those obtained by MM. Fremy and Lameyran, and published in the *Bulletin de Pharmacie.* (t. i. p. 358.) According to their experiments, the gas procured from a similar source is composed of

| | |
|---|---|
| Sulphuretted hydrogen gas, | 80 |
| Carburetted hydrogen, | 15 |
| Carbonic acid, | 5 |
| | 100 |

We agree with the editors that this subject requires further elucidation. A mixture of carbonic acid and carbonic oxide gases could not occasion the very disagreeable odour ascribed to the gas by M. Pluger, nor does that gentleman appear to have tested for the presence of sulphuretted hydrogen.—*Annales des Sciences Naturelles for June* 1827.

15. *Singular action of Phosphoric acid on Albumen.*—In his essays on the animal fluids Berzelius stated, that a solution of albumen is not precipitated by phosphoric acid; whereas Engelhart, in his interesting researches on the colouring matter of the blood, found that albumen is coagulated even in a dilute solution by phosphoric acid. As Engelhart was at Stockholm last winter, he and Berzelius inquired into the cause of difference in their statements, and discovered that they were both right. A solution of phosphoric acid, which had been kept some time in the laboratory, did not precipitate a solution of albumen; but phosphoric acid, recently prepared either by the action of nitric acid on phosphorus or by direct combustion, caused an abundant precipitate. On further examination, it was found that phosphoric acid, recently ignited, always throws down albumen; but that after being kept in solution for a few days, it loses that property. The coagulating power is restored by heating the acid to redness, but disappears again after the interval of a day.

The cause of these phenomena is by no means apparent. It does not depend on a higher degree of oxidation, for the change ensues in close vessels equally as by exposure to the air. Perhaps, says Berzelius, there may be some peculiar compound of water and the acid, which is not formed at the moment of solution, and which has not the property of precipitating albumen.—*Annales de Chimie et de Physique*, xxxv. 110.

*Remark on the preceding notice by* Dr TURNER.—On comparing the facts observed by Berzelius and Dr Engelhart, with the formation of the pyrophosphate of soda, described by Mr Clark in the 14th number of this Journal, it appeared probable that phosphoric acid heated to redness may be converted into pyrophosphoric acid, or undergo that change which enables it to form a white salt with silver. To put this supposition to the test of experiment, some fragments of phosphorus were treated in a platinum crucible by nitric acid, and the product heated to redness. The solution of the resulting pure phosphoric acid precipitated a dilute solution of albumen ; but when carefully neutralized by carbonate of soda, and then mixed with a solution of the nitrate of silver, the common yellow phosphate subsided. Consequently, it was not in the state of pyrophosphoric acid.

16. *On the Manufacture of Bromine.*—M. Balard, to whom we are indebted for the discovery of bromine, and for the knowledge of its most remarkable properties, has established a manufacture of that substance for sale. In consequence of the improvements which he has introduced into his process, he is able to sell bromine at the following prices: 4 francs the drachm, 14 francs the half ounce, 23 francs an ounce.—*An. de Ch. et de Ph.* xxxv. 111.

17. *Researches on the Fermentation of Curd and on the Caseous Oxide and Caseic Acid.* By M. HENRI BRACONNOT.—Of the curd of skim-milk, spontaneously coagulated, 750 grammes were mixed with about two pints of water, and exposed in an open vessel for the space of a month to a temperature varying from 20° to 25°C. The putrefaction having fully attained its height at the end of that time, the process was discontinued ; and M. Braconnot states, that all the products of spontaneous decomposition are obtained in this manner as completely as by waiting for a much longer period. The whole products were put into a filter of linen, through which passed a liquid very slightly coloured, which reddened litmus paper, gave no indication of the presence of sulphuretted hydrogen or carbonate of ammonia, but contained an appreciable quantity of acetate of ammonia. This liquid, on being concentrated by evaporation, yielded a product of a very fetid odour, owing apparently to the presence of an oily substance. Towards the close of the evaporation vapours of acetic acid passed over, and a liquid of the consistence of syrup remained, which concreted on cooling into a granulated reddish mass like honey, and of a saline bitter taste. Treated by alcohol of 37°, it was separated into parts, the one soluble and the other insoluble. The former was erroneously regarded by Proust as the *caseate of ammonia*, and to the latter he has, with equal impropriety, applied the name of caseous oxide.

18. *Caseous Oxide.*—To obtain this substance quite pure, it is necessary, after washing it well with alcohol, to treat it with animal charcoal, and dissolve it several times in boiling water, from which it is separated by evaporation. In this state it is a beautiful white powder, inodorous, and of a slight bitter taste. It is heavier than water, and is soluble in fourteen parts of water at 22° C. On allowing the solution to evaporate spontaneously, the caseous oxide crystallizes either in the form of elegant dendritic ramifications, or in rings composed of delicate acicular crystals of a silky lustre.

The aqueous solution of caseous oxide exposed to a moderately warm temperature runs easily into putrefaction. The liquid becomes turbid, deposits whitish flakes, and emits an exceedingly offensive odour, like that evolved during the decomposition of the most highly azotized animal principles. The product of the fermentation does not act as a ferment to sugar.

The aqueous solution of pure caseous oxide yields with infusion of gall-nuts a white flaky precipitate, soluble in excess of the precipitant. The persulphate of iron, and muriate of lime, and baryta, occasion no change. The muriate of platinum and sulphate of alumina act in a similar way, proving the absence of an ammoniacal salt. The sub-acetate of lead gives a white precipitate. Caseous oxide is more soluble in muriatic acid than in water. Boiling alcohol, as Proust observed, takes up very little; and of that which is dissolved a part is deposited on cooling in the form of a light white powder.

The caseous oxide takes fire when strongly heated, and burns with flame without leaving any residue. Heated in a glass retort, it fuses and swells up at a temperature higher than 212°F. On raising the heat gradually, the caseous oxide was not sublimed, but a large quantity of the carbonate and hydrosulphate of ammonia was generated. At a still higher temperature, a quantity of fatty matter was distilled of the consistence of suet. If, instead of distilling the caseous oxide, a small fragment of it is placed in a tube open at both ends, and suddenly heated by the blowpipe flame, it is almost entirely sublimed without change, but is easily decomposed by a renewal of the heat.

The presence of sulphur in caseous oxide is demonstrated by the formation of sulphuretted hydrogen; and it is further proved by rubbing a piece of silver with it while heated, when the sulphuret of silver is formed. When decomposed by nitric acid it does not yield any oxalic acid, as Proust states. M. Braconnot obtained a yellow fluid oil, and a yellowish liquid of a bitter styptic taste, in which he detected ammonia and sulphuric acid, but no oxalic acid.

M. Braconnot has not made the ultimate analysis of caseous oxide; but from the facts above enumerated, it obviously possesses the characters of an animal substance. He states with Proust that it contains very little oxygen, and is of opinion that *caseous oxide* is a very improper name for it. M. Braconnot considers it to be formed during the putrefaction of all animal matters, and proposes to call it *aposepedine,* from απο and σηπεδων, result of putrefaction. It is also generated in some diseases; at least Braconnot supposes that the granular matter which M. Lassaigne, and after him M. Col-lard, have found in the black matter vomited in some affections of the stomach, is aposepedine.

19. *Caseic Acid.*—The substance called *caseate of ammonia* by Proust, and separated by the action of alcohol from impure caseous oxide or aposepedine, appears to be a very complex substance. The alcoholic solution, on standing for about a month, deposited a little animal matter which Proust supposed to be gum. It yielded likewise some rather large flattened hexahedral crystals, which were quite clear and transparent, and proved to be phosphate of soda and ammonia, derived, M. Braconnot conceives, from the serum contained in the curd. He admits, however, that he has not proved that this salt really exists in milk. The alcoholic solution, after depositing the double phosphate, was found to contain the following substances: 1. Free acetic acid; 2. Aposepedine; 3. Animal matter soluble in water and insoluble in rectified alcohol, supposed to be osmazome; 4. Animal matter soluble both in water and alcohol; 5. Yellow oil, fluid and very pungent; 6. Brown resin, slightly sapid; 7. Acetate of potash; 8. Muriate of potash; and, lastly, Traces of the acetate of ammonia. The caseic acid of Proust has, therefore, no existence; and the acidity of the supposed compound is owing to acetic acid, while its pungency is chiefly occasioned by the yellow oil.

The insoluble matter left after the fermentation of 750 grammes of curd was allowed to ferment during another month, and was then washed and dried. It weighed 36 grammes, which consisted of margarate of lime 14.92 grammes; margaric acid 2.57; oleic acid retaining margaric acid and a brown animal matter 18.51 grammes.—*An. de Ch. et de Ph.* xxxv. 159.

20. *On the Identity of the acidulous Malate of Althein with Asparagin.* (*An. de Ch. et de Ph.*, xxxv. 175—In a memor addressed to the Society of Pharmacy at Paris, M. Bacon Professor at the school of medicine of Caen, announced the discovery of a new vegetable alkali, derived from the root of the marsh-mallow (*Althæa officinalis*), and to which he accordingly applied the name of Althein. M. A. Plisson, at the request of M. Henry, has repeated the experiments of M. Bacon, and has come to the conclusion, that what the latter chemist regarded as a supermalate of althein is asparagin. The crystals obtained from the marsh-mallow occur in the form of a rectangular octahedron, six-sided prism, or a right rhombic prism, a series of crystallization which M. Plisson finds exactly similar to that of asparagin. The supposed supermalate does not contain any malic acid. When properly purified, it does not act on test paper, and has the same relation to chemical re-agents as asparagin.

M. Plisson states, that when asparagin is boiled for some time with hydrate of lead or magnesia, it is resolved into ammonia and a new acid, neither of which he believes to have existed previously. To the new acid he has given the name of *asparartic acid,* from *Asparagus ars.* It was prepared by boiling the hydrate of lead with asparagin from the mallow, washing the white powder that remains, and decomposing it by means of sulphuretted hydrogen. By evaporating the filtered liquid, the acid was obtained. It crystallizes in small brilliant scales somewhat like those of boracic acid. It has little taste; is sparingly soluble in cold water, and less soluble in alcohol. The aqueous solution of it reddens litmus, and does not precipitate solutions of the acetate of lead, nitrate of silver, muriate of baryta or lime, sulphate of magnesia, salts of iron, sulphate of copper, corrosive sublimate, protosulphate of manganese, or emetic tartar. It forms with magnesia a very soluble salt, which has an alkaline reaction.

According to these researches of M. Plisson, the new alkali althein does not exist. We believe he has established this point; but some of his observations on his new acid it would be desirable to have confirmed by other experiments.

21. *Analysis of a newly discovered Mineral Spring at Stanley, near Wakefield.* By Mr W. West.—(*Quarterly Journal of Science for July* 1827.)

An imperial gallon contains of

| | |
|---|---|
| Dry bicarbonate of soda, | 56.0 grains. |
| Sulphate of soda, | 5.8 |
| Muriate of soda, | 8.75 |
| Muriate of lime, | 2.1 |
| | 72.65 grains. |

The gaseous contents of the water consist of variable proportions of carbonic acid, sulphuretted hydrogen, and carburetted hydrogen. The last is continually emitted from the spring in larger quantity than the water can absorb; and a portion of the other two also escapes from its surface. The spring was discovered in consequence of boring for coal, and the water appeared at a depth of eighty yards from the surface. It runs in all seasons at the rate of six gallons per minute.

22. *Test for the presence of Nitric Acid.* By Dr Liebig.—The liquid to be examined must be mixed with a sufficient quantity of a solution of indigo in sulphuric acid to acquire a distinct blue colour, a few drops of sulphuric acid added, and the whole boiled. If a nitrate is present, the liquid will be bleached, or, if the quantity is very small, rendered yellow. By this process nitric acid may be detected though diluted with 400 times its weight of water; or, by adding a little muriate of soda to the liquid before applying heat, 1–500th part of nitric acid may be discovered.—*Journal of Science for July* 1827, p. 204.

23. *Separation of Arsenic from Nickel or Cobalt.* By M. Woehler.—The following process is perhaps the most convenient for procuring nickel and cobalt from arsenic. It is founded upon the circumstance, that many alloys, when heated with sulphuret of potash, are changed into a mixture of sulphurets, and that sulphuret of arsenic is very soluble in sulphuret of potash. One part of copper nickel, fused and reduced to fine powder, is to be mixed with three parts of carbonate of potash and three of sulphur, and heated in a Hessian crucible. The heat is to be gradually raised to redness, and until the mass is just entering into fusion, but by no means so high

as to fuse the sulphuret of nickel which is formed. When cold water is to be added, which will dissolve the sulphuret of potash, and leave the sulphuret of nickel in the form of a yellow crystalline powder, retaining perhaps a little copper or cobalt but no arsenic, if the operation has been properly conducted. If, however, the object is to procure nickel quite pure, it should be fused a second time with sulphur and potash.

The method of freeing cobalt from arsenic is the same as for nickel; but it is then necessary to perform the operation a second time. The cobalt (that of Tunaberg,) has never been perfectly freed from arsenic by one operation, but has never retained any after the second.—*Journal of Science for July* 1827, p. 209.

24. *Experiments on the Nature of Labarraque's Disinfecting Soda Liquid.* By Mr Faraday.—The uncertainty concerning the nature of the disinfecting liquid of M. Labarraque, which was announced as a compound of chlorine and soda, induced Mr Faraday to investigate the subject experimentally, and he has conducted the inquiry with that sagacity and precision for which he is distinguished. The liquid was prepared by transmitting well washed chlorine into a solution of carbonate of soda, in the proportions directed by M. Labarraque; that is, 2800 grains of crystallized carbonate of soda were dissolved in 1.28 pints of water; and being put into a Woulfe's apparatus, two-thirds of the chlorine evolved from a mixture of 967 grains of salt, with 750 grains of oxide of manganese, when acted upon by 960 grains of oil of vitriol, diluted with 750 grains of water, were passed into it; the remaining third of the chlorine being partly dissolved in the washing water, and partly retained in the open space of the retort and washing vessel. The gas was readily absorbed by the solution, but from the beginning to the end of the process, not a particle of carbonic acid was disengaged from it; so that it contained chlorine, in addition to the soda and carbonic acid.

The resulting solution possessed all the characters of Labarraque's soda liquid. It was of a very pale yellow colour, and had but little odour of chlorine. Its taste was at first sharp, saline, and scarcely at all alkaline, but with a persisting biting effect upon the tongue. When applied to turmeric paper, it first reddened and then bleached it. When boiled, it did not give out chlorine, nor undergo any other perceptible change, the taste and bleaching power being nearly the same as before. This is a decisive proof that the chlorine, though in a state ready to bleach or disinfect, must not be considered as in the ordinary state of solution, either in water or in a saline fluid; for ebullition will freely carry off the chlorine under the latter circumstances. When brought to dryness by rapid evaporation it left a dry mass containing scarcely any chlorate of soda, and chloride of sodium, and which still bleached powerfully. Its bleaching power compared to the liquid before evaporation was as 30 to 76. When carefully evaporated, it gave a mass of damp crystals, which, when redissolved, had the taste, smell, and bleaching power of the original solution, with almost equal strength. The effect of spontaneous evaporation was very different. A portion of the bleaching liquid, set aside in an evaporating bason for six weeks, yielded crystals which had the appearance and properties of carbonate of soda. The chlorine had disappeared. The crystals had no bleaching power, and contained but a very minute quantity of the chlorate of soda and chloride of sodium.

From the researches of Mr Faraday, it appears that Labarraque's disinfecting liquid contains a peculiar compound of chlorine, carbonic acid, and soda, the two latter being in the same proportion as in the common carbonate. The name at first applied to it is therefore not applicable, and gives an erroneous idea of its nature. Carbonic acid gas may be transmitted in large quantity through the solution without carrying off the chlorine; but stronger acids displace it readily. The chlorine is also displaced by the force of crystallization. The compound resists the action of boiling; not only is chlorine not disengaged, but very little chloric acid is generated. The liquid deteriorates, however, by keeping. In a portion of it kept in a well-stopped bottle for six weeks during summer, reaction was proved to have taken place between the alkali and the chlorine, some of the chlorate of soda and chloride of sodium having been formed.

Mr Faraday has shown, that the phenomena are quite different when a solution of carbonate of soda is *saturated* with chlorine. At first, Labarraque's liquid is formed; but when more chlorine is transmitted through the solution, carbonic acid gas is freely disengaged, and the saturated liquid contains only a trace of carbonate of soda, and has all the properties of a solution of caustic soda changed with chlorine. Accordingly, on the application of heat, free chlorine is disengaged, and the liquid becomes colourless, yielding by evaporation the chlorate of soda and the chloride of sodium.—*Journal of Science for July* 1827. p. 84.

25. *On the Means of ascertaining the Purity of Sulphate of Quina.* By Mr PHILLIPS. (*From the Philosophical Magazine and Annals for February* 1828.)—The great demand which has arisen for this important medicine, and the high price at which it is necessarily sold, have excited some, who are careless as to the means by which they acquire gain, to sophisticate it in a vast number of ways, and by every means which talent misapplied could suggest.

Having repeatedly of late been requested to examine various samples of sulphate of quina, I thought it might be useful to state the several modes which may be employed for that purpose: and I make the present communication with the greater confidence, because I have received the very able assistance of my friend, Mr John T. Barry of Lombard Street, to whose chemical skill, and the opportunity of frequently applying it, I am indebted for the greater number of hints and facts detailed in this paper.

Pure sulphate of quina has the form of minute fibrous crystals, it is inodorous, and its taste is bitter. If certain vegetable products, such as starch or sugar, be mechanically mixed with it, they may possibly be observed by merely inspecting the preparation with a glass.

1*st*, If the sulphate of quina be mixed with a considerable proportion of foreign matter, it may probably be detected by dissolving the salt in question in about three hundred times its weight of water,—say one grain in about five fluid drachms of boiling distilled water. On cooling, pure sulphate of quina will be deposited in feathery crystals in twenty-four hours, if there be no adulteration.

*2dly,* As indirect, but as good collateral evidence, the taste of sulphate of quina of known good quality may be compared with that of another sample. Thus when pure, a grain of sulphate of quina will render nearly a pound and a-half of water, or 10,500 grains, sensibly bitter.

*3dly,* The alkalies either pure or their carbonates, if but slightly in excess, always occasion precipitation at ordinary temperatures in a solution of sulphate of quina containing only 1-1000th of its weight, or less than one grain in two fluid ounces of water.

*4thly,* A solution of tannin occasions a very sensible precipitate in an aqueous solution of sulphate of quina, containing only 1-10,000th of its weight of the salt, provided there be no acid in excess. Kino is that form of tannin which best answers the purpose. It is, however, to be observed, that the salts of morphia, cinchonia, strychnia, &c. are similarly affected by tannin; but they are not likely to be mixed with sulphate of quina.

*5thly,* Sulphate of quina suspected to contain sugar, gum, or other substances soluble in cold water, may be tried by digesting the same portion of the salt in small and successive portions of water to saturation. If the sulphate of quina be pure, and the solutions all properly saturated, they will have the same taste and specific gravity; and similar portions will yield by evaporation equal quantities of solid residuum.

*6thly,* A repetition of the above process, substituting alcohol for water, answers for extracting resin and some other substances, because sulphate of quina is soluble in alcohol to only a limited extent.

*7thly,* If a white substance insoluble in cold water be found in the sulphate of quina, heat the mixture to about 170° of Fahrenheit. This will render starch soluble, and its presence may be determined by the addition of an aqueous solution of iodine, which will immediately occasion a blue colour, and eventually a blue precipitate. The iodine should be added in very small quantity.

*8thly,* Sulphate of quina has been adulterated with ammoniacal salts. These are rendered obvious by adding a little of the suspected salt to a solution of potash. If any ammoniacal salt be present, ammoniacal gas will be readily detected, either by the smell, or by holding over the mixture a piece of turmeric paper, or a bit of glass moistened with acetic acid.

*9thly,* To ascertain whether sulphate of quina contains any earthy salts, such as sulphate of magnesia or sulphate of lime, burn a portion of it in a silver or platina crucible, or even in a clean tobacco-pipe. Any earthy salt, or any matter indestructible by heat, will of course remain in the vessel.

*10thly,* To ascertain that the sulphate of quina contains the proper quantity of sulphuric acid and quina, dissolve a little in pure muriatic or nitric acid, and add a solution of muriate or nitrate of barytes; 60 parts should give about 17.3 to 17.4 of sulphate of barytes; or the method may be varied without the trouble of drying the precipitate. Dissolve 60 grains of sulphate of quina in water slightly acidulated with muriatic or nitric acid; add a solution of 18 grains of nitrate of barytes, and separate the precipitated sulphate of barytes by filtering. If nitrate of barytes be now added to the clear solution, it should still occasion slight precipitation, for 60 of sulphate of quina contain 5.8 gr. of sulphuric acid, equivalent to 19.1 of nitrate of barytes.

This test is only to determine that there is no crystallized vegetable matter uncombined with sulphuric acid in the sulphate of quina; the detection of earthy or alkaline sulphates has already been provided for.

11*thly,* Sulphate of quina should lose not more than from 8 to 10 per cent. of water by being heated till deprived of its water of crystallization. Mr Barry informs me that he once examined a sample which contained more than 40 per cent. of water in excess diffused through it.

26. *A New Method of Separating Manganese from Lime and Magnesia.* By PROFESSOR STROMEYER.—We are informed in a letter from Professor Stromeyer, that he has found the following method successful in procuring the complete separation of manganese from magnesia and lime. To an acid liquid containing the peroxide of iron together with manganese, lime, and magnesia, the carbonate of soda is added in the usual manner, so as to precipitate the first, while the three latter oxides are held in solution by an excess of carbonic acid; and in order to prevent any manganese from falling, the actual precipitation of the iron is effected by the bicarbonate instead of the carbonate of soda. After acidulating the filtered solution and concentrating it by evaporation, a current of chlorine gas is transmitted through it. On neutralizing the free acid by the gradual addition of bicarbonate of soda, the manganese subsides in the form of the red oxide, being thus completely separated from the magnesia and lime.

## III. NATURAL HISTORY.

### ZOOLOGY.

27. *Baron Ferussac's Work on the Cephalopodous Mollusca.*—A complete Monograph on the Natural History of Cephalopodous Animals, is now preparing for publication at Paris, by Baron Ferussac. The work is in folio, and is illustrated by numerous drawings, taken chiefly from a very extensive series of specimens in the possession of that distinguished naturalist. Much confusion still prevails in the Natural History of this highly interesting and remarkable tribe of molluscous animals, both in regard to the characters of the species, and the synonyms employed by authors, which we have no doubt will be removed by the labours of Baron Ferussac, who has described an immense number of species, and has been at great pains to examine the objects described.

## IV. GENERAL SCIENCE.

28. *Royal Medal adjudged to Sir H. Davy.*—The Royal Society of London has adjudged one of the royal medals to Sir H. Davy, for his method of protecting the copper of ships' bottoms.

29. *Medal adjudged to M. Struve.*—The Royal Society has adjudged a gold medal to M. Struve of Dorpat, for his observations on double and multiple stars.

30. *Copley Medal adjudged to Dr Prout.*—The Royal Society has adjudged a Copley medal to Dr Prout, for his mode of analysis of animal and vegetable substances.

31. *Copley Medal adjudged to Lieutenant Foster.*—The Royal Society has adjudged a Copley medal to Lieutenant Foster, for his observations on the magnetical needle and the pendulum at Port Bowen.

32. *Medal adjudged to Sir Thomas Brisbane.*—The Astronomical Society has adjudged one of their medals to Sir Thomas Brisbane, for his valuable astronomical observations made in New South Wales.

33. *Keith Medal adjudged to Dr Brewster.*—The Royal Society of Edinburgh has adjudged the Keith medal to Dr Brewster, for his discovery of two new fluids in the cavities of certain minerals.

## ART. XXIII.—CELESTIAL PHENOMENA,

*From April 1st, to Juy 1st, 1828. Adapted to the Meridian of Greenwich, Apparent Time, excepting the Eclipses of Jupiter's Satellites, which are given in Mean Time.*

N. B.—The day begins at noon, and the conjunctions of the Moon and Stars are given in Right Ascension.

### APRIL.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 17 | 30 | 56 | ☽ ☌ λ ♍ ☽ 17′ N. |
| 2 | 8 | | | ☽ ☌ ♃ |
| 2 | 23 | ¼ | | ♄ in Quad. ☉ |
| 4 | 15 | 45 | 58 | Im. I Sat. ♃ |
| 5 | 20 | | | ♃ ☌ 2 α ♎ |
| 6 | 10 | 14 | 28 | Im. I. Sat. ♃ |
| 7 | 0 | 6 | | ☾ Last Quarter. |
| 7 | 12 | 41 | 30 | Im. II. Sat. ♃ |
| 7 | 23 | 57 | 26 | ☽ ☌ β ♍ ☽ 39′ N. |
| 8 | 23 | | | ♀ ☌ A ♉ |
| 13 | 12 | 8 | 23 | Im. I. Sat. ♃ |
| 13 | 21 | 18 | | ● New Moon. |
| 13 | 21 | 17 | ¾ | Sun Eclipsed Invisible. |
| 14 | | | | ☿ Greatest Elong. |
| 14 | 15 | 15 | 26 | Im. II. Sat. ♃ |
| 16 | 23 | 25 | 1 | ☽ ☌ 1 δ ♉ ☽ 41′ N. |
| 16 | 23 | 56 | 57 | ☽ ☌ 2 δ ♉ ☽ 49′ N. |
| 19 | 15 | 14 | | ☉ enters ♉ |
| 20 | 14 | 2 | 25 | Im. I. Sat. ♃ |
| 21 | 17 | 18 | | ☽ First Quarter. |
| 21 | 22 | | | ♅ Quad. ☉ |
| 22 | 10 | 35 | 37 | ☽ ☌ 1 α ♋ ☽ 23′ N. |
| 22 | 11 | 53 | 20 | ☽ ☌ 2 α ♋ ☽ 2″ N. |
| 27 | 15 | 56 | 31 | Im. I. Sat. ♃ |
| 29 | 10 | 25 | 1 | Im. I. Sat. ♃ |
| 29 | 10 | 44 | | ○ Full Moon. |
| 29 | 11 | | | ☽ ☌ ♃ |
| 29 | 10 | ¼ | | ♃ ☍ ☉ |
| 29 | 14 | 25 | 38 | Em. III. Sat. ♃ |
| 29 | 15 | 36 | 51 | ☽ ☌ 2 α ♋ ☽ 69′ N. |

### MAY.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 2 | 12 | 9 | 4 | Em. II. Sat. ♃ |
| 4 | 9 | | | ☿ ☌ ο ♓ |
| 6 | | | | ♅ Stationary. |
| 6 | 5 | 32 | | ☾ Last Quarter. |
| 6 | 14 | 26 | 54 | Em. I. Sat. ♃ |
| 8 | 8 | 55 | 38 | Em. I. Sat. ♃ |
| 9 | 14 | | | ♄ ☌ δ ♊ |
| 9 | 14 | 43 | 48 | Em. II. Sat. ♃ |
| 10 | 17 | 8 | 51 | ☽ ☌ ζ ♓ ☽ 59′ N. |
| 12 | 9 | | | ☽ ☌ ☿ |
| 12 | 15 | | | ♀ ☌ ε ♊ |
| 13 | 9 | 50 | | ● New Moon. |
| 14 | 7 | 44 | 53 | ☽ ☌ δ ♉ ☽ 44′ N. |
| 15 | 10 | 49 | 48 | Em. I. Sat. ♃ |
| 19 | | | | ♀ Greatest Elong. |
| 20 | 15 | 34 | | ☉ enters ♊ |
| 21 | 11 | 11 | | ☽ First Quarter. |
| 22 | 12 | 44 | 12 | Em. I. Sat. ♃ |
| 22 | 12 | | | ☿ ☌ A ♉ |
| 23 | 4 | ½ | | ☿ Sup. ☌ ☉ |
| 24 | 17 | | | ☿ ☌ 2 κ ♉ |
| 26 | 15 | | | ☽ ☌ ♃ |
| 27 | 4 | | | ♀ ☌ κ ♊ |
| 27 | 9 | 11 | 58 | Em. II. Sat. ♃ |
| 28 | 20 | 17 | | ○ Full Moon. |
| 30 | | | | ♂ Stationary. |
| 31 | | | | Near ⚵ ⚴ |
| 31 | 9 | 7 | 16 | Em. I. Sat. ♃ |

### JUNE.

| D. | H. | M. | S. | |
|---|---|---|---|---|
| 1 | 11 | 57 | 10 | ☽ ☌ β ♍ ☽ 29′ N. |
| 2 | 20 | | | ☿ ☌ 132 ♉ |
| 3 | 11 | 47 | 39 | Em. II. Sat. ♃ |
| 4 | 10 | 18 | 21 | Em. III. Sat. ♃ |
| 4 | 11 | 2 | | ☾ Last Quarter. |
| 7 | 11 | 1 | 50 | Em. I. Sat. ♃ |

| D. | H. | M. | S. | | D. | H. | M. | S. | |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 10 | | | ☿ ☌ ε ♊ | 20 | 2 | 52 | | ☽ First Quarter. |
| 11 | 12 | 10 | 22 | Im. III. Sat. ♃ | 21 | 0 | 8 | | ☉ enters ♋ |
| 11 | 23 | 12 | | ● New Moon. | 22 | 21 | | | ☽ ☌ ♃ |
| 16 | 1 | 30 | 40 | ☽ ☌ 1 α ♋ ☽ 40′ N. | 27 | | | | ☿ Greatest Elong. |
| 16 | 2 | 48 | 42 | ☽ ☌ 2 α ♋ ☽ 16′ N. | 27 | 3 | 48 | | ○ Full Moon. |
| 17 | 12 | | | ☿ ☌ ♄ | 30 | 11 | 14 | 32 | Em. I. Sat. ♃ |
| 18 | 17 | | | ♂ ☌ τ ♐ | 30 | 15 | | | ♂ ☍ ☉ |

### *Times of the Planets passing the Meridian.*

APRIL.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | h. | ′ | h | ′ | h | ′ | h | ′ | h | ′ | h | ′ |
| 1 | 22 | 36 | 2 | 34 | 17 | 9 | 13 | 58 | 6 | 15 | 19 | 31 |
| 7 | 22 | 25 | 2 | 40 | 16 | 59 | 13 | 33 | 5 | 54 | 19 | 9 |
| 13 | 22 | 22 | 2 | 47 | 16 | 48 | 13 | 9 | 5 | 33 | 18 | 48 |
| 19 | 22 | 25 | 2 | 53 | 16 | 36 | 12 | 44 | 5 | 13 | 18 | 33 |
| 25 | 22 | 32 | 3 | 0 | 16 | 22 | 12 | 19 | 4 | 52 | 18 | 5 |

MAY.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22 | 43 | 3 | 5 | 16 | 8 | 11 | 53 | 4 | 31 | 17 | 42 |
| 7 | 22 | 58 | 3 | 10 | 15 | 52 | 11 | 27 | 4 | 10 | 17 | 18 |
| 13 | 23 | 18 | 3 | 14 | 15 | 39 | 11 | 1 | 3 | 49 | 16 | 55 |
| 19 | 23 | 44 | 3 | 17 | 15 | 15 | 10 | 34 | 3 | 28 | 16 | 31 |
| 25 | 0 | 9 | 3 | 17 | 14 | 53 | 10 | 8 | 3 | 7 | 16 | 7 |

JUNE.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 45 | 3 | 15 | 14 | 26 | 9 | 37 | 2 | 42 | 15 | 38 |
| 7 | 1 | 12 | 3 | 10 | 13 | 59 | 9 | 10 | 2 | 20 | 15 | 13 |
| 13 | | 33 | 3 | 3 | 13 | 31 | 8 | 44 | 1 | 58 | 14 | 48 |
| 19 | 1 | 46 | 2 | 52 | 13 | 1 | 8 | 18 | 1 | 37 | 14 | 21 |
| 25 | 1 | 05 | 2 | 37 | 12 | 29 | 7 | 53 | 1 | 15 | 13 | 57 |

### *Declination of the Planets.*

APRIL.

| | Mercury. | | Venus. | | Mars. | | Jupiter. | | Saturn. | | Georgian. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. | ° | ′ | ° | ′ | ° | ′ | ° | ′ | ° | ′ | ° | ′ |
| 1 | 4 | 11 S. | 19 | 43N. | 23 | 31 S. | 14 | 23 S. | 22 | 40 N. | 20 | 19 |
| 7 | 4 | 31 | 21 | 42 | 23 | 41 | 14 | 12 | 22 | 39 | 20 | 17 |
| 13 | 3 | 32 | 23 | 23 | 23 | 50 | 13 | 59 | 22 | 38 | 20 | 16 |
| 19 | 1 | 27 | 24 | 42 | 23 | 57 | 13 | 46 | 22 | 36 | 20 | 15 |
| 25 | 1 | 30N. | 25 | 40 | 24 | 4 | 13 | 32 | 22 | 36 | 20 | 19 |

MAY.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 10N. | 26 | 14N. | 24 | 12 S. | 13 | 18 S. | 22 | 32N. | 20 | 13 S. |
| 7 | 9 | 22 | 26 | 26 | 24 | 21 | 13 | 4 | 22 | 29 | 20 | 13 |
| 13 | 13 | 54 | 26 | 16 | 24 | 33 | 12 | 50 | 22 | 26 | 20 | 14 |
| 19 | 18 | 21 | 25 | 45 | 24 | 48 | 12 | 37 | 22 | 22 | 20 | 15 |
| 25 | 22 | 9 | 24 | 55 | 25 | 8 | 12 | 26 | 22 | 18 | 20 | 16 |

JUNE.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 | 52 N. | 23 | 38 N. | 25 | 35 S. | 12 | 15 S. | 22 | 12N. | 20 | 17 S. |
| 7 | 25 | 28 | 22 | 17 | 26 | 3 | 12 | 7 | 22 | 7 | 20 | 19 |
| 13 | 24 | 43 | 20 | 48 | 26 | 35 | 12 | 0 | 22 | 2 | 20 | 22 |
| 19 | 23 | 3 | 19 | 19 | 27 | 7 | 11 | 56 | 21 | 56 | 20 | 24 |
| 25 | 20 | 51 | 17 | 40 | 27 | 38 | 11 | 55 | 21 | 49 | 20 | 26 |

The preceding numbers will enable any person to find the positions of the planets, to lay them down upon a globe, and to determine their times of risings and settings.

## ART. XXIV.—LIST OF PATENTS GRANTED IN SCOTLAND SINCE NOVEMBER 2, 1827.

29. November 2. For certain Improvements in Bedsteads, Beds, Couches, and other articles of furniture principally designed to be used on shipboard. To SAMUEL PRATT, county of Middlesex.

30. November 2. For certain Improvements on Bedsteads, and in the making, manufacturing, or forming articles to be applied to or used in various ways with Bedsteads, from a material or materials hitherto unused for such purpose. To THOMAS BREIDENBACK, county of Warwick.

31. November 22. For an Improved apparatus for the better manufacture of Sugar from the Canes. To WILLIAM FAWCETT, county of Lancaster.

32. November 28. For certain processes and apparatus for printing and preparing for manufacture Yarns of Linen, Cotton, Silk, Woollen, or any other Fibrous Material. To BENNET WOODCROFT, county of Lancaster.

33. November 27. For certain Improvements in the Combination and Arrangement of Mechanical Powers applicable to the purposes of driving Machinery, and Lifting and Moving Heavy Bodies. To LEMUEL WELLMAN WRIGHT, county of Surrey.

34. November 29. For certain Improvements in the Combination and Arrangement of Machinery for Making Metal Screws. To LEMUEL WELLMAN WRIGHT, county of Surrey.

35. December 6. For a Cartridge or Case, and method of more advantageously enclosing therein shot or other missiles, for the purpose of loading Fire-Arms and Guns of different descriptions. To JOSHUA JENOUR Jun. county of Middlesex.

1. January 4, 1828. For an Improvement or Improvements on or in Refrigerators for cooling Fluids. To ROBERT WHEELER, county of Bucks.

2. January 4. For Improvements in Safety Lamps. To THOMAS BOUNER, county of Durham.

3. January 10. For an Improved method of constructing and working an Engine for producing Power and Motion. To WILLIAM PARKINSON, county of Lincoln.

4. January 17. For a New or Improved method or methods of prodelling Vessels through or on the water by the aid of Steam or other Mechanical Force. To WILLIAM NAIRN, county of Mid-Lothian.

5. January 22. For an Improvement or Improvements in making Paper by Machinery. To GEORGE DICKINSON, county of Kent.

6. January 29. For a New and Improved Method of Ballasting Ships or Vessels. To RALPH REWCASTLE, of Newcastle-upon-Tyne.

7. February 13. For an Improvement in applying Heat to the purpose of Distillation. To ROBERT STEIN, county of Middlesex.

8. February 13. For Certain Improvements in that part of the Process of Paper Making which relates to the Cutting. To THOMAS BOUSOR CROMPTON, county of Lancaster.

9. February 23. For Certain Improvements in Machinery for Propelling Boats and other Vessels, which Improvements are also applicable to water wheels and other purposes. To GEORGE JACKSON, city of Dublin.

## Art. XXV.—Register of the Barometer, Thermometer, and Rain-Gage, *kept at Canaan Cottage*. By Alex. Adie, Esq. F.R.S. Edin.

The Observations contained in the following Register were made at Canaan Cottage, the residence of Mr Adie, by means of very nice instruments, constructed by himself. Canaan Cottage is situated about 1¼ mile to the south of Edinburgh Castle, about 3 miles from the sea at Leith, and about ¼ of a mile N. of the west end of Blackford Hill. The ridge of Braid Hills is about 1 mile to the south, and the Pentland Hills about 4 miles to the west of south. The height of the instruments is 300 feet above high water-mark at Leith. The morning and evening observations were made about 10 A.M. and 10 P.M.

### DECEMBER 1827.

| D. of Week. | Day of Month. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| S. | 1 | 45 | 40 | 42.5 | 39 | 47 | 43 | 28.52 | 28.85 | .17 |
| S. | 2 | 43 | 42 | 42.5 | 39 | 45 | 42 | 29·15 | 29.45 | .50 |
| M | 3 | 45 | 52 | 48.5 | 40 | 49 | 44.5 | 29.33 | 29.08 | .48 |
| T. | 4 | 51 | 54 | 52.5 | 49 | 53 | 51 | 29.26 | 29.31 | |
| W. | 5 | 51 | 47 | 49 | 46 | 54 | 50 | 29.40 | 29.15 | |
| T. | 6 | 38 | 38 | 38 | 35 | 46 | 40.6 | 29.52 | 29.83 | .28 |
| F. | 7 | 45 | 43 | 44 | 33 | 50 | 41.5 | 29.53 | 28.98 | .18 |
| S. | 8 | 41 | 44 | 42.5 | 37 | 43 | 40 | 29.37 | 23.46 | |
| S. | 9 | 43 | 44 | 43.5 | 39 | 46 | 42.5 | 29.43 | 29.22 | |
| M. | 10 | 52 | 51 | 51.5 | 39 | 54 | 46.5 | 28.92 | 28.81 | .13 |
| T. | 11 | 47 | 43 | 45 | 42 | 47 | 44.5 | 28.77 | 28.76 | .04 |
| W. | 12 | 40 | 38 | 39 | 36 | 43 | 39.5 | 29.17 | 29.18 | |
| T. | 13 | 39 | 43 | 41 | 36 | 44 | 40 | 29.15 | 28.93 | |
| F. | 14 | 48 | 40 | 44 | 35 | 50 | 42.5 | 28.70 | 29.09 | .25 |
| S. | 15 | 46 | 41 | 43.5 | 36 | 47 | 41.5 | 28.96 | 28.94 | .09 |
| S. | 16 | 40 | 40 | 40 | 35 | 43 | 39 | 29.09 | 29.41 | .08 |
| M. | 17 | 43 | 46 | 44.5 | 37 | 47 | 42 | 29.50 | 29.15 | .24 |
| T. | 18 | 43 | 43 | 43 | 37 | 49 | 43 | 29.36 | 29.06 | .35 |
| W. | 19 | 49 | 40 | 44.5 | 38 | 52 | 45 | 28.78 | 28·92 | |
| T. | 20 | 39 | 40 | 39.5 | 38 | 43 | 40.5 | 28.93 | 29.03 | |
| F. | 21 | 43 | 40 | 41.5 | 40 | 45 | 42.5 | 28.98 | 29.02 | |
| S. | 22 | 43 | 36 | 39.5 | 38 | 44 | 41 | 29.17 | 29.28 | |
| S. | 23 | 37 | 46 | 41.5 | 32 | 43 | 37.5 | 29.59 | 29.34 | .03 |
| M. | 24 | 52 | 41 | 46.5 | 41 | 52 | 46.5 | 29.06 | 29.50 | .06 |
| T. | 25 | 44 | 52 | 48 | 38 | 52 | 45 | 29.81 | 29.77 | .02 |
| W. | 26 | 52 | 50 | 51 | 51 | 54 | 52.5 | 29.99 | 29.86 | |
| T. | 27 | 47 | 38 | 42.5 | 44 | 53 | 48.5 | 30.05 | 30.37 | |
| F. | 28 | 42 | 35 | 38.5 | 35 | 43 | 39 | 30.42 | 30.32 | |
| S. | 29 | 29 | 31 | 30 | 24 | 35 | 29.5 | 30.27 | 30.13 | |
| S. | 30 | 31 | 33 | 32 | 25 | 36 | 30.5 | 30.01 | 29.68 | |
| M. | 31 | 42 | 46 | 44 | 29 | 47 | 38 | 29.12 | 28.96 | |
| | Sum, | 1350 | 1317 | 1333.5 | 1163 | 1456 | 1309.5 | 909.31 | 908.84 | 2.90 |
| | Mean. | 43.58 | 42.58 | 43.08 | 37.52 | 46.97 | 42.24 | 29.333 | 29.324 | |

### JANUARY 1828.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| T. | 1 | 42 | 37 | 39.5 | 37 | 48 | 42.5 | 29.28 | 29.52 | |
| W. | 2 | 41 | 44 | 42.5 | 32 | 43 | 37.5 | 29.36 | 28.89 | .05 |
| T. | 3 | 38 | 37 | 37.5 | 32 | 47 | 39.5 | 29.03 | 29.37 | .04 |
| F. | 4 | 37 | 35 | 36 | 39 | 35 | 37 | 29.28 | 29.35 | .40 |
| S. | 5 | 42 | 35 | 38.5 | 34 | 43 | 38.5 | 29.54 | 29.68 | |
| S. | 6 | 36 | 35 | 35.5 | 32 | 39 | 35.5 | 29.70 | 29.79 | |
| M. | 7 | 35 | 35 | 35 | 33 | 36 | 34.5 | 29.81 | 29.78 | |
| T. | 8 | 36 | 35 | 35.5 | 33 | 38 | 35.5 | 29.94 | 29.95 | |
| W. | 9 | 35 | 31 | 33 | 33 | 38 | 35.5 | 29.95 | 29.80 | |
| T. | 10 | 28 | 26 | 27 | 26 | 34 | 30 | 29.65 | 29.46 | .39 |
| F. | 11 | 25 | 31 | 28 | 15 | 31 | 23 | 29.36 | 29.26 | |
| S· | 12 | 35 | 36 | 35.5 | 30 | 36 | 33 | 29.42 | 29.36 | |
| S. | 13 | 37 | 35 | 36 | 33 | 37 | 35 | 29.20 | 29.41 | |
| M. | 14 | 35 | 31 | 33 | 32 | 36 | 34 | 29.50 | 29.54 | |
| T. | 15 | 31 | 28 | 29.5 | 28 | 32 | 30 | 29.68 | 29.65 | |
| W· | 16 | 31 | 30 | 30.5 | 26 | 31 | 28.5 | 29.67 | 29.70 | |
| T. | 17 | 31 | 32 | 31.5 | 27 | 32 | 29.5 | 29.69 | 29.77 | |
| F. | 18 | 49 | 51 | 50 | 34 | 51 | 42.5 | 29.60 | 29.61 | |
| S· | 19 | 50 | 51 | 50.5 | 46 | 52 | 49 | 29.65 | 29.70 | |
| S. | 20 | 51 | 49 | 50 | 47 | 53 | 50 | 29.77 | 29.72 | |
| M. | 21 | 52 | 50 | 51 | 48 | 53 | 50.5 | 29.66 | 29.60 | .20 |
| T. | 22 | 48 | 45 | 46.5 | 44 | 51 | 47.5 | 29.66 | 29.71 | |
| W. | 23 | 46 | 48 | 47 | 43 | 50 | 46.5 | 29.84 | 29.85 | |
| T. | 24 | 42 | 51 | 46.5 | 46 | 53 | 49.5 | 29.74 | 29.64 | |
| F. | 25 | 46 | 42 | 44 | 43 | 50 | 46.5 | 29.63 | 29.59 | |
| S. | 26 | 41 | 43 | 42 | 37 | 44 | 40.5 | 29.67 | 29.78 | .40 |
| S. | 27 | 46 | 45 | 45.5 | 40 | 50 | 45 | 29.91 | 30.01 | .21 |
| M. | 28 | 41 | 36 | 38.5 | 36 | 45 | 40.5 | 30.02 | 29.94 | |
| T. | 29 | 42 | 48 | 45 | 33 | 46 | 39.5 | 29.77 | 29.66 | |
| W. | 30 | 51 | 48 | 49.5 | 44 | 52 | 48 | 29.52 | 29.41 | .05 |
| T. | 31 | 49 | 43 | 46 | 44 | 53 | 48.5 | 29.50 | 29.46 | |
| | | 1249 | 1223 | 1236 | 1107 | 1339 | 1223 | 918.00 | 917.96 | 1.70 |
| | | 40.29 | 39.35 | 39·82 | 35·71 | 43.19 | 39.35 | 29.613 | 29.612 | |

### FEBRUARY 1828.

| D. of Week. | D. of Mon. | Thermometer. Morn. | Thermometer. Even. | Thermometer. Mean. | Register Therm. Min. | Register Therm. Max. | Register Therm. Mean. | Barometer. Morn. | Barometer. Even. | Rain. |
|---|---|---|---|---|---|---|---|---|---|---|
| F. | 1 | 43 | 41 | 42 | 38 | 49 | 43.5 | 29.57 | 29.56 | |
| S. | 2 | 42 | 38 | 40 | 37 | 49 | 43 | 29·63 | 29.92 | .20 |
| S. | 3 | 42 | 46 | 44 | 34 | 45 | 39.5 | 30.13 | 29.73 | |
| M. | 4 | 45 | 50 | 47.5 | 40 | 51 | 45.5 | 29.80 | 29.56 | |
| T. | 5 | 51 | 50 | 50.5 | 49 | 52 | 50.5 | 29.61 | 29.62 | .13 |
| W. | 6 | 51 | 48 | 49.5 | 46 | 54 | 50 | 29.71 | 29.69 | |
| T. | 7 | 48 | 40 | 44 | 44 | 54 | 49 | 29.56 | 29.60 | .03 |
| F. | 8 | 41 | 33 | 37 | 33 | 47 | 40 | 29.71 | 29.64 | .09 |
| S. | 9 | 39 | 34 | 36.5 | 29 | 39 | 34 | 29.66 | 29.70 | |
| S. | 10 | 34 | 31 | 32.5 | 31 | 37 | 34 | 29.62 | 29.33 | |
| M. | 11 | 32 | 31 | 31.5 | 28 | 34 | 31 | 29.46 | 29.82 | |
| T. | 12 | 33 | 28 | 30.5 | 26 | 35 | 30.5 | 29.98 | 29.96 | |
| W. | 13 | 32 | 32 | 32 | 25 | 37 | 31 | 29.88 | 29.60 | |
| T. | 14 | 30 | 30 | 30 | 28 | 32 | 30 | 29.12 | 29.18 | .15 |
| F. | 15 | 35 | 27 | 31 | 27 | 39 | 33 | 29.34 | 29.56 | |
| S. | 16 | 35 | 35 | 35 | 22 | 42 | 32 | 29.56 | 29.48 | |
| S. | 17 | 35 | 31 | 33 | 33 | 43 | 38 | 29.37 | 29.22 | |
| M. | 18 | 35 | 34 | 34.5 | 27 | 41 | 34 | 29.11 | 29.00 | |
| T. | 19 | 37 | 37 | 37 | 31 | 38 | 34.5 | 29.05 | 28.81 | |
| W. | 20 | 43 | 32 | 37.5 | 29 | 44 | 36.5 | 28.84 | 28.86 | .23 |
| T. | 21 | 38 | 40 | 39 | 29 | 41 | 35 | 28.88 | 28.90 | .05 |
| F. | 22 | 41 | 39 | 40 | 39 | 45 | 42 | 28.99 | 29.11 | |
| S. | 23 | 42 | 39 | 40.5 | 36 | 43 | 39.5 | 29.24 | 29.37 | |
| S. | 24 | 40 | 48 | 44 | 30 | 47 | 38.5 | 29.38 | 29.20 | .04 |
| M. | 25 | 48 | 45 | 46.5 | 47 | 54 | 50.5 | 29.38 | 29.58 | |
| T. | 26 | 55 | 50 | 52.5 | 41 | 57 | 49 | 29.54 | 29.57 | .02 |
| W. | 27 | 52 | 42 | 47 | 49 | 56 | 52.5 | 29.82 | 30.00 | .04 |
| T. | 28 | 48 | 49 | 48.5 | 39 | 50 | 44.5 | 30.02 | 30.05 | |
| F. | 29 | 54 | 45 | 49.5 | 47 | 56 | 51.5 | 30.10 | 30.11 | |
| | | 1201 | 1125 | 1163 | 1014 | 1311 | 1162.5 | 855.84 | 855.79 | .98 |
| | | 41.41 | 38.79 | 40.10 | 34.47 | 45.21 | 40.09 | 29.512 | 29.51 | |

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Fig 3

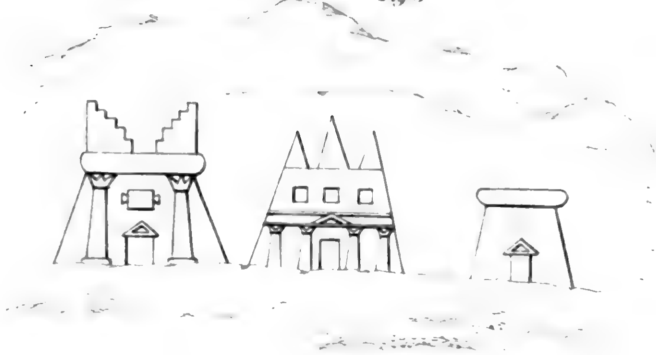


Fig 1

Fig 2

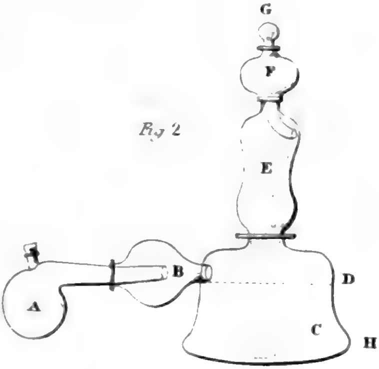


Fig 4

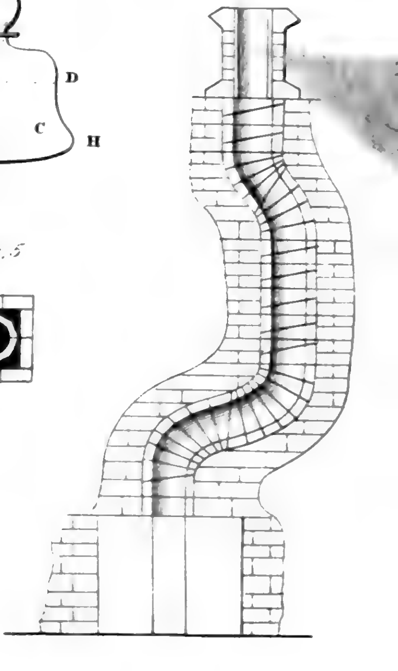


Fig. 5

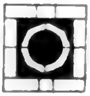
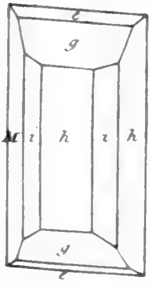


Fig 6



W.H. Lizars Sc.

Fig 1

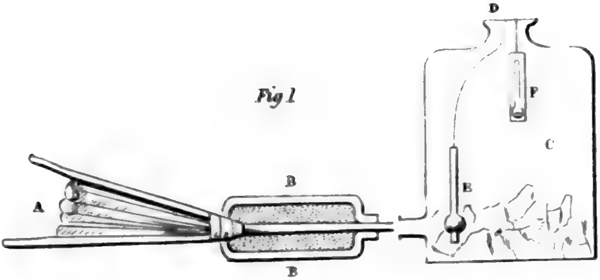


Fig. 2

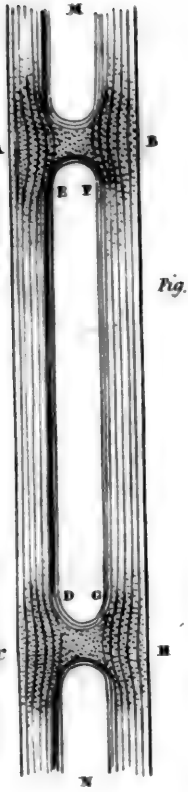


Fig. 3

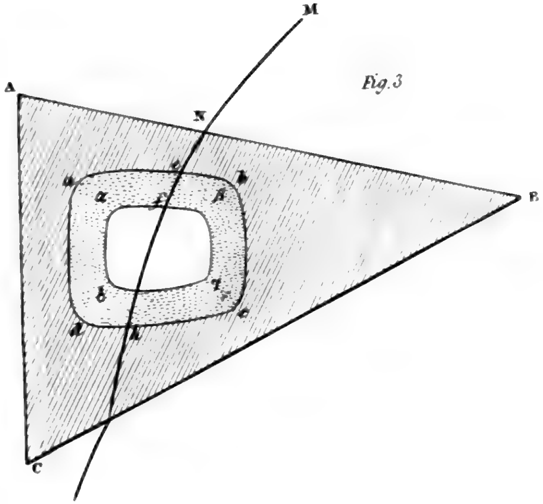
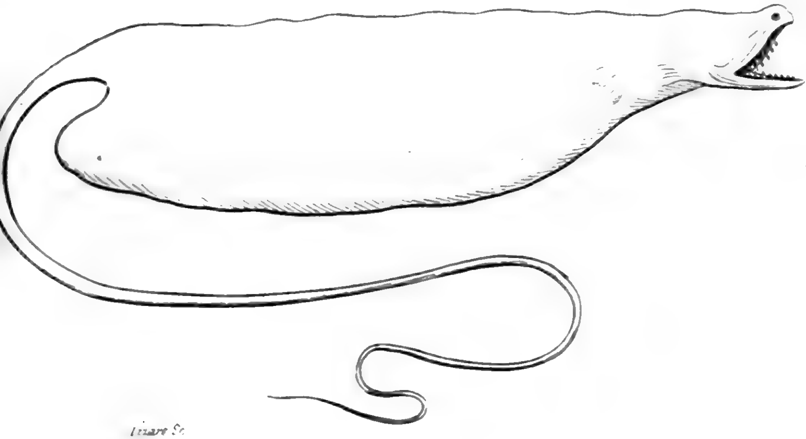


Fig. 4



Lizars Sc.

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