THURSDAY, AUGUST 2, 1894.

LORD KELVIN ON GENERAL PHYSICS.[1]

Popular Lectures and Addresses by Sir William Thomson (Baron Kelvin), P.R.S., LL.D., D.C.L., &c. In three volumes. Vol. II. "Geology and General Physics." With illustrations. NATURE Series, pp. x. + 599, with index. (London and New York: Macmillan and Co., 1894.)

II.

AT the present time, when the need for a fully-equipped and well-manned National Physical Laboratory for expensive and for secular observations is sometimes discussed, it is interesting to quote from Lord Kelvin's Presidential address to the British Association at Edinburgh in 1871 as follows:—

"The success of the Kew Magnetic and Meteorological Observatory affords an example of the great gain to be earned for science by the foundation of physical observatories and laboratories for experimental research, to be conducted by qualified persons, whose duties should be, not teaching, but experimenting. Whether we look to the honour of England, as a nation which ought always to be the foremost in promoting physical science, or to those vast economical advantages which must accrue from such establishments, we cannot but feel that experimental research ought to be made with us an object of national concern, and not left, as hitherto, exclusively to the private enterprise of self-sacrificing amateurs, and the necessarily inconsecutive action of our present Governmental Departments and of casual Committees."

"On the Continent there exist certain institutions, fitted with instruments, apparatus, chemicals, and other appliances, which are meant to be, and which are made, available to men of science, to enable them, at a moderate cost, to pursue original researches."

"The physical laboratories which have grown up [in Universities] show the want felt of Colleges of Research; but they go but infinitesimally towards supplying it, being absolutely destitute of means, material or personal, for advancing science except at the expense of volunteers, or for securing that volunteers shall be found to continue even such little work as at present is carried on."

And in connection with the still urgently pressing need for a systematic abstract of papers and of a central comprehensive report of annual progress in physics, such as is already satisfactorily accomplished by our friends the chemists, the following quotation from the same address is likewise of interest:—

"A detailed account of work done and knowledge gained in science Britain ought to have every year. The *Journal of the Chemical Society* and the *Zoological Record* do excellent service by giving abstracts of all papers published in their departments. The admirable example afforded by the German *Fortschritte* and *Jahresbericht* is before us; but hitherto, so far as I know, no attempt has been made to follow it in Britain. It is true that several of the annual volumes of the *Jahresbericht* were translated, but a translation . . . cannot supply the want. An independent British publication is for many obvious reasons desirable. The two publications, in German and English, would, both by their differences and their agreements, illustrate the progress of science more correctly and usefully than any single work could do."

From the same address I cull the following detached morsels:—

"Our knowledge of the dark lines is due to Fraunhofer. Wollaston saw them but did not discover them." "The old nebular hypothesis supposes the solar system . . . . to have originated in the condensation of fiery nebulous matter. This hypothesis was invented before the discovery of thermodynamics, or the nebulæ would not have been supposed to be fiery."

In amongst the more geological portion of the book there comes a Presidential address to the Society of Telegraphic Engineers, from which it may be useful to extract the following compact statements concerning atmospheric electricity:—

"In fair weather the surface of the earth . . . . is always found negatively electrified. . . . The more common form of statement is that the air is positively electrified, but this form of statement is apt to be delusive. . . . . The surface of the earth is negatively electrified, and positive electrification of the air is merely inferential, ... the lower regions of the air [such air as comes in through windows] are negatively electrified. . . . . It is not always negative, however. I have found it positive on some days. In broken weather . . . . it is sometimes positive and sometimes negative. Now hitherto there is no proof of positive electricity in the air at all in fine weather; but we have grounds for inferring that probably there is positive electricity in the upper regions of the air."

Opening the book now at page 360, we find a paper which might well have been included in the volume on "Navigational Affairs," being on the subject of the Rate of clocks and chronometers as influenced by the mode of suspension. It is rather surprising to learn that the rough and ready conditions of a pocket by day and a pillow by night give a watch a better chance of going correctly than many other modes of support, such as hanging on a nail or even lying flat on a table. If a correctly-going watch be hung up by a single long thread normal to its plane it begins to gain, and if its case has n times the moment of inertia of the balance-wheel, it gains one in $2n$ swings; a watch actually tried, whose n was 650, gained more than a minute (67 seconds) in a day when so suspended. Suspend it by a bifilar suspension and gradually move the threads further apart, so as to increase the natural rate of swing of the case, and the watch gains more and more, until, when the periods of case and wheel coincide, it gains furiously, and then either stops altogether or else begins to lose equally furiously. Separate the threads a little more still, and the losing rate begins to diminish, until ultimately, when the constraint is great, it begins to keep correct time again. Thus by suspending a chronometer judiciously it can be adjusted to time without touching the hands; but if it be suspended so as to have a quick natural period of swing, it cannot be expected to keep good time. If placed on a cushion to protect it from jars, its case is not unlikely to have a quick swing-period;

[1] (Continued from page 293.)

it should be firmly fixed to something with a considerable moment of inertia, and then placed on its cushion. Any fairly regular motion of the case is fatal to good going. And as to astronomical clocks, they should be fixed to stone piers with the same sort of care as is bestowed on transit instruments.

Another paper, "On a New Astronomical Clock," notes the defects of Graham's dead-beat escapement, and suggests a new one, wherein the escapement wheel is carried by a loose friction collar at a rate a trifle faster than the proper rate, so that its pellets engage the pendulum only occasionally, receiving the necessary check and maintaining the motion of the pendulum sufficiently, even though they only touch once a minute or so.

In a paper "On Beats of Imperfect Harmonies," of date 1878, Lord Kelvin virtually lends his support to the view advocated by Koenig, that in the appreciation of harmony the ear detects phase-differences and is not limited to analysis of a complex note into simple harmonic constituents. For instance, a harmony of even and odd vibration numbers (like 2 : 3) will have one kind of phase relation, while a harmony of two odd numbers will have another kind, the most obvious feature of these phase relations being the way successive maxima and minima coincide or oppose. In general the shape of the curve representing the composition of two notes varies in appearance, as is well known, according to the phase in which they are compounded. If one of the constituents is out of tune there will be a gradual transition from one of these phase-relations to another. "In favourable circumstances . . . a variation of the sound recurring periodically in the successive cycles is distinctly heard. . . . It is this variation which is called the 'beat' on the imperfect harmony."

Lord Kelvin has made experiments on pure tuning-fork tones, and his experience is "that in every case the ear does distinguish the two halves of the period of each beat. . . . The ear distinguishes the quality of the sound represented by the sharp-topped and flat-hollowed curve from that represented by the flat-topped and sharp-hollowed curve. In the one case the pressure of air close to the ear rises very suddenly to, and falls very suddenly from, its maximum, and (as in cases of tides in which there is a long hanging on low water) there is a comparatively slow variation of pressure for a few ten-thousandths of a second on each side of the instant of minimum pressure; in the opposite phase-relation there is a slow change before and after the time of maximum pressure, and a rapid change before and after the time of minimum pressure."

The ear is thus found able to distinguish between a push and pull on the tympanum; or the receiving apparatus is not symmetrical on either side of zero. This is equivalent to saying that second order of small quantities must affect the sound as heard, and on this can be based the usual theory of the difference and summation tones of Helmholtz.

But the mode of expression adopted by Lord Kelvin is not that of interference of any resultant simple tones; he prefers to think of the actual phase changes as directly detected by the ear, and says that "a *revolving character* which I perceive in the beat is to me certainly distinct enough to prove that the ear does distinguish between these configurations, which are one of them the same as the other taken in the reverse order of time."

According to his experiments it is singular how very faint is the disturbance necessary to bring out these beat tones: much less than would appear to be necessary on Helmholtz' theory of difference tones, whose amplitude is proportional to the product of the constituent amplitudes. Thus, "if when the approximate harmony C E is being sounded, with the E slightly out of tune and the beats on it heard, the faintest sound of G is produced by a very gentle excitation of the fork by the bow, instantly a loud beat at half speed is heard. . . . It is marvellous how small an intensity of the sound G is required to give a smooth unbroken loud beat in the double period." This practical method of tuning a major third, by addition of the minor third above it, completing the common chord, is of course well known; but the ordinary Helmholtz explanation, of beats between the C E difference tone and the E G difference tone, scarcely seems to fit the above observed facts.

Again, if the notes C E G are sounded and one of the notes (say C) is flattened, the beats are not only very audible but "the sound dies beating, the beats being distinctly heard all over a large room as long as the faintest breath of sound is perceptible. The smooth melodious periodic moaning of the beat is particularly beautiful when the beat is slow (at the rate, for instance, of one beat in two seconds or thereabouts), being, in fact, sometimes the very last sound heard when the intensities of the three notes chance at the end to be suitably proportioned."

Incidentally an inconvenient usage of musical nomenclature is mentioned in a note. The word "tone," which is now coming to be used to mean a pure sine curve disturbance or simple note, means in music the interval of the major or minor or tempered second.

Those who have to do with acoustics must have often experienced the inconvenience of the ordinary childish nomenclature of intervals—a fourth, a third, a seventh, and so on—especially when these intervals are being numerically expressed at the same time. To call the interval 2 : 3 a fifth, 3/4 a fourth, and 1·25 a third, is often confusing. Might I suggest that these intervals, when true, might be named readily and intelligibly as respectively a do-sol, a sol-do, or if preferred a do-fa, and a do-mi; similarly a minor third would be a mi-sol; a major and a minor tone would be a do-re and a re-mi respectively; and so on.

It might be convenient to drop the *l* in sol, so as to make all the syllables of two letters; and then the flattening or sharpening of notes might be indicated readily by a final *a* or *e*; thus a flattened major tone would be a do-rea (the same as a re-mi), and a sharpened one a do-ree.

On the tempered scale the intervals could be called *cg*, *gc*, *ce*, *eg*, &c., with perfect ease.

Again, the ordinary musical notation, with its various clefs, if it were not hallowed by usage, would seem a barbarous piece of stupidity. Undoubtedly a couple of lines should have been understood as missing between the bass and treble clefs, instead of only one; so that the F label could be affixed to the top line of the bass instead of to the second from the top (see fig.); or rather, since the second line from the bottom is G, the same as in the treble, no labelling would be wanted, and one clef would serve for all instruments—a change which would

surely save a Conductor something? I wonder if it is too late now to make the change! This, however, is a digression, and Lord Kelvin is not to be held responsible for any of these musical notation heresies.

The remaining parts of the book consist, for the most part, of Presidential addresses and a couple of Royal Institution lectures. The first R.I. lecture, "On the origin and transformation of motive power," is now of only historical interest. It is of date 1856, and in it the energy of motion is called "dynamical" or "actual" energy, though in a note the author says that he very soon after suggested the name kinetic.

It is followed by the address to Section A at York in 1881, on the practical utilisation of wind and water power; and then begin the quite recent articles. First, an article on the Dissipation of Energy for the *Fortnightly Review* of 1892, wherein the author points out how near Carnot was to an appreciation of the second law of thermodynamics, and justifies his own limitation of its statement to "inanimate material agency" by the following:—

"My statement of this axiom was limited to inanimate matter because not enough was known either from the natural history of plants and animals or from experimental investigations in physiology to assert with confidence that in animal or vegetable life there may not be a conversion of heat into mechanical effect not subject to the conditions of Carnot's theory. It seemed to me then, and it still seems to me, most probable that the animal body does not act as a thermodynamic engine in converting heat produced by the combination of the food with the oxygen of the inhaled air, but that it acts in a manner more nearly analogous to that of an electric motor working in virtue of energy supplied to it by a voltaic battery. . . . It is, however, conceivable that animal life might have the attribute of using the heat of surrounding matter, at its natural temperature, as a source of energy for mechanical effect, and thus constituting a case of affirmative answer for Carnot's last thermodynamic question.[1] The influence of animal or vegetable life on matter is infinitely beyond the range of any scientific inquiry hitherto entered on. Its power of directing the motions of moving particles, in the demonstrated daily miracle of our human free-will, and in the growth of generation after generation of plants from a single seed, are infinitely different from any possible result of the fortuitous concourse of atoms."

"Considerations of ideal *reversibility* . . . have no place in the world of life."

In an address on the opening of the Physical and Chemical Laboratories of the North Wales College, Bangor, it is stated that there is no philosophical division whatever between chemistry and physics; both "investigate the properties of matter." I would suggest that properties common to many kinds of matter belong to Physics, while the properties whereby one kind of matter differs from other kinds belong to Chemistry. Of course there can be no sharp line of demarcation, but instinctively we are conscious of a difference; and wherever the investigation is concerned essentially with specific varieties of matter, it is felt that the interest attaching to it is a chemical interest. Properties of matter in general, in its different states indeed but without regard to whether the matter is pure or impure simple or compound—those usually belong to Physics.

In this Bangor address there are some interesting reminiscences of the old building of Glasgow University, and of the early days of students' laboratory work there, where under the inspiration of their unique teacher, even theological students worked away at practical experimental physics. And an excellent training too! The modern system of different curricula for each class of professional students, even in the early stages of their degree course, is probably not half so wise as the old Scotch system, where everyone had a year at natural philosophy as well as a year at metaphysics; and the course for everyone up to a degree standard was the same, whatever he was going to be. Specialisation at an early stage is now largely advocated, but I believe that our descendants will regard it as a mistake; or certainly that in effecting a partially required reform we are running now too far into an opposite extreme.

A good wholesome uniform range of subjects, with sufficient variety for different tastes but no reprieve from any course, is the best pregraduate course for all but intellectual weaklings; and for weaklings to attempt to specialise, as they sometimes do now, because it is easier to pass a high stage badly than a low stage well, cannot be really useful or satisfactory.

Those who are incompetent to go deep, and are necessarily superficial, let them try to give their surface breadth; and for those who can go deep, let them spread wide too. A liberal culture and wide information can hurt nobody of decent ability, and it need not be inconsistent with any depth to which a man's genius can carry him. True depth is an affair of genius. Training has chiefly to do with breadth. (This is another digression.)

Of the author's brief annual addresses as President of the Royal Society, the first is on the recently observed slight shift of the earth's polar axis, and on the Faraday centenary; the second on terrestrial magnetism, and the conceivable modes by which the sun may be able to disturb it. The following sentence may be quoted: "I find it unimaginable but that terrestrial magnetism is due to the greatness and rotation of the earth." And on the hypothesis that magnetic disturbances are caused by the direct action of the sun acting as a variable magnet, he says:—"In eight hours of a not very severe magnetic storm, as much work must have been done by the sun in sending magnetic waves out in all directions through space as he actually does in four months of his regular heat and light. This result, it seems to me, is absolutely conclusive against the supposition that terrestrial magnetic storms are due to magnetic action of the sun; or to any kind of

[1] This question was:—"Is it possible to derive mechanical effect from heat of average temperature?"

dynamical action taking place within the sun, or in connection with hurricanes in his atmosphere, or anywhere near the sun outside.

"It seems as if we may also be forced to conclude that the supposed connection between magnetic storms and sun-spots is unreal, and that the seeming agreement between the periods has been a mere coincidence."

The next year's address is on electric radiation, the experiments of Hertz, and electric discharge in gases; with a reference to Mr. Crookes' discovery of vacuum-stresses as an outcome of experimental troubles experienced in his weighing of thallium, and with a characteristic foot-note by Lord Kelvin to the word "troubles":—"Tribulation, not undisturbed progress, gives life and soul, and leads to success when success can be reached, in the struggle for natural knowledge." It is followed by the speech delivered at the unveiling of Joule's statue in Manchester Town Hall on December 7, 1893, and by the Royal Institution lecture on Isoperimetrical Problems; this last being an attempt at popularising the calculus of variations! From how to surround a maximum acreage with a given boundary subject to certain conditions, and how to plan a railway route with a minimum of expense, the author ascends to recent researches in the problem of three bodies, and to the geometrical representation of problems of dynamical stability by the method of geodetics. The most curious part of this lecture is not scientific but social, viz. the treatment accorded to that unfortunate hero, "Horatius Cocles." The representation of Dido as a cute Phenician adventuress successfully wheedling a reasonable plot of ground out of a sarcastic African chief is fair enough, but the spectacle of the stout old warrior with his wounded leg scrambling after a plough along a single furrow from morning till night over all kinds of country, in order to secure as much of the public cornland as possible at the hands of his grateful countrymen, is an odd reading of the legend. That he was awarded a piece of land such that it would take two oxen the whole of a day to plough it, is a statement poetic perhaps in its terms but more precise in its meaning than if expressed in some extinct units of measurement; but to suppose that it was to be ploughed round, and that Horatius must guide the plough, and guide it with a constant eye to secure the maximum of benefit for his minimum of service, is hardly fair either to the memory of the patriot or to the spirit of the Romans in their early and wholesome days.

It can hardly be said even now to represent the attitude of any nation with respect to the services of its military or political heroes, but it may very well be held as a typical illustration of the way in which most countries at present attempt to reward their inventors through the medium of their patent laws.

Whether the author half intended the Horatian episode as a satire, or whether (as is more probable) he is taking the story as a myth for whose social significance or historical bearing he cares nothing, it serves as a popular introduction to what else would be rather an abstruse subject—a subject, indeed, which few people would have ventured to use as the basis for a Friday evening discourse.

These, then, are the varied and highly readable contents of this small book. May the author long live with undiminished vigour, and give us many more of these recreations of a great mind.

OLIVER J. LODGE.

THE FLORA OF CEYLON.

A Handbook to the Flora of Ceylon: containing Descriptions of all the Species of the Flowering Plants indigenous to the Island, and Notes on their History, Distribution and Uses. By Henry Trimen, M.B. (Lond.), F.R.S., Director of the Royal Botanic Gardens, Ceylon. With an Atlas of Plates illustrating some of the more interesting Species. Part i. Ranunculaceæ—Anacardiaceæ. 8vo. pp. xvi. 327, with plates i.-xxv. (4to). Part ii. Connaraceæ—Rubiaceæ. pp. 392, with plates xxvi.-l. (Published under the authority of the Government of Ceylon. London: Dulau and Co., 1893-94.)

WHEN Dr. Trimen left England at the beginning of 1877 to undertake the directorate of the Ceylon Gardens, he had already formed the determination to elaborate the flora of Ceylon, and to publish a descriptive handbook of its botany. Those who knew him knew that this work would only be undertaken after due preparation and without undue haste, but that it would be pushed forward steadily and with all reasonable speed to a satisfactory consummation: and the two instalments now before us amply justify such a conclusion.

Dr. Trimen was fortunate in having had so careful a predecessor as G. H. K. Thwaites, whose "Enumeratio Plantarum Zeylaniæ," published in 1858-64, he rightly describes as "an extremely accurate and most valuable work," rendered more useful by the extensive series of illustrative specimens distributed by Thwaites to the principal herbaria of the world. The first work of the new Director was to bring this up to date, which he did in a "Systematic Catalogue," published in 1885, and arranged in accordance with the "Genera Plantarum." In the course of a visit to England in 1886, Dr. Trimen found time to examine the invaluable Ceylon Herbarium of Hermann, preserved in the British Museum, upon which Linnæus based his Flora Zeylaniæ; and he published a complete enumeration and identification of the plants therein contained, with notes, in vol. xxiv. of the *Journal of the Linnean Society*. Various new species have from time to time been published by Dr. Trimen in the *Journal of Botany*; and these, with the results of the rest of his work, are embodied in the "Handbook."

In his younger days, Dr. Trimen was known as a painstaking British botanist, and the "Flora of Middlesex," issued in 1869, for which he was mainly responsible, initiated a new departure in works of the kind. It was marked by thoroughness and accuracy; every page showed care and research: and these qualities are abundantly manifest in this Ceylon "Handbook." A careful correlation of the work of predecessors in the same field is another characteristic shared by each book; and in each there was need for this, for Middlesex plants have been recorded since the days of William Turner, while the Cingalese flora has been treated of by various authors from Hermann (1717) downwards.

The opening sentence of the brief introduction strikes the key-note of the work, with which the two volumes before us are in perfect harmony. "One principal object of this Handbook is to enable observers in Ceylon to ascertain the name of any plant they may find growing wild. When this is arrived at, they are in a position to learn all that may have been written about it in botanical and other literature, to appreciate its relationships to other plants, to trace its distribution in other lands, and to intelligently investigate its properties and uses." The book being intended as a guide to the flora of Ceylon, the descriptions have been made wholly from Ceylon specimens, and the information given under each species is restricted to what affects it as a Ceylon plant. Technicalities have been avoided so far as this could be done consistent with accuracy, and the definitions of orders and genera are only such as are shown by the species found in Ceylon.

The same restriction is carried out in the references to published books and papers, which are almost entirely limited to those wherein the species is noticed as a Ceylon plant. The Latin name is followed by the vernacular names when known, in Cingalese and Tamil. Thwaites's distributed numbers are always quoted, and figures of the species, preference being given to such as are known to have been made from Ceylon specimens, are referred to. After the description, made wherever possible from living specimens, come the general distribution and comparative frequency in Ceylon, and notes as to the times of flowering and colour of the flowers—points which are not always to be found in works of this kind, but which are very useful to the field botanist, especially if he be a beginner. In addition to these matters, information is frequently added on peculiarities in structure, or on the properties, products, and uses of the plants, with brief notes on the history and nomenclature of the species. The diagnostic description of each order is followed by keys for the rapid determination of the genera and species. Dr. Trimen has wisely refrained from the startling novelties in nomenclature which are to be met with in various transatlantic local floras, where they are more than usually out of place; and lays down dogmatically that "no botanical name in the modern taxonomic sense can be of earlier date than 1753, when Linnæus first definitely published his binominal nomenclature."

Our colonial floras are for the most part so largely drawn up from dried specimens by botanists unacquainted with the plants in a living state, that their usefulness in the field must be considerably diminished. Their value for herbarium work is undoubted, a fact of which one is continually reminded by the absence of any enumeration for some countries, and the unfortunate incompleteness of most of those which have been set on foot. New Zealand and Australia are well provided for, although the unflagging zeal of Baron Ferdinand von Mueller and his many helpers has already added so much to our knowledge that the "Flora Australiensis" is by no means up to date. Africa, both South and Tropical, is less fortunate, the "Flora Capensis" remaining where it was at the death of Harvey in 1866, and the "Flora of Tropical Africa," although now once more in progress, having come to a standstill in 1877. Thanks to the energy of Sir Joseph Hooker, we are within reasonable distance of the completion of the "Flora of British India"; and the useful "Index Floræ Sinensis," although not a descriptive flora in the sense of those mentioned, is proceeding steadily. But we greatly need floras for the South American continent; and Mr. Hemsley's handsome Botany of the "Biologia Centrali Americana" can hardly be considered exhaustive for the region of which it treats. To take a much more limited area, we have no compendium for Madagascar, and our knowledge of its wonderful flora has to be gleaned from a large number of scattered papers.

The existing floras, however, do not contain in any great degree descriptions drawn from living material; and it is fortunate that the small area to which Dr. Trimen is restricted has enabled him to treat his plants in this rational manner. It is to be regretted that his aims will be to some extent frustrated by the unnecessarily bulky form which his "Handbook" has assumed. The two volumes already issued contain between seven and eight hundred pages, and at least as many more must be occupied by the remainder of the work. The paper employed is much too thick, and by a different arrangement of type considerable saving of space might have been effected, without materially detracting from the appearance of the volumes. It may well be, however, that when the work is completed, Dr. Trimen will issue an abridgement for use in the field, which would occupy to the present handbook the position which Mr. Hayward's "Botanist's Pocket-book" holds with regard to our larger British manuals.

A word must be said in praise of the excellent quarto plates which accompany the "Handbook." They are selected from a series of several thousand drawings, begun in 1823, when Mr. Moon was Director of the Gardens, and preserved in the library. These are entirely the work of three members of one family. Haramanis de Alwis, who has just died at a very advanced age, held the post of draughtsman to the Gardens for thirty-eight years, and was succeeded by his sons, one of whom has held the post for twenty-seven years. Most of the drawings here reproduced are his work.

JAMES BRITTEN.

OUR BOOK SHELF.

Biskra and the Oases and Desert of the Zibans. By Alfred E. Pease, F.R.G.S. Pp. 112. (London: Edward Stanford, 1894.)

HAVING spent six months in Biskra, Mr. Pease thought it worth while to use the knowledge gained during this period to supplement the comparatively slight information given in handbooks to the provinces of Oran, Algeria, Constantine, and Tunisia.

Biskra, Biskra-en-Nokkel, or Biskra aux Palmiers, is a beautiful green oasis, from which visits can be conveniently made to neighbouring oases in the Sahara. The oasis is about five kilometres in length, and its width ranges from one hundred to seven hundred metres. The town is situated 111 metres above sea-level in lat. 34° 52′ N., and long. 5° 42′ E. Upon the oasis flourish 160,000 date palms, 6000 olive trees, as well as fig, orange, citron, and lemon trees. The people are kindly and unsophisticated, and the climate is delightful during most of the year, being specially suitable for persons suffering from pulmonary complaints. Tourists who like to leave the beaten track, and seekers after a refuge from an English winter, will be attracted to Biskra if they read Mr. Pease's little book.

Practical Photo-Micrography. By Andrew Pringle. (London: Iliffe and Son, 1894.)

WORKERS in this fascinating branch of science will no doubt be well acquainted with the author's large treatise, a book which is suitable, more especially, for those who wish to devote themselves very considerably to this kind of work, and to enter into all the details connected with it. The publication of the present book will not appeal so much to the interest of this class of readers, but will be welcomed more by those who wish to get a good working idea of photo-micrography. With this intention this manual has been kept within very reasonable limits, is decidedly explicit, and thoroughly practical. In the seventeen chapters the reader is led through all the manipulations, from the choice of instruments to suit his purse, kinds of plates to use, colour treatment of objects, and general photographic procedure, &c., to those dealing with good hints on lantern-slides, cover-glass preparations, and section cutting and staining. The text is accompanied with numerous well-chosen illustrations, and the get-up of the book is all that could be desired. It may interest our readers to know that in the above pages we are informed that no apparatus is recommended on hearsay, or is any statement made or step suggested "outside the knowledge and practice of the writer."

Twelve Charts of the Tidal Streams on the West Coast of Scotland. By F. Howard Collins. Small folio. (London: J. D. Potter, 1894.)

MR. COLLINS has elaborated the work of the Hydrographic Office by producing a set of charts showing the direction of the tidal streams on the west coast of Scotland at intervals of one hour from the time of high water at Greenock. The twelve charts are prefaced by a note describing how they should be used, and a tide-table. The sources of his information are duly acknowledged, and the work was carried out with the assistance of Captain Wharton, the hydrographer. The work is similar in scope and method to the atlas of tides in the North Sea by the same author. It is a serious defect that no method has been adopted for distinguishing the velocity of the tidal streams, or at least of indicating the furious tidal races which occur in many channels and off many headlands. So far as the direction of the streams is concerned, this compact set of charts should be useful to yachtsmen, and is not without interest for oceanographers.

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 intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

On Some Methods in Meteorology.

Is it not a *desideratum* in our rainfall records that they should give, with the amount of rain, not mere rain-days (or days' rain), but the exact time (or as near an approximation to that as possible), during which rain has fallen? This might at least, surely, be expected from our observatories and better equipped stations. Some of our continental neighbours are before us in this respect. Thus, the Geneva record, for more than thirty years, has contained as one of its items, "hours of rain." May we not then ask why an institution like that at Greenwich, goes on giving the number of days on which rain fell; a momentary sprinkle being thus put in the same category with an incessant downpour of twenty-four hours?

One might here remark on the great fulness of detail and excellence of arrangement in records of the weather at various continental stations (*e.g.* Pola); which are apt to lead us into invidious comparisons.

With regard to measurement of bright sunshine, the burning-glass method leaves much to be desired from a scientific point of view, and the photographic method seems likely to supplant it increasingly. But might not the concentrated rays be got to produce some other physical effect (metal-expansion?) than burning paper, yielding a more exact record of the amount of sunshine?

Again, may it not be said that the graphic method is far too little utilised in meteorology? Probably nine persons out of ten would agree that they apprehend a truth of statistical nature, a numerical variation, much better every way—more quickly, more clearly, more retentively—through a graphic curve, than through a column of figures, or a verbal description. Yet we have only to turn over the pages of our meteorological publications (and others dealing with figures) to see that this method is used very sparingly. And it is easy to pick out cases where the want of it is felt very plainly. I can recall one such case in a valuable paper by one of our ablest meteorologists (Dr. Buchan), published a short time ago in the Scottish Society's *Journal*, on mean temperature in the neighbourhood of London during 130 years. Here we find paragraph after paragraph, over several pages, describing how certain smoothed values of temperature had varied, now above, now below the line of average. This imposes a considerable strain on the imagination, proves, I am afraid, somewhat tedious reading, and leaves, perhaps, no very distinct impression after all. A simple diagram, giving the curves themselves, would here be an effective labour-saving contrivance, both to the author and his readers.

But to multiply diagrams means great expense, it will naturally be urged. Now the cost of a well-finished diagram (and we all like such) is no doubt considerable. But with the aid of photography diagrams can now be reproduced very cheaply; and it seems to me open to consideration whether we might not do well to sacrifice a little fineness and finish, for the sake of a freer and more frequent use of the method, and the greater clearness of comprehension which that would ensure. Moreover, such diagrams are not to be regarded as a mere addition, and therefore requiring more space; they may even mean an economy of words and space. There are frequent cases in which it is not necessary to give all the figures involved; the object being merely to point out a relation, the salient features of a curve. And if the diagram can be relied upon for accuracy, little need be said about it, in some cases; it tells its own tale. Then again, the photographic reproduction of an author's diagram may even prove a gain in accuracy; some intermediate perils are avoided. I believe, in fine, that the graphic method has a great future before it, not only in science, but in other domains; and the sooner we set about developing its capabilities to the utmost, the better.

A. B. M.

Magnetism of Rock Pinnacles.

IT is well known that the Riffelhorn powerfully affects the compass, and the like has been observed on other peaks in Switzerland; but I have never seen any record of similar observations in this country.

Four years ago, on a visit to the Lizard, accident drew attention to a strong influence on the compass exhibited by a crag on the moors near Kynance. I have taken the opportunity of a visit this year to ascertain whether that were a solitary case. I find that such influence, though not general, is by no means uncommon. Most of the rocks in which it was observed were serpentine; it occurred also in hornblende schist; there were no sufficient opportunities of testing the other rocks of the district. The influence was exhibited only in rather prominent crags, but among them often in lower adjacent blocks, as well as in the absolute summits. At a few yards' distance it was always imperceptible.

I saw no traces in any case of the crag having been struck by lightning. This was the only point to which I gave attention; but it would be natural also to inquire if all kinds of rock can possess the property, if wet or weather affects it, and if it be temporary or permanent.

I used a common pocket compass, taking the bearings of some distant object, first a few feet off, then in four surrounding positions as near as the compass could be held to the stone I was testing. The effects varied from no deviation or slight, to cases where the needle swung completely round while still a foot or two away. Among the strongest noted were some crags north of Kynance Cove, and some on a headland about a quarter of a mile south of Coverack, both consisting of serpentine. Any one whose holidays take him to a rocky neighbourhood, may find interest in carrying out similar observations.

Cockfield, July 28. E. HILL.

The Aurora Australis.

THE following report of a brilliant Aurora, seen in the Indian Ocean, will be interesting to many of your readers :—

THE AURORA AUSTRALIS.—When sailing along the Indian Ocean from the Cape of Good Hope to Australia, and in about the vicinity of St. Paul's Island, longitude 76° 17′ east, latitude 4 1°22′ south, an Aurora Australis of remarkable grandeur was seen by those on board the ship *Isle of Arran.* Describing it yesterday, Captain Carse said his chief officer and he had a beautiful view of the phenomenon on two nights (April 28 and 29). It was a very fine sight, the streams of light in spraylike form shooting upward for fully thirty degrees, lighting up with wonderful brightness the whole southern part of the heavens. Some very bad weather was experienced by the ship in the locality of St. Paul's. High confused seas prevailed with a strange continuance of easterly winds.—*Herald*, May 23.

No report was received that this was seen in any part of Australia, and I have seen no report that the brilliant Aurora seen in the northern hemisphere on March 30 was seen in this part of the world. H. C. RUSSELL.

P.S.—I got position and date from Captain Carse.

Absence of Butterflies.

THE most common butterflies—as, for instance, *Picris Brassicæ, Coleas Rhamni, Vanessa Urticæ*—were very rare hereabouts this spring too (*cf.* NATURE, vol. l. p. 225), and the same has been observed at Frankfort-on-Maine. As for *Picris*, this scarcity might have been predicted with certainty last autumn, as, here and at Frankfort, the cabbage-plants in fields and gardens were almost exempt from their usual ravagers, the caterpillars of the said species. If the extraordinary dryness of last year's summer should be connected with these facts, it cannot have acted through the damage done to the food-plants, but must have operated more directly upon the insects themselves. D. WETTERHAN.

Freiburg, July 28.

A STRANGE LIGHT ON MARS.

SINCE the arrangements for circulating telegraphic information on astronomical subjects was inaugurated, Dr. Krueger, who is in charge of the Central Bureau at Kiel, certainly has not favoured his correspondents with a stranger telegram than the one which he flashed over the world on Monday afternoon :—

"Projection lumineuse dans région australe du terminateur de Mars observée par Javelle 28 Juillet 16 heures Perrotin."

This relates to an observation made at the famous Nice Observatory, of which M. Perrotin is the Director, by M. Javelle, who is already well known for his careful work. The news therefore must be accepted seriously, and, as it may be imagined, details are anxiously awaited ; on Monday and Tuesday nights, unfortunately, the weather in London was not favourable for observation, so whether the light continues or not is not known.

It would appear that the luminous projection is not a light outside the disc of Mars, but in the region of the planet not lighted up by the sun at the time of observation. The gibbosity of the planet is pretty considerable at the present time. Had there been evidence that the light was outside the disc, the strange appearance might be due to a comet in the same line of sight as the planet. If we assume the light to be on the planet itself, then it must either have a physical or human origin ; so it is to be expected that the old idea that the Martians are signalling to us will be revived. Of physical origins we can only think of Aurora (which is not improbable, only bearing in mind the precise locality named, but distinctly improbable unless we assume that in Mars the phenomenon is much more intense than with us), a long range of high snow-capped hills, and forest fires burning over a large area.

Without favouring the signalling idea before we know more of the observation, it may be stated that a better time for signalling could scarcely be chosen, for Mars being now a morning star, means that the opposition, when no part of its dark surface will be visible, is some time off.

The Martians, of course, find it much easier to see the dark side of the earth than we do to see the dark side of Mars, and whatever may be the explanation of the appearances which three astronomers of reputation have thought proper to telegraph over the world, it is worth while pointing out that forest fires over large areas may be the first distinctive thing observed on either planet from the other besides the fixed surface markings.

THE INTERNATIONAL GEOLOGICAL CONGRESS.

THE sixth meeting of this Congress will be held at Zurich, commencing on August 29. The Congress was founded at Philadelphia in 1876, the first meeting being held at Paris in 1878 ; subsequent meetings have been—Bologna, 1881 ; Berlin, 1885 ; London, 1888 ; Washington, 1891. As one result of discussions at the Paris meeting, committees were appointed in different countries to draw up reports on classification, nomenclature, &c. At Bologna these reports were received and discussed, the greater part of the time being thus spent. An additional committee was then appointed to prepare a geological map of Europe ; this work is still in progress, but the committees on nomenclature, &c., have practically lapsed, and but little attention has been paid to such subjects at the more recent meetings. At the Washington Congress a committee was appointed to report on the Bibliography of Geology. Lists of bibliographies for each country were to be prepared, and printed in the report of the Washington meeting ; but the volume has recently appeared without such lists. It is hoped that the committee will submit a report on this important subject at Zurich.

Prof. E. Renevier, of Lausanne, is nominated President of the Zurich meeting. He has been an active member of the Congress from the commencement, and the excellent arrangements for the forthcoming meeting are no doubt largely due to his powers of organisation. Prof. A. Heim, of Zurich, is Vice-President ; Prof. H. Golliez, of Lausanne, is Secretary ; M. C. Escher-Hess, of Zurich, is Treasurer. This apparently exhausts the list of officers of the organising committee, democratic Switzerland dispensing with "president of honour," "honorary members of committee," &c., which have largely figured in the lists of previous Congresses, even in that of Washington. Not having such honorary lists upon which to draw for funds, the subscription for membership is double that previously charged, but is even now only 25 francs.

The arrangements made for the Zurich meeting differ somewhat from those of previous sessions. There will be no formal discussion on nomenclature, classification, &c. ; but, after transacting general business, the Congress will divide into three sections, meeting simultaneously. The subjects for discussion will be : (1) General and Tectonic Geology ; (2) Stratigraphy and Palæontology ; (3) Mineralogy and Petrography. Amongst the papers promised are: K. von Zittel, Palæontology; M. de Bertrand, Structure of the Western Alps; A. Heim, Geology of the Environs of Zurich; A. Michel-Lévy, the Unification of Petrographical Nomenclature; E. Suess, Tectonic Geology. There will also be papers on glacial geology; and Captain Marshall Hall will submit a proposal for an international survey and record of glaciers.

At the Zurich meeting, however, papers and discussions will form but a comparatively small part of the work. Excursions have always played a prominent part in the arrangements for the various meetings; but hitherto they have been mainly made after the close of the Congress. At Zurich the Congress will practically divide into five excursion sections, starting on September 3, traversing the Alps in different directions, and all converging on Lugano, where the closing meeting will be held on September 14. These excursions would alone make the Zurich meeting memorable; they have been planned to include the most interesting districts of the Swiss Alps, and to facilitate the study of many intricate problems concerning the structure of the mountains and the petrographical nature of the rocks. After investigation of the northern flanking ranges of folded secondary rocks, the central crystalline zone will be crossed, and in some cases glacial phenomena can be well studied. Prof. Heim will conduct a party over the country which he has so well described, starting from St. Gall and crossing the Alps of Glarus, the Vorder Rhein, and the eastern Lepontine Alps; Prof. Schmidt will conduct the party from Schwtz over the St. Gotthard; Prof. Baltzer, starting at Lucerne, will take a line some miles further west; Prof. Schardt, starting at Bulle, will traverse the western end of the Bernese Alps and part of the Pennine Alps, and will reach Lugano by the Simplon. These four excursions are for pedestrians only, and those only are invited who are accustomed to long walks and climbing, hard beds, and frugal living. A more elaborate circular tour in the Alps will be conducted by MM. Ruffieux and Ruchonnet, of Lausaunne; this will traverse a wider district, and the work will be done with less fatigue. Profs. Renevier and Golliez will be the scientific directors of this tour.

Supplementary excursions will start from Lugano after September 14, one of which, conducted by Profs. Brückner, Du Pasquier, and Penck, will study the glacial phenomena of the Italian Lakes, thence by the Tyrol to Munich, and finally to the Lake of Constance.

Before the Congress there will be excursions in the Jura—five for pedestrians—as follows: French Jura, M. Schardt; Vaudois Jura, M. Jaccard; Bernese Jura, M. Rollier; Bâle and the Argovian Jura, M. C. Schmidt; Argovian Jura and Soleure, &c., M. Murlberg. There will also be a long circular tour in the Jura by MM. Ruffieux and Ruchonnet, with MM. Renevier and Gollitz as scientific directors; the latter part of this will be much devoted to glacial questions, and will therefore be preparatory to the special glacial excursion starting from Lugano.

Arrangements have been made for inclusive charges for all these excursions. For the pedestrian tours, they are 50 or 60 francs for the Jura excursion of five or six days each, and 300 francs for the circular Jura tour of fourteen days.

For the longer excursions in the Alps, after the Congress, the prices are from 150 to 250 francs for the pedestrian tours of eight to thirteen days, and 400 francs for the circular tour of thirteen days.

A guide-book to the various excursions is in preparation. This will contain about 300 pages of text, and will be amply illustrated by plates and sections; it will form a most useful handbook to the geology of Switzerland. A new geological map will also be published, on the scale of 1 : 500,000; this will be a reduction of the official maps of the Swiss Geological Survey, which is now completed.

Special guide-books to the important geological collections at Lausanne and Zurich are in preparation. As usual at such meetings, geological maps and other publications, photographs, specimens, &c., will be exhibited.

W. TOPLEY.

THE DISCS OF JUPITER'S SATELLITES.

THE discussion which is now taking place between two well-known observers—namely, Profs. Pickering and Barnard—as to the forms which the satellites of the planet Jupiter assume at various times, is one not only of absorbing interest, but, moreover, of a nature somewhat delicate, for the bodies in question are so minute as to baffle any but the very best and trustworthy observers. Such observations, then, to be of any value at all, must be either made in the clearest of atmospheres with a moderately large aperture, or in a moderately clear atmosphere with a very large aperture. Considering these two conditions, one would doubtless think that the larger the instrument the more chance there would be of finding out the shape of a body, and with a very clear atmosphere in addition these chances would be very greatly increased. On the other hand, however, we have the facts still in our mind of Schiaparelli's wonderful observing powers, which enabled him to notice the doubling of the canals of Mars with his small aperture long before they were declared "double" by other observers. In this case one would have thought that such an observation would have been more easily observed with large apertures than with the small telescope which was at his disposal.

Let us, however, turn to the facts at hand with regard to the satellites that are now under discussion; but first a few words with regard to the instrumental equipment employed and the observing stations.

Prof. Pickering's observations have been made at the Observatory that is situated near Arequipa, in Peru, at an altitude of more than eight thousand feet, where the sky during a large part of the year is nearly cloudless. The telescope employed has shown that there is a remarkable degree of steadiness in the atmosphere, and night after night atmospheric conditions prevail, which, as he says, "occur only at rare intervals, *if ever*, in Cambridge." Several of the diffraction rings surrounding the brighter stars are visible, close doubles in which the components are much less than a second apart are readily separated, and powers can be constantly employed which are so high as to be *almost useless* in Cambridge. In fact, he says that in many researches the gain is as great as if the aperture were doubled. The aperture of the refractor employed is 13 inches.

Prof. Barnard has made his observations, on the other hand, with the now well-known 36-inch refractor of the Mount Hamilton Observatory, a description of which here would be unnecessary; suffice it to be mentioned that Prof. Burnham has increased the number of double stars by about 200 during his brief use of this instrument, most of which are beyond the reach of the majority of telescopes.

Turning now to the observations of the satellites themselves, we find the first account of Prof. Pickering's observations in the March number of *Astronomy and Astro-Physics* for the year 1892.

On October 8, a series of measurements was made of the diameters of the satellites. On the next evening it was noticed that the disc of the first was not circular but very elliptical. Early observations on the tenth confirmed the measurements made on the eighth, but after an examination of the other satellites the first was again measured, when, as Prof. Pickering says, "to my astonishment, instead of showing an elliptical disc, it showed one that was perfectly circular, precisely like the other satellites." He further goes on to say that the disc gradually began to lengthen again and assume the elliptical form. From these observations it was concluded that the first satellite had the form of a prolate spheroid or ellipsoid, or, in other words, was egg-shaped. A week later each of the other satellites had been recorded to some extent elliptical. Curious to relate, the three outer satellites, according to the observations, appeared *shortened* equatorially, not *lengthened*, showing that they did not seem to revolve round their minor axes.

It was not surprising to notice that Prof. Pickering was at first rather sceptical about the truth of these observations, and assuming that they might be produced optically or otherwise, he employed every method which would eliminate such ambiguity. These researches gave a negative result. It occurred to him, also, that the effects seen might be due to light and dark spots, suitably placed upon the surface, but during the time of the satellites' transits, and when they were about to disappear, no such spots were seen, although some surface markings on the first, third, and fourth satellites have been discovered.

The results to be gathered from the observations made up to this time may be summed up as follows:—

(1) The first satellite is a prolate ellipsoid revolving about one of its minor axes in a period of 13h. 3m.; and (2) the discs of the second, third, and fourth satellites at regular intervals assume the forms of ellipses, and these periodic changes are presumably produced, as is thought, by rotations upon their axes.

The second contribution on the form of the satellites appeared in the May number of the same journal for the following year, and Prof. Pickering opens with the statement that "what have appeared to be most natural suppositions have been found so frequently to be contradicted by the facts, that it seemed best to take nothing for granted with regard to them." The observations here deal first with the direction and period of rotation, giving as a result a probable retrograde motion of rotation for the first satellite.

With regard to the change of forms, it was noticed that the first satellite on January 13 appeared distinctly shortened equatorially when at its minimum phase, the phenomenon lasting thirty-four minutes; while the second satellite is occasionally described as appearing long, like the first. At the maximum phase the second, like the two outer satellites, has appeared round; and the third, at some of its minima retains the elliptical phase for a longer time than at others. Thus, for instance, it remained short for the three days, January 13, 14, and 15, consecutively.

The next account of further observations are contained in a long paper entitled "The Rotation of Jupiter's Outer Satellites," which appeared in the following June number. The observations here are given more in detail, but we will confine ourselves to the main points, commencing with those relating to the largest and most easily observed of the group, *i.e.* the third. This satellite, according to Prof. Pickering, presents an elliptical phase twice during its revolution in its orbit at an interval of about thirty-four hours after passing conjunction. When on the eastern side it presents an elliptical disc, and the inclination of the major axis to the orbital planes is clearly marked and has been measured on several occasions, the mean value being $-10^{\circ}\cdot5$ P. angle. We have here also some important observations of details visible on this disc of the satellite, which, as Prof. Pickering says, "can without much difficulty be made out."

A careful study shows that the marking usually appears forked, and is sometimes turned to the right and sometimes to the left, and at other times it is seen double, appearing like the letter X turned on one side. Another appearance of the markings on the surface of the same satellite is as if an equatorial belt on one side had been drawn out in both directions of the poles, its breadth increasing as the limb is approached, being in fact trumpet-shaped. A measurement of the position angle of the axis of the belt gave $+15^{\circ}\cdot5$.

Special precautions were taken to find out whether the belt were a genuine phenomenon, or an illusion due either to the instrument or the observer, but these resulted in it being declared real. The observations for the determination of the rotation of this satellite implied a period of rotation coinciding with that of the revolution of the satellite in its orbit.

A recapitulation of the facts relating to the third satellite observed up to this time may be made here:—

Two observers see the disc flattened at regular intervals, and agree upon direction of flattening. Both see a belt in same position, direction, and character of detail, and both remark that the observations are not very difficult, but quite evident when attention is called to them.

The details in the other satellites seem to be more difficult to see than those on the third. The direction of the bands (one or two) in the first satellite lies in an approximately north and south line, while on only one occasion there was detail detected on satellite II., and this consisted simply of a small patch or spot.

The observed facts with regard only to the forms of these discs are:—

The shape of the first is elongated. The regularly recurring changes of shape of the discs of the outer satellites (caused apparently by rotation). The change of position angle of the major axis of the third, and probably of the fourth in different parts of their orbits. The peculiar behaviour of satellite III., which in October and November was recorded as shortened in the polar direction, but which was afterwards recorded upon two nights as perfectly round, when it should have exhibited its maximum ellipticity. The frequently recorded lengthening (equatorially) of satellite II., which is not corroborated by recent observation. Apparent irregularities in period and ellipticity of the second and, perhaps, the fourth, and the occasional irregular non-elliptical shape of the disc of the third.

Such, then, is the sum total of the observations which up to that time had been made by Prof. Pickering, and we will now turn our attention to the re-examination of the satellites by Prof. Barnard with the help of the great Lick refractor. (*Astronomy and Astro-Physics* for April, 1894).

He commences by telling us that the satellites I., III., and IV. often undergo singular transformations of apparent form during certain stages of their transits across the face of Jupiter, but he had never "seen any of these moons other than round when off the disc of the planet."

In the latter end of the year 1893 to the beginning of 1894, with a power of 1000 diameters, and sometimes higher, he made numerous observations, with the object of detecting, if present, deviations from the disc forms.

The results showed that no such deformations were observed, and Prof. Barnard is inclined to think that the surface markings of the satellites themselves, when near the edges of the discs, might readily cause apparent distortions in these satellites, as they certainly do so when the satellites are in transit, especially when very high magnifying powers on a small telescope are employed. It is curious, he adds, that such deformations should escape detection with our great telescope, even with the most casual observations, considering how conspicuous are the distortions recorded at Arequipa. It is of interest to note one or two remarks accompanying some of the observations, thus:—

		h. m.	
1893 ...	Dec. 3 ...	...	I. is near transit, following, it appears slightly elongated towards Jupiter.
1893 ...	Dec. 11 ...	9 18 ...	I., II., III., each is round, IV. seems a little deficient on following side, as if a slight phase existed, &c.
1894 ...	Jan. 28 ...	6 50 ...	I., II., III. are round, IV. is slightly deficient on following side, as if a slight phase or a dark area existed in it.

The time referred to above is Standard Pacific time, 8 hours slow on Greenwich.

The notes, however, are generally of the following type, a few of which may be mentioned here.

		h. m.	
1893 ...	Aug. 28 ...	14 30 ...	All four are round.
	Sept. 3 ...	13 0 ...	All four are round.
	Sept. 24 ...	12 48 ...	III. is perfectly round.
	Sept. 25 ...	15 0 ...	All four are round and clearly defined.
	Oct. 1 ...	16 40 ...	I. and III. perfectly round.
	Nov. 6	11 54 ...	III. is beautifully round.
		14 40 ...	III. is perfectly round.
	Dec. 10 ...	9 25 ...	All four are round. North Pole of III. is white.

These observations show that either the satellites on the whole appear generally round, or that the Lick observers have been so unfortunate as to observe them just at those times when the circular discs were to be seen. This seems at first thought to be very improbable, for the reason, as Prof. Barnard himself remarks, that the Arequipa observations indicate distortions that are apparently so very conspicuous.

In the June number of *Astronomy and Astro-Physics* (p. 423), Prof. Pickering gives in reply a short note to the observation made by Prof. Barnard. There are here, also, some measures of the position angle of the elongation of the first satellite as secured by himself and Mr. Douglas upon six different nights, a copy of which is below.

I. Satellite.

Time	P.A.	Dev.	Obs.	Diff.	Corr.
1892, Nov. 28 ...	100°·5	3°·7		°	°
,, ,, ...	108·3	8·7	P	+ 7·8	+0·7
Dec. 26 ...	100·0	7·6	D		
,, ,, ...	106·1	4·9	P	+ 6·1	-1·0
,, 29 ...	103·8	5·0	D		
,, ,, ...	116·8	3·2	P	+13·0	+5·9
1893, Jan. 1 ...	90·0	6·0	D		
,, ,, ...	95·7	3·4	P	+ 5·7	-1·4
,, 13 ...	99·2	4·2	D		
,, ,, ...	104·8	3·7	P	+ 5·6	-1·5
,, 17 ...	92·4	3·8	P		
,, ,, ...	97·9	3·2	D	+ 4·6	-2·5
		±4·8		+ 7·1	±2·2

Each measure is the mean of six readings, taken alternately in opposite directions. These measures show that the observations are fairly concordant, only that there seems to be a mean personal correction of about 7°·1. The first column gives the date of observation, the second the observed position-angle of the major axis of the disc, the third the average deviation of the readings which combined give the individual measures, the fourth the observers, the fifth the differences between these results, and the sixth these differences corrected by the constant angle 7·1.

In the last column, the mean 2°·2 indicates the average difference between the corrected measure of the two observers upon any night, which shows a remarkable accordance between the measures.

There can be no doubt that there was some peculiarity about this satellite that was under measurement at the time, a peculiarity which, as Prof. Pickering says, was apparent when it was not in transit, but which vanished at regular intervals of 6h. 32m. Why Prof. Barnard has not been able to witness what seems to be a very distinct phenomenon, if it be not really "personal," seems to raise considerable surprise. Although Prof. Pickering does not deny the existence of the equatorial belts, yet he will not accept it as an explanation of the changes of form noticed, for he says, "such a belt could not have produced the effects observed by us in Arequipa."

A further investigation on the forms of the discs has recently been made by Prof. Schaeberle (*The Astronomical Journal*, No. 321, p. 70), with the intention of detecting, if possible, the rapid change of phase which Prof. Pickering's observations so strongly advocate. The results showed, however, that, by tabulating the ratios of the measured major and minor axes of the several elliptical discs, a practically constant form for the outline was always obtained. We may mention here that to Profs. Campbell and Schaeberle the first satellite appears round only when "it is near to or projected on the disc of Jupiter, and elongated in the direction of the planet's equator in all other positions."

In judging between the weights that ought to be applied to observations made at Arequipa and Mount Hamilton, a fact here is mentioned that is by no means insignificant in showing the superiority, in this case at any rate, of the Mount Hamilton observations over those made at Arequipa.

The observations in question relate to the abnormal forms of the shadows of the satellites, the true forms of which were observed at the Lick Observatory by Prof. Schaeberle and by other observers at different places and times.

The shadows of these satellites as they pass before the disc of Jupiter become at times apparently distorted to observers on the earth's surface, owing to the oblique illumination of the satellites in some positions of the earth, and to the spherical nature of Jupiter's surface.

These distortions reach sometimes very considerable proportions, more considerable, in fact, than the changes of shapes of the satellites, as observed by Prof. Pickering. This being so, it is curious indeed that from Arequipa we have, as far as is known, no mention of such shadow distortions at all, and as Prof. Schaeberle remarks, "one would naturally suppose that an observer, after having discovered, as he believed, a periodic variation in the form of a satellite, would seek to verify his results by examinations of the satellite's shadow during its transit across the disc of the planet."

An idea of the size of the distortions alluded to may be gathered from Prof. Schaeberle's statements that, at the time of the Arequipa observations in January of last year, the longest (longitudinal) diameter of every shadow just after the ingress on the visible disc of Jupiter was "more than twice the breadth of the shadow, while at egress just the reverse condition of things existed."

Such, then, is the present state of affairs. Prof. Pickering sees these small bodies regularly changing their shapes; Prof. Barnard sees them always perfectly round; while Profs. Schaeberle and Campbell see them only round when near to or projected on the disc, and at all other times constantly elongated.

The only conclusion that can be drawn, if one is at liberty to draw any at all, is that in the estimation of the shapes of such small bodies a great amount of personal error is liable to creep in, and the estimation of such must be left for future determination.

It would be interesting, however, to know how the observations would differ, if Prof. Barnard and Schaeberle had the use of the Arequipa instrument at a favourable opportunity, and Prof. Pickering the Mount Hamilton refractor. W. J. S. Lockyer.

GEOLOGY AND SCENERY IN IRELAND.[1]

Mr. R. Welch, of Belfast, well-known as a photographer of Irish scenery, has of late years utilised his intimate knowledge of the country, and his keen judgment as an artist, in the preparation of special series of photographs illustrating archæological and scientific features. The brilliant exposures of volcanic and sedimentary rocks along the coast of Co. Antrim have of the Geological Survey of Ireland have always been willing to give information as to suitable illustrative localities.

Two samples will show something of the detail and the range of these photographic records. Fig. 1 shows one of the fine quarry-sections on Cave Hill, Belfast. The chalk below, with lines of flints, and the basaltic lavas of the upper plateau, are always an effective contrast; but at this point dykes of dolerite are numerous, cutting through both series. The large one in the centre of the picture is columnar in its upper portion, and has a somewhat wavy course. A smaller sinuous dyke climbs towards it from the right. In the left of the original photograph, a delicate bifurcating intrusive sheet is clearly seen near the top of the horizontal lavas. Fig. 2 is a still more specialised illustration. The whole stream

Fig. 1.—A Quarry Section on Cave Hill, Belfast.

led him to form a group of pictures which might serve as a companion to any ordinary text-book of geology; and he is rapidly extending the series by additions from the counties of Down, Donegal, and even from the far south-west. As I have had the pleasure of assisting Mr. Welch in the production of his first geological catalogue, I can make no comment on its character as a publication; but I need not hesitate to point out what valuable aid is being given to science by the recording of the physical features of Ireland, not haphazard in a series of general landscapes, but with a special geological eye. The excursions of the Belfast Naturalists' Field Club have been the means of calling attention to exposures in places outside the ordinary tourist-track; and the officers

[1] A Catalogue of Geological Irish Views, by R. Welch, 49 Lonsdale Street, Belfast.

of Glenariff is seen pouring into a pot-hole some four feet across, and the smooth sides of the hole, and the swirl of waters in its still active portion, have been admirably rendered. On the left, the rock, which is a red Triassic sandstone, shows the grooving and smoothing action of the stream. It would be interesting to photograph this spot again after an interval of twenty years.

The reproduction of such views as these in the form of lantern-slides makes them still more valuable to teachers. It is pleasant to know that Co. Antrim has its geological features now recorded for us more completely than those of any other county in the British Isles; and Mr. Welch may be congratulated on undertaking this and other scientific missions in the midst of more immediately popular professional work. The recent visit of the Geologists' Association to Ireland did much to direct attention to the geological features, as well as to the scenic beauties, of the eastern coast; it may be hoped that Mr. Welch's photographic series will form an introduction and an inducement to another visit, this time to the fascinating variety of igneous rocks and Mesozoic strata in the north.

GRENVILLE A. J. COLE.

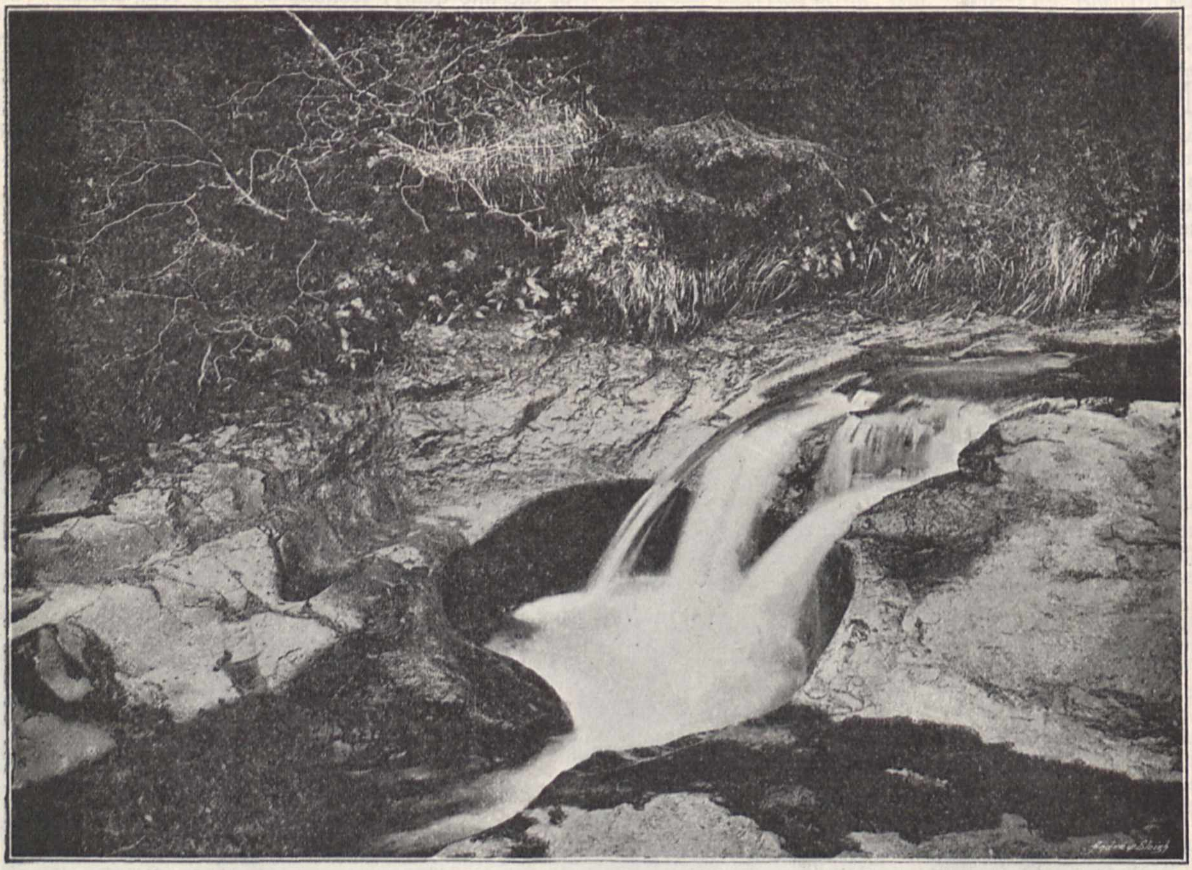


FIG. 2.—Pot-Hole excavated in Triassic Sandstone, Glenariff.

NOTES.

WE are pleased to learn that Prof. Prestwich, F.R.S., has been made Foreign Member of the R. Accademia dei Lyncei, Rome, for geology and palæontology.

WE regret to hear of the death, from typhoid fever, of Prof. G. H. Williams, of Baltimore. The United States has of late years produced a band of admirable petrographers, amongst whom Prof. Williams has long held a foremost place. His early death will be lamented by a large circle of friends in Europe.

WE are sorry to have to record the death, at the age of sixty-six, of the Rev. Edward Hale, who had been for some years the senior science master of Eton College. Mr. Hale died on July 25.

THE annual meeting of the Institution of Mechanical Engineers was opened at Manchester on July 31, and is proceeding. Prof. Kennedy is presiding.

THE sixty-second annual meeting of the British Medical Association is taking place at Bristol under the presidency of Dr. E. Long Fox, who delivered his presidential address at the evening meeting of Tuesday last.

THE British Pharmaceutical Conference began its annua meeting at Oxford on Tuesday, July 31, when Mr. N. H. Martin, of Newcastle-on-Tyne, took the chair, and delivered an address.

THE autumn meeting of the Iron and Steel Institute of Great Britain, which this year takes place at Brussels, from August 20 to 24, will probably be very well attended, about 500 members having already intimated their intention of being present. The arrangements for the meeting are being organised by an influential local reception committee, of which M. Gillon, president of the Society of Engineers of Liège, is chairman, in conjunction with the general secretary of the Institute, Mr. Bennett H. Brough. During the meeting, excursions will be made to the Antwerp Exhibition, the Mariemont Collieries, the Couillet Steel Works at Charleroi, the works of the Cockerill Company at Seraing, and the Angleur Steel Works at Liège. The programme of papers to be read and discussed is a long one, there being no less a number than ten arranged for. The first on the list is, "On the Use of Caustic Lime in the Blast Furnace," by Sir Lowthian Bell. Other papers are to be contributed by Messrs. R. A. Hadfield, T. W. Hogg, H. C. Jenkins, W. G. M'Millan, John Parry, and D. Selby-Bigge, respectively, and there are to be two papers of local interest, written by Belgian engineers. Their titles are, "On the Coal-Mining Industry of Belgium," by M. Briart, President of the Society of Engineers of Hainaut; and "On the Iron and Steel Industries of Belgium," by M. A. Gillon, President of the Society of Engineers of Liège.

THE Medical Congress which is to be held in Calcutta from December 24 to 29 next, and to which we briefly referred in our issue of July 5, is, according to present arrangements, to be divided into six sections, viz.: I. Medicine and Pathology. II. Surgery, including Ophthalmology. III. Obstetrics and Diseases of Women and Children. IV. Public Health. V. Medico-legal Medicine and Insanity. VI. Pharmacology. It is hoped that medical men from countries other than India will co-operate to make the Congress a success. Special efforts are being made to secure the comfort of visitors.

THE programme of the one hundred and eleventh meeting of the Yorkshire Naturalists' Union has been issued. The meeting will be held on August 6, at South Cave, for the investigation of the neighbourhood of Drewton Dale, Weedley Springs, and Wold Dale. The sciences of geology, botany, vertebrate zoology, entomology, and conchology will be officially represented by members told off for the purpose; and if the weather be favourable, the meeting will, no doubt, prove as popular as those on former occasions.

THE eighth meeting of the International Ophthalmological Congress will be held at Edinburgh in the second week of this month, under the presidency of Dr. Argyll Robertson. It is thought that about 300 ophthalmic surgeons will be present. The last meeting took place at Heidelberg in 1888.

THE spring of next year will see established at Earl's Court an exhibition, on a large scale, devoted to the products of India.

THUNDERSTORMS occurred over the southern and midland parts of England on Sunday, accompanied by heavy falls of rain, amounting to nearly one inch in several places. Over the southern and south-western parts of England, as well as in the south of Ireland, the total rainfall during July has greatly exceeded the average, in many places being double the usual amount, while at Jersey the total was about seven inches, which is nearly three times the average for July, and it is the heaviest fall in that month during the last twenty-nine years. In the east of Scotland and north-east of England the rainfall for the month was rather less than the average.

WE have received from Dr. W. Doberck, a copy of the observations and researches made at the Hong Kong Observatory in the year 1893. The meteorological observations are given for every hour, while the means and various deductions from them have been carefully arranged in tables in a convenient form for future use. The mean temperature during the last ten years was 71°·3, the maximum was 93°·9, and the minimum 32°·0. The average rainfall for a period of thirty years was 90·17 inches; rain mostly falls between May and August. Dr. Doberck gives a useful summary of the climate investigated from ten years' observations. There is a well-marked variation of climate; the winter is cool, its mean temperature being about 60°, while in summer it rises a little above 80°; at this season Europeans suffer much from the excessive dampness of the air. The solar radiation is very considerable in all months; the maximum during 1893 was 154°, in August. Much attention is paid to the study and prediction of typhoons; telegrams giving information about them were issued on eighty-seven days, and with a view to the systematic study of these storms, observations are regularly extracted from ships' logs. During the year no less than 672 logs with entries during typhoons were received, and these were supplemented by observations made at about forty land stations. These various useful researches, in addition to the regular astronomical and magnetical observations, try the powers of the small staff to the utmost, and Dr. Doberck states that the work is much hampered by want of sufficient office accommodation.

THE *Lancet* states that Dr. Bornand, the eminent Swiss consultant lately deceased at Berne, bequeathed his fortune (which was considerable) to the Académie de Lausanne for the endowment of a chair of Embryogeny in that school. His *armamentarium chirurgicum* and his microscopical instruments he also presented to the Académie, while his magnificent library become property of the *bibliothèque cantonale* of his native Canton de Vaud.

WE learn from the *Academy*, that the Pengelly Memorial Fund now amounts to about £1360; and the committee have determined to proceed immediately with the erection of a lecture theatre, as part of the proposed addition to the Natural History Museum at Torquay, of which Mr. Pengelly was the founder.

A CIRCULAR has been sent to us announcing the proposed formation of a society, whose headquarters are to be located at Sydney, to be called "The Palæographical Society of Australasia." The following are among the objects which the society is being established to promote:—"To collect, illustrate, and place on record, examples of all systems of old time written characters, whether in the form of pictograms, symbolisms, or phonograms, as also representations of the various mnemonic aids to memory used by so many savage and barbarous peoples. To undertake the collection and formation of a library, to consist of works treating of or connected with Palæography and kindred sciences, as also collections of photographs and other exact copies and illustrations of rock inscriptions, cave paintings, &c. To afford a means of communication and co-operation between those interested in the science of Palæography, who are now unable to obtain this mutual aid. To assist students as far as possible in the work of deciphering new or unknown characters." The Society will, it is announced, be formed as soon as the initial membership reaches a hundred; when, therefore, that number of intending members send in their names, &c., to one or other of the gentlemen named below, a meeting will be called for the purpose of electing officers, passing of rules, &c. The subscription fee is to be one pound per annum. It is intended to establish a periodical as organ of the society, in which will appear original articles on the science of Palæography, with illustrations of various scripts. Further particulars may be obtained from Dr. A. Carroll, Kogarah, Sydney, N.S.W.; or Mr. Elsdon Best, Wellington, New Zealand.

A NUMEROUSLY attended meeting of the Essex Field Club was held last Saturday, in the Navestock district, under the conductorship of the Rev. S. Coode Hore and Prof. R. Meldola, F.R.S. Alighting at Brentwood Station, the party were driven to the site of an ancient entrenchment, which the conductors had identified with the "alate temple of the Druids," described by Dr. Stukeley in the last century. A *fac-simile* of Stukeley's figure, made by Mr. Walter Crouch, was handed round for inspection. Nothing of these ancient remains is now to be seen, excepting a circular depression, and a fosse connected with it, situated in a field bordering the road. From this spot the party proceeded to Navestock Park, the estate of Lord Carlingford, where they were most hospitably entertained at luncheon by Mr. and Mrs. D. P. Sellar, of Dubrook. An ordinary meeting of the Club was held after luncheon, and a discussion took place respecting the proposed cession of certain Essex parishes to Hertfordshire and Cambridgeshire, under the Parish Councils Act. A resolution protesting against this cession was unanimously passed, and a copy ordered to be sent to the Essex County Council and to the Essex Members of Parliament. The members next proceeded to inspect an ancient earthwork in a wood near the park, which earthwork is entered as a camp in the ordnance map. It consists of a well-defined rampart and ditch, and is of an oblong form, with a spur at one angle. The site is now known as "Fortification Wood," but was formerly known as the "Defence of Navestock." The party next proceeded towards the Roding Valley, and were conveyed to Curtismill Green, an outlying fragment of old Hainhault Forest, which, with Epping Forest, formerly constituted the Forest of Waltham. Here they were shown an upright stone, which the conductors had identified as "Richard's Stone," one of the boundary stones set up at the time of the perambulation of the Essex Forest in 1641-1642. Standing by this stone, marking the extreme north-eastern extension of the old forest, Prof. Meldola gave a short account of the history of the perambulation, and stated that with his colleague, Mr. Coode Hore, and Mr. William Cole, the hon. secretary, and his brothers, they had now found five out of the seven boundary stones referred to in the perambulation. The fragment of primitive forest between "Richard's Stone" and the "Navestock Stone" was much admired, as far as time permitted an inspection, and a desire was expressed that steps should be taken for securing the permanent preservation of all these interesting boundary marks, the more especially as the forest of Hainhault has, with the exception of a few isolated patches, been entirely cultivated out of existence. From "Richard's Stone" the party drove through some of the most picturesque parts of the county to South Weald, where, at the "Tower Arms," tea was awaiting them. After tea another meeting was convened for the purpose of hearing a most interesting paper by Mr. Coode Hore, in which he gave a series of notes on the history of Navestock in Saxon and Norman times, and made reference to the prehistoric remains visited in the course of the day.

THE annual report of the Director of the Royal Botanic Garden, Calcutta, for the year 1893–94, has just reached us. During the year the Herbarium was enriched by more than 16,000 specimens, and the Garden in return sent out numerous specimens to various botanical institutions in different parts of the world. Reference is made to a great storm which raged for nearly the whole of three days in the month of May, and the damage done was so great that for about six weeks after its occurrence the whole of the out-door labour staff was engaged in making repairs. A more suitable platform for Colonel Kyd's monument was erected, the roads in the grounds were generally improved, and the gardens are reported to have been maintained in a high state of efficiency.

M. L. CAYEUX (*Bull. Soc. Geol. France*) describes radiolarians from rocks in Brittany which are generally admitted to be pre-Cambrian. They occur in siliceous bands in the "Phyllades de Saint-Lô." The evidence for the pre-Cambrian age of these beds is stated by Dr. Barrois. Many of the radiolarians described belong to the genera still existing.

A PAPER on the "Shasta-Chico Series," of N. California and Oregon (*Bull. Geol. Soc. Amer.*), by Messrs. J. S. Diller and T. W. Stanton, is interesting as discussing the limits of the Cretaceous and Jurassic formations on the Pacific Coast. The series has a maximum thickness, on Elder Creek, Tehama Co., California, of 30,000 feet; the whole set of beds graduating into one another as one continuous series. It was formerly supposed that the lower (Knoxville) beds graduate into the Mariposa beds—the highest Jurassic; the authors contend that there is both a physical and palæontological break between them. The highest Cretaceous rocks are not here represented, and the Téjon beds, which probably are not the oldest Eocene, rest unconformably upon the Chico series. In Middle and Southern California the Téjon beds are believed to be conformable to the Chico beds.

PROF. H. F. OSBORN discusses the characters and faunal relations of the Laramie Mammals (*Bull. Amer. Mus. Nat. Hist.* vol. v., p. 311), and shows that they are more nearly related to the Puerco (Eocene) mammals than they are to those of the Jurassic series. This is specially illustrated by the evolution of the teeth. In the same volume, there are papers by Prof. Osborn, Dr. J. L. Wortman, and Ch. Earle, on the Lower Miocene mammalia of North America. The White River deposits have a maximum thickness of about 800 feet, and they represent a great period of time, during which the Titanotheriidæ, Rhinocerotidæ, Equidæ, and Oreodontidæ underwent considerable modification, amounting in some cases to changes of true generic significance.

A NEW design for large spectroscopic slits is described by Mr. Wadsworth in the current number of the *American Journal of Science*. Of the various forms of double motion spectroscope slits which have been designed, the two forms in most common use are the parallel ruler form, as fitted to most German instruments, and that form in which the jaws slide in guides, and are moved simultaneously in opposite directions by a right and left hand screw. The first form is convenient but somewhat bulky, and makes it difficult to determine the exact width of the slit. The second form, in which the screw is necessarily at one side of the jaw, gives rise to a twisting strain tending to make the slit wider at one end than at the other, an objection which becomes very serious in slits above 5 cm. in length. The author's new form, designed for Prof. Langley, has the advantage of giving a central thrust on both jaws while keeping the slit accurately centred. This is accomplished by making the milled head move the whole jaw system along the slit plate by means of a nut screwed to the latter, while another screw on the same shaft, but of double the pitch, moves the nearer jaw independently in the opposite direction. Thus the centre of the slit remains fixed, the jaws opening out from it. A spring provides for the return motion, and takes up all back lash in the screw. The graduated head gives by its motion over a graduated drum the whole number of turns and fractions of a turn, enabling the width of the slit to be determined at a glance. The thrust being central, there is no tendency to twist the jaws in their guides. The slit has a clear opening of 10 cm.

IT appears that the public in Brooklyn, U.S.A., are making use of the stray current from the electrical tramways, driving motors and lighting lamps, by connecting the terminals to the metallic framework of the overhead railways and to the water-pipes; while it is proposed in one of the suburban telephone exchanges to utilise the above current, and do away with the batteries. The loss of energy on the American lines where the current is supplied by a trolley wire, and the return takes place by the rail, is very considerable, and the above use of the stray current is much more likely to draw the attention of the tramway companies to these losses than the corrosion of the water- and gas-pipes, the damage to which we have on previous occasions referred.

ACCORDING to the *Pioneer Mail*, Allahabad, the anthropometrical system of identification has already proved of practical use in Bengal. Previous convictions against six men, who had been sentenced in districts beyond Calcutta, were traced by its means.

Engineering for July 27 is a special number, and is, for the most part, taken up with a description (with illustrations) of the various mills and appliances used in the manufacture of cotton at or near Manchester, in which city the Institution of Mechanical Engineers is at present holding its summer meeting. This section of the number is, in fact, specially designed for the use of those who are taking part in the meeting of the Institution.

PART 2 of vol. xv. of the *Journal* of the Sanitary Institute contains, besides Proceedings of the Institute, notes on sanitation abroad, &c., an article by Dr. Louis Parkes, entitled "The Possibility of the Spread of Disease through the River Waters supplied to London," being a review of the evidence given by the bacteriological witnesses before the Royal Commission on Metropolitan Water Supply, 1893.

THE August number of *Natural Science* contains the following articles:—"The Evolution of the Thames," Dr. J. W. Gregory; "Some Account of the Gall-making Insects of Australia," W. W. Froggatt; "Books of Reference in the Natural Sciences," C. Davies Sherborn; "Some Reforms in the Oxford University Museum," E. S. Goodrich; "Hertwig's 'Preformation or New Formation,'" P. Chalmers Mitchell; and a special illustrated supplement on "Taxidermy as a Fine Art." The process illustrations in this supplement, and in the article by Mr. Goodrich, are for the most part very successful.

THE "Proceedings of the Physical Society of London," vol. xii. part 4, has just been issued.

THE August part of *Science Gossip* has a portrait of Dr. Ludwig Mond, F.R.S., the munificent donor of the new laboratory for physical and chemical research in connection with the Royal Institution, to which we referred at length in our issue of July 5.

ANOTHER remarkable nitrogen compound, nitramide NO_2NH_2, is described in the current *Berichte* by its discoverers, Drs. Thiele and Lachman, of Munich. A short time ago, these chemists showed that by the action of sulphuric and nitric acids upon urethane a nitro-derivative, nitrourethane $NO_2 . NHCOOC_2H_5$, was produced. When this substance is dissolved in water, and the concentrated solution is mixed with a large excess of a concentrated solution of caustic potash in methyl alcohol, and the mixture cooled by ice, a potassium salt of the composition $NO_2 . NK . COOK$ is deposited in crystal plates. If these crystals are placed in water they instantly decompose with great rise of temperature into potassium carbonate and nitrous oxide. If, however, they are placed in a mixture of ice and sulphuric acid, carbon dioxide is evolved, and the new substance nitramide is produced. It may be extracted by means of ether, and upon evaporation of the latter it is left behind in the form of clear colourless prisms. The crystals melt at 72°, but the least trace of moisture lowers the melting point very considerably. Nitramide is readily soluble in water, ether, and alcohol, but difficultly soluble in benzene. The aqueous solution reacts strongly acid. Nitramide is volatile, considerably so even at the ordinary temperature. It is an unstable substance, and decomposes on mixing with copper oxide or lead chromate, or even on admixture with powdered glass, great rise of temperature occurring in each case. The products of decomposition are nitrous oxide and water. When heated rapidly above its melting point it explodes. Nitramide is instantly decomposed by alkalies, not only by caustic alkalies but also by carbonates, ammonia, borax, and even sodium acetate, in the cold, with evolution of nitrous oxide. It would thus appear to be incapable of forming salts, at any rate in solution. The crystals explode violently, with production of flame, when a drop of caustic soda or potash is allowed to fall upon them. The ethereal solution of the crystals yields with ammonia a precipitate of an ammonium salt, but it decomposes almost immediately with evolution of gas. Concentrated sulphuric acid or hot water similarly provoke violent decomposition. Upon reduction a substance endowed with powerful reducing properties is produced, which would appear to be hydrazine $\begin{array}{c}NH_2\\|\\NH_2\end{array}$. The discoverers of this interesting substance are continuing the study of its reactions, and are attempting to prepare it in a purely inorganic manner.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*), a Hygian Snake (*Elaps hygiæ*) from South Africa, presented by Mr. J. E. Matcham; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. J. A. Brand; a Common Paradoxure (*Paradoxurus typus*) from India, presented by Mr. E. Stallard; a Suricate (*Suricata tetradactyla*) from South Africa, presented by Miss Champneys; an Indian Cobra (*Naia tripudians*) from India, presented by Mr. Angus M. Kinloch; two Slowworms (*Anguis fragilis*), British, presented by Mr. T. E. Gunn; two —— Opossums (*Didelphys*, sp. inc.) from South America, a Common Cassowary (*Casuarius galeatus*) from Ceram, a Hawk-headed Parrot (*Deroptyus accipitrinus*) from Brazil, two Hamadryads (*Ophiophagus elaps*) from India, deposited; a Pleasant Antelope (*Tragelaphus gratus*), bred in Germany, purchased; a Thar (*Capra jemlaica*), a Red Deer (*Cervus elaphus*), three Cairo Spiny Mice (*Acomys cahirinus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

SPECTROSCOPIC VELOCITIES OF BINARIES.—The determination of the elements of double-star orbits from spectroscopic measurements has been attempted by two methods. That due to Dr. Wilsing, which is a very convenient one, is only applicable to cases of small eccentricities; another method, developed by Dr. Rambaut, is not subject to this limitation, but is rather elaborate. In No. 3242 of the *Astronomische Nachrichten*, Prof. R. Lehmann-Filhés works out a method somewhat akin to that of Dr. Rambaut, but which he claims to have discovered independently, and which does not require difficult calculations or constructions. If both components of a spectroscopic double are bright enough to give a measurable spectrum, as is the case with β Aurigæ and ζ Ursæ Majoris, the velocities as determined from the displacement of the lines in the spectrum are taken as relative, and the investigation then deals with the motion of one mass with respect to the other considered as stationary. If, on the contrary, only one of the components gives a measurable spectrum, as in the case of Algol and α Virginis, the motion must be referred to the centre of gravity of the system, the radial velocity of which must be determined and subtracted from the observed velocities. The period of the star is easily determined by observing a considerable number of periodic variations, and all observations can then be reduced to a single revolution by adding or subtracting multiples of the period. These spectroscopic velocities are then plotted as ordinates with the times as abscissæ, and a wavy curve is thus obtained showing the maximum and minimum velocities relative to the solar system. If these velocities are referred to the centre of gravity of the system, the areas of the curve above the axis of abscissæ must be equal to those below, *i.e.* the total displacements must neutralise each other. This gives a condition which the curve must fulfil, and which serves to control the observed velocities. Another condition is that the area intercepted between the maximum positive ordinate and the next point of intersection with the axis of abcissæ must be equal to the area of the curve between that point and the maximum negative ordinate, this representing the motion of the star from the ascending to the descending node. Prof. Lehmann-Filhés gives simple formulæ for determining the various elements of the orbit from the corrected curve. Comparing his method with that of Dr. Rambaut for the case of β Aurigæ, he finds 0·158 for the eccentricity, where the latter found 0·156, and 57°·93 for the longitude of the ascending node, against Dr. Rambaut's 57°·43, showing differences which are well within the errors of observation. The real daily motion is found to be 90°·726, corresponding to a period of 3·968 days. The apparent semi-major axis of the orbit comes out as 7,516,000 English miles, which agrees very closely with the value obtained by Dr. Rambaut, viz. 7,500,000.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE annual summer meeting of the Institution of Naval Architects was held last week, at Southampton, commencing on Tuesday, July 24, and concluding on the Friday following.

The President of the Institution, Lord Brassey, occupied the chair during the sittings, which were held in the theatre of the Hartley Institute. There were only seven papers set down for reading during the three sittings that were held for business purposes, the meeting being, perhaps, rather more of a social nature than usual. The following is a list of the papers:—

(1) "On the Harbour and Docks of Southampton," by John Dixon, Dock and Marine Superintendent of the London and South Western Railway Company.

(2) "On the Importance of Economy of Fuel in very Fast Vessels, and on the advantages to be derived from Heating the Feed-water," by J. A. Normand, of Havre.

(3) "On the Influence of Circulation on Evaporative Efficiency of Water Tube Boilers," by J. I. Thornycroft.

(4) "On the Design of Mail Steamers, with special reference to their use for War Purposes," by J. H. Biles.

(5) "On a Rapid Method of Calculating Wetted Surfaces," by Archibald Denny.

(6) "Recent Experience with Cylindrical Boilers and the Ellis and Eaves Suction Draught," by F. Gross.

(7) "The Ventilation of Steamships, with special reference to the Removal of Explosive and Foul Gases from Bulk Oil Steamers," by S. H. Terry and J. F. Flannery.

Mr. Dixon's paper does not call for extended reference at our hands; it was intended chiefly as a guide to members who were about to visit the Southampton Docks in the afternoon, and was excellently designed for this purpose. Perhaps the most generally interesting part of the paper was contained in the appendices, in which a brief history was given of the various steamship companies that used the docks at Southampton. In a note attached to the paper, some interesting historical details were given. Although Southampton is a very ancient town, its importance was not great in the early days of this century. In the year 1811, we learn that the chief trade was with Jersey, Guernsey, Alderney, and Sark. Several sloops were running between these islands and Southampton. There was also a carpet and a silk manufactory, as well as mills for manufacturing blocks and pumps for the Navy. The number of houses in the town then was 1582, and the population was under 8000. The ship-building industry, however, goes back to very early days, Mr. Dixon stating that in the reign of Henry V. the famous ships *Grace Dieu* and *Holy Ghost* were built at Southampton; this was about the year 1414. One of the vessels was built by Robert Berd, and the other by William Soper; and it is curious to notice that one of the well-known yacht-designers of the district is now a Mr. Soper. Each of the ships referred to cost about £500. During the last century, and in the early days of this century, a very large number of ships for the Royal Navy were built in this district. At a small place called Bucklers Hard, now seldom heard of, a number of famous ships were constructed. This is on the little river Exe, which flows through the New Forest and past Beaulieu Abbey to the Solent. Three ships of the British Fleet which were at Trafalgar, were built there, the most celebrated being Nelson's *Agamemnon* and the *Swiftsure*. Another interesting historical fact stated by Mr. Dixon, was that the timbers of the celebrated American frigate *Chesapeake* were used, when that vessel was broken up, in the construction of a mill at Wickham, near by. The building still exists, and is known as "Chesapeake Mill." The late Admiral of the Fleet, Sir Provo W. Parry Wallis, who died only a short time ago, in 1813 took the *Chesapeake* into Halifax, after her encounter with the *Shannon*.

M. Normand's paper was one of considerable value, and, though short, contained a good deal of useful information. The well-known scientific attainments of French naval architects are excellently represented in M. Normand's firm, and from the Havre yard have been turned out some of the torpedo boats which have been most worthy to be placed in competition with the productions of the Thames builders, Thornycroft and Yarrow. M. Normand is an original designer, his conclusions being based on scientific deduction. He is not content, as some other constructors of fast vessels are, to simply follow the lead of others, ignorantly copying whatever they may see to be successful. As is usually the case with scientific workers, M. Normand is generous in giving information to others, even to his competitors; although he would probably be the first to acknowledge his indebtedness in this respect to the two leading torpedo boat-builders of this country. Indeed, the interchange of information in this way across the channel has always been a pleasant feature in the rivalry of the builders of these beautiful little craft. Torpedo boats are not supposed to be economical vessels, and it has been said that "the mission of a torpedo boat is to run a trial trip." There certainly was a great deal of truth in this remark in the old days of premium for speed, when a boat might earn for her builders several thousand pounds over her contract price if she could scramble through her six runs on the mile without breaking down. In such a case, as there was no restriction in regard to coal burned, economy of fuel was little thought about, and indeed in the ultimate work for which torpedo boats are designed, should they ever be brought to the stern realities of war, it would be a small matter whether much or little coal were burned to attain the high speed. To get to the scene of operation, however, a torpedo boat might have to run a long distance, and in that case her radius of action in regard to coal stowage would be a serious consideration. Moreover, trial trips of torpedo boats now extend over a considerable length of time, and the amount of coal that has to be carried has become an important factor in regard to the total weight, which, of course, in turn governs the speed to a large extent. M. Normand has recognised these facts; he tells us that in his last torpedo boats he has found, by the official trials, that the coal burned per I.H.P. per hour ranged from 1·1 lb. up to 15 knots, and to somewhat less than 2 lb. at 25 knots. These figures seem very low, and the author is certainly within the mark in saying that the consumption is not more than two-thirds of that of a number of similar craft. Another interesting and valuable piece of information given, us by M. Normand, is that the total weight of engines and boilers of the boats above alluded to, is about 48 lb. per maximum I.H.P. and even this extremely light machinery is further reduced in weight, notably in the case of the *Forban*, now under construction at Havre; a vessel, it will be remembered, which is expected to reach a speed of 30 knots an hour, although we believe the contract speed is 29 knots. It may be mentioned here, that Mr. Yarrow has under construction, for the Russian Government, a vessel which is guaranteed to make 30 knots. M. Normand further tells us in his paper, that in high-speed vessels a reduction in the weight of any part of the ship allows the whole displacement to be reduced by about 4½ times the weight saved, if the speed, steaming distance, weight of armament, and general conditions remain unchanged. The author attributes the remarkable economy of his engines to several causes, but more particularly to the feed-heater that he uses. This, he informs us, gives an economy in fuel of at least 20 per cent. The figures seem somewhat startling, but they are vouched for by the author, and have been obtained on official trials. The principle of this feed-heater was enunciated for the first time in 1886 by the author's brother, M. Benjamin Normand. It is a direct application of the first law of thermodynamics. The heating steam is taken, in the ordinary compound engine, at mid-stroke from the low-pressure cylinder by a special valve. In three or four stage expansion engines it is taken direct from the low-pressure casing, all the work previously given in the engine by the heating steam being a direct gain. The author ascribes the economy of 20 per cent., before mentioned, to two causes, viz.: (1) That which results from the number of thermal units saved by using, for heating the feed, steam which has already done work. This may amount to from 10 per cent. to 14 per cent., according to the pressure. (2) That which results from the better circulation of the water in the boiler, a greater proportion of that water being at a boiling temperature. As a practical example of the advantages of this heater, it may be stated that simply by putting it into use, the revolutions of the engine in one vessel were increased from 305 to 335 per minute.

A short discussion followed the reading of this paper, in which both Mr. Thornycroft and Sir Nathaniel Barnaby took part. The chief point of interest was the statement by Mr. Thornycroft, that in the case of the *Daring*, a torpedo boat destroyer recently built by his firm, he believed the weight of machinery per I.H.P. was even less than that stated by M. Normand.

Mr. Thornycroft's paper, like that which preceded it, contained a good deal of valuable information in a small compass.

It dealt especially with one feature in the boiler which has been invented by the author. This steam generator, it will be remembered, consists chiefly of three horizontal cylinders arranged, in cross section, in the form of a triangle. Two of the cylinders are placed in the wings of the furnace, whilst the third, which is above, at the apex of the triangle, the fire-grate forming the base. The top cylinder is connected to the two wing cylinders by two series of curved pipes, which are so arranged as to deliver into the top cylinder at its upper part ; they thus deliver above the water-level of the boiler, which is about half-way up the top cylinder. Connecting the top cylinder with the two wing cylinders, respectively, are two external pipes; the whole, of course, is enclosed by a smoke-jacket, and the steam generation occurs in the connecting pipes. The method of working of the Thornycroft boiler is as follows :—The heat from the furnace playing on the pipes or tubes, which connect the top cylinder to the two wing cylinders, causes generation of steam, the flow of which is upwards. As is nearly always the case when steam is generated in small pipes, a great deal of water is also carried upwards with the steam. This water is delivered into the top cylinder, and from thence is free to flow downwards to the two wing cylinders, from whence it can rise again through the generating tubes, and so on in continuous cycle so long as there is water to be evaporated. The success of a water-tube boiler in practical working may be said to be dependent on its circulation, so that when rapid evaporation takes place, and water is quickly driven away from the heating surface, other water should be there to flow in to take its place. Mr. Thornycroft has always claimed that this circulation is most effectually attained by having the steam-generating tubes deliver in the upper part of the top cylinder. The principle has been questioned, and in order to set the matter at rest experimentally, the author had made a boiler purely on his system, and also one in which the design was so modified as to bring the generating tubes into the top cylinder below the water surface. If we have made our explanation clear, it will be seen, as stated by the author, that in either boiler, pressure in the lower vessel is that due to the full depth of water in the boiler, in addition to the steam pressure, and reduction of density in the generating tubes will be available for causing circulation ; whilst reduction in pressure in the wing cylinder below that due to the head of water in the boiler, will reduce the circulation. In fact, the circulation of water in the boiler is governed by variations of pressure. In order, therefore, to measure these variations, Mr. Thornycroft had recourse to a water gauge connecting the top and bottom cylinders, the height of the column of water showing the greater or lesser pressure in the wing cylinder. The results of the trials were shown by a diagram in which curves were assigned to each series of experiments. When the steam-generating tubes were arranged as in the normal Thornycroft boiler, as the rate of evaporation increased, the height of the water in the gauge-glass showed a steady and comparatively small pressure in the wing cylinder. Thus, when the evaporation was increased from 3 lb. to 20 lb. per square foot of heating surface per hour, from and at 212° Fahr., the fall was about 2 inches of water. With the boiler having tubes delivering below the water-level when the evaporation was raised from 3 lb. per hour per square foot of heating surface to about 15 lb., the fall in pressure in the wing cylinder was from 3 inches to 7 inches, roughly. Thus it will be seen that the circulation of water in a boiler of this class, where the tubes deliver above water-level, must be more energetic than when the tubes deliver below water-level. In both of these experiments, what are called the down-comer tubes, that is to say, the two tubes at the ends of the cylinders provided for completing the circuit of circulation, were in use. The utility of these tubes has, however, been questioned, and in order to throw light on this point, Mr. Thornycroft next made a series of experiments with a boiler in which the tubes delivered below the water-level, and the down-comer tubes were out of use. The results were interesting and instructive. The reduction in pressure in the wing cylinder was extremely rapid as the evaporation increased ; after a time, however, the curve reached its lowest point, and then suddenly bent upwards, showing an increase in the pressure. This last phenomenon Mr. Thornycroft attributed to the fact that the steam, instead of rising uniformly in the tube, as it would when the evaporation was moderate, was driven out at the lower end ; and this, of course, would tend still more to check the circulation. The diagram is well worthy of study on the part of those interested in any class of boiler design, and it may be found in the *Transactions* of the Institution.

In the discussion which followed the reading of this paper, the most interesting feature was a description, by Mr. Pilcher, of the device used by Mr. Maxim in making the boiler of his flying machine. This boiler, it may be stated, is a marvel of lightness. It is a Thornycroft boiler with very small generating tubes about ⅜ inch in diameter ; it is said to have given off steam equivalent to 300 I.H.P. at a pressure of 300 lb. to the square inch ; the weight of the boiler itself being but 3 lb. per I.H.P. With the small diameter tubes it was found impossible to keep up circulation sufficient to prevent the destruction of the boiler, and, in order to aid the natural circulation, Mr. Maxim introduced what may be described as injector circulation. He carried the feed-pipe of the boiler into the down-comer tube, covering the orifice of his feed-pipe by a conical valve, which was attached to a long spindle, and, working through a stuffing-box, was carried outside the pipe. The valve was kept closed by means of an external spiral spring, so adjusted as to give a pressure of 50 lb. to the square inch on the valve. The feed-pump naturally would overcome this additional pressure, so that the pressure in the feed-water on the boiler side of the pump would be 50 lb. above the boiler pressure, and thus 350 lb., the boiler pressure being 300 lb. It will be seen, therefore, that, on the hydraulic pressure opening the valve, the feed-water would be injected with some velocity into the boiler, and thus would set up a circulating current. In this way it was found that the boiler in the flying machine could be made to work very perfectly.

Prof. Biles, in his paper, described a method by which he proposed to transform mail steamers into war vessels in the event of hostilities. Details were worked out by the author, and given in the paper ; but into these we need not enter. The most noticeable feature was a long recess in the side of the ship, into which the author proposed to pack an armoured belt when the vessel was required to take up its warlike *rôle*.

The scope of Mr. Denny's paper is described by its title. Mr. Morrish, of the Admiralty, in the discussion which followed, gave a formula used by Mr. Froude at Haslar, which appeared to us even more simple than the method described by Mr. Denny. We must refer our readers to the *Transactions* for these formulæ.

Mr. Gross gave details of certain trials made with the system of burning fuel in steam boilers, referred to in the title of his paper. A very good result in regard to economy of fuel was obtained with one vessel referred to ; the consumption being 1·3 lb. per I.H.P. per hour of South Wales coal for the main engines. We fail to see, however, in what respect "suction" draught differs from "forced" draught in regard to economy. As Sir Edward Harland humorously stated in the discussion : "If one wishes to remove a person from a certain position, it does not much matter whether one gives him a pull by the nose, or applies pressure from behind." There may, of course, be some occult virtue in "suction" as compared to pressure, but we certainly have never heard it satisfactorily accounted for.

The last paper was read by Mr. Terry. It is remarkable how those tank steamers which carry oil in bulk may be freed from the insidious vapours which always arise whenever a little of these hydrocarbon oils are present. Mr. Terry tells us—and he is confirmed in this by Mr. Martell, Lloyd's chief surveyor, who has naturally had thorough opportunities of seeing these matters in practical work—that, in the same spaces that have been occupied by petroleum, rice, and other perishable food, cargoes have been carried without detriment. So successful have the results been, that it is now proposed to carry even tea in these tank steamers.

We cannot deal with the many pleasant excursions that were really the leading feature of the meeting. The proprietors of the various mail steamers, the London and South-Western Railway Company, and those gentlemen who had estates in the neighbourhood, seemed to vie with each other in entertaining the members of the Institution. On Friday morning a visit was paid to Portsmouth Dockyard, where many interesting features were shown by Admiral Fane, the superintendent, and the officers of the permanent staff. In the afternoon an excursion was made round the Isle of Wight, on board the *Frederica*, a vessel of 1509 tons, and about 6000-h.p., which had been lent by the London and South-Western Railway Company for the purpose.

ON THE NEWTONIAN CONSTANT OF GRAVITATION.[1]

I.

IT is probably within the knowledge of most of those present that Sir Isaac Newton, by his great discovery of gravitation and its laws, was able to show that a single principle, ideally simple, viz. that every particle in the universe attract- any other particle towards itself with a force which is proportional to the product of their masses divided by the square of the distance between them, would completely and absolutely account for the three laws of planetary motion which Kepler had given to the world.

Newton also showed that a spherical body, whether uniformly dense or varying in density according to any law from the centre to the surface, would attract bodies outside with the same force that it would do if it could all be concentrated at its centre, *i.e.* that all the attractions varying in amount and direction produced by particles in all parts of a sphere need not be considered separately, but may be treated in this simple way.[2]

Nevertheless, though Newton's great discovery is sufficient to bring the whole of the movements of the planets and their satellites, whether their simple Keplerian motions or the disturbances produced by their mutual gravitation, the motions of comets, of binary stars, of the tides, or the falling apple, under the domain of a single and simple principle, though it enables one to compare the masses of the sun, the planets and their satellites, and of those binary stars whose parallax has been determined, one thing can never be made known by astronomical research alone, though we may know that twenty-eight suns would be required to make one Sirius; that the sun is equal to 1048 Jupiters, that Jupiter is more than double all the rest of the solar system put together, or that the moon is 1/80 of the earth; no observations of these bodies can ever tell us how many tons of matter go to make up any one of them.

Though we know from first principles of dynamics, by the mere consideration of centrifrugal force, that the whole sun attracts each ton of the earth with a force equal to a weight here of a little more than one pound, and that if it were not for this, every ton of the earth would continue its journey into space in a straight line for ever, and though we know in the same way that the whole earth attracts each ton in the moon with a force equal to the weight of ten ounces and no more, we cannot tell by any astronomical observation whatever, how many tons there are in all.

Newton showed that to complete his law and to put in the numerical constant (the Newtonian Constant of Gravitation) that would convert his proportion into an equality, two methods are available: we may either make observations on the disturbance of the earth's gravitation by the action of isolated parts of it, we may either find the relative attraction of an isolated mountain or the strata above the bottom of a deep mine, or we may make an artificial planet of our own and find the attraction which it exerts.

The Newtonian Constant will be known if we know the force of attraction between two bodies which we can completely measure and weigh. Employing the C.G.S. system of measurement, the Newtonian Constant is equal to the force of attracttion in dynes between two balls weighing a gramme each, with their centres one centimetre apart. Of course it may be referred to pounds and inches or tons and yards, but as soon as all the quantities but G in Newton's equation

$$\text{Force} = G\,\frac{\text{Mass} \times \text{Mass}}{\text{Distance}^2}$$

are known, no matter in what units the quantities are measured, G is known. The conversion of its numerical value from one system of measurement to another is of course a mere matter of arithmetic.

Of the first method of finding G, depending on the attraction of a mountain first attempted by Bouguer at the risk of his life in the hurricanes of snow on Chimborazo, of the experiments of Maskelyne, of Airy and of others, I cannot now find time to speak; I can only refer to Poynting's essay on the subject. It is the second method with an artificial planet that I have to describe to-night.

[1] A lecture delivered at the Royal Institution on June 8, by Prof. C. V. Boys, F.R.S.

[2] Only last night I learned that it was the difficulty of proving this, and not the erroneous value of the moon's distance, that delayed the publication of Newton's discovery for so long.

Now let me give some idea of the minuteness of the effect that has to be measured. Is a wall built true by the aid of a plumb-line vertical, or does it lean outwards? Newton s principle shows that the plumb-bob is attracted by the wall, yet it hangs vertically. The attraction is so small that it cannot be detected in this way. Even the attraction of a whole mountain requires the most refined apparatus to detect it. Do two marbles lying on a level table rush together? According to Newton's principle they attract one another; yet if they were a thousand times smoother than they are, no movement of attraction could be detected.

Leaving matters of common experience, let us go into the physical laboratory where instruments of the highest degree of precision and delicacy (at least so they are called) are found on every table. What precautions are taken to prevent the attractions of the fixed and moving parts from interfering with the result which they are constructed to measure? None. The attractions are so small, that in no apparatus in use for the measurement of electrical, magnetic, thermal, or other constants are they ever thought of, or is any provision necessary to prevent their falsifying the result. Nevertheless, the attractions exist, and if only the means are delicate enough they can be detected and measured. The Rev. John Mitchell was the first to devise a successful method. He was the first to invent the torsion balance with which Coulomb made his famous electrical researches, and which bears Coulomb's name. He devised and he made apparatus for this purpose, but he did not live to make any experiments.

After his death Cavendish remodelled Mitchell's apparatus and performed the famous Cavendish experiment. By means of the apparatus, of which for the second time I show a full-size model in this theatre, Cavendish measured the force of attraction between two balls of lead, one 12 and the other 2 inches in diameter, and with their centres 8·85 inches apart. The same experiment has since been made by Reich, by Baily, and more recently by Cornu and Baille with greatly superior apparatus of one quarter of the size. All these observers actually determined the attraction between masses which could be weighed and measured, and thus found with different degrees of accuracy the value of G.

Let me explain now that this G, the gravitation constant, or as I prefer to call it, for the sake of distinction, the Newtonian Constant of Gravitation, has nothing to do with that other quantity generally written *g*, which represents the attraction at the earth's surface. This is a purely accidental quantity, which depends not only upon G, but also upon the size of the earth, its mean density, the latitude, the height above the sea, and finally upon the configuration and the composition of the neighbouring districts. *g* is eminently of a practical and useful character; it is the delight of the engineer and the practical man; it is not constant, but that he does not mind. It is of the earth, arbitrary, incidental, and vexatious. Prof. Greenhill should spell his name with a little *g*. G, on the other hand, represents that mighty principle under the influence of which every star, planet, and satellite in the universe pursues its allotted course; it may possibly also be the mainspring of chemical action. Unlike any other known physical influence, it is independent of medium, it knows no refraction, it cannot cast a shadow. It is a mysterious power, which no man can explain; of its propagation through space, all men are ignorant. It is in no way dependent on the accidental size or shape of the earth; if the solar system ceased to exist it would remain unchanged. I cannot contemplate this mystery, at which we ignorantly wonder, without thinking of the altar on Mars' hill. When will a St. Paul arise able to declare it unto us? Or is gravitation, like life, a mystery that can never be solved?

Owing to the universal character of the constant G, it seems to me to be descending from the sublime to the ridiculous to describe the object of this experiment as finding the mass of the earth or the mean density of the earth, or, less accurately, the weight of the earth. I could not lecture here under the title that has always been chosen in connection with this investigation. In spite of the courteously expressed desire of your distinguished and energetic secretary, that I should indicate in the title that, to put it vulgarly, I had been weighing the earth, I could not introduce as the object of my work anything so casual as an accidental property of an insignificant planet. To the physicist this would be equivalent to leaving some great international conference to attend to the affairs of a county council, I might even say of a parish council. That is the business of the geologist. The object of these investigations is to find the value of G. The earth has no more to do with the investigation than the table has upon which the apparatus is supported. It does interfere and occasionally, by its attraction, breaks even the quartz fibres that I have used. The investigation could be carried on far more precisely and accurately on the moon, or on a minor planet, such as Juno; but as yet no means are available for getting there.

I shall not have time to-night to describe the work of former investigators, and for this there is little need, since it is all collected in Poynting's Adams prize essay "On the Mean Density of the Earth," published this year. I cannot even find time to explain in more than the merest outline what I have done to develop the apparatus of Cavendish, so that he would hardly recognise in my glorified bottle-jack the balls and lever which have made his name famous. The following table, given by Poynting, however, represents the results of the labours of investigators up to the present time.

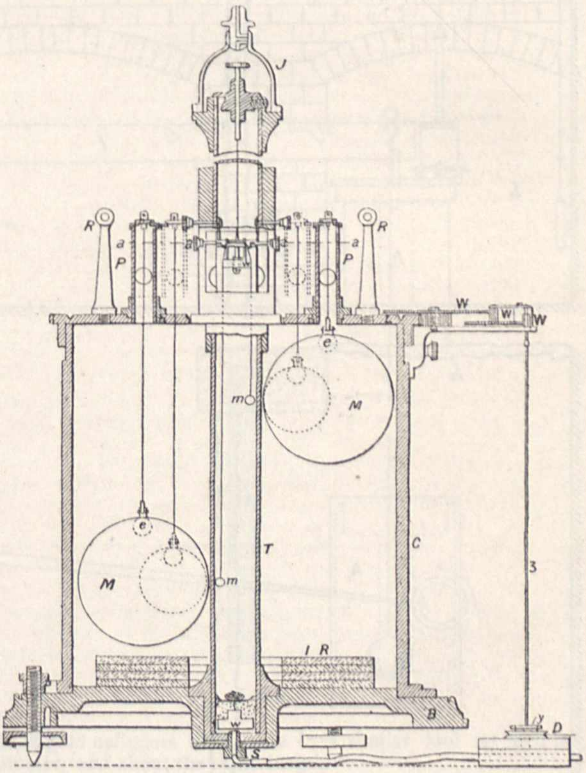
Summary of Results hitherto obtained.

Approximate date	Experimenter	Method	Result
			Δ
1737–40	Bouguer	Plumb-line and pendulum	Inconclusive
1774–76	Maskelyne and Hutton	Plumb-line	4·5–5
1855	James & Clarke	,,	5·316
1821	Carlini	Mountain pendulum	4·39–4·95
1880	Mendenhall	,,	5·77
1854	Airy	Mine pendulum	6·565
1883	Von Sterneck	,,	5·77
1885	Von Sterneck	,,	About 7
1797–98	Cavendish	Torsion balance	5·448
1837	Reich	,,	5·49
1840–41	Baily	,,	5·674
1852	Reich	,,	5·583
1870	Cornu and Baille	,,	5·56–5·50
1889	Boys	,,	In progress
1879–80	Von Jolly	Common balance	5·692
1878–90	Poynting	,,	5·493 (5·46–5·52)
1884	König, Richarz, and Krigar Menzel	,,	In progress
1886–88	Wilsing	Pendulum balance	5·579
1889	Laska	,,	In progress

In connection with this table I cannot lose the opportunity of quoting Newton's extraordinary prophecy, marvellous in that without any direct knowledge he gave a figure which was nearer the truth than that found by many of the experimenters that came after him. The passage is as follows:—

"Unde cum Terra communis suprema quasi duplo gravior sit quam aqua, et paulo inferius in fodinis quasi triplo vel quadruplo aut etiam quintuplo gravior reperiatur; verisimile est quod copia materiæ totius in Terra quasi quintuplo vel sextuplo major sit quam si tota ex aqua constaret; præsertim cum terram quasi quintuplo densiorem esse quam Jovem jam ante ostensum sit." (Newton's "Principia," 2nd edition, 1714, p. 373, line 10.)

I have placed on the wall the diagram of the apparatus which I showed in action when lecturing here upon quartz fibres five years ago. With this I was able, for the first time, to show to an audience the effect of the very small attraction exerted between a two-inch cylinder of lead and a little one weighing only a gramme or fifteen grains. The apparatus which I have to describe to-night is the same in principle, the main distinction being that it is so designed and constructed that I can tell precisely where every gravitating particle is placed. In the design of this apparatus I have been, as everyone will admit, bold—most would have preferred the word reckless; but knowing the truth of the principles which I had developed, and having faith and confidence in the quartz fibre, I deliberately chose to reduce all the dimensions to an extent which caused the forces, and especially the couples, to be insignificant in comparison with any which had been within the reach of the experimenter hitherto. The whole difficulty of Cavendish, Reich, and Baily had been to measure so minute an effect; instead of increasing this, I diminished it enormously, being satisfied that I should be able to make a proportionately more accurate measure by so doing. Cornu reduced the dimensions to one-quarter; I have reduced the chief one to one-eightieth. Cavendish had a force equal to 1/3650 grain's weight to measure; I have less than a five-millionth. By the use of the long lever, Cavendish had the effect of a force of 1/100 grain's weight on an arm an inch long; I have less than a twelve-millionth of a grain on an arm of that length. His forces were fourteen hundred times as great as mine; his couples or twisting forces were a hundred and twenty thousand times as great. One advantage gained by the use of small apparatus, in which alone the attracting balls can be made large compared with the length of the beam, is the increased sensibility, the greater angle of deflection produced by the attractions when the period of oscillation is the same. This is more especially the case in my apparatus where the two sides are at different levels. But the greatest advantage is in a direction whence it might least be expected. In spite of every



By permission of the *Engineer.*]

FIG. 1.

endeavour that may be made to keep the air quiet, to exclude draughts, to keep all the apparatus at one temperature in a vault of constant temperature, infinitesimal differences must exist; one side of the apparatus must be hotter than the other, though no thermometer could be made which would detect the difference. In consequence of this difference of temperature the air circulates, and so creates a draught which blows upon the mirror and the suspended balls. Now I have shown that in apparatus geometrically similar these disturbances are likely to be in the proportion of the seventh power of the linear dimensions, while the gravitational couples vary only as the fifth power; the relative disturbances are therefore likely to be in the proportions of the squares of the linear dimensions, so that if we make our apparatus ten times as large, the mirror is likely to be one hundred times as unsteady. In addition to this, the time needed to bring the apparatus to a steady state is far greater with large apparatus. After making the geometrical measures I leave my apparatus, small as it is, three days, if possible, before observing deflections and periods.

The diagram (Fig. 1) is a vertical section through the apparatus. B and C represent an accurately turned brass box with a lid L, which can be made to turn round insensibly by the action of the wheels W W. The lid carries two tubular pillars, P P, from the tops of which the balls, M M, hang by phosphor-bronze wires, being definitely held in place by geometrical clamps on the heads of the pillars. The lid also carries two supporting pillars, R R. In the centre tube the "beam mirror," N, hangs by means of a quartz fibre from an adjustable torsion head surmounted by a bell jar, and from the ends of the mirror the two gold balls, *m m*, hang by separate quartz fibres. Four rings of india-rubber are placed on the base to prevent destruction of the apparatus in case the balls should drop by any accident. Now it is evident that if the lid is turned from the position in which it is shown, that is, with all four balls in one plane, in which position the attractions do not tend to twist the central torsion fibre at all, then these attractions will produce a couple increasing with the angle up to a certain point (65° in the particular case), after which the couple falls off again and becomes zero when it has turned 180°.

Since the effect is a maximum at 65°, very great accuracy in the measurement of this angle is of little consequence. By means of a small telescope at a distant table, and the divided edge and vernier, I can tell the angle with certainty to 1/20 degree; an uncertainty of one-quarter of a degree would be of but little consequence. Again, if the pair of gold balls twist about an axis which is not exactly that round which the lead balls are carried, if there is any small eccentricity of the gold or lead balls, then eccentricity in the common plane removes the gold balls from a position of minimum effect, eccentricity across the plane removes them from a position of maximum effect, and if the levels of the gold balls are not precisely the same as those of the lead balls, again the departure is from a position of maximum effect. All these three eccentricities can be determined with an accuracy of 1/1000 inch. Errors of 1/100 inch would make a barely perceptible effect upon the result. The design, therefore, is such that a great number of measures which are difficult, and can at the best only be made with a second quality degree of accuracy, are of so little consequence that this degree is more than abundant. The final result depends directly upon a few measures which, as I hope to show, can be made with facility and most accurately. These are the horizontal distance from centre to centre of the wires by which the lead balls are suspended, the horizontal distance between the centres of the quartz fibres by which the gold balls are suspended, the angle through which the mirror is deflected, the masses of the lead but not of the gold balls, and the natural time of oscillation of the mirror when the balls are suspended and when a thin cylinder of small moment of inertia, but of the same weight as the balls, is suspended axially in their stead.

Before going more into detail and showing how the operations are carried out so that all the quantities may be known with a sufficient degree of accuracy, it will be convenient to project upon the screen a drawing of the vault in which the experiments have been made. Prof. Clifton has kindly allowed me the free use of the vault under the Clarendon Laboratory at Oxford. This is shown in Fig. 2, of which the upper portion represents an elevation, and the lower part a plan. The instrument itself stands upon the table A_1 in the corner, where it is screened from temperature disturbances, which my presence in the distant corner and a very small flame produce, by an octagon house of double wood lined with cotton-wool and by double felt screens, f_1 f_2. On the second table, A_2, are placed a large astronomical telescope, T, through which the large scale, S, is seen by reflection from the mirror in the apparatus, a small reading telescope, *t*, to read the angle of the lid and vernier, a pulley-wheel, p_1, and a driving-wheel, *d*. The pulley-wheel p_1 keeps the cord *b* which passes round p_2 and p_3, and is attached to the cart, *g*, always tightly stretched, so that the observer at the telescope can always keep a little flame carried by the cart immediately behind the particular division under observation.

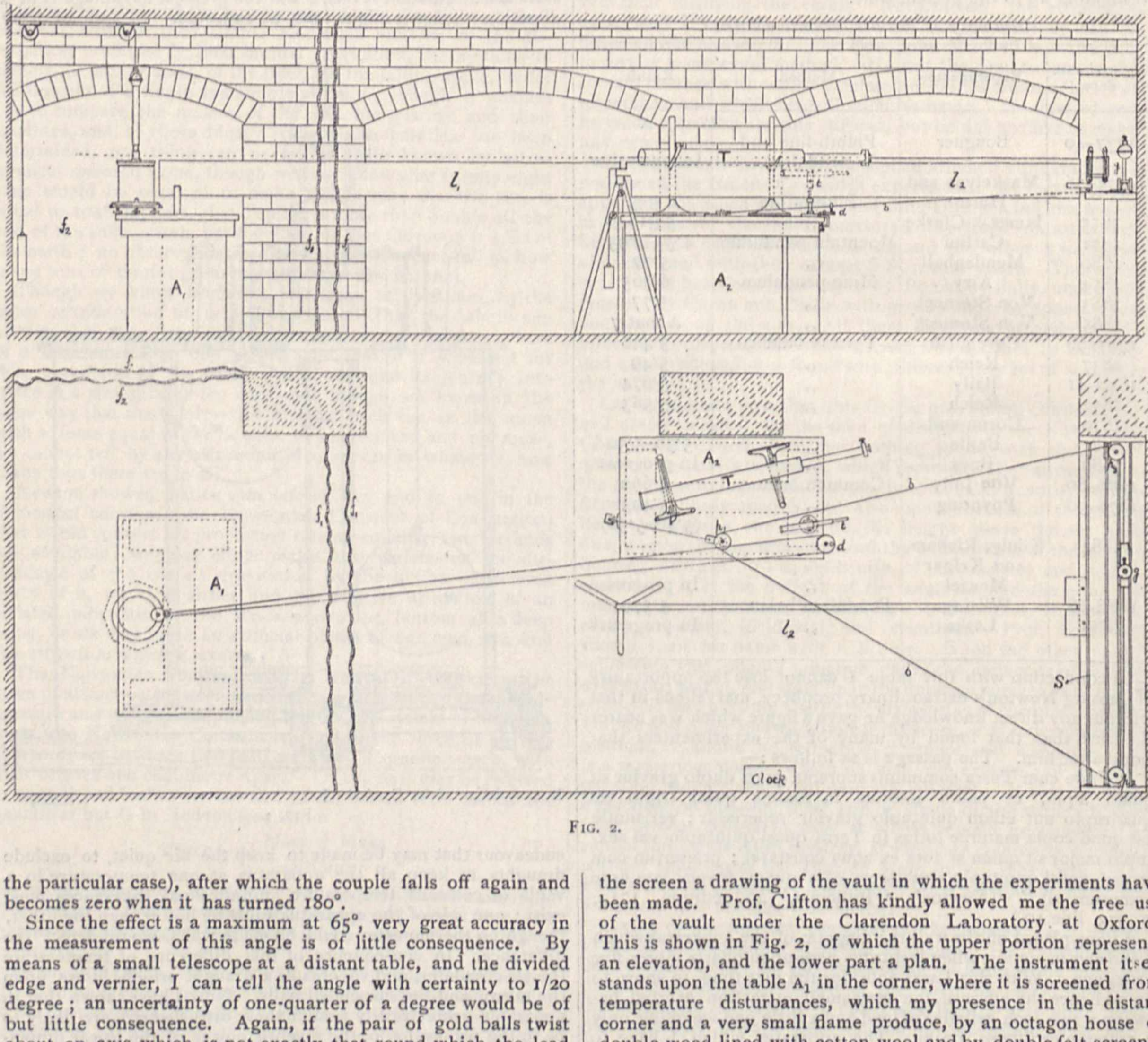


Fig. 2.

The driving wheel *d* is made with a very large moment of inertia, and the handle is near the axis, so that its motion is necessarily steady. A very light cord passes round this, across the room, and after passing through a hole in the screen passes also round the little wheel D (Fig. 1), and thus serves to drive the train W W, and so carry the lid and balls round almost insensibly. Two hundred and thirty turns of *d* are required to move the lead balls from the + to the − position. I generally turn the handle 130 times, and then when the mirror is approaching an elongation, turn the handle the remaining 100 times, finally stopping when the lid reading, as observed in the small telescope, is correct. The large scale, S, is 9 feet long, and is divided into 50ths of an inch. There are 4800 divisions.

Two beams, l_1 l_2, are seen in Fig. 2. The upper surfaces of these are straight, and are adjusted by screws until they are truly level. These are used when the true optical distance from the mirror to the scale is being measured. A steel tape, on which I engraved a fine line near each end, rests upon the beams. At one end a slider carrying a microscope is placed so as to see a fine line at the centre of the mirror accurately in focus, while at the other a corresponding slider is placed so that a projecting brass rod rests against the scale. At the same time cross lines engraved upon the plate-glass bases are placed exactly over the lines engraved on the steel tape. When afterwards the microscope is focussed upon the end of the brass rod, the distance between the cross lines, as measured by a scale, is the amount that has to be added to the distance between the engraved lines upon the tape, in order to obtain the distance from the scale to the mirror.

Overhead wheels are shown in Fig. 2, fastened to the roof above the apparatus, and again close to the end wall These serve many purposes, as will appear later. Among others, the middle one of each carries a cord fastened at one end to a crossbar joined at its ends by guys to the pillars R of the lid (Fig. 1), and at the other to heavy balance-weights to counterbalance the balls M M and part of the lid. Thus the friction is greatly reduced, and the tremor set up by rotating the lid is in a corresponding degree slight.

All time observations are made chronographically upon a drum by the Cambridge Scientific Instrument Company. This is placed in the adjoining vault. Two time-markers record with their points less than 1/100 inch apart, one of them marking every second of the clock, with special marks for minutes and half-minutes, and the other every depression of the key at my right hand. The late Prof. Pritchard kindly lent me an astronomical clock for the purpose, to which I fitted time-marking contacts ; but into the details of these I must not enter. He also allowed me to make use of one of his assistants to keep me informed of the rate of the clock from time to time.

I have up to the present spoken vaguely of the large lead balls and of the small gold balls, but have given no indication as to how they are made and how I can be sure of the truth of their form and their homogeneity. Mr. Munro, whose capacity for turning accurate spherical work is well known, made for me two moulds of hard cast-iron, which I have on the table. One of these is for a 4½-inch lead ball, and one for a 2¼-inch lead ball. Each mould is made in two halves, so truly as to shape and size that the thin steel disc that was used as a template would distinctly rattle when in its place, but when a strip of cigarette-paper was inserted on one side it could not be got in at all. The upper half of each of these moulds is provided with a cylindrical steel plunger accurately fitting a central hole in the mould, and with its end turned to the same spherical surface when it is pressed home upon its shoulder. The lower half of each mould has a ¼-inch central cylindrical hole, into which the lug of the brass ball holder exactly fits. There is also a small hole at the side which can be stopped with a brass plug. The balls are made as follows :—The interior of the mould is smoked and then screwed up as tight as possible. It is then heated until a piece of lead upon it begins to melt. The necessary quantity of pure lead melted in an earthen pot is then carefully skimmed and poured in until the cylindrical neck is full. The mould is then made to rest upon a cold iron slab, and a blowpipe is directed upon the upper part so that it cools from below upwards, and not from the surface inwards; more lead is added to keep the neck full. As soon as the lead in the neck solidifies the plunger is inserted, and the whole is placed in a hydraulic press. The plunger is forced down upon its seat, the lead, already free from bubbles and vacuous cavities, is compressed until at last the excess of solid metal flows through the small side hole in the form of wire. The ball is thus made true in form, necessarily homogeneous, which no alloy is likely to be, and definite in size. When cold it can be lifted from the mould, when after cutting off the wire which projects from its equator, it is ready for weighing.

The small gold balls are made by melting the required quantity of pure gold in a hole in a bath brick, and, as in the case of the lead, letting it cool from below upwards, so as to avoid cavities. It is then inserted in a pair of polished hemispherical hardened steel dies, which Mr. Colebrook made for the purpose, and beaten, being turned between each blow, and annealed once or twice until a perfect polished sphere, without a mark upon it, is the result. I make these in pairs of exactly the same weight, and, as in the case of the lead balls, thus obtain truth of form, accuracy of size, and homogeneity all in a very perfect—more than sufficiently perfect—degree. These are each suspended from a quartz fibre of the necessary length, to the other end of which a hook and eye is fastened. Into the very important details of these operations it is impossible, for want of time, for me to enter. The gold balls are ·2 and ·25 inch in diameter, and a

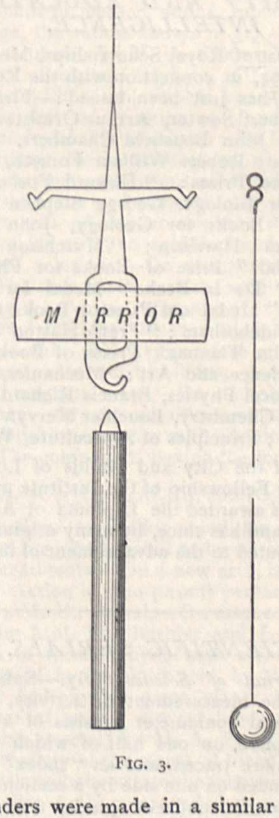


FIG. 3.

pair of gold cylinders were made in a similar tool ·25 inch in diameter, and about the same length.

Perhaps the most important detail in the whole apparatus is the "beam mirror," which is of the form shown in Fig. 3. It is necessary, as far as possible, to reconcile the following incompatible conditions. It should be as light as possible, have as small a moment of inertia as possible, the optical definition should be as perfect as possible, and, almost most important of all, the form should be such that the resistance offered by the viscosity of the air should be reduced to the smallest possible degree. By cutting the middle portion out of an optically perfect round mirror all these conditions are realised in some degree, and the optical definition is actually more perfect in the horizontal direction than that due to the whole disc. This is fastened to a cross-shaped support of gilt copper. The ends of the mirror have vertical grooves of microscopic fineness cut in their thickness, so that the quartz fibre hanging from the cross-arm above may rest definitely in them. The central hook is for the purpose of hanging the "counterweight," *i.e.* a slender silver cylinder of exactly the same weight as the gold balls with their fibres and hooks. By this means the unknown moment of inertia of the mirror may be eliminated with the fibre equally stretched in both cases, a most necessary condition, for I have found that the torsional rigidity is seriously affected by variation in stretching.

Means are provided by which I can effect the transfer of the gold balls from the beam to the side hooks or the reverse, or change their places without opening the window; but these and numerous other important details I must pass over.

Unfortunately accidents are liable to happen, and, as I know by dearly-bought experience, the gold balls may sometimes be precipitated down the central tube. I have recovered them sometimes by an india-rubber tube, let down through the window aperture, sucking at the other end until they closed the open end, when they could be drawn up. Latterly I have made use of a magnetised tuning-fork to pick up a very small fragment of iron tied to a silk line, by means of which I could draw up a diaphragm with anything that might have fallen upon it.

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE following list of Royal Scholarships, Medals and Prizes awarded July, 1894, in connection with the Royal College of Science, London, has just been issued:—First Year's Royal Scholarships: Robert Sowter, Arthur Ormiston Allen, Henry Thomas Davidge, John Bousfield Chambers. Second Year's Royal Scholarships: Robert William Forsyth, William Longshaw. Medals and Prizes: "Edward Forbes" Medal and Prize of Books for Biology, George Stephen West; "Murchison" Prize of Books for Geology, John James Green, Francis Chambers Harrison; "Murchison Medal," not awarded; "Tyndall" Prize of Books for Physics, Part I., Robert Sowter; "De la Beche" Medal for Mining, John Ball; "Bessemer" Medal and Prize of Books for Metallurgy, Charles Howard Sidebotham; "Frank Hatton" Prize of Books for Chemistry, John Thomas. Prizes of Books given by the Department of Science and Art: Mechanics, Harold Rigby Cullen; Astronomical Physics, Francis Richard Penn, Robert Sowter; Practical Chemistry, Bouchier Mervyn Cole Marshall; Mining, John Ball; Principles of Agriculture, William Wilson.

THE Council of the City and Guilds of London Institute have conferred the Fellowship of the Institute upon Dr. W. E. Sumpner, who was awarded the Diploma of Associate of the Institute in 1887, and has since, by many original and valuable researches, contributed to the advancement of the electrical industry.

SCIENTIFIC SERIALS.

American Journal of Science, July.—Spiral goniometry in its relation to the measurement of activity, by Carl Barus. One type of the spiral goniometer consists of a "dial" in the form of a circular plate, on one half of which a series of concentric semicircles are traced, and an "index" in the form of another plate, bounded on one side by a semicircle, and on the other by two symmetric confluent spirals, traced so that equal increments of angle correspond to equal radial increments. These two parts are mounted on the same axis in such a manner as to be capable of revolving independently. When they are connected by a spring and made to actuate a dynamometer, the angle between the fundamental diameters of the dial and index can be read off by counting the number of semicircles visible on the revolving disc. These will be apparently drawn out into circles, and can be counted at any speed. This gives a means for measuring the activity of motors. In another form, the index outline is not a spiral but a diameter, and the semicircles are cut off in the outline of a spiral.—On some methods for the determination of water, by S. L. Penfield. This difficult operation may be considerably facilitated by the use of special forms of bulb tubes, which enable the analyst to separate the expelled water from the mineral, and weigh it in a closed tube. Two bulbs are blown half-way along the length of the tube, and kept cool by a strip of wet cloth. The water is driven up into the first of these. After it is all expelled, the glass is fused down upon the substance, and the end containing the substance is pulled off. The water is then weighed in the remaining part of the tube. For cases where the water is only expelled with difficulty, the author uses a kind of charcoal furnace, protecting the glass by a sheet of platinum foil. For entirely decomposing a mineral by fusion with sodium carbonate, the substance is placed in a platinum boat inside the combustion tube, and a sheet of platinum is wrapped round the outside. The tube must be well supported, as it is apt to fuse, but it does not leak even at a full white heat. The method is accurate, and superior to the use of porcelain or platinum. The latter is found at high temperatures to permit of the passage of gases through its substance.—The detection of alkaline perchlorates associated with chlorides, chlorates, and nitrates, by F. A. Gooch and D. Albert Kreider. The chlorates are destroyed by treating with the strongest hydrochloric acid and evaporating to dryness. The nitrates are decomposed by a saturated solution of manganous chloride in the strongest hydrochloric acid, the manganese being then eliminated by sodium carbonate. The perchlorates are then tested for by fusing with anhydrous zinc chloride.

American Meteorological Journal, July.—Changes in the definitions of clouds since Howard, by H. H. Clayton. The author quotes extracts from various authorities to show that there has been a gradual evolution since Howard. Thus a distinction between high and low cirro-stratus and high and low cirro-cumulus has been established, and the lower forms called alto-stratus and alto-cumulus. The stratus has been separated into fog and low sheet clouds, and two distinct forms of rain cloud recognised. He agrees with Hildebrandsson that ten terms, all compounded of Howard's four fundamental types, would fully meet the requirements of practical meteorology.—The newspaper weather maps of the United States, by R. De C. Ward. The history of the publication of these maps is given, together with specimens of those now issued. At present only four daily papers in the United States print weather maps regularly. The *New York Herald* was the first paper to issue them in the United States, and it occasionally prints them now, to illustrate special weather conditions.—Psychrometer studies, by H. A. Hazen. This paper is a criticism of the introduction to the tables recently published by Dr. J. Hann, of Vienna, and has especial reference to the difficulty found in using the wet and dry bulb thermometers when the temperature is near or below the freezing point. Prof. Hazen states that nearly all the difficulty vanishes when the thermometers are well ventilated.—List of cloud photographs and lantern-slides, by R. De C. Ward. A list of typical cloud forms, classified according to the international system, has been prepared, with an explanation of each, for use in lectures. The photographs are chiefly from pictures taken by Riggenbach and Manucci, during various positions and conditions.

Wiedemann's Annalen der Physik und Chemie, No. 8.—On the mechanical effects of waves upon resonators at rest, by Peter Lebedew. The case of electromagnetic waves is the first dealt with. Instruments called magnetic and electric resonators, respectively, were constructed in such a manner that they could be suspended by quartz fibres parallel to the planes of their coils. One of these was arranged so as to resound to the magnetic, the other to the electric components of the waves only. It was found that both resonators behaved in the same way. When "tuned" to a higher pitch, they were attracted by the incident wave system; when tuned lower, they were repelled, the maximum effects occurring when most closely approaching perfect resonance. The phenomena can be explained by supposing that the excitation of electric resonators obeys the laws governing all elastic vibrations, and that the laws of Coulomb and Ampère with respect to the relation between impulse and motion also apply to electric oscillations. The experiments are analogous to attempts to elucidate the molecular forces attending the propagation of light.—On the velocities of sound in air, gases, and vapours for simple tones of different pitches, by James Webster Low. From experiments performed with a Quincke interference tube, it appears that, contrary to the results obtained by Kundt, Regnault, König, and others, for closed tubes, the velocity of sound in air and in carbonic acid is the same for notes of different pitch and intensity when they are propagated in open space.—On the seat of the electric charge in condensers, by A. Kleiner. The experiments were performed chiefly on mica condensers, one coating of which consisted of pure mercury, and the other of tinfoil. The discharges obtained after the coatings had been taken off and replaced were about 5 per cent. less than those from the undisturbed condenser.

When the mica sheet was split in two, approximately equal discharges were obtained from the original condenser and the condensers formed with each of the parts, thus exhibiting the analogy with a magnet when broken into parts.—On the magnetisation of iron cylinders, by O. Grotrian. The parts of an iron cylinder not too short in comparison with its diameter, magnetised by a homogeneous field in the direction of the axis, are very differently magnetised when saturation has not been reached, the outside parts being much more strongly magnetised than the axial ones.

SOCIETIES AND ACADEMIES.

LONDON.

Chemical Society, June 21.—Dr. H. E. Armstrong, President, in the chair.—The following papers were read: A specimen of early Scottish iron, by Miss M. D. Dougal.—The interaction of sulphide with sulphate and oxide of lead, by J. B. Hannay. The two equations—$PbS + PbSO_4 = 2Pb + 2SO_2$ and $PbS + 2PbO = 3Pb + SO_2$—given by Percy, to represent the reactions occurring in lead smelting, are insufficient. A much more complex reaction occurs, since metallic lead when formed attacks the remaining sulphate, producing litharge, which in turn reacts with the sulphide; further, some of the sulphide is removed by solution in the metallic lead, whilst some is volatilised as the compound PbS,SO_2.—The mineral waters of Cheltenham, by T. E. Thorpe.—The oxidation of tartaric acid in presence of iron, by H. J. H. Fenton. Tartaric acid is oxidised by certain agents in presence of a trace of ferrous salt with formation of a new crystalline dibasic acid, $C_4H_4O_6$, $2H_2O$; it is a powerful reducing agent, and forms crystalline salts.—The supposed relation between the solubility of a gas and the viscosity of its solvent, by T. E. Thorpe and J. W. Rodger. From the results of their own experiments on the viscosity of solutions of gases, the authors are led to modify the conclusions of Winkler respecting the relation between solubility and viscosity.—The specific character of the fermentative functions of yeast cells, by A. J. Brown. Pasteur's view of the cause of the exhibition of the fermentation functions of yeast cells is that it is a starvation phenomenon brought about by lack of free oxygen during the life of the cells in a fermentable liquid. The fermentative power was measured by Pasteur as the ratio of yeast to sugar; the author finds, however, that there is no direct constancy of proportion between the weight of yeast formed and of sugar fermented. Pasteur's experiments are consequently insufficient, and his theory unproven.—Observations on the influence of temperature on the optical activity of organic liquids, by P. Frankland and J. MacGregor. The authors have measured the rotatory powers of methylic and ethylic salts of active glyceric and diacetylglyceric acids at various temperatures; the percentage increase in rotation as the temperature rises is greater for the methylic than for the ethylic salts.—The maximum molecular deviation in the series of the ethereal salts of active diacetylglyceric acid, by P. Frankland and J. MacGregor.—The preparation of sulphonic derivatives of camphor, by F. S. Kipping and W. J. Pope. The sulphonic chlorides and bromides of camphor and its halogen derivatives are best prepared by treating the ammonium salts of the corresponding sulphonic acids with phosphoric chloride.—Dextro-rotatory camphorsulphonic chloride, by F. S. Kipping and W. J. Pope.—On the combination of chlorine with carbon monoxide under the influence of light; preliminary notice, by G. Dyson and A. Harden. There is a well-marked period of photochemical induction in the amount of chemical action occurring when light acts on a moist mixture of equal volumes of carbon monoxide and chlorine.—Solution and pseudo-solution, part ii., by S. E. Linder and H. Picton.—Solution and pseudo-solution, part iii., by H. Picton and S. E. Linder. The continuation of previous work on solutions is described in these two papers.

PARIS.

Academy of Sciences, July 23.—M. Lœwy in the chair.—On the photographs of the moon obtained with the great *coudé* equatorial of the Paris Observatory, by MM. Lœwy and Puiseux. The difficulties met with in taking these lunar photographs are detailed, and an account is given of the methods used in overcoming them. Further, the photographs obtained are discussed and compared with maps and previous photographs.—On a new series of sulphophosphides, the thiohypophosphates, by M. C. Friedel. The iron, aluminium, zinc, copper, lead, silver, mercury, and tin salts are described. The series is viewed as consisting of salts of the general type $P_2S_6M'_4$.—On two menhirs found in Meudon wood, by M. Berthelot. Two previously undescribed sandstone menhirs have their characteristics given in detail.—On the reduction of any differential system whatever to a completely integrable form, by M. Riquier. The conclusions of this memoir are summarised as follows:—"Being given a differential system involving any number of unknown functions and any number of independent variables, simple eliminations, together with differentiations, allow, in general, of putting them into a completely integrable form, of which the order is nearly always superior to one, and approximates to a linear and completely integrable form of the first order."—On the specific inductive capacity of glass, by M. F. Beaulard. The influence of the time of charging has been studied by the ballistic method and k calculated for an instantaneous charge, the author finds $k = 3{\cdot}9$.—On the electrolysis of copper sulphate, by M. A. Chassy. With a neutral saturated solution of copper sulphate at 100° and a current density of a hundredth of an ampère per square centimetre, a bright red deposit of cuprite in forms derived from the cube and octahedron is obtained. By lowering the temperature, diminishing the concentration, or augmenting the current density, varying proportions of metallic copper can be obtained along with the red crystals. In determinations of current by electrolysis of copper sulphate it is necessary, in order to avoid serious error, to acidulate and pass the current through cold dilute solutions.—On manganese steel, by M. H. Le Chatelier. The anomalous results found previously by the author in studying the electric resistance of (13 per cent.) ferromanganese are explained by the formation of two allotropic varieties of the metal. The temperature of transformation is 740°, that temperature at which soft iron passes from the magnetic to the non-magnetic state.—On metaphthalodicyanacetic ether, by M. Locher.—Organo-metallic combinations of borneol, camphor, and monochlor-camphor with aluminium chloride, by M. G. Perier. The compounds having the formulæ

$$(C_{10}H_{18}O)_2Al_2Cl_6,\ (C_{10}H_{16}O)_2Al_2Cl_6, \text{ and } (C_{10}H_{15}ClO)_2Al_2Cl_6$$

have been obtained in crystalline condition. They are very unstable in air, and are readily acted on by water with production of the original constituents.—On a new acid, isocampholic acid, by M. Guerbet.—Action of phosphorus pentachloride on tetrachloroquinone, by M. Et. Barral.—On essence of Pelargonium from Réunion, by MM. Ph. Barbier and L. Bouveault.—On the condensation of formaldehyde with alcohols of the fatty series in presence of hydrochloric acid, by M. C. Favre.—On the existence of hydroxyl in green plants, by M. A. Bach.—On the presence of several distinct kinds of chlorophyll in the same vegetable species, by M. A. Étard.—Researches on the causes of the toxicity of the serum of blood, by MM. Mairet and Bosc. The authors demonstrate the following conclusions:—(1) Blood serum has both toxic and coagulating properties. (2) The coagulating properties are destroyed by heat or by the addition of sodium chloride or sulphate. (3) The symptomatic effects produced by intravenous injections of pure serum are mostly due to the toxic properties of the serum, the coagulating effects making themselves felt only near the limit of the toxic action. (4) The alcoholic extract has no toxic or coagulating properties, these being only shown by the precipitate. (5) By partial precipitation with alcohol, the toxic and coagulating substances may be separated. (6) Both belong to the albumenoids.—On the structure of the membrane of Corti, by MM. P. Coÿne and Cannieu.—On the metamorphoses of *Cecidomyia destructor*, Say, and on the puparium or larval envelope before its transformation into a chrysalis, by M. A. Laboulbène.—On the origin of "sphères directrices," by M. Leon Guignard.—The radical tubercles of *Arachis hypogea*, L., by M. Henri Lecomte.—Influence of the distribution of humidity in the soil on the development of chlorosis of the vine on a calcareous soil, by MM. F. Houdaille and M. Mazade.—On a magnetic perturbation, by M. Moureaux.

BERLIN.

Physiological Society, June 8.—Prof. du Bois Reymond, President, in the chair.—Dr. J. Munk gave an account of an experiment made on a dog as to the nutritive value of gelatine. Up to the present it was only known that gelatine alone could not make good the need for proteids, but that a diet of gelatine with some proteid leads to a reduction of proteid metabolised. Dr. Munk had propounded the question, how far can gelatine take the place of proteids? and had carried on an experiment of four days' duration. After the dog had been placed in nitrogenous equilibrium on a diet of meat-meal, rice and fat containing 9½ grms. of nitrogen in the form of proteid, five-sixths of this nitrogen was replaced by nitrogen in the form of gelatine: the animal continued in nitrogenous equilibrium. It appears from this that by the administration of gelatine the nitrogen necessary as proteids can be reduced far below the minimum metabolised in starvation, without any commencing metabolism of tissue nitrogen. Dr. Munk made a further communication on metabolism. It is known that the administration of carbohydrates to dogs leads to a saving of proteids. Recently it has been supposed that this saving is determined by the possibility that the carbohydrates lessen the putrefactive changes which proteids undergo in the intestine, so that they are absorbed unchanged in larger quantities. Since it is known that proteids are absorbed very rapidly from the intestine of dogs, and that the absorption is complete in about six hours, Dr. Munk gave a dog at one time 100 grms. sugar along with his meal of proteid, and at another time the proteid meal in the morning and the 100 grms. sugar later on after an interval of thirteen hours, when presumably there would be little or no proteid in the intestine. In both these experiments he noticed the same saving of proteids. In the first there was additionally a falling off of the ethereal sulphates in the urine, evidencing diminished putrefaction of proteids in the intestine. In the second case, where the sugar was given separately from the proteids, the ethereal sulphates were very slightly lessened in amount, so that here apparently there was no diminution of the putrefactive changes, and still the carbohydrates had saved the proteids. These experiments do not support the view recently put forward.—Prof. König gave an account of his experiments on Dr. Zumft for determining the position of the layers of the retina which are sensitive to light.

June 22.—Prof. du Bois Reymond, President, in the chair.—Dr. Marcuse gave an account of experiments on frogs in studying pancreatic diabetes. After having satisfied himself that extirpation of the pancreas in frogs leads in most cases, at latest after two days, to a distinct diabetes, he investigated the effect on this of total extirpation of the liver. Although the frogs lived from two to five days after the operation, no diabetes was observed in any one case. Notwithstanding the numerous hypotheses as to the influence of the liver and pancreas on the sugar of the blood, it is not as yet possible to offer a satisfactory explanation of the above observations. Prof. Zuntz had recently endeavoured by a lengthy series of experiments to determine whether any one alone of the food-stuffs, proteids, fats, or carbohydrates can be regarded as the source of muscular energy. The experiments were made on a dog, which can be fed and nourished quite well on either proteids or fats or carbohydrates (rice and sugar), and showed that each one of the above three food-stuffs suffices to provide the energy necessary for the work done by the muscles. Comparative experiments made to determine which of the three food-stuffs can be most advantageously employed for supplying this energy, have not as yet led to any decisive result. This important research is to be continued.

GÖTTINGEN.

Royal Society of Sciences.—In the *Nachrichten*, No. 2, 1894, the following papers are published:—A. von Koenen: On the age of the mineral veins of the Harz Mountains.—J. Disse: On epithelial buds in the olfactory region of mammalia.—W. Voigt: On media without internal forces, and on a mechanical interpretation of the Maxwell-Hertz equations thereby furnished.—J. Bohls: Notes on the capture and natural history of *Lepidosiren* in Paraguay.—E. Ehlers: On *Lepidosiren paradoxa* (Fitz) and *articulata* (nov. spec.) from Paraguay.—P. Günther: Gauss's researches in the theory of the elliptic functions.—Robert Fricke: An application of the ideal theory to the substitution groups of the automorphous functions.—E. Riecke: The theorem of the thermodynamic potential of a heterogeneous system in equilibrium, with an application to van der Waal's theory and to the law of the boiling-point.—W. Felgentraeger: Whiston's isoclinal chart and the secular change of magnetic inclination in the east of England.—W. Nernst and R. Abegg: On the freezing-point of dilute solutions.—C. Fromme: On the self-induction and electrostatic capacity of resistance coils, and their influence on magnetic phenomena.—F. v. Dalwigk: On a substitute for Dirichlet's principle.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—London Matriculation Directory, No. xvi., June, 1894 (London).—Practical Work in General Physics: W. G. Woollcombe (Oxford, Clarendon Press).—Smithsonian Institution Report of the U.S. National Museum, 1892 (Washington).—Die Wissenschaftlichen Grundlagen der Analytischen Chemie: W. Ostwald (Leipzig, Engelmann).—Verzeichniss der Elemente der bisher berechneten Cometenbahnen: Dr. J. G. Galle (Leipzig, Engelmann).—Studien über Docoglosse und Rhipidoglosse Prosobranchier: Dr. B. Haller (Leipzig, Engelmann).—Psychologie des Grands Calculateurs et Joueurs d'Échecs: A. Binet (Paris, Hachette).—A Dictionary of the Economic Products of India: Prof. J. Watt, 6 Vols. (Calcutta).—Gesammelte Werke von H. Hertz: Band 3, Die Prinzipien der Mechanik (Leipzig, Barth).

PAMPHLETS.—Demonstration du Principe de l'Equivalence: M. G. Mouret (Niort, Lemercier).—Bericht über die Thätigkeit des Königlich Preussischen Meteorologischen Instituts in Jahre 1893: W. von Bezold (Berlin).—A Short Guide to the Larmer Grounds, Rushmore, &c.: Lieut.-General Pitt-Rivers—The Consumption of Steam and Water in Steam-Engines: W. I. Ellis (J. Heywood).

SERIALS.—Quarterly Journal of Microscopical Science, July (Churchill).—Mathematical Gazette, No. 2 (Macmillan).—Physical Society of London, Proceedings, Vol. xii. Part 4 (Taylor and Francis)—Longman's Magazine, August (Longmans).—Good Words, August (Isbister).—Sunday Magazine, August (Isbister).—Zeitschrift für Physikalische Chemie, xiv. Band, 3 Heft (Leipzig, Engelmann).—Journal of the Sanitary Institute, July (Stanford).—Transactions and Proceedings of the New Zealand Institute, 1893, Vol. xxvi. (Wellington).—Humanitarian, August (Hutchinson).—Century Illustrated Magazine, August (Unwin).—New Science Review, Vol. 1, No. 1 (26 Henrietta Street).—English Illustrated Magazine, August (198 Strand).—Chambers's Journal, August (Chambers).—Proceedings of the Edinburgh Mathematical Society, Vol. xii. (Williams and Norgate).—Quarterly Journal of the Geological Society, Vol. L. Part 3, No. 199 (Longmans).—Geological Journal, August (Stanford).—National Review, August (Arnold).—Contemporary Review, August (Isbister).

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