THURSDAY, FEBRUARY 21, 1878

THE HEAD-MASTERS ON SCIENCE TEACHING[1]

IT is much to the credit of the head-masters that they should have moved voluntarily in the matter of science teaching. The great majority of them are known to look upon it without hostility, but have hesitated to introduce it into their schools, in ignorance of its educational value, of the time and teaching power necessary, of subjects, methods, cost. Since the Report of the Science Commission all see that it must come, and that it is better for the schools to shape the system to be adopted leisurely and in concert than to wait till it is forced upon them from without. A few schools have already accepted it in principle; a very few have worked it adequately for some years past; to these the Head-Masters' Committee have applied for information, and their published answers are before us.

Questions were issued to the masters of twenty-four schools, of whom nineteen replied. They refer to the time spent on science in actual school work, the percentage of boys taught, the age at which teaching should begin, the subjects included, the methods and texts employed, the intellectual results apparent, the value of laboratory work, the cost of appliances, the influence, good and evil, of university scholarships, the text-books recommended; and it was requested that the answers might convey not individual theories of what might and ought to be, but a record of what had been and was being done in each particular school.

It is evident that the first question, as to time spent in teaching, is vital to the whole, and should determine primarily the comparative weight due to the answers sent from each head-master. Unfortunately the answers to it are in a great measure unreliable. Only one school gives the total number of its actual working hours; some do, and some do not apparently include hours of "preparation" in their estimate; one large school, Clifton, omits to reckon the extra time given to special classes, and probably others do the same; while Harrow, Magdalen, and Dulwich, all valuable witnesses, make no return. Taking the answers as they stand, eleven of the nineteen schools give from two to four hours only as a maximum per week, inclusive of practical work; and in some cases, at least, this is probably correct, representing also many more schools than are included in the list. Such schools have made a good beginning, are feeling their way to more extended teaching, and will hail the information given in these pages. But their maximum would be thought ludicrous in the case of literature or mathematics; it gives no real chance to science either as a storehouse of useful knowledge, or as a weapon of intellectual training; and accordingly the evidence valuable to schoolmasters is contained mainly in the answers sent by the remaining schools.

These may be tabulated as follows:—

[1] Appendix to Report of Head-Masters' Committee, 1877. Answers to Questions on Natural Science.

School.	Hours per week given to science in different parts of school.	Percentage of boys learning science.
Bradford	10, 4, 3, 2	No return.
Clifton[1]	10, 4	90
Giggleswick	8, 6, 5, 2	80
King's College ...	7, 5, 5	No return.
Manchester	12, 9, 3½	No return.
Newcastle-under-Lyme	7, 4, 2	90
Taunton	10, 8, 4, 3	87
Wellington	6, 3½, ½	73

As regards the age at which the study should commence, Clifton, Taunton, and Wellington think that it cannot begin too early; the rest give years ranging from ten to thirteen. All the schools agree in teaching chemistry and physics; three teach botany, three geology. All test progress by periodical frequent examinations within the school, Clifton and Taunton specifying the period as once in three weeks. All but one speak highly of the use of note-books; five object strongly to examinations from without, two find them useful. Bradford, Clifton, Taunton, Wellington celebrate the good effects of science as a school subject, from its stimulating power, its bringing apparently dull boys to the front, its inculcating a comprehension of physical law. Six schools make practical laboratory work compulsory; one, Clifton, has regard to special aptitude shown by boys; one alone, Bradford, would not enforce it at all.

The evidence as to cost is complicated; the questions were well arranged, but many of the answers give aggregate sums, without saying how many boys the outlay was calculated to supply. It would seem, however, that the costly appliances of Clifton, including chemical and physical laboratories and lecture-rooms with fittings of every kind, cost about 5*l.* per head of pupils intended to be taught; those of Newcastle about 4*l.* per head; of Giggleswick 3*l.*; of Taunton less than 2*l.*: that is to say, chemistry and physics may be taught for ever to one hundred boys with an original expenditure of 200*l.*, and cannot where money is plentiful cost more than 500*l.* For the further consolation of beginners and of poorer schools we learn that a Clifton master's apparatus for three chemical and three physical lectures a week cost 8*l.* once for all, exclusive of air-pump and balance, and that in lecturing for five years he has not spent 3*l.* a year; while the Taunton master announces that a man with leisure and dexterity to make his own apparatus can begin with table, gas, water, a few shelves, and 5*l.*; and adds that his own lectures cost only 6*d.* each.

Valuable opinions are reported as to the influence exercised by the universities on school teaching. All head-masters know that the mischief inflicted on education by the Oxford and Cambridge system is incalculable, and the opinion finds expression in these answers. To gain a science scholarship a boy must abandon during the last two or three years of his school course all subjects except science, with such a minimum of classics and mathematics as may secure him against a pluck in the Little-go; and, *mutato nomine*, the same is true of candidates for either classical or mathematical scholarships.

[1] This is from private information. The returns given in the Report are not so high.

Those who think that school education should be general; that literature, mathematics, and science should share it in fair proportions; and that entrance scholarships at the university should be awarded to general excellence, will understand how the present system disheartens every thoughtful educator, who groans over the intellectual development of his best boys distorted in obedience to this tyranny of special prizes, which he nevertheless must win, or forfeit his reputation as a teacher.

An exhaustive list of text-books is given by the various schools. Some of them are valuable to the teacher only; others indispensable to the pupils. With very few exceptions their price is exceedingly moderate, though expensive books such as Watts' "Dictionary of Chemistry," and Weinhold's "Practical Physics," should have their place in the school library as books of reference.

It is clear that the publication of this Report marks a step in advance along the path of scientific education. It contains not opinions, but facts; not theories of what the teaching should be, but records of what it is; and this not scattered through the discursive pages of a Blue-book, but condensed into a pamphlet of thirty pages. Not less instructive is the comparative unanimity with which different schools, swayed by independent traditions, advancing on different lines, and ignorant of each other's movements, have worked out the same practical results and are teaching the same subjects by the same methods. The problem is virtually solved; the difficulties inherent in the recasting of an ancient system have disappeared so soon as they were honestly faced; and the head-masters, who perhaps looked shyly on advice from without, will listen to it, let us hope, when recommended by their colleagues. To this end the contents of the Report should be summarised, and circulated amongst the schools. It would be easy for the head-masters and science-masters of the schools which have answered questions to constitute an informal committee. A small working sub-committee would soon formulate a scheme of science teaching, based on the conclusions of the Duke of Devonshire's Commission, giving accurate particulars as to methods, books, tests, and cost of teaching chemistry and physics, with further information on the subject of museums, workshops, botanical gardens, and observatories; and this paper, drawn up in the simplest and most practical shape, might be sent at once to all first-class schools with the imprimatur of the entire committee. It would hardly fail to gain converts amongst present schools; each new head-master, appointed, as they are appointed now, with an understanding that they shall find room for science in their curriculum, would hail it as of the highest value; and when compulsory legislation comes, as come it must, the necessary details will all be ready to its hand.

W. TUCKWELL

FRANKLAND'S RESEARCHES IN CHEMISTRY[1]

Experimental Researches in Pure, Applied, and Physical Chemistry. By E. Frankland, Ph.D., D.C.L., F.R.S., &c. (London: Van Voorst.)

THE section (II.) that Dr. Frankland devotes to his researches in Applied Chemistry is not the least interesting of the work, though the chief topics are Gas and Water. The author's investigation of White's process for manufacturing hydrocarbon gas by passing steam over red-hot coke, and carbonising the gas in the retort, led to the clear distinction of the illuminating from the non-illuminating constituents of the hydrocarbon gas and of ordinary coal-gas. It was shown that marsh gas is valueless as a light producer during combustion, and that the luminosity of a gas flame is due to the heavier hydrocarbons present, whose illuminating value can be deduced from analysis and expressed in terms of olefiant gas. Such an indirect method of estimating the illuminating value of a sample of gas is certainly interesting, but it is clearly unsafe; for it involves the assumption that the illuminating value is directly proportional to the percentage of a hydrocarbon mixture of unknown constitution, calculated somewhat empirically into equivalents of the well-defined ethylene. Moreover, some recent experiments by Dittmar seem to show that ethylene does not contribute nearly so much to the luminosity of a hydrogen gas flame as benzole vapour. Hydrogen containing as much as 10 per cent. of ethylene gave a very feebly luminous flame, while hydrogen charged with only 3 per cent. of benzole vapour afforded a brilliant light when the gas was burned. Fortunately Dr. Frankland does not wholly rely upon the method in comparing—as he does in his introductory remarks on the gas investigations—the London supply of 1851 with that of 1876; for he has partially employed the photometer as a check. In 1851 the London gas supply contained 7·01 per cent. of olefiant gas, or its equivalent of other illuminating hydrocarbon, while in 1876 the percentage was 7·02. From these data it was concluded that there was no difference in illuminating power although the 1876 gas should be, according to the Act of Parliament, four candles better than that of 1851. Dr. Frankland says:—

"The improvement of the coal gas sold in London has been only imaginary, for no real alteration has been effected. It has been made to appear better, by testing it with improved burners; but, as consumed by the burners almost universally employed, it gives no more light in 1876 than it did in 1851—a conclusion which is confirmed by the results of simultaneous comparative trials made by Mr. Humpidge with two burners, one of them similar to those by which London coal gas was tested in 1851, and the other, the so-called 'gas referee's burner,' at present employed in testing London coal gas. At 4 P.M. on June 6, 1876, the gas supplied by the Chartered Company to South Kensington Museum gave, when consumed at the rate of five cubic feet per hour from the 1851 test-burner, a light equal to 11·1 standard candles, and on June 28, at 3 P.M., a light equal to 10·5 standard candles; but when the same gas was tested at the same hours by the present referee's burner, it gave, when consumed at the same rate, a light equal to 14·3 candles on June 6, and a light equal to 14·5 candles on June 28."

There is no doubt that the photometric determinations in the above cases substantially agreed with the analytical results, which latter may, in consequence, be accepted so far. The general result, however, is eminently unsatisfactory to all persons interested, save the gas company.

The second inquiry undertaken in connection with gas was that on the igniting point of coal-gas. The chief facts elicited possess so much general interest that we may mention them here. They were:—1. That coal-gas ignites at a much lower temperature than marsh-gas, but at a higher temperature than hydrogen or carbonic oxide.

[1] Continued from p. 219.

2. That the admixture of the vapour of carbon bisulphide does not sensibly lower the igniting point of coal-gas, although alone, or mixed with hydrogen or carbonic oxide, this vapour inflames at 400° F. 3. The Davy lamp, which is a protection in explosive mixtures of air and firedamp, is not safe in similar mixtures of air and coal-gas.

The third paper in the section discusses the possibility of making metallic magnesium available as a source of artificial light : and the last paper, relating to the use of illuminating materials, describes the construction of a gas-burner, in which the waste heat of the flame is made to raise the temperature of both air and gas to 500° or 600° F. before combustion, and thus to increase the luminosity of the flame.

The author's group of papers on water examination and purification, and on the treatment of sewage and other refuse, occupies nearly 300 pages of the volume before us. The value of Dr. Frankland's investigations in sanitary chemistry has been variously estimated, and a glance over the pages before us recalls the wordy warfare that has been waged between the upholders of Dr. Frankland's system of water analysis and of the conclusions founded upon the data afforded by it, and those that put their trust in the method devised by Messrs. Wanklyn, Chapman, and Smith. We anticipate that the republication of Dr. Frankland's papers will impart fresh vitality to a controversy that seemed, happily, to be on the wane. If, however, a renewal of the controversy is likely to lead to re-investigation and substantial improvement in the existing methods of water analysis, we shall not regret the re-opening of the subject.

The chief aim of all modern methods of water analysis is the detection and estimation of organic (especially sewage) contamination. Dr. Frankland seeks to attain the end in view by direct estimation of the "organic" carbon and nitrogen in the water, while Messrs. Wanklyn, Chapman, and Smith attempt to estimate the nitrogenous organic matter in water by breaking up the organic bodies and separating their nitrogen in the form of ammonia—"albumenoid ammonia." A rather extended experience in the use of both methods has led us to conclude that Dr. Frankland's plan, though nearly perfect in point of theory, is not as satisfactory in practice; while the rival method rests on a bad foundation, but is not likely to lead to error in excess. We may state this much without trenching too far upon technical ground, but we do so in order to justify the desire above expressed for a re-investigation of the subject, conducted with a view to render the theory and practice of water analysis equally satisfactory.

It is scarcely necessary to mention that we find in this section Dr. Frankland's valuable papers on the development of fungi in potable water ; on the deterioration of potable water during its passage through cast iron mains and leaden service pipes ; on the methods of softening "hard" water, and on the comparative purity of water from various geological strata, and from different sources such as mountain streams and lakes, rivers, shallow wells, artesian wells, and springs. In addition, experimental data are given showing the extent to which polluted water can be purified by various means and rendered fit for domestic purposes. These papers, together with those on sewage treatment, are of especial value to sanitary engineers, and will no doubt be more freely consulted in their present well-connected form than when scattered through other publications.

In Section III. Dr. Frankland returns to gases and vapours—evidently favourite subjects of study with him since the date of his discovery of the alcohol radicles—but now from the physical side. The first investigations detailed in the section are those upon the effect of pressure on combustion, which led him to conclude that the luminosity of ordinary flames] is chiefly due to the presence of incandescent vapours or gases of high density, rather than to solid particles. The author's experiments on the combustion of hydrogen and carbonic oxide under great pressure proved that incandescent gases and vapours emit light in proportion to their density, and that a continuous spectrum can be afforded by dense gas as well as by solid or liquid matter. These observations led to the suspicion that the sun's photosphere consists of gases or vapours only, and ultimately to the commencement of a new line of research in conjunction with Mr. J. Norman Lockyer, who was then engaged on his researches on the physical constitution of the sun. Dr. Frankland was soon obliged to relinquish the investigation, owing to pressure of other work ; but in Mr. Lockyer's hands it has since afforded results of the highest interest and value.

Excluding a chapter on climate, and some miscellaneous observations, the last research detailed in the volume before us is a highly important one on the source of muscular power. This inquiry is really complementary to the well-known investigation of Profs. Fick and Wislicenus on the same subject, for Dr. Frankland ascertained by direct calorimetrical determinations the potential energy locked up in muscle and in its chief products of oxidation—urea, uric acid, and hippuric acid—and proved that the store available was much less than would suffice to account for the work done by Fick and Wislicenus in the ascent of the Faulhorn. Frankland's experiments conclusively proved that the muscular force expended by the two professors in the ascent of the mountain must have been chiefly derived from the oxidation of non-nitrogenous matters, since it could not have been produced by the oxidation of muscle or other nitrogenous constituents of their bodies. This investigation is one of the most valuable in the section, and will be re-read with special interest in connection with the Rev. Prof. Haughton's latest researches.

We cannot conclude this short sketch of Dr. Frankland's admirable researches without giving expression to the hope we entertain that the well-arranged volume before us may prove to be but an instalment of the life-work of its distinguished author. J. EMERSON REYNOLDS

FLORA OF TROPICAL AFRICA

Flora of Tropical Africa. By Daniel Oliver, F.R.S., F.L.S., Keeper of the Herbarium and Library in the Royal Gardens, Kew, and Professor of Botany in University College, London. Assisted by other botanists. Vol. iii. Umbelliferæ to Ebenaceæ. Published under the Authority of the First Commissioner of Her Majesty's Works. (London : L. Reeve and Co., 1877.)

THE third volume of Oliver's "Flora of Tropical Africa" includes fourteen natural orders, mostly belonging to the sub-class Gamopetalæ of the Dicotyledons. The two orders, Umbelliferæ and Araliaceæ, both by Mr. W. P. Hiern, and occupying the first thirty-two pages, were printed in 1871 along with vol. ii., the rest being all new. The district included in the present volume is of course the same as that mentioned in the previous ones, extending on each side of the equator for somewhere about fifteen degrees. It is divided into six regions, two on the west side of the continent, distinguished as Upper and Lower Guinea, two on the east side; Nile Land and Mozambique and the intervening region divided into the north and south-central. The district is therefore one of vast extent, and will probably yield many new forms when further exploration renders our knowledge of the country and of its productions more complete than it is at present.

The Umbelliferæ are represented in the flora by twenty-one genera and about forty-four species. The number of genera is small when contrasted with the thirty-four found in Britain. Several familiar British forms are found in this flora, of which it will only be necessary to mention *Sanicula europæa*, *Conium maculatum*, *Anthriscus sylvestris*, *Daucus carota*, and *Caucalis infesta*. Five genera are, however, endemic in Africa. The genus *Peucedanum* is interesting as including two species, *P. araliaceum* and *P. fraxinifolium*, both small glabrous trees. The Araliaceæ are unimportant, and represented by only three genera and fourteen species.

By far the most important monograph in the present volume is that on the Rubiaceæ, by Mr. W. P. Hiern. It occupies over 200 pages, or nearly as many as the monograph of the Compositæ, the joint production of Messrs Oliver and Hiern. The Rubiaceæ form a very extensive tropical and sub-tropical order, most richly represented in America. Tropical Africa, however, possesses seventy-eight genera, about thirty of which are endemic, and three of these are now described for the first time by Mr. Hiern. The genus *Coffea* is fully treated of by Mr. Hiern. The *C. arabica* occurs in four of the districts of the flora, but not in the two Central regions. The new coffee, *C. liberica*, Hiern, which promises to be of so much value, is here noticed. It is the source of the Liberian coffee, and probably of the Cape Coast coffee. The berries are said to be larger, the flavour finer, and at the same time the plant is more robust and productive than the ordinary *C. arabica*. The *C. arabica* has the flowers pentamerous, while in *C. liberica* they are 7- or 6-merous; or, according to the key to the species, 6 to 8-merous. The genus *Sarcocephalus* is an interesting one, the fruits cohering to form a pseudocarp known as the peach, or country fig, of Sierra Leone. The shape and colour of the pseudocarp is that of a strawberry, but in flavour it resembles an apple. Unfortunately if eaten to excess it acts as an emetic. Two familiar species of *Galium* are also included in the flora, namely, *G. aparine* and *G. mollugo*.

The Valerianaceæ are represented by the European *Valerianella dentata* only. The Dipsaceæ by three genera, *Scabiosa* yielding two familiar species. Both these small orders are by Mr. Hiern.

The Natural Family Compositæ, the joint production of Prof. Oliver and Mr. Hiern, occupies the chief place in the volume, as would be expected of the largest order of flowering plants. The number in the tropical region of Africa, 468 species, is small compared with the 1,300 species occurring in the Cape flora. In tropical Africa there are 117 genera, seventeen being endemic, and all of these latter either small or monotypic. Many of the forms are of great interest, and some of the genera very extensive. It is curious to meet with *Erigeron alpinus* in Abyssinia, along with *Senecio vulgaris*, and others, some of them familiar weeds. The genus *Tarchonanthus* forms a small tree, and it was upon a species of this genus that Dr. Welwitsch found the only species of *Viscum* he met with in Angola.

The Campanulaceæ are by Mr. W. B. Hemsley, who reduces the peculiar Abyssinian plants known as *Tupa* to the genus *Lobelia*, and describes two species, *L. rhynchopetalum* and *L. giberroa*. One species of *Lightfootia*, from Lower Guinea, is of interest. In it (*L. welwitschii*) the ovary is almost wholly superior, while in all others the ovary is inferior, the plant thus looking very unlike the other members of the Campanulaceæ. Four genera of Ericaceæ occur, but only one species of *Erica*, viz., *E. arborea*, thus contrasting with the Cape flora where the species are most numerous. The Ericaceæ, Plumbagineæ, and Primulaceæ are by Prof. Oliver, but are small and unimportant. The Myrsineæ and Sapotaceæ are by Mr. J. G. Baker, and the Ebenaceæ by Mr. Hiern, who has already published a monograph of this group.

The greater part of the volume is by Mr. Hiern, who contributes about 270 pages, while, along with Prof. Oliver, he contributes 207 pages more. About twenty pages each are contributed by Messrs. Baker and Hemsley, while eight only are from the pen of Prof. Oliver alone. This handsome volume of about 550 pages adds another to the long series of "Floras" now so well known and so highly appreciated that have from time to time issued from Kew.

W. R. McNab

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Marine Fossils in the Gannister Beds of Northumberland

I take the earliest opportunity to announce, through your columns (if you will allow me to do so), that on the 9th of this month (February), while conducting the usual weekly field-work in connection with this college, I had the good fortune to find marine fossils in the lower coal measures, or gannister beds of Northumberland. The locality is about half-way between the Stocksfield Station, on the Newcastle and Carlisle Railway, and the village of Whittonstall. As I have more than once insisted on the fact that hitherto no marine forms had been found in this series in this country, I wish to be the first to destroy the effect which that negative evidence may have produced. The importance which the study of the gannister fauna has assumed since the publication of Prof. Hull's recent paper on the Classification of the Carboniferous Rocks in the *Quarterly Journal of the Geological Society*, need not be dwelt on.

Full details of the find will be published elsewhere.

G. A. Lebour

College of Physical Science, Newcastle-on-Tyne, February 12

Liquids having a Specific Heat Higher than Water

In Nature, vol. xvii. p. 252, it is stated: "Hitherto water has been regarded as possessing a greater specific heat than any other body excepting hydrogen. E. Lecker has shown to the Vienna Academy that mixtures of methylic alcohol and water have a specific heat higher than that of water, and accordingly take the second place," &c. Can you spare me a corner to point out that in 1869 the specific heats of some mixtures of ethylic alcohol and water were proved by Dr. A. Dupré and myself to be considerably higher than that of water, *e.g.* a mixture containing 20 per cent. alcohol, has a specific heat of 104 3, water = 100 (*Phil. Trans.*, 1869, 591; Watts's Dict., 2nd Supplement, 475). Moreover, we especially mentioned "that our experiments furnished the first example of a liquid having a specific heat higher than that of water." Since 1869 Dr. Dupré has estimated (*Proc. Roy. Soc.*, xx. 336) the specific heats of mixtures of methylic alcohol and water without finding any such mixture to possess a specific heat above that of water.

University College, London F. J. M. PAGE

Age of the Sun in Relation to Evolution

I HAVE read Mr. Plummer's letter along with his article in the *Popular Science Review*, and am surprised at his objections to my paper on the "Age of the Sun's Heat."

It matters not whether the sun's heat was derived from the contraction of his mass or from the falling in of meteorites, or of comets, as advocated by Mr. Plummer in the article referred to, we could only have had a supply of heat sufficient for twenty or thirty million years, at the present rate of radiation. Probably not much more than half of this would be available for the formation of the stratified rocks, and the development of life on the globe; a length of time irreconcilable alike with geology and evolution. We are therefore compelled to look for some other source than gravity as the origin of the sun's heat. It will not do to lengthen this period by assuming that the rate of radiation was less during past ages than at present, because we should have to assume that the temperature in the past was also less, a conclusion at variance with the known facts of geology and of palæontology. I never supposed that the rate of radiation in the past may not have been greater than now. Nor did I ever suppose that there is any antecedent improbability whatever in the collision of stellar masses. What I maintained (*Quart. Journ. of Science* for July, 1877) was that the formation of a sun is an event which, on an average, can only be witnessed once in about 15,000 years, or the number of visible stars would be greater than it actually is. And this, I think, is a sufficient reason why we should not expect any historical record of such an event. Further, it does not necessarily follow that the two bodies coming into collision should possess equal mass or velocity in order to have their motion of translation converted into heat. If it be true that the stars derived their heat from loss of motion then this may quite well explain why their motions are so small. In a word, the energy which the sun has been dissipating into space through past ages, always existed in the form of motion. Collision only changed it from one form to another, viz., from the motion of translation to molecular motion.

JAMES CROLL

The "Phantom" Force[1]

IT might be supposed that permanent and entirely local or "internal" force-pairs of this kind acting on innumerable material couplets in a system would so disturb the individual energies of their motions that no general conclusion as to the total change of energy during the progress of such a system's motion could be drawn; but the simple law that impulses act independently of each other and of existing motions soon shows that the whole gain of energy in the system is the sum of the separate gains in the several mass-couplets due to their absolute or several actions and reactions at every instant of the motion, and that when these abstract force-pairs are all permanent, the above constancy of the sum of their actual and potential energies is possessed by the whole system as perfectly as would be the case by one only of its couplets, or component pairs. That this is not merely an abridged expression for the resulting actual energy in all the possible different phases that such a system may go through, briefly stated for any initial and final configurations and initial motion of the system by means of the negative scale or potential function of all the several component force-pairs supposed known; not merely, that is to say, a logical consequence of arbitrary and fanciful definitions, but a conclusion full of importance and of real natural signification depends, firstly, upon the fact that the thing defined as "impulse," or the gradient of the scale, which is here independent of the time and depends only on the mutual configuration, is not permanent by a very rare occurrence, but that it is often so, and under very various circumstances; and again that this impulse, or flux of momentum, or gradient of energy, occurs in many other motions with conditions of equal simplicity; and lastly, and above all, on the fact pointed out at the beginning of these reflections, that while we are able to use, and of our free will to call into existence force in innumerable ways, we learn from our experience that this impulse is invariably *caused or dictated by* a certain special efficacy or compulsion, which our power of exercising it as we please so as either to annul, to modify, or to increase it at will with the consequence of obtaining with it any effective impulses that we desire, shows us to be a different kind of quantity from the impulses that we either thus obtain, or that we see it producing in surrounding nature. Newton's second law of motion in fact recognises this specific difference between the magnitudes of a force and of its effect, when it asserts that forces *produce their whole effects* (that is to say, remain unaffected in their efficacies) whatever may be the state *of rest* or of motion of the bodies upon which they act. As it is found that forces or compulsions (measured as they are in statics by additions, subtractions, and oppositions to a standard force) are always proportional to the free impulse, or undisturbed acceleration of a mass-unit which they can produce, so that by taking the impulsive effect and the active compulsion of any one standard force as the units for measuring these quantities respectively, they are then said to be numerically equal to each other in every force; it yet follows from their specific independence that they are not identical in kind as they are in measure. The same is true of the products obtained by multiplying them separately by any small space through which a force acts; and it would be an obvious misstatement to assert that the sum of the works of a compulsion, and of the free impulse which it produces taken negatively, is constant when a force acts freely; because this would be confusing in one sum two different quantities; a result which it seems must arise from the simple fact that our part in mechanical "compulsions" distinguishes and removes them from the category of impulses to which they would otherwise belong, and leads us to regard them as *the causes of* the impulses which we observe. The language adopted by Newton (and used also by D'Alembert) in the proposition quoted at the beginning of this letter is that in a proper mechanical system, *compulsions equal to* the observed impulses reversed, will (as is obvious) arrest in their origin all changes of motion in the system, and will (with the immutable force conditions proper to the system) hold in balance, or give a complete account of all the forces (other than those immutable ones) acting upon it. Using the principle of virtual velocities in this case of equilibrium of balancing forces, Newton expresses the rule for exploring all the mechanical efficacies (superadded to the immutable ones) acting in the system by concluding that the sum of all the similar "works of *compulsion*," or of all the "actions" in a short time corresponding to a small motion of the system, when the reversed ones have been introduced, will be a constant quantity. Thus both Newton and D'Alembert agree in this, that they recognise in forces *causes which differ from* the effects which they produce. By what similar laws of work found to hold true in a proper conservative system the modern science of energy (which deals with the phenomena of causation in a wider and more diversified form) seeks to extend the method of cancelling the counteracting causes, or the principle of energy conservation here laid down by Newton for a mechanical one, to the far larger, but less thoroughly explored and exhausted field of all the onward flowing streams of physical agencies which we perceive following their natural bents or inclinations around us, I will presently endeavour to explain. It should be noticed in connection with this general extension of the principle, that the "work" of a force *in a short time*, however fixed its efficacy, or its rate of doing work *in a short space* (or of producing *momentum* in the short time) may be, is incidental, and not a fixed quality of the agent force like its faculty of tension, since a force as often diminishes as increases actual energy by a momentary action, and thus no fixed rule is drawn from the natural tendency of force to impart momentum, that potential energy necessarily becomes, or even necessarily tends to become, actual energy in every mechanical energy-transformation. The mechanical stress of friction is an example of the opposite tendency; and it also furnishes us with an example of a force whose *working power* only, and not its motive tendency, is a mechanical "*agent*" which we can summon up at will; but

[1] Continued from p. 303.

of which we still regard the motive tendency as similar to that of other mechanical forces, because it can maintain equilibrium with them.

If the natural office of force as a bond between space and matter is to ward off contact between material points, and to endow them with impenetrability (for this marked feature as far as it has been explored appears to be inherent in all matter) by absorbing at the proper places the energy of motion, and by curbing and accelerating it elsewhere according to these dictates, it must be implanted in material points in such permanent pairs as have just now been described; for the third law in Newton's master-summary is often held (with how much correctness, perhaps, may be questioned), to assert that all the forces of nature consist of an action and a reaction in equal and opposite pairs, and be omnipresent with a particle to protect it, its permanent impulse, or rate of doing work, being at the same time referrible to the space or distance between the mutually impinging, or colliding pair of atoms. A mechanical system so constituted, as we have seen, if not disturbed by the forces of foreign bodies outside of it will have the sum of its actual and potential energies constant. If we include those foreign bodies (endowing their forces at the same time with persistency), and if we find that the whole material universe as far as we can explore it admits of being comprehended in one system of this kind, a mechanical explanation of all known physical agencies might thus, apparently, be arrived at. In every particular of the motion of any group of bodies in it, however, except the single one of its total energy, we would be obliged to abandon (as Newton does) the local centres of reckoning of the several force pairs, and betake ourselves to the mass-centre of the group as our origin of reference for noting all the forces, and tracing all the motions of a body completely in its wanderings through the system. If this obligation, and the end to which it leads us of referring force at last to perfectly abstract realms of space and matter terrifies and affronts the scientific sense, it is sufficient consolation to observe that if force were not ultimately so referred, and if its impulse was exerted in those local spaces only in which we find it acting apparently as a simple action and reaction, there would be as many distinct kinds of energy of motion and of configuration (which we would still retain as expressing the local laws of force) as there are local spaces, with countless complex rules for mutual equivalence of these several energies connected with the common path of the body in several of them together, which would effectually defy even a modern physicist to disentangle and employ! We may rest thankfully contented with the laws that Newton has traced out. But does the simple mechanical system which we have just imagined really represent that of nature? Are nature's force pairs really all permanent? (We will suppose that they are all dual and reciprocal, for, as will presently be noticed, a special and peculiar explanation only can be given of forces which are absolutely external or solitary without any physical qualification); and is the sum of their mechanical energies a constant quantity, as we know that it becomes when all the other kinds of energy in material nature are added to it? The answer is very obvious, but it betrays at the same time a complete ignorance of the extent and depth of the question that we put. The readily-preferred response is "No; the sum of the mechanical energies, as far as they can be recounted, is not constant, for numberless forces, and mechanical energies proceeding from them are being constantly produced by heat, radiation, chemical action, and other physical agencies, or are being employed to renovate those agents with energy in equivalent stores, but whose special kinds *are not* mechanical." At the same time the progress of physical inquiry reveals to us in the operations of these agents microscopical, or rather hyper-microscopical, actions of force, and invisible charges of actual energy, with which our earlier knowledge of these agencies was entirely unacquainted, and a little step of inductive generalisation only is needed (I believe that this view was unfolded by Helmholtz many years ago, but I have not been able to rediscover his remarks and demonstrations[1]) to suppose that all physically-generated forces form but visible and changing resultant-links in an invisible chain of persistent forces, of which we hold some of the most prominent loops in our hands, and thoughtfully wonder what they are.

In his Glasgow lecture on "Force" (in NATURE, vol. xiv. p. 463), an important hint was offered by Prof. Tait regarding an apparent character of potential energy, founded on the mathematical condition that quantities whose units of measurement are of the same dimensions in space, mass, and time, are of the same kind. It follows from this that the potential energy of a force, or the energy received from and transferred to it is of the same kind as actual energy of material motion, because they are both measured by the same combination of the units of space, time, and mass.

Let us first observe that it cannot be *matter* in motion which constitutes the potential energy, unless this matter can traverse itself and other matter freely (because, itself the cause of force, it cannot itself experience any), and therefore that it is something not matter, but both resident in and proportional to matter, and also free; and that its energy of motion as an occupant of matter is actual, and in a state of freedom is potential energy. Imagine a perfect reflection of the material universe to be formed by a plane in space; then the changes of energy of motion of the reflected image of any mass particle taken negatively are equal and opposite to the similar changes of energy of the particle itself, and would measure in a kinetic form the amount of the work of force upon it; but the *tendency* of energy of this form and of the actual form to pass into each other would not be accounted for. In our present knowledge of its transformations it scarcely seems possible that a simpler picture of potential energy as a form of energy of motion than this downright imitation of the actually-existing motions could be reasonably offered. The proposition that force must be a process of transformation of *a new energy of motion*, so astonishingly complex, I confess staggered me, and even led me to doubt if the simple laws of force and motion laid down in the "Principia" could be really so perfect and complete as they appear, amid the pell-mell of motions which the thought suggests! I began this letter shortly before going to Plymouth, intending to recommend much more careful experiments than even Mr. Crookes has carried out with the radiometer, and with his recent, most effective form of the instrument, the otheoscope, in order to test and examine the question of the laws of force (especially with the idea of possibly isolating a single force) seriously; and though much induced to do so by the warm and timely words of commendation passed on Mr. Crookes' labours in his opening address to Section A at Plymouth (NATURE, vol. xvi. p. 314) by Prof. G. C. Foster, I have been unable from other occupations to finish it until now. But I have entirely abandoned my original intention, in great part, by reason of a new light on the exceedingly abstruse and puzzling question which the able remarks by "X" in NATURE (vol. xvi. pp. 438, 457) have afforded me about the real characters of force and of potential energy.

Newcastle-on-Tyne A. S. HERSCHEL

(*To be continued.*)

[1] They are, I find, contained in a paper of some length in vol. vi. of "Taylor's Scientific Memoirs," 1853, pp. 114—162.

Cumulative Temperatures

UNDER the above heading, among the "Meteorological Notes" in your issue of last week, I notice the announcement that "To simplify the difficulty of obtaining sums of temperature . . . M. von Sterneck has recently proposed to obtain these indirectly by observation of the sums of actions produced by the temperature." And that M. von Sterneck's proposal is to employ for this purpose a pendulum clock in which the variation of rate due to the raising or lowering of the centre of gravity of the pendulum under variations of temperature is, through its influence upon the daily error of time shown on the dial, employed for determining the mean temperature of the air throughout the twenty-four hours. And the notice concludes by saying that M. von Sterneck has also proposed to apply the same principle to determine the variations in atmospheric pressure and in the intensity of magnetism.

In reference to this subject it is only right to point out to the readers of NATURE (a term synonymous with the general body of lovers of science all over the world) that the merit of these suggestions is, by priority, due to one of our own countrymen, Mr. W. F. Stanley, who, at the *soirée* given by the President of the Royal Society as far back as April, 1876, exhibited two instruments in which the chronometrical method of determining thermometric and barometric averages was carried out with very marked success.

One of these to which the name chrono-thermometer was applied, consisted of a clock, the pendulum of which was a mercurial thermometer, its centre of gravity being raised or lowered by the expansion or contraction of a column of mercury under variations of temperature. In the other instrument, or chrono-barometer, the pendulum consisted of a glass tube containing a column of mercury, the rising and falling of which under influences of barometric pressure raised or lowered the centre of gravity of the pendulum and varied the rate of the clock accordingly. The clock-train in both instruments was so arranged that the dial-readings could, by an exceedingly simple calculation, be interpreted in terms of mean daily thermometrical or barometrical] variations. As the alteration in the lengths of the pendulums takes place second by second throughout the day, it follows that the daily error of time shown on the dial must be proportional to the mean of the variations of the thermometer or barometer during the same period.

The method of estimating, by observation of the rate of an uncompensated time-keeper, the mean amount of heat received during any given period, without the necessity of recording the actual temperature at any particular time, is not by any means new, for the chronometrical thermometer, an instrument which has for many years been employed at the Royal Observatory for testing the rates of chronometers under variations of temperature, is founded upon the same principle. This instrument consists of a chronometer in which the usual compensation for temperature is reversed; that is to say, in the balance the positions of the brass and the steel are interchanged, the latter being outside, so that variations of temperature produce an exaggerated effect upon the rate of the instrument.

M. von Sterneck is probably the first to suggest the employment of the chronometrical method to the determination of mean variations in the vertical intensity of terrestrial magnetism, but he has, I think, been anticipated in its application to the computing of thermometric and barometric averages.

Scientific Club, February 18 CONRAD W. COOKE

BACTERIA IN WATER

IT is well known that water—whether tap or ordinary distilled—possesses the property of contaminating, with a growth of bacteria, any "cultivation" liquid inoculated with it, but the morphological condition in which these organisms occur in it is open to question; it may be supposed on the one hand, that they exist as developed bacteria, and are not apparent under the microscope merely in consequence of their scarcity, as shown by Mr. Lister in the account of his recent admirable investigation of the lactic fermentation, to be the case with some specific ferments, or, on the other hand, that they are present as "germs" of the bacteria, bodies yet far more minute than the mature forms, and on that account invisible—ultra-microscopic. Which of these alternatives is true I have endeavoured to determine by experiment, the details of which will shortly be published, and the general result is here briefly communicated.

M. Pasteur has recently stated in the *Comptes Rendus*, that if a cylinder of water be allowed to stand for several weeks at a constant temperature, the organisms in it sink to the bottom, leaving the upper portion free, and incapable of contaminating. Following this method and placing a vessel of ordinary distilled water in an apparatus constructed for the purpose of maintaining an invariable temperature, after seven or eight days a specimen of the water was taken from the bottom of the vessel by a pipette closed with the finger and dipped into it. The water so taken was in appearance perfectly bright and pellucid, but under the microscope it was found to contain amorphous particles, some spores of filamentous fungi, micrococci in great numbers, bacteria of the common form (*B. Termo*) and bacilli (long and extremely slender filaments). All of these forms were motionless, or exhibited only Brownian movement. No such forms could be detected in the upper layers of the water, nor in a specimen taken from the bulk of that from which the experiments were made. As regards limpidity, there was no difference between the top and bottom portions.

I have made four experiments with specimens of water obtained from two different sources, and in all I have been able by this method of subsidence to prove the presence of organisms in great numbers in the sediment. It may be mentioned that they stain with facility by Hæmatoxylon, and are thereby rendered more readily apparent.

These observations show that bacteria occur in water under their usual forms, and that they are not generally distinguished on account of their small number, in any one portion of the water, when disseminated through its mass. The observed contaminating property of distilled water is thus accounted for without necessitating the assumption of "germs" of any sort, an hypothesis which is unsupported by observation.

The examination, by cultivation, of the difference in contaminating properties of the upper and lower layers, stated by M. Pasteur to exist, has as yet been inconclusive.

G. F. DOWDESWELL

OUR ASTRONOMICAL COLUMN

THE URANIAN SATELLITES, ARIEL AND UMBRIEL.—The following positions of the two interior satellites of Uranus for the ensuing fortnight are derived from the data furnished by Mr. Marth in the January number of the *Monthly Notices* of the Royal Astronomical Society, and are for 11h. G.M.T., or about the time of the planet's meridian transit. There must be many telescopes in this country which will command the two exterior satellites, Titania and Oberon, but, so far as we know, neither Ariel nor Umbriel have yet been certainly observed here with any but Mr. Lassell's reflectors. Prof. Newcomb states that Ariel is intrinsically brighter than Umbriel; he thinks that Ariel at least belongs to that class of satellites of which the brilliancy is variable, and dependent on its position in its orbit, and he adds that the evidence of variability of some kind seems indisputable, since he has repeatedly failed to see it with the Washington refractor when the circumstances—distance from the primary not excepted—were favourable, and when the next satellite, Umbriel, though less favourably situated, was visible. "On the other hand," he remarks, "there were two occasions, 1874, January 28, and 1875, March 25, when it was surprisingly conspicuous," and at these times the angle of position was about 350°. Prof. Newcomb further expresses the opinion that where any difficulty is experienced in seeing the outer satellites, he would not hesitate to pronounce it impossible to see the inner ones.

Nevertheless, the success which has attended the search for one, at least, of the satellites of Mars by English observers who are provided with large instruments, may perhaps induce them to look for the close satellites of Uranus at the present opposition.

	Ariel.				Umbriel.			
		°		″		°		″
Feb. 22	Pos.	179	Dist.	13·6	Pos.	29	Dist.	14·6
,, 23	,,	11	,,	15·1	,,	355	,,	17·4
,, 24	,,	207	,,	11·2	,,	214	,,	13·1
,, 25	,,	77	,,	5·2	,,	178	,,	18·6
,, 26	,,	340	,,	8·7	,,	40	,,	11·5
,, 27	,,	181	,,	14·2	,,	0	,,	19·5
,, 28	,,	13	,,	14·8	,,	228	,,	10·0
March 1	,,	211	,,	10·2	,,	183	,,	20·3
,, 2	,,	95	,,	4·9	,,	59	,,	8·6
,, 3	,,	344	,,	9·8	,,	5	,,	20·8
,, 4	,,	183	,,	14·6	,,	253	,,	7·5
,, 5	,,	15	,,	14·4	,,	187	,,	21·1
,, 6	,,	216	,,	9·2	,,	91	,,	6·9
,, 7	,,	112	,,	5·1	,,	9	,,	21·2

PIGOTT'S OBSERVATIONS OF VARIABLE STARS.—Some years since it was suggested, we believe, by Prof. Argelander, that the Royal Society might have in its possession manuscripts of Edward Pigott of York, amongst which might be found observations of variable stars that would prove of importance in the history of their fluctuations. It would appear, however, that none of Pigott's papers are preserved in the Society's *Archives*, an ineffectual search having been lately made for them.

THE TEMPLE OBSERVATORY, RUGBY.—Mr. G. M. Seabroke, as Curator of the Temple Observatory, has issued a Report upon proceedings during the year 1877. The whole of the measures of double-stars, 398 in number, during the last three years up to the time of dismantling the old Observatory, have appeared in vol. xliii. of the *Memoirs* of the Royal Astronomical Society. More recently investigations into the motions of stars in the line of sight by the spectroscopic method have occupied Mr. Seabroke's attention, but the chief work in the year has been the rebuilding of the Observatory. The Report contains an outline of its history and a description of the instruments to which reference may be made in future years. The equatorial of 8¼ inches aperture, by Alvan Clarke, was formerly in the possession of the Rev. W. R. Dawes, and an interesting letter from him upon its capabilities is appended to the Report. Not the least notable of its performances is its having shown the close satellite of Saturn, Mimas, on many occasions, and we know that its former possessor was not likely to have mistaken faint stars for the satellite.

The observatory is open to the members of the school at certain hours on fine evenings when opportunities for observing with the equatorial and transit are afforded them. It should be mentioned that in addition to the Alvan Clark refractor the observatory possesses a twelve-inch With-reflector which is chiefly used with the spectroscope.

The cost of the new observatory and house for the curator, upwards of 1,230*l.*, has been defrayed by subscriptions from the masters, old Rugbeians, and others in the school, upon the occasion of its tercentenary.

GEOGRAPHICAL NOTES

AFRICAN EXPLORATION.—The two African Societies of Berlin, which are now combined, have resolved to turn their attention to practical (*i.e.*, commercial) objects as well as scientific ones with regard to the great continent in which the travels of Cameron and Stanley have revealed vast stores of the most varied products. The twin societies therefore invite all German merchants, manufacturers, &c., to participate in their efforts to open up a great African commerce, and announce that the German Government is ready to grant a preliminary sum of 100,000 marks (5,000*l.*) to further the object in question. The Germans seem determined that no single nation, more especially England or Portugal, shall have the supremacy on the Congo. In Switzerland a new geographical society has been formed for the same object as the above.—An official telegram from Zanzibar to Brussels announces the death at Zanzibar of Dr. Maes and Capt. Crespel, who were sent out by the International African Association as leaders of an exploring colony in Central Africa. With them were M. Cambier and Ernest Marno, and they were to establish a station somewhere in the Tanganyika region, which would form a centre of further exploration. The death is also announced of Capt. Elton, who, with Mr. Cotterill, was surveying the route between the north end of Lake Nyassa and the east coast.

ARCTIC EXPLORATION.—The Committee on Naval Affairs of the U.S. Congress have adopted a report from Mr. Benjamin A. Willis recommending the equipment of an Arctic expedition as proposed by Capt. Howgate. At a public meeting held by the New York Geographical Society to discuss the subject of polar exploration a paper by Capt. Howgate was read on his intended colony. Lord Dufferin, governor-general of Canada, was elected an honorary member of the Society, and returned thanks in his usual style. He referred to himself as "a potentate whose sceptre touches the pole, and who reigns over a larger area of snow than any monarch of the earth."

THE PAMIR.—We learn from the *Turkestanskiya Vedomosi*, that two members of the Pamir expedition, MM. Skassi and Schwarz, have returned to Tashkend, M. Severtsoff remaining for some time at Osh. The expedition, which started in September last, has met with great difficulties from deep snow and the cold weather, the thermometer falling as low as 31° Celsius below zero. Owing to the absolute want of forests, wood was brought by yaks. No inhabitants were found in the Pamir, nor even in the valley of Alay, the Kirghiz having already left the valley for warmer regions. The rarity of air on those great heights, which exceed 15,000 feet, occasioned much suffering to the members of the expedition. The Valley of Alay was reached from that of Fergana, by way of the Shart Pass, and from the Alay the expedition followed the path which was followed by Gen. Skobeleff in 1876. M. Severtsoff reached as far as the Lok-sai River, which the natives said flows into the Lob-nor, under the name of the Tarim-gol. Thence he was compelled by the deep snow to return, without reaching the problematic meridional ridge which was the aim of the expedition. Prof. Schwarz has determined the latitudes and longitudes of six places, and has made numerous magnetical observations; a complete survey of the route was made by the topographers, the heights of a hundred points were determined, partly barometrically and partly geodetically. M. Severtsoff has brought in a large ornithological collection.

EDUCATIONAL TRAVEL.—We learn that a society is in course of formation at St. Petersburg for the organisation of travels for children and for young men. The travels of the children are intended for the general development of the intellectual faculties and of the power of observation, and those of the young men will be arranged so as to give them a practical knowledge of some branch of science, together with an acquaintance with their own country. The travellers will be divided into several groups—natural sciences, history, ethnography, &c., and each section will be placed under the leadership of some well-known specialist. The success of the botanical and geological excursions, which were organised during several summers by the members of St. Petersburg and Moscow Societies of Natural Sciences, lead us to expect that the new enterprise will be successful.

PRSHEVALSKY AND MACLAY.—The Russian Geographical Society has received telegrams from Col. Prshevalsky, dated Fort Alexandrovsky, announcing that the traveller is now recovering from an illness, and will continue his journey to Tibet; and from Dr. Mikluho-Maclay, announcing his return from New Guinea to Singapore.

SEA TRADE WITH SIBERIA.—We learn that several Bremen and Moscow merchants have formed a company for sea trade with Siberia. A large steamer, with two barges and a small river steamer on board, will start from Bremen in July next for the mouth of the Ob or of the Yenisei. Leaving the river steamer and the barges for river communication, the large steamer will return with Siberian wares.

GEOGRAPHICAL BIBLIOGRAPHY.—In the last part for 1877 of the *Zeitschrift* of the Berlin Geographical Society will be found a copious list, covering 100 pages, of the principal geographical works published between November, 1876, and November, 1877.

RUSSIAN GEOGRAPHICAL SOCIETY.—The Great Constantine gold medal of the Russian Royal Geographical Society was awarded this year to M. Zakharoff for his remarkable Manchurian dictionary, the result of many years' study of the language and life of the Manchurians, during his residence as Consul at Kuldja. The gold medal of Count Lütke was awarded to Capt. Rykacheff, of the Physical Observatory of St. Petersburg, for his researches into the distribution of atmospherical pressure throughout Russia. Small gold medals were awarded to M. Marx for ten years' meteorological observations at Yeniseisk, and to Col. Tillo for his levelling between the Aral and Caspian.

A NEW UNDERGROUND MONSTER

A RECENT communication from Fritz Müller, of Itajahy, in Southern Brazil, to the *Zoologische Garten* contains a wonderful account of the supposed existence of a gigantic earthworm in the highlands of the southern provinces of Brazil, where it is known as the "Minhocao." The stories told of this supposed animal, says Fritz Müller, sound for the most part so incredible, that one is tempted to consider them as fabulous. Who could repress a smile at hearing men speak of a worm some fifty yards in length, and five in breadth, covered with bones as with a coat of armour, uprooting mighty pine trees as if they were blades of grass, diverting the courses of streams into fresh channels, and turning dry land into a bottomless morass? And yet after carefully considering the different accounts given of the "Minhocao," one can hardly refuse to believe that some such animal does really exist, although not quite so large as the country folk would have us to believe.

About eight years ago a "Minhocao" appeared in the neighbourhood of Lages. Francisco de Amaral Varella, when about ten kilometres distant from that town, saw lying on the bank of the Rio das Caveiras a strange animal of gigantic size, nearly one metre in thickness, not very long, and with a snout like a pig, but whether it had legs or not he could not tell. He did not dare to seize it alone, and whilst calling his neighbours to his assistance, it vanished, not without leaving palpable marks behind it in the shape of a trench as it disappeared under the earth. A week later a similar trench, perhaps constructed by the same animal, was seen on the opposite side of Lages, about six kilometres distant from the former, and the traces were followed, which led ultimately under the roots of a large pine tree, and were lost in the marshy land. Herr F. Kelling, from whom this information was obtained, was at that time living as a merchant in Lages, and saw himself the trenches made by the "Minhocao." Herr E. Odebrecht, while surveying a line of road from Itajahy into the highlands of the province of Santa Caterina, several years ago, crossed a broad marshy plain traversed by an arm of the river Marombas. His progress here was much impeded by devious winding trenches which followed the course of the stream, and occasionally lost themselves in it. At the time Herr Odebrecht could not understand the origin of these peculiar trenches, but is now inclined to believe that they were the work of the "Minhocao."

About fourteen years ago, in the month of January, Antonio José Branco, having been absent with his whole family eight days from his house, which was situated on one of the tributaries of the Rio dos Cachorros, ten kilometres from Curitibanos, on returning home found the road undermined, heaps of earth being thrown up, and large trenches made. These trenches commenced at the source of a brook, and followed its windings; terminating ultimately in a morass after a course of from 700 to 1,000 metres. The breadth of the trenches was said to be about three metres. Since that period the brook has flowed in the trench made by the "Minhocao." The path of the animal lay generally beneath the surface of the earth under the bed of the stream; several pine trees had been rooted up by its passage. One of the trees from which the Minhocao in passing had torn off the bark and part of the wood, was said to be still standing and visible last year. Hundreds of people from Curitibanos and other places had come to see the devastation caused by the Minhocao, and supposed the animal to be still living in the marshy pool, the waters of which appeared at certain times to be suddenly and strangely troubled. Indeed on still nights a rumbling sound like distant thunder and a slight movement of the earth was sensible in the neighbouring dwellings. This story was told to Herr Müller by two eye-witnesses, José, son of old Branco, and a stepson, who formerly lived in the same house. Herr Müller remarks that the appearance of the Minhocao is always supposed to presage a period of rainy weather.

In the neighbourhood of the Rio dos Papagaios, in the province of Paranà, one evening in 1849 after a long course of rainy weather, a sound was heard in the house of a certain João de Deos, as if rain were again falling in a wood hard by, but on looking out, the heavens were seen to be bright with stars. On the following morning it was discovered that a large piece of land on the further side of a small hill had been entirely undermined, and was traversed by deep trenches which led towards a bare open plateau covered with stones, or what is called in this district a "legeado." At this spot large heaps of clay turned up out of the earth marked the onward course of the animal from the legeado into the bed of a stream running into the Papagaios. Three years after this place was visited by Senhor Lebino José dos Santos, a wealthy proprietor, now resident near Curitibanos. He saw the ground still upturned, the mounds of clay on the rocky plateau, and the remains of the moved earth in the rocky bed of the brook quite plainly, and came to the conclusion that it must have been the work of two animals, the size of which must have been from two to three metres in breadth.

In the same neighbourhood, according to Senhor Lebino, a Minhocao had been seen several times before. A black woman going to draw water from a pool near a house one morning, according to her usual practice, found the whole pool destroyed, and saw a short distance off an animal which she described as being as big as a house moving off along the ground. The people whom she summoned to see the monster were too late, and found only traces of the animal, which had apparently plunged over a neighbouring cliff into deep water. In the same district a young man saw a huge pine suddenly overturned, when there was no wind and no one to cut it. On hastening up to discover the cause, he found the surrounding earth in movement, and an enormous worm-like black animal in the middle of it, about twenty-five metres long, and with two horns on its head.

In the province of São Paulo, as Senhor Lebino also states, not far from Ypanema, is a spot that is still called Charquinho, that is, Little Marsh, as it formerly was, but some years ago a Minhocao made a trench through the marsh into the Ypanema River, and so converted it into the bed of a stream.

In the year 1849, Senhor Lebino was on a journey near Arapehy, in the State of Uruguay. There he was told that there was a dead Minhocao to be seen a few miles off, which had got wedged into a narrow cleft of a rock, and so perished. Its skin was said to be as thick as the bark of a pine-tree, and formed of hard scales like those of an armadillo.

From all these stories it would appear conclusive that in the high district where the Uruguay and the Paranà have their sources, excavations, and long trenches are met with, which are undoubtedly the work of some living animal. Generally, if not always, they appear after continued rainy weather, and seem to start from marshes or river-beds, and to enter them again. The accounts as to the size and appearance of the creature are very uncertain. It might be suspected to be a gigantic fish allied to *Lepidosiren* and *Ceratodus*; the "swine's snout," would show some resemblance to *Ceratodus*, while the horns on the body rather point to the front limbs of *Lepidosiren*, if these particulars can be at all depended upon. In any case, concludes Herr Müller, it would be worth while to make further investigations about the Minhocao, and, if possible, to capture it for a zoological garden!

To conclude this remarkable story, we may venture to suggest whether, if any such animal really exist, which, upon the testimony produced by Fritz Müller, appears very probable, it may not rather be a relic of the race of gigantic armadilloes which in past geological epochs were so abundant in Southern Brazil. The little *Chlamydophorus truncatus* is, we believe, mainly, if not entirely, subterranean in its habits. May there not still exist a larger representative of the same or nearly allied genus, or, if the suggestion be not too bold, even a last descendant of the Glyptodonts?

SUN-SPOTS AND DECLINATION RANGES

THE excellent article by Mr. Broun in a recent number of NATURE puts before us in a very clear manner the strong grounds that we have for believing in a true connection between sun-spots and terrestrial magnetism. If the argument were not already sufficiently powerful it might be yet further strengthened by bearing in mind that not merely do the most prominent inequalities march together in these two phenomena but the correspondence extends likewise to those waves of shorter period that ride as it were on the back of the longer ones. In a paper which is now before the Royal Society I have shown this intimacy of correspondence by comparing together the sun-spot and declination range records for the cycle extending from the minimum of 1855 to that of 1867. All the prominent sun-spot waves are reproduced by magnetic declination waves, the latter, however, invariably lagging behind the former.

Then with regard to the long period cycle under discussion I make it to begin for sun-spots with September 15, 1855, which was a minimum point, and to end with March 15, 1867, which was another minimum point. On the other hand the corresponding cycle for declination range begins with February 15, 1856, and ends with August 15, 1867. Thus the length of period is the same in both; the magnetic cycle lagging, however, five months behind that for sun-spots.

I may also mention that I am at present comparing together the Prague declination ranges with the sun-spot curve determined from Hofrath Schwabe's observations, and although the comparison is not finished, I believe that this lagging behind will form a prominent feature of the results. Further back than Schwabe we cannot go, as the sun-spot records are not sufficiently accurate for this kind of work.

I am not sure, however, that I quite agree with Mr. Broun when he says "no doubt the admission of the existence of a causal connection between the two phenomena is opposed to the hypothesis, which many other facts render wholly untenable, that the magnetic variations are due to the heating action of the sun."

As far as sun-spots and declination ranges are concerned, what are the facts regarding the connection between them? These are two in number. In the first place, all the considerable oscillations of the sun-spots are reproduced in the declination-ranges. Secondly, the reproductions in the declination-ranges lag, it appears, behind the corresponding sun-spot waves. This latter fact strikes me as being rather in favour of the view which regards declination-ranges to be (like temperature-ranges) in some way the result of an influence from the sun which is of the nature of an emanation or radiation. But I will not press the point except to remark that this and a host of other questions, some of them of great importance, must wait for their solution until we shall have obtained a sufficiently complete and continuous record of solar activity, and along with it an equally complete and continuous record of the radiant power of the sun.

From the observatories already established, we have a reasonable prospect of receiving good magnetical information, and there is abundance of meteorological activity, but it is nearly, if not absolutely, impossible, from the observations already made, to tell whether the sun be hotter or colder as a whole, when there are most spots on his surface. The sooner we get to know this the better for our problem.

BALFOUR STEWART

THE ISLANDS OF ST. PAUL AND AMSTERDAM

AS is now well known, a French expedition visited these islands towards the close of 1874 for the purpose of watching the transit of Venus across the sun on December 9 of that year. M. G. de l'Isle accompanied the expedition as botanist; Dr. Rochefort, with M. Vélain to assist him, were to look after the zoological and geological departments. M. Vélain, who was a pupil of Prof. Lacaze-Duthiers has just published, in the *Archives de Zoologie Expérimentale et Générale* (tome 6, 1877), a most interesting account of these islands and their fauna, with, in addition, a very detailed account of the collections of shells made. We are indebted to the extreme kindness of M. Vélain for the excellent illustrations which accompany this notice, which are taken from the original memoir.

FIG. 1.—Ninepin Rock.

If the reader wishes to fix the exact position of these curious islands he has only to trace along the line of lat. 40° S., and about mid-way in the Southern Ocean between the Cape of Good Hope and Melbourne, near long. 80° E., he will find them.

Their discovery has been claimed by the Dutch and the Portuguese. Placed just in the grand ocean route for all vessels leaving the Cape for Australia or China, they were doubtless, despite their isolation, long known. The history of our knowledge of them from 1522 to the present day is well, though briefly, written by M. Vélain.

The *Novara* called at St. Paul in 1857, and stayed for fourteen days, and we are indebted to Hochstetter for an excellent account of the geology of the island, though the weather was so bad at the time that the collections made were not numerous.

In June, 1871, the English frigate *Megæra* was wrecked on this island and most of the 400 souls that were aboard her had to reside on it for over three months.

On September 30, 1874, the members of the Transit of Venus expedition landed on St. Paul and spent thereon over three months.

Both the islands are essentially volcanic. In 1696 when van Vlaming visited St. Paul, the vast crater occupied its central part, and was above and quite isolated from the sea, and it seems to have been even thus in 1754, but at present the sea flows freely into it, and at the place of communication there is a depth of upwards of six feet. It attains a height of about 250 metres and its contour line is not much more than five nautical miles. A little to the north of the entrance to the crater where the sea has broken in there is a wonderful pinnacle of basaltic lava, which receives the name of the Ninepin rock (Fig. 1). The rocks composing it are trachitic, of a compact texture, but more or less zoned. These rocks, full of silex, and poured forth in great measure under the sea, exhibit still the traces of the energetic alterations which they underwent, not only at the moment of their emission, but also after their complete solidification, for they have been traversed since their formation in every way; not only numerous fissures forced up by the impetuous escape of gaseous emanations but by the force of geysers, which latter considerably increased the amount of silex on the rock, and this so much so that the walls of such fissures through the trachytic rock are formed of a very able solid enamel of silex which is rarely hollow, and all the alkalies have totally disappeared. A microscopical examination shows, amid a highly developed amorphous paste, crystals of felspath, and pyroxene, with notable quantities of silex, amorphous (opal) or crystalline (tridymite); but the lavas of different periods of eruption seem to differ in their compositions.

A wonderful core of basalt columns is to be seen at the little North Island (Fig. 2) which consists of little else than columns, though many of them are now thrown down. Some of the more compact of the lavas present a more or less picturesque outline, as can be seen at Hutchinson Point (Fig. 3), towards the south-east of the island. Their endurable and adhesive glissades could alone furnish such needle-shaped projections as would be capable of resisting the extreme and never-ceasing violence of the seas that beat on them. Along with the basaltic lavas, there will be found here and there on their upper surfaces little cones of scoriæ thrown up from little supplementary volcanoes; sometimes these will be found here and there quite isolated, at other times they will be found forming a ring as it were around the principal crater. They form a record of the fact that long after the great original outburst that formed this island there were numerous smaller eruptions, and that the source of volcanic power endured for a considerable time.

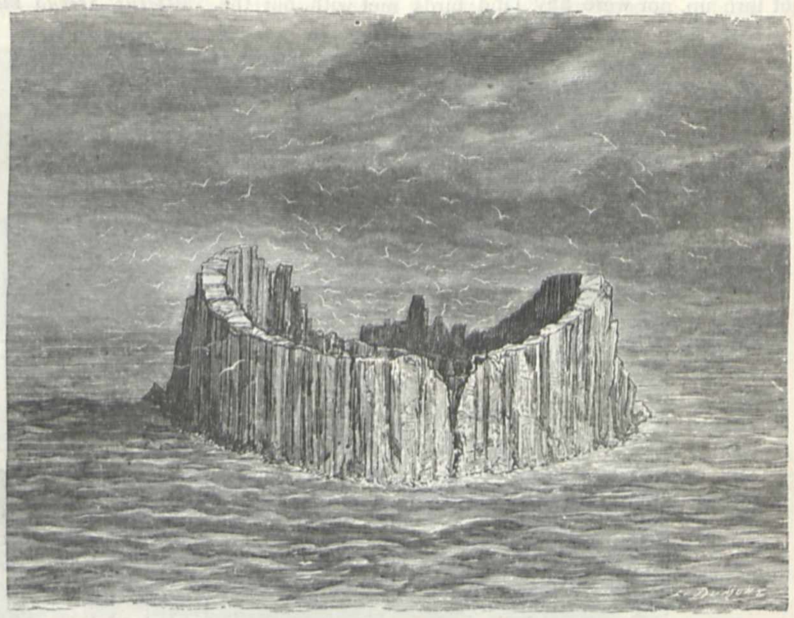

FIG 2.—North Island.

Although at the period of Lord Macartney's visit (1793), Dr. Gillian remarks that there were spots on the island too warm to walk on, yet there is not a trace of recent volcanic action to be now felt or seen, except in the interior of the crater. M. Vélain informs us that the botanical collections made will be fully described by Dr. de l'Isle (from fifty to fifty-five species, not counting algæ, were found), and that the rich and large collections of marine animals, including fish, Crustacea, Echinoderms, Ascidians, Hydro-

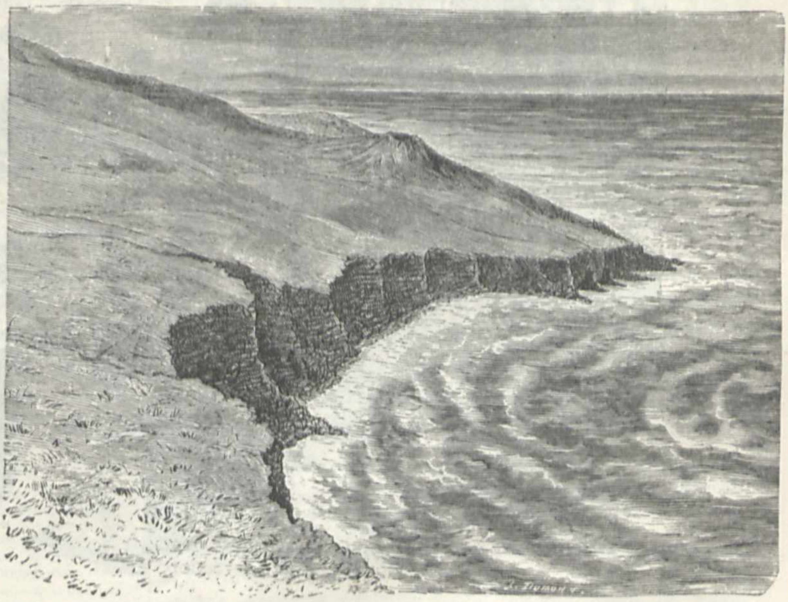

FIG. 3.—Lava Cliffs—Hutchinson Point.

zoa, and Alcyonaria, will be described under the superintendence of Prof. Lacaze Duthiers.

In this present memoir M. Vélain himself gives some most graphic descriptions of the birds that were met with. The little swift seen by Dr. Scherzer, of the *Novara*, did not turn up, nor were any land birds met with, but the aquatic birds abounded in immense numbers. Among these were the following :—*Diomedea exulans*, *D. fuliginosa*, *D. melanophrys*, *D. chlororhyncha*, *Ossifraga gigantea*, *Procellaria capensis*, *P. cinerea*, *P. hæsitata*, *Puffinus æquinoctialis*, *Stercorarius antarcticus*, *Prion vittatus*, *Sterna melanoptera*, and last, but by no means

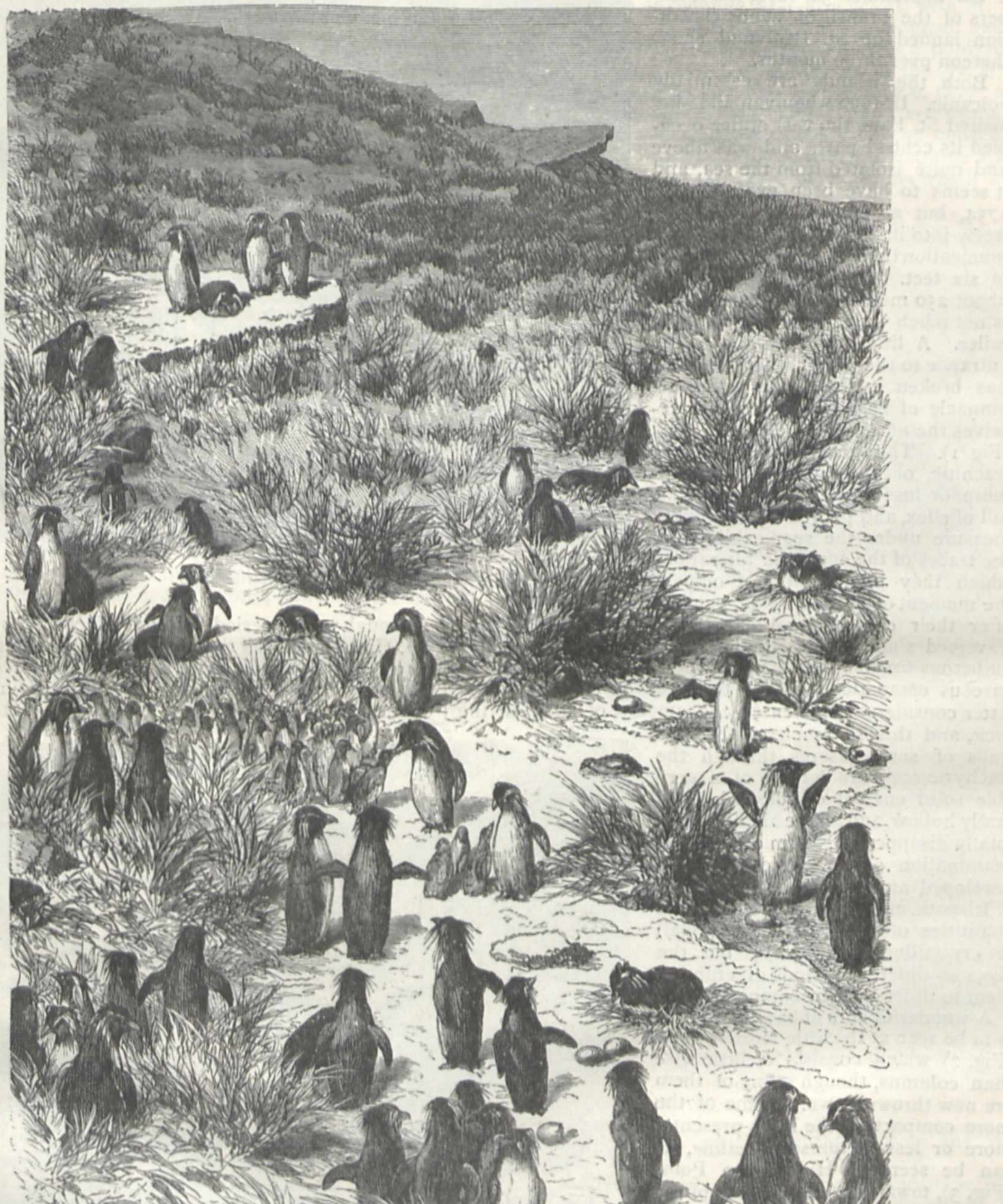

Fig. 4.—Penguins and Young.

the less important, *Eudyptes chrysolopha*. The history of these last birds, though often told, is ever strange, and seems always new. In the month of September these penguins began to lay ; there were two colonies of them, the larger of which contained millions of the birds ; the ground seemed alive with them. But it would be impossible, in a few words, to tell the reader all that M. Vélain has here written about their village life and their infant-schools ; about their wonderful powers of diving ; nor do we wonder that he looks back with no regret to the pleasant hours he spent in their midst, and we quite agree with him that such intelligent birds can't merit that nasty English word "stupid."

The accompanying illustration (Fig. 4) will give some slight notion of a nesting station of these interesting birds. At the time of the arrival of the expedition (October) the birds were preparing to hatch; each pair kept entirely to themselves; each nest had two eggs, large, nearly round, of a dirty white colour, but marked here and there with a few russet spots. Both birds partook of the cares attendant on the incubation, and took turn about on the nest. The bird off duty would at once make for the sea, faithfully returning at the appointed time, and never failing to waddle direct to its own nest, though no human being could see a difference between the thousands that were strewn about. Sometimes the whole camp of birds would have to be traversed ere the nest sought for would be gained, and a bird trying to make a short cut would be sure to be attacked by those whom it disturbed, for they are not at all tolerant of one another, and in this they also prove that they are not stupid, for surely neither stupid people nor stupid birds ever quarrel. On M. Vélain arriving in their midst, they would one and all set up an immense, and beyond measure stunning cry, but soon they would calm down, and seem not to mind his presence. The incubation lasted for five weeks. The little ones made their appearance covered all over with a fine close down, and looked like balls of fine grey-coloured wool. They soon got tired of the comforts of their nests, and began to assemble together with their little brothers and sisters of the same colony in large infant schools, which are presided over by some of the sedate old birds. Many times a day, at stated intervals, they are fed, the other portions they spend in sleeping and talking, and a little fighting. Space will not permit us to refer to many curious details about their swimming lessons.

M. Vélain's description of the molluscs of Saint Paul is an important contribution to science; the new species are well illustrated on four plates. As was to be expected, there are forty species of Gasteropods to but nine of Acephala, and there is but a single Brachiopod; no land-shells seem to have been found. The cuttle-fish taken are not enumerated, but one gigantic ten-armed species was often alluded to by the fishermen, and at last, as if to prove their assertions true, one morning, after a great storm, a specimen thereof was thrown ashore, and fortunately was at once photographed; unfortunately only its head, arms, and pen could be preserved. The generic name of Mouchezis (after the commander of the expedition) has been proposed for it. Probably it comes near to Steenstrup's Architeuthis, which it resembles in size, by its having circular-shaped suckers, which were ornamented by a row of fine horny denticulations and by their arrangement on the arms, but from which it differs by the singularly shortened form of the short arms, which presented quite the appearance of having been abruptly truncated instead of running out to a more or less tapering point as in most cephalopods; and then the inferior termination of the dorsal ossicle is quite unlike that described by Steenstrup in his genus. *Mouchesia Sancti-Pauli* measured from the tip of its longest arms to the end of the body, upwards of twenty-two feet. A species of Ommastrephes swarmed in the adjacent sea and seemed to be the chief food of the penguins.

E. PERCEVAL WRIGHT

NOTES

SYSTEMATIC botany has lost one of its greatest living names in the death of Elias Magnus Fries, Emeritus Professor of Botany in the University of Upsala. He was born August 15, 1794, and died on February 8 inst. His very numerous works, especially on fungi and lichens, give him a position as regards those groups of plants only comparable to that of Linnæus. His services to science were recognised by the Royal Society in his election as a foreign member in 1875.

THE funeral service of M. Claude Bernard took place at Paris, at the public expense, on Saturday, February 16, at St. Sulpice, in presence of an immense assembly. The interment took place at Père-la-Chaise. The chief mourners were MM. Bardoux, the Minister of Public Instruction, Dumas and Bertrand, Perpetual Secretaries of the Academy of Sciences, Fizeau, President, Mezières, Chancellor of the Academy of Sciences, M. Paul Bert, who is filling the chair of Claude Bernard at the Jardin des Plantes, and Laboulaye. These gentlemen delivered addresses at the grave, which will be published in the *Comptes Rendus* and official papers.

FROM the last report of Dr. Dohrn, the director, we notice that the zoological station at Naples has developed a most remarkable degree of activity, and is becoming a valuable centre of biological research. By the generosity of the Prussian Government it has been provided with a small steamer, and the uninterrupted expeditions in this vessel have secured to the laboratories an enormous and most varied stock of material for research. Dr. Dohrn has carefully organised a plan for the systematic examination of the entire fauna of this part of the sea, to be accompanied by exhaustive description. The literary portion of the work will consist of elaborate monographs on all the families and species represented in the Gulf of Naples. They will not be prepared by the members of the station only, but it is hoped to procure the assistance of all familiar with this special department, and the contributions can be in English, French, German, or Italian. Two monographs on the Elenophoræ and Balanoglossi will appear during the present year, and arrangements have been made for the speedy preparation of eleven others. These will all be based, in regard to nomenclature and classification, on a work shortly to appear under the title, "Prodromus Faunæ] Mediterraneæ," which will contain a complete abstract of the literature on this subject up to the present time. The details of anatomical and embryological investigation will form the leading feature of the whole work.

THE Radicals in the French Chamber cannot be accused of opposition to the claims of science. We notice that in a late session a member of the extreme left proposed an amendment to the budget of instruction, which provided for the appropriation of 30,000 francs for an expedition to California to observe the next transit of Mercury, 40,000 for the continuation of the explorations in Northern Africa, where it has been proposed to admit water from the Mediterranean, and 100,000 to enable the Abbé Debès to make a journey across Africa from Zanzibar to the Congo. As the appropriation was granted, we may hope soon to see the latter portion of it cause the appearance of a new rival of Stanley, for the Abbé has had, like Livingstone, invaluable experiences as a missionary, which will enable him to enter upon the undertaking with great promises of success.

THE Astronomical Section of the French Academy has been summoned by the Minister of Instruction to nominate two candidates for the vacant position of the late M. Leverrier.

IN Parisian scientific circles Prof. Charles Friedel is mentioned as the probable successor to the place in the Chemical Section of the Academy rendered vacant by the death of Victor Regnault.

A NEW Archæological Institution at St. Petersburg was opened on January 27 last. The director and founder of the Institution, M. N. W. Katcholoff, delivered the inaugural address, in which he pointed out the importance of the archæological investigation of the great Russian empire, and the great support the Institution will offer to students of Russian archæology. He also announced that the Russian Government had permitted the publication of a special organ of the Institution the first part of which would shortly appear, and would contain valuable details dating from the time of Alexander I.

A NEW Society of Ethnography, Archæology, and History is to be founded at the University of Kazan.

THE Annual Archæological Congress of France will take place this year at Mans and Laval, beginning at the former place on May 20 and closing at the latter on May 28.

AN interesting course of lectures has been inaugurated in connection with the new museum of ethnography at Paris, which is well adapted to heighten the value of these extensive collections. Nearly every afternoon is appropriated to a discourse by some well-known *savan* on topics illustrated in the museum. Among the subjects for the remainder of the month we notice "The Industrial Products of Central Asia," by M. de Ujfalvy; "The Ancient Mexicans," by Dr. Hamy; "The Lambaquis of Brazil," by M. Wiener; "Feathers, and their Employment among Savage Tribes," by M. Milne-Edwards; "Peruvian Ceramic," by M. Wiener; "Exploration of the Sahara," by Commander Roudaire; "The Useful Plants of Equatorial America," by M. André, &c. Like most of the lectures in Paris, these are free to the public.

THE works for establishing the monster captive balloon at the Tuileries have begun in the court of the old palace. The Municipal Council of Paris voted the demolition of the ruins at its last sitting. It is proposed by the Corporation that the demolition be completed for the opening of the Paris Exhibition.

NEWS from Berlin states that Signor Martinelli has started from Athens for Olympia in order to take the casts of the sculptures recently excavated, particularly of the Apollo of the western front of the building and of the Hermes of Praxiteles. The exhibition of the Olympian casts at Berlin will be deferred until Signor Martinelli has finished his work. All the other casts are now complete at the Campo Santo, near the Berlin Dome. The second volume of the "Ausgrabungen von Olympia," with thirty-five photographic plates, is in course of publication.

SIR JOHN LUBBOCK'S Ancient Monuments' Bill passed the second reading on Tuesday. We hope that it will this session pass successfully through the final stage.

MR. W. ACKROYD writes to us with reference to the mechanism of the ear and the bearing it may have on the structure and use of the telephone. In man the drum is inclined to the axis of the external ear passage at about an angle of 46°, and may be less or more in other animals. Mr. Ackroyd thinks that here we are taught that the best disposition of a membrane designed to receive aërial impulses is that of a less or greater angle to the resonating cavity in which it is placed, the value of this angle probably depending upon the depth and form, &c., of such cavity, points only to be ascertained by experiment. In communicating these ideas the other day to Mr. Wilson, of the Physical Laboratory, South Kensington, he stated that Mr. Newth, of the Chemical Laboratory, had found that his telephone worked best when he spoke into it in a slanting direction. Mr. Ackroyd thinks that telephonists will receive many valuable ideas from the study of the comparative morphology of the external auditory apparatus as Bell did by studying the action of the human tympanic membrane.

WE learn from the Annual Report of the Russian Hydrographical Department, just appeared, that during the year 1876 the officers of the department took soundings in the Baltic Sea and along the Finnish shores for 1,100 miles, in the Gulf of Bothnia for 2,130 miles, in Lake Onega for 870 miles, and in the Black Sea for 2,170 miles.

THE Central Physical Observatory at St. Petersburg has issued its report for 1876, containing meteorological observations made during that year at ninety-eight stations, according to the international regulations. An appendix gives the results of the hourly observations made at Moscow during the last fourteen years.

WE are glad to announce the opening at St. Petersburg of a new hygienic society. It is divided into five sections: Biology; Statistics and Epidemiology; Hygiene of towns, manufactures, and public buildings; Hygiene of schools; and Hygiene of food. Prof. Zdekauer is president of the Society, and among the members are some of the most prominent names in the St. Petersburg University and Academy of Sciences.

SINCE January 5 a new *Allgemeine Technikerzeitung* has been appearing at Leipzig (Schäfer) every week. It is a well-written serial and contains frequent reports of the latest progress of the natural sciences from a practical point of view.

THE German Emperor has presented a most valuable collection of arms and weapons to the Ethnographical Department of the Royal Museum of Berlin. The collection was made by Herr Erdmann, the German Consul at Samarang (Java), and consists of weapons from Java, Sumatra, Borneo, Celebes, Flores, Amboina, and other islands of the great Archipelago.

EARTHQUAKES are reported from the Lower Danube on January 31 at 4.30 A.M. It is also announced that the cities of Lima and Guayaquil, in South America, have suffered terribly from recent shocks.

FOR the first time since 1840 Lisbon has been visited by snow. Besides 1840 the years 1837 and 1839 were characterised by this phenomenon.

IN studying the vibrations of solid bodies, M. Dubois has recently got some interesting effects by use of water mixed with vermilion. If this be put on the branches of a tuning-fork which is vibrated, striæ are produced, the vermilion settling in the grooves of the liquid, and giving a figure. Operating first with tuning-forks, then with sounding-tubes and vibrating-plates, M. Dubois arrived at these two laws:—1. Two sounds produced by different instruments give the same separation of striæ, if these sounds are of the same pitch. 2. Two sounds of different pitch give striæ inversely proportional to the numbers of vibrations of the sounds. In the case of the pipes (which were open), a small band of paper carrying the liquid charged with vermilion was fixed with wax at the open part. The vibration of the air immediately produced striæ. The blast being adapted to give a grave fundamental sound, a certain set of equidistant divisions was produced; then on blowing to sound the octave, these divisions remained, but a second set of intermediate lines appeared.

AT p. 113, vol. xvi. of NATURE we drew attention to the gratuitous distribution of a little pamphlet entitled "Notes for Observations of Injurious Insects." This was issued under the auspices of a few well-known entomologists with a view of obtaining any information, however varied, on the habits of the insects and the conditions of the crops most conducive to their increase. It will be remembered that the late Mr. Andrew Murray took a lively interest in the question of the destruction of the crops by insect pests, and read a paper on the subject before the Society of Arts, so that the returns which have been received in answer to the above-mentioned pamphlet and which are now embodied in the form of a report will be specially interesting to entomologists and valuable to cultivators. It is satisfactory to find that some well-known pests were not so abundant in some districts last year as they were in the preceding year; thus we are told that near Isleworth but little injury was noticed amongst the onions from the fly, *Anthomyia ceparum*, though in 1876 it was very destructive, which indeed was the case generally in the western suburbs of London, and perhaps also in other parts. Two remedies are recommended for warding off the insects; one by scattering amongst the plants some pulverised gas-lime, and the other by watering with the liquid from pigsties. The clouded yellow butterfly (*Colias edusa*) was, it seems, "the great appearance of the year," and was first seen near Dumfries early in June, and across the south of England it was generally observable from June till October. The frequent death of the larvæ when feeding on various clovers and trefoils is mentioned as a point of interest relatively to its permanent settlement, as also the great difference in the quantity of the sexes noticed at various stations which may be followed by coincident variety of appearance next year. The report is published by Mr. T. P. Newman, Botolph Lane, Eastcheap, from whom we believe copies may be obtained. Every information on the subject will also be supplied on application to the Rev. T. A. Preston, The Green, Marlborough, Wilts, E. A. Fitch, Esq., Maldon, Essex, or Miss E. A. Ormerod, Dunster Lodge, Spring Grove, Isleworth.

THE St. Petersburg University has addressed a note to the Ministry of Public Instruction requesting that the necessary steps be taken for the preservation of any valuable manuscripts which may be found in the Turkish towns occupied by Russian troops. Valuable manuscripts were preserved in this way from destruction in the War of 1829, and important manuscripts have already been discovered in the mosques of Tirnova.

A SMALL Japanese "blue" book comes to us in the shape of a report by the department of Public Hygiene on some of the mineral waters of the country and the uses to which they may be put. Japan seems to contain a great variety of such waters.

AT the meeting of the Musical Association on February 4 a paper was read by Mr. D. J. Blaikley, "respecting a Point in the Theory of Brass Instruments." The necessary difference in form between such instruments and conical tubes was pointed out, and a new experimental method for determining the positions of the nodal points in tubes, especially applicable to such as are of varying section, was shown. As an instance may be given a conical tube open at both ends and of the pitch C 512 vib. The node is nearer the small than the large end of the tube, and by sinking one end in water and holding a fork of the pitch of the tube over the other, the exact position of the node is shown by the level of the water when the tube is giving its maximum resonance.

THE additions to the Zoological Society's Gardens during the past week include two Macaque Monkeys (*Macacus cynomolgus*) from India, presented by Lieut-Col. Fielden; a Grivet Monkey (*Cercopithecus griseo-viridis*) from North-east Africa, presented by Mr. E. H. Lockley; a Garden's Night Heron (*Nycticorax gardeni*) from South America, presented by Mr. Henry Bottrell; three Chimpanzees (*Troglodytes niger*) from West Africa, deposited; a Black-faced Spider Monkey (*Ateles ater*) from East Peru, a Collared Peccary (*Dicotyles tajaçu*) from South America, a Globose Curassow (*Crax globicera*) from Central America, a Black-footed Penguin (*Spheniscus demersus*) from West Africa, a Hey's Partridge (*Caccabis heyi*) from Arabia, purchased.

ON COMPASS ADJUSTMENT IN IRON SHIPS[1]

I.—*New Form of Marine Azimuth and Steering Compass with Adjuncts for the complete Application of the Astronomer-Royal's Principles of Correction for Iron Ships.*

THIRTY-EIGHT years ago the Astronomer-Royal showed how the errors of the compass, depending on the influence experienced from the iron of the ship, may be perfectly corrected by magnets and soft iron placed in the neighbourhood of the binnacle. Partial applications of his method came into immediate use in merchant steamers, and within the last ten years have become universal not only in the merchant service, but in the navies of this and other countries. The compass and the binnacles before you are designed to thoroughly carry out in practical navigation the Astronomer-Royal's principles. The general drawback to the complete and accurate realisation of plans for carrying out these principles heretofore, has been the great size of the needles in the ordinary compass which renders one important part of the correction, the correction of the quadrantal error for all latitudes by masses of soft iron placed on the two sides of the binnacle, practically unattainable; and which limits, and sometimes partially vitiates, the other chief part of the correction, or that which is performed by means of magnets placed in the neighbourhood of the compass. Five years ago my attention was forced to this subject through my having been called upon by the Royal Society to write a biographical sketch of the late Archibald Smith, with an account of his scientific work on the mariner's compass and ships' magnetism, and I therefore commenced to make trial compasses with much smaller needles than any previously in use; but it was only after three years of very varied trials, in the laboratory and workshop, and at sea, that I succeeded in producing a mariner's compass with the qualities necessary for thoroughly satisfactory working in all weathers and all seas, and in every class of ship, and yet with small enough needles for the perfect application of the Astronomer-Royal's method of correction for iron ships. One result at which I arrived, partly by lengthened trials at sea in my own yacht, and partly by dynamical theory analogous to that of Froude with reference to the rolling of ships, was that steadiness of the compass at sea was to be obtained not by heaviness of needles or of compass-card, or of added weights, but by longness of vibrational period[1] of the compass, however this longness is obtained. Thus, if the addition of weight to the compass-card improves it in respect to steadiness at sea, it is not because of the additional friction on the bearing-point that this improvement is obtained; on the contrary, dulness of the bearing-point, or too much weight upon it, renders the compass less steady at sea, and, at the same time, less decided in showing changes of the ship's head, than it would be were the point perfectly fine and frictionless, supposing for the moment this to be possible. It is by increasing the vibrational period that the addition of weight gives steadiness to the compass; while, on the other hand, the increase of friction on the bearing-point is both injurious in respect to steadiness, and detrimental in blunting it or breaking it down, and boring into the cap, and so producing sluggishness, after a short time of use, at sea. If weight were to be added to produce steadiness, the place to add it would be at the very circumference of the card. My conclusion was that no weight is in any case to be added, beyond that which is necessary for supporting the card; and that, with small enough needles to admit of the complete application of the Astronomer-Royal's principles of correction, the length of period required for steadiness at sea is to be obtained, without sacrificing freedom from frictional error, by giving a large diameter to the compass-card, and by throwing to its outer edge as nearly as possible the whole mass of rigid material which it must have to support it.

In the compass before you (Fig. 1), these qualities are given by supporting the outer edge of a card on a thin rim of aluminium, and its inner parts on thirty-two silk threads or fine copper wires stretched from the rim to a small central boss of aluminium, thirty-two spokes, as it were, of the wheel. The card itself is of thin strong paper, and all the central parts of it are cut away, leaving only enough of it to show conveniently the points and degree-divisions of the compass. The central boss consists of a thin disc of aluminium, with a hole in its centre, which rests on the projecting lip of a small aluminium inverted cup mounted with a sapphire cap, which rests on a fixed iridium point (Figs. 2 and 3).

Eight small needles from 3¼ inches to 2 inches long, made of thin steel wire, and weighing in all fifty-four grains, are fixed like the steps of a rope ladder on two parallel silk threads, and slung from the aluminium rim by four silk threads or fine copper wires through eyes in the four ends of the outer pair of needles.

The weight of the central boss, aluminium cup, and sapphire

[1] Report of paper read to the Royal United Service Institution, February 4, by Sir Wm. Thomson, LL.D., F.R.S., P.R.S.E., Professor of Natural Philosophy in the University of Glasgow, and Fellow of St. Peter's College, Cambridge. Revised by the Author. [The Council of the U.S.I. have kindly permitted us to publish Sir W. Thomson's paper in advance, and have granted us the use of the illustrations.—ED.]

[1] The vibrational period, or the period (as it may be called for brevity) of a compass, is the time it takes to perform a complete vibration, to and fro, when deflected horizontally through any angle not exceeding 30° or 40°, and left to itself to vibrate freely.

cap, amounts in all to about five grains. It need not be more for a 24-inch than for a 10-inch compass. For the 10-inch compass the whole weight on the iridium point, including rim, card, silk threads, central boss, and needles, is about 180 grains. The limit to the diameter of the card depends upon the quantity of soft iron that can be introduced without inconvenient cumbrousness on the two sides of the binnacle to correct the quadrantal error. If, as sometimes may be advisable in the case of a pole or masthead compass, it be determined to leave the quadrantal error uncorrected, the diameter of the compass-card may be anything from 12 to 24 inches, according to circumstances. A 24-inch card on the new plan will undoubtedly have less frictional error or "sluggishness" for the same degree of steadiness than any smaller size; but a 12-inch card works well even in very unfavourable circumstances, and it will rarely, if ever, be necessary to choose a larger size unless for convenience to the steersman for seeing the divisions, whether points or degrees. You see hanging over the table, from the roof, one of my 12-inch pole-compasses. Specimens of 15-inch and 24-inch pole-compasses have also been made. The last-mentioned may be looked at with some curiosity, as being probably the largest compass in the world. It will no doubt be properly condemned as too cumbrous for use at sea, even in the largest ship, but there can be no doubt it would work well in a position in which a smaller compass would be caused to oscillate very wildly by the motion of the ship. The period of the new 10-inch compass is in this part of the world about forty seconds, which is more than double the period of the A card of the Admiralty standard compass, and is considerably longer than that of the ordinary 10-inch compass, so much in use in merchant steamers. The new compass ought, therefore, according to theory, to be considerably steadier in a heavy sea than either the Admiralty compass or the ordinary 10-inch compass, and actual experience at sea has thoroughly fulfilled this promise. It has also proved very satisfactory in respect to frictional error; so much so that variations of a steamer's course of less than half a degree are shown instantly and surely, even if the engine be stopped, and the water perfectly smooth.

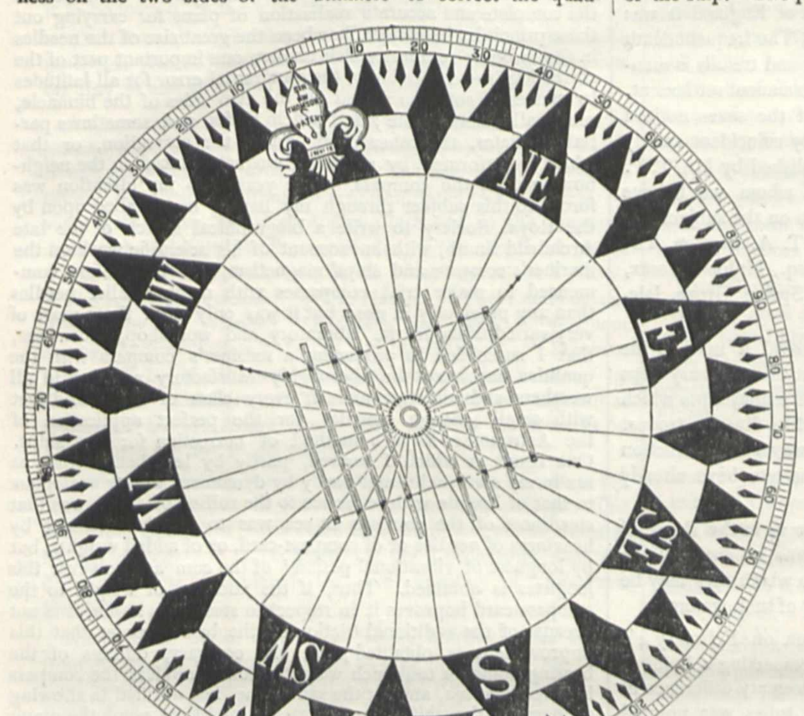

Fig. 1.

With the small needles of the new compass, the complete practical application of the Astronomer-Royal's principles of correction is easy and sure: that is to say, correctors can be applied so that the compass shall point correctly on all points, and these correctors can be easily and surely adjusted at sea, from time to time, so as to correct the smallest discoverable error growing up, whether through change of the ship's magnetism, or of the magnetism induced by the earth, according to the changing position of the ship. To correct the quadrantal error I use a pair of solid or hollow iron globes placed on proper supports, attached to the binnacle on two sides of the compass. This mode is preferable to the usual chain boxes, because a continuous globe or spherical shell of iron is more regular in its effect than a heap of chain, and because a considerably less bulk of the continuous iron suffices to correct the same error. When in a first adjustment in a new ship, or in a new position of a compass in an old ship, the quadrantal error has been found from observation, by the ordinary practical methods, it is to be corrected by placing a pair of globes in proper positions according to the following table:—

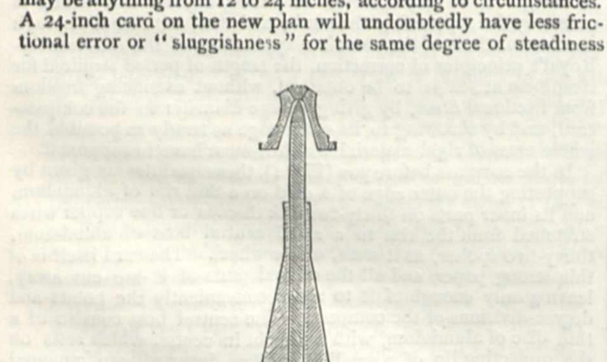

Fig. 2.

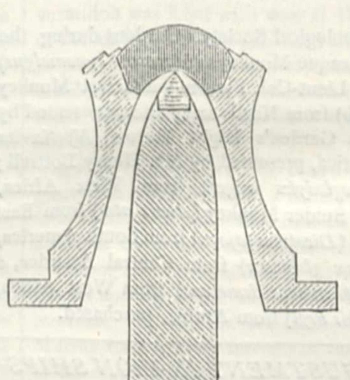

Fig. 3.

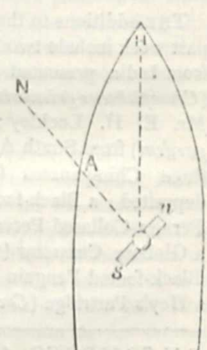

Fig. 4.

Table for Correction of Quadrantal Error.

Error to be Corrected.	Distances of the Nearest Points of Globes from Centre of Compass.									
	9-inch globes.	8½-inch globes.	8-inch globes.	7½-inch globes.	7-inch globes.	6½-inch globes.	6-inch globes.	5½-inch globes.	5-inch globes.	4½-inch globes.
°	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1	20·52	19·38	18·24	17·10	15·96	14·82	13·68	12·54	11·40	10·26
1½	17·36	16·39	15·42	14·46	13·50	12·54	11·57	10·61	9·65	8·68
2	15·36	14·51	13 66	12·81	11 95	11·10	10·24	9·39	8·53	7·68
2½	13·94	13·16	12·39	11·61	10·84	10·07	9·29	8·52	7·74	6·97
3	12·84	12·13	11·42	10·70	9·99	9·28	8·57	7·85	7·14	5·42
3½	11·98	11·32	10·65	9·99	9 32	8·65	7·99	7·32	6·66	5·99
4	11·26	10·63	10·01	9·39	8·76	8·13	7·51	6·88	6·26	5 63
4½	10·66	10·07	9·47	8·88	8·29	7·70	7·10	6·51	5·92	5·33
5	10·13	9·57	9·01	8·45	7·88	7·32	6·75	6·19	5·63	5·07
5½	9·67	9·13	8·59	8·06	7·52	6·99	6·45	5·91	5·38	4·84
6	9·27	8·75	8·24	7·72	7·21	6·70	6·18	5·66	5·15	4·53
6½	8·91	8·41	7·92	7·42	6·93	6·44	5·94	5·44	4·95	4·46
7	8·58	8·10	7·63	7·15	6 67	6·20	5·72	5·24	4·77	4·29
7½	8·28	7·82	7·36	6·90	6·44	5·98	5·52	5·06	4·60	4·14
8	8·01	7·57	7·12	6·68	6·23	5·79	5·34	4·90	4·45	4·01
8½	7·76	7·33	6·90	6·47	6·04	5·60	5·17	4·74	4·31	3 88
9	7·53	7·11	6·69	6·27	5·86	5·44	5·02	4·60	4·18	3·76
9½	7·32	6·91	6·50	6·09	5·69	5·28	4·87	4·47	4·06	3·66
10	7·11	6·72	6·32	5·93	5·53	5·14	4·74	4·35	3 95	3·55
10½	6·93	6·54	6·16	5·77	5·39	5·00	4·62	4·23	3·85	3·46
11	6·75	6·37	6·00	5·62	5·25	4·87	4·50	4·12	3·75	3·37
11½	6·58	6·22	5·85	5·49	5·12	4·76	4·39	4·02	3·66	3·29
12	6·43	6·07	5·71	5·36	5·00	4·64	4·29	3·93	3·57	3·22

When the quadrantal error has been thus once accurately corrected, the correction is perfect to whatever part of the world the ship may go, and requires no adjustment at any subsequent time, except in the case of some change in the ship's iron, or of iron cargo or ballast sufficiently near the compass to introduce a sensible change in the quadrantal error. The vast simplification of the deviations of the compass effected by a perfect correction of this part of the whole error has not, as yet, been practically appreciated, because, in point of fact, this correction had rarely, if ever, in practice, been successfully made for all latitudes. The pair of large needles of the compass ordinarily used in merchant ships does not, as has been shown by Capt. Evans and Archibald Smith, admit of the correction of the quadrantal error in the usual manner, without the introduction of a still more pernicious error, depending on the nearness of the ends of the needles to the masses of chain, or of soft iron of whatever kind, applied on the two sides of the compass to produce the correction. The Admiralty standard compass, with its four needles proportioned and placed according to Archibald Smith's rule, is comparatively free from this fault: but even with it, and still more with the stronger magnets of the larger compasses of merchant ships, there is another serious cause of failure depending on the magnetism induced in the iron correctors by the compass needles, in consequence of which, if the quadrantal error is accurately corrected in one latitude, it will be found over-corrected in high magnetic latitudes, and under-corrected in the neighbourhood of the magnetic equator. The new compass was specially designed to avoid both these causes of failure in the correction of the quadrantal error; and experiment has shown that with it the correction by such moderate masses of iron as those indicated in the preceding table, is practically perfect not only in the place of adjustment, but in all latitudes.

When once the quadrantal error has been accurately corrected, the complete application of the Astronomer-Royal's principles becomes easy and sure, if the binnacle is provided with proper appliances for readjusting the magnetic correctors from time to time, whether at sea or in port. But the system of nailing magnets to the deck, in almost universal use in the merchant service, is not satisfactory, and is often even dangerous. It always renders needlessly tedious and cumbrous the process of readjustment by the adjuster in port, and it leaves the captain of the ship practically no other method of readjustment at sea than removing the magnets altogether, or taking them out of their cases and replacing them in inverted positions. The Astronomer-Royal himself pointed out that his correcting magnets should be mounted in such a manner that their distances from the compass can be gradually changed, so as always to balance the ship's magnetic force as it alters, whether by gradual loss of her original magnetism through lapse of time, or by the inductive influence of the earth's vertical magnetic force coming to zero, and then becoming reversed in direction when a ship makes a voyage from the northern to the southern hemisphere. The not carrying out of this essential part of his plan, whether through no method or no sufficiently convenient method of adjustment having been hitherto provided, has undoubtedly taken away much of the credit among many practical men to which the Astronomer-Royal's method is justly entitled. I have, therefore, introduced into the binnacles provided for my compass, when it is to be used in iron ships, a complete system of adjustable correctors for perfectly correcting the error of the compass for every position of the ship's head when she is on even keel, and a vertical adjustable magnet below the compass, for correcting the heeling error (more properly speaking, a magnet, which is vertical when the ship is on even keel, and which shares the inclination of the ship when she heels over to either side).

An objection which has often been made to the use of correctors at all, and particularly to the use of correctors for a standard compass, is that they conceal the actual state of the ship's magnetism, and that readjustment of the correctors at sea leaves the navigator without means of judging, when he returns from a foreign voyage, how much of the changed error found on readjustment in port depends on changes which have been made in the correcting magnets, and how much on changes of the ship's own magnetism. This objection I meet by providing that at any moment my correctors can be removed or set to any degrees of power to which they may have been set at any time in the course of the voyage, and again reset to their last position with perfect accuracy. The appliances for changing the adjustment are under lock and key, so that they can never be altered, except by the captain or some properly authorised officer. Farther, to facilitate the use of the correctors, I graduate the scales accurately to correspond to definite variations of the force which they produce on the compass. Thus, as soon as the error has been determined by the known method of observation at sea, the corrector may at once be altered to the proper degree to correct it. Of course the officer performing the adjustment will satisfy himself of its correctness by a second observation. The objection of "delicacy of manipulation," and the difficulty of carrying it out, except by a professional adjuster, of which so much has been said, is entirely done away with when adjustable correctors, with scales thus accurately graduated, are provided with the binnacle.

The binnacles before you are of two kinds adapted to the two different methods given by the Astronomer-Royal for correcting the semi-circular part of the error; one, the square one, for correcting, by two sets of magnets, fore-and-aft and thwart-ship respectively; the other, the round one, for correcting by a single magnet, or group of bars equivalent to a single magnet, placed under the centre of the compass with its magnetic axis in the proper direction to balance the whole disturbing force on the compass due to that part of the ship's magnetism which is unchanged when she is put on different courses in the same magnetic latitude. The two sets of instructions, in the two printed pamphlets before you, explain sufficiently, for the two binnacles, the arrangements of the magnetic correctors in the two cases, and how to use them in practice.

The principle in each case is easily understood. In the system employed in the square binnacle the whole constant force, due to the part of the ship's magnetism which remains constant when the ship is put on different courses, is regarded as being replaced by three constant "component" forces in the direction of three lines, at right angles to one another—one fore-and-aft, one thwart-ship, and the third perpendicular to the deck. The fore-and-aft component is balanced by the fore-and-aft correcting magnets, the thwart-ship component by the thwart-ship magnets, and the component perpendicular to the deck by the heeling corrector, which is a bar-magnet, adjustable to the proper height, in a line perpendicular to the deck, through the centre of the compass and of the binnacle.

In the round binnacle the component perpendicular to the deck is balanced by a heeling corrector, just as in the square one; but, instead of considering separately two components parallel to the deck, their resultant or the single component parallel to the deck, which, with the component perpendicular to the deck, constitutes the whole force, is balanced by a single magnetic force parallel to the deck. This force is obtained by turning the revolving corrector round the central axis of the binnacle, and raising it or lowering it until the proper direction and proper magnitude of force are produced.

One novel feature in the last binnacle is the way in which, by aid of the guide-ring graduated to logarithmic cosecants, and the vertical scale graduated to equal proportionate differences of force, the adjustment to correct the compass on one course may be performed without disturbing its accuracy on another course on which it has been previously adjusted. The principle of this arrangement is most easily explained by aid of the mathematical notation of trigonometry, in connection with the annexed diagram (Fig. 4), in which O represents the compass-card, A, a point of the ship which was in the direction of the correct magnetic north, N, at the time of the first supposed adjustment, *ns*, the position of the axis of the revolving corrector set to correct the compass on that course, H the ship's head. We have (according to the notation of the instructions)—

$$HOA = H,$$
$$nOH = C;$$
$$\text{therefore,}\quad nOA = H + C.$$

Now the correction on the first supposed course, if it did not annul the force due to the magnetism of the ship and correctors, reduced it to a force in the line OA. Hence the component perpendicular to OA due to the corrector must be kept unchanged in subsequent correction, so as not to disturb the adjustment for that first course. Let F be the magnitude of the force due to the revolving corrector. Its direction being On, its component perpendicular to OA is equal to F sin nOA. Hence, if F be increased by raising, or diminished by lowering, the corrector, the angle nOA must be altered so that sin nOA shall vary inversely as F, or cosec nOA directly as F. In other words, $\frac{F}{\operatorname{cosec} nOA}$ must be kept constant, and, therefore, the difference between log F and log cosec nOA must be kept constant. When the guide-ring is placed according to Rule 2, Section 4, of the Instructions, the reading upon it is the value of log-cosec (H + C). The reading on the vertical scale is always proportional to the logarithm of F. Hence Rule 3 secures that the change of magnitude and direction of the correcting force does not vitiate the correction on the course H.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

Oxford.—An examination for the Burdett-Coutts Scholarship will be held in the University Museum, on Monday, March 11, and three following days, at 10 A.M., for the purpose of electing a scholar on that foundation. Candidates are requested to call on the Professor of Geology at 34, Broad Street, with certificates of their standing, and the consent of the head or vicegerent of their College or Hall, on Friday, March 8, between 4 and 5 P.M.

Cambridge.—The exhibition offered by the Clothworkers' Company, to non-collegiate students of the University, for proficiency in physical science, has been awarded to J. G. M'Cubbin, who was educated at the Manchester Grammar School. The exhibition is of the annual value of 50*l*., and is tenable for three years. The next examination for a similar exhibition open to non-collegiate students who have not resided more than one term, or who have not commenced residence, will be held on July 15 and 17, in connection with the examination conducted by the Oxford and Cambridge Schools Examination Board. Intending candidates can obtain full information on application to the Rev. R. B. Somerset, censor of non-collegiate students, Cambridge.

Gilchrist Educational Trust.—A course of six Gilchrist Science Lectures for the People, will be delivered in the Bristol Athenæum, by members of the Council and Staff of University College, Bristol, as follows:—February 22, The Action of Heat, by S. P. Thompson, B.Sc., B.A.; March 5, Heat and the Steam Engine, by J. F. Main, B.A. Camb., D.Sc. Lond; March 12, The Ocean a Carrier of Heat, by W. L. Carpenter, B.A., B.Sc.; March 19, Heat within the Safety Lamp, by S. P. Thompson, B.Sc., B.A.; March 26, the Sun's Heat, by J. F. Main, B.A. Camb., D.Sc. Lond.; April 2, the Chemistry of Burning, by W. W. J. Nicol, M.A. The same course is to be given at Bath, Bridgwater, Trowbridge, and Newport (Monmouthshire).

The Birkbeck Institution.—The Lord Mayor has promised to preside at a meeting, to be held at the Mansion House on Wednesday afternoon, the 27th inst., at three o'clock, for the purpose of inaugurating a fund to provide the Birkbeck Institution with a building suitable to its large and important operations, and to enable it to take advantage of the many opportunities for further usefulness which are from time to time presented. As the Institution is doing such an important educational work amongst the young men and women of the metropolis, it is hoped that the friends of education will liberally assist the movement to accomplish so desirable an object. The number of students has been steadily increasing for some years past, and, notwithstanding alterations and extensions of the building, it is impossible any longer to accommodate those attending the Institution. Some indication of the work will be gained from the fact that 3,304 persons joined the Institution during the past term.

St. Petersburg.—The professors of the High School of Medicine for Ladies at St. Petersburg, among whom are many names well known in science, have addressed a petition to the Minister of Public Instruction, in which they claim for ladies who have completed their studies at the high schools, the same degrees as for men. They support their request by pointing out that the five years' theoretical and practical study at the ladies' school are quite as extensive as those pursued by male students, and rather more extensive in the department of female diseases; that the monthly and yearly examinations have always proved that the ladies possess a very thorough knowledge of their subjects, and finally, that during their service with the army in Roumania and Bulgaria, the ladies have given numerous and sufficient proofs of their high capacity for acting as surgeons.

Freiburg.—The university is attended at present by 334 students, including 41 in the theological faculty, 70 in the philosophical, 76 in the legal, and 147 in the medical. It possesses a library of 300,000 volumes, and well-equipped scientific laboratories and collections, but fails of late years to rank among the influential German universities, partly on account of the rivalry of its neighbours, Tübingen, Heidelberg, and Strasburg.

Würzburg.—The corps of instructors numbers at present 40 ordinary professors, 5 extraordinary professors, and 17 privat docenten. The number of students, 947, shows a decrease of about 50 on the past half year. On January 2 the 296th anniversary of the foundation of the university was celebrated, and an address delivered by the rector, Prof. Risch, on the national importance of the German universities and their relations to the empire. In the course of the address the Imperial Government was sharply criticised for having, with the exception of the ample provisions for Strasburg, utterly neglected the university system of the country, and failed to introduce the uniformity of management and many other reforms, the need of which is painfully felt since the formation of a united Germany. Prof. Sachs, the well-known botanist, has been raised into the nobility, possibly in recognition of his refusal of a flattering call to Berlin.

HANOVER AND AIX-LA-CHAPELLE.—The two large polytechnics in these cities show a striking diminution in point of attendance during the past year, a fact which would seem to show that the various technical branches in Germany are being overcrowded. Hanover is attended at present by 725 students and the instructors number 46. Aix-la-Chapelle has suffered a reduction of 200 students in comparison with 1876.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, January 17.—"New Determination of the Mechanical Equivalent of Heat," by J. P. Joule, LL.D., F.R.S.

An account is given by the author, of the experiments he has recently made, with a view to increase the accuracy of the results given in his former paper, published in the *Philosophical Transactions* for 1850. The result he has now arrived at, from the thermal effects of the friction of water, is, that taking the unit of heat as that which can raise a pound of water, weighed *in vacuo*, from 60° to 61° of the mercurial thermometer; its mechanical equivalent, reduced to the sea-level at the latitude of Greenwich, is 772·55 foot-pounds.

February 7.—"On the Comparison of the Standard Barometers of the Royal Observatory, Greenwich, and the Kew Observatory," by G. M. Whipple, B.Sc., F.R.A.S., Superintendent of the Kew Observatory.

Owing to certain statements having been circulated as to a large difference existing between the standard barometers of the above two chief meteorological establishments in this country, the Kew Committee decided to institute a direct comparison between them, by the conveyance of a number of instruments to and fro, several times between the two observatories.

The author accordingly did this, having made three extended experiments of this nature, details of which are given in the paper, the results being as follows:—

Mean difference from—

1st series of	128 comparisons	—Greenwich-Kew	= + 0·0016 inch.
2nd ,,	144	,, ,, ,,	= + 0·0007 ,,
3rd ,,	72	,, ,, ,,	= + 0·0014 ,,
Final mean of	344	,, ,, ,,	= + 0·0012 ,,

Certain experiments were also made to determine the necessary corrections to be applied to the Greenwich barometer on account of inequality of distribution of temperature around it. When these corrections are applied the difference between the two standards is reduced to 0·0001 inch, that is to say, the two instruments virtually agree.

In conclusion the author tenders his thanks to the Astronomer-Royal, for the facilities he afforded for the prosecution of the experiments, and to Messrs. Ellis and Nash for assistance they rendered.

Geological Society, January 23.—Prof. P. Martin Duncan, F.R.S., president, in the chair.—J. Eunson, C.E., R. C. Forster, Walter Mawer, Richard H. Solly, and the Rev. Arthur Watts, were elected Fellows of the Society. The following communication was read:—On the secondary rocks of Scotland.—Part III. The strata of the Western Coast and Islands, by John W. Judd, F.R.S., F.G.S., Professor of Geology in the Royal School of Mines. The existence of scattered patches of fossiliferous strata, lying between the old gneissic rocks and the masses of tertiary lava in the Hebrides, has been known to geologists for more than a century. By Dr. Macculloch, who did so much for the elucidation of the interesting district in which they occur, these strata were referred to the lias; but Sir Roderick Murchison showed that several members of the oolitic series were also represented among them. Later researches have added much to our knowledge of the more accessible of these isolated patches of Jurassic rocks in the Western Highlands. During the seven years in which he has been engaged in the study of these interesting deposits, the author of the present memoir has been able to prove that not only is the Jurassic system very completely represented in the Western Highlands, but that associated with it are other deposits representing the carboniferous, poikilitic (permian and trias), and cretaceous deposits, the existence of which in this area had not hitherto been suspected; and by piecing together all the fragments of evidence, he is enabled to show that they belong to a great series of formations, of which the total maximum thickness could have been little, if anything, short of a mile. The relations of the scattered patches of mesozoic strata to the older and newer formations respectively, are of the most interesting and often startling character. Sometimes the secondary rocks are found to have been let down by faults, which have placed them thousands of feet below their original situations in the midst of more ancient masses of much harder character. More usually they are found to be buried under many hundreds, or even thousands, of feet of tertiary lavas, or are seen to have been caught up and inclosed between great intrusive rock-masses belonging to the same period as the superincumbent volcanic rocks. Occasionally the only evidence which can be obtained concerning them is derived from fragments originally torn from the sides of tertiary volcanic vents, and now found buried in the ruined cinder-cones which mark the sites of those vents. In some cases the mineral characters of the strata have been greatly altered, while their fossils have been occasionally wholly obliterated by the action of these same igneous forces during tertiary times. In every case the survival to the present day of the patches of secondary rocks can be shown to be due to a combination of most remarkable accidents; and a study of the distribution of the fragments shows that the formations to which they belong originally covered an area having a length of 120 miles from north to south, and a breadth of fifty miles from east to west. But it is impossible to doubt the former continuity of these secondary deposits of the Hebrides with those of Sutherland to the north-east, with those of Antrim to the south, and with those of England to the south-east. From the present positions of the isolated fragments of the mesozoic rocks, and after a careful study of the causes to which they have owed their escape from total removal by denudation, the author concludes that the greater portion of the British Islands must have once been covered with thousands of feet of secondary deposits. Hence it appears that an enormous amount of denudation has gone on in the Highlands during tertiary times, and that the present features of the area must have been, speaking geologically, of comparatively recent production—most of them, indeed, appearing to be referable to the pliocene epoch. The alternation of estuarine with marine conditions, which had, on a former occasion, been proved to constitute so marked a feature in the Jurassic deposits of the Eastern Highlands is now shown to be almost equally striking in the Western area; and it is moreover pointed out that the same evidence of the proximity of an old shore-line is exhibited by the series of cretaceous strata in the west. The succession and relations to one another of the series of deposits, now described as occurring in the Western Highlands, is given in the following table:—

Miocene Volcanic and Intervolcanic Rocks.

UNCONFORMITY.

		Maximum thicknesses. feet.
Cretaceous.	1. Estuarine clays and sands with coal	20 +
	2. White chalk with flints (zone of *Belemnitella mucronata*)	10 +
	3. Estuarine sandstones with coal	100
	4. Upper greensand beds	60

UNCONFORMITY.

Jurassic.	5. Oxford clay	?
	6. Great estuarine series	1000
	7. Lower oolite	400
	8. Upper lias	100
	9. Middle lias	500
	10. Lower lias	400
	11. Infralias	200
	12. Poikilitic	1000 +

UNCONFORMITY?

Carboniferous strata (coal-measures).

UNCONFORMITY.

Old Gneiss Series and Torridon Sandstones.

Although no traces of the upper oolite or the neocomian formations have as yet been detected in the Western Highlands, yet it is argued that when we consider how enormous has been the amount of denudation, and how singular the accidents to which all the existing relics of the secondary period have owed their escape from total destruction, we cannot but regard it as a most rash and unwarrantable inference to conclude that no deposits belonging to those periods were ever accumulated within the district under consideration. The carboniferous strata of the Western Highlands have been detected at but a single locality; and even there, being exposed in a series of shore reefs that are only occasionally well displayed, can only be studied under favourable conditions of tide and wind. They consist of sandstones and shales with thin coaly seams, and their age is placed beyond question by the discovery in them of many well-known plants of the coal-measures, including species of *Lepidodendron*, *Calamites*, *Sigillaria*, and *Stigmaria*. The poikilitic strata consist of conglomerates and breccias at the base, graduating upwards into red marls and variegated sandstone, which contain concretionary limestones and occasional bands of gypsum. These strata have not as yet, like their equivalents in the Eastern Highlands (the reptiliferous sandstone of Elgin and the Stotfield rock) yielded any vertebrate remains. They were evidently deposited under similar conditions with the beds of the same age in England, and are not improbably of lacustrine origin. The Jurassic series presents many features of very great interest. The infralias is better developed than is perhaps the case in any part of the British Islands; and in the district of Applecross a series of estuarine beds, containing thin coal-seams, is found to be intercalated with the marine strata. The lower lias, in its southern exposures, presents the most striking agreement with the equivalent strata in England, but when traced northwards exhibits evidence of having been deposited under more littoral conditions; the lower division (lias α, Quenstedt) is represented by a great thickness of strata; while the upper (lias β) is absent or rudimentary. The middle lias is grandly developed, and consists of a lower argillaceous member and an upper arenaceous one, the united thickness of which is not less than 500 feet. The upper lias singularly resembles in the succession of its beds, and its palæontological characters, the same formation in England. The inferior oolite is formed by series of strata varying greatly in character within short distances, and betraying sufficient signs of having been accumulated under shallow-water conditions. Above the inferior oolite we find a grand series of estuarine strata, partly arenaceous and partly calcareo-argillaceous; and this is in turn covered conformably by an unknown thickness of blue clays with marine fossils of middle Oxfordian age. At the very lowest estimate, the Jurassic series of the Western Highlands could not have had a thickness of less than 3,000 feet! The cretaceous strata of the Western Highlands, though of no great thickness, are of surpassing interest. They consist of two marine series alternating with two others of estuarine origin. At the base we find marine deposits of upper greensand age, strikingly similar to those of Antrim, but in places passing into conglomerates along old shore lines. Above the upper greensand beds occur unfossiliferous sandstones, in which thin coal-seams have been detected, and these are in turn covered by strata of chalk, converted into a siliceous rock, but still retaining in its casts of fossils (*Belemnitella*, *Inoceramus*, *Spondylus*, &c.), and in its beautifully preserved microscopic organisms (*Foraminifera*, *Xanthidia*, &c.) unmistakable proofs of its age and the conditions of its deposition. Above this representative of the highest member of the English chalk there occur argillaceous strata with coal-seams and plant-remains which are perhaps the equivalent of younger members of the cretaceous series, not elsewhere found in our islands, or, it may be, they must be regarded as belonging to periods intermediate between the cretaceous and tertiary epochs. It is greatly to be regretted that these cretaceous deposits of the Western Highlands are so unfavourably displayed for our study as to present scarcely any facilities for the collection of their fossils; for these, if found, might be expected to throw a flood of light on some of the most obscure palæontological problems of the present day. Although the comparison and correlation of the secondary strata of the Highlands with those of other areas, and the discussion of the questions of ancient physical geography thereby suggested, are reserved for the fourth and concluding part of his memoir, the author takes the opportunity of making reference, in bringing the present section of his work to a close, to several problems on which the phenomena now described appear to throw important light. In opposition to a recent speculation which would bring into actual continuity the present bed of the Atlantic and the old chalk strata of our island, he points to the estuarine strata of the Hebrides as demonstrating the presence of land in that area during the cretaceous epoch. He also remarks on the singular agreement of the conditions of deposition of both the silurian and cretaceous strata of the Scottish Highlands and those of the North American continent. But he more especially insists on the proofs, which we now have, that the Highlands of Scotland, as well as the greater part of the remainder of the British Islands, were once covered by great deposits of secondary strata, and that the area has been subjected to enormous and oft-repeated denudation. He dwells on the evidence of the vast quantities of material which have been removed subsequently to the mesozoic and even to the miocene period, and he maintains the conclusion that many, if not all, of the great surface-features of the highlands must have been produced during the very latest division of the tertiary epoch, namely the pliocene.

Mathematical Society, February 14.—Lord Rayleigh, F.R.S., president, and subsequently Mr. C. W. Merrifield, F.R.S. vice-president, in the chair.—The following communications were made:—On a general method of solving partial differential equations, Prof. Lloyd Tanner.—On the conditions for steady motion of a fluid, Prof. Lamb (Adelaide), (particular cases of the conditions were given by Stokes in the Cambridge *Phil. Trans.* for 1842).—On a property of a four-piece linkage and on a curious locus in linkages, Mr. A. B. Kempe.—On Robert Flower's new mode of computing logarithms (1771), Mr. S. M. Drach.—On the Pluckerian characteristics of the modular equations, Prof. H. J. S. Smith, vice-president, F.R.S.—Mr. Drach also exhibited drawings of tricircloids made some thirty years since for Mr. Perigal.

Royal Microscopical Society, February 6.—Anniversary.—H. C. Sorby, president, in the chair.—The report of the Treasurer was submitted to the meeting.—The report of the Council stated that the library and instruments of the Society were in a satisfactory condition, and obituary notices of deceased Fellows, Dr. Bowerbank and Dr. Henry Lawson, were read by the Secretary. Messrs. Glaisher and Curties having been appointed scrutineers, a ballot for officers and council for the ensuing year took place with the following result:—President, H. J. Slack; Vice-presidents, Dr. L. S. Beale, Dr. C. T. Hudson, Sir John Lubbock, Bart., and Mr. H. C. Sorby; Treasurer, Mr. J. W. Stephenson; Secretaries, Mr. Chas. Stewart and Mr. Frank Crisp; Council, Mr. John Badcock, Mr. W. A. Bevington, Dr. R. Braithwaite, Mr. Chas. Brooke, Mr. C. J. Fox, Dr. W. J. Gray, Mr. E. W. Jones, Dr. Matthews, Mr. S. J. McIntire, Dr. John Millar, Mr. Thos. Palmer, and Mr. F. H. Ward; Assistant-secretary, Mr. Walter W. Reeves. The retiring president then delivered his annual address, which chiefly treated of the results of his investigations into a method of obtaining the refractive indices of minerals.

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