THURSDAY, JANUARY 15, 1914.

APPLICATIONS OF POSITIVE RAYS.

Rays of Positive Electricity and their Application to Chemical Analysis. By Sir J. J. Thomson, O.M., F.R.S. Pp. vii + 132 + 5 plates. (Longmans Green and Co., 1913.) Price 5*s.* net.

ALL physicists and chemists will welcome this account by the author of his wonderful series of researches, begun seven years ago, on positive rays. This name, "positive rays," is preferable to "canal-rays," originally applied to the stream of positively-charged particles which passes through a hole in a flat cathode; and the author's choice of the word "particle" to denote an atom carrying a positive charge, and the word "corpuscle" for what is generally now termed an electron, will not be challenged.

After a description of Goldstein's experiments, an account is given of Wien's discovery that these rays are deflectable by powerful magnetic fields. The theory of the deflection is shortly and clearly stated; and also the theory of the electrostatic deflection of a particle. Then follows an account of the author's first experiments, made in 1906, for which he devised an apparatus allowing of the simultaneous application to a bundle of positive particles both an electrostatic and a magnetic force. The arrangement is so devised as to apply these forces at right-angles to each other; and the result, as Sir Joseph Thomson has described in numerous papers and lectures, is to convert the luminous point (if a Willemite screen be used) into a parabola. The position of the parabola on the screen is conditioned by the intensity of the forces applied; but if these be kept uniform, it depends, *inter alia*, on the masses of the particles. Now the mass is simply related to the atomic or molecular weight, and hence the nature of the particles can be identified.

It is found, however, that the same mass may hold one or more charges; hence in deducing the atomic weights, this has to be borne in mind.

Descriptions are given, with figures, of the instruments employed; but from a practical point of view the figures might have been improved. In Fig. 6, for example, connections for maintaining an electrostatic field are not shown, and neither in that figure nor in Fig. 13 is any arrangement shown for introducing gas. Indeed, one wonders, in reading this book, what gases were present to cause the kathode rays to pass, for they cease in a high vacuum. Sir Joseph Thomson points out the necessity for removing air very thoroughly with a pump before applying absorption with cooled charcoal; are the residual gases traces of neon and helium? or are they minute traces of oxygen and nitrogen, corresponding to the vapour-pressures of the gases condensed on the charcoal? or do the conducting gases come off the electrodes, or off the walls of the tube? It would have been useful if information on this point had been given. In this connection, on p. 25, we are told that the gas to be used is kept in *A*, Fig. 13; but there is no means of introducing a gas into *A*; the gas is said to be stored over a column of mercury; how then is mercury vapour excluded? The same want of precision applies to the description of the photographs. It is exceedingly difficult, if not impossible, to follow on the plates the peculiarities described in the text; for example, Fig. 28 is described on pp. 48 and 49. Eight parabolas are mentioned in the text, but only five appear in the photograph. Possibly the negatives may show more than the prints; but if so, it should have been stated, and a diagrammatic reproduction of the photographs should have been given. In this connection, too, it may be mentioned that there is a considerable number of misprints; the well-known "effect" is due to Doppler, not Döppler; and commas are frequently substituted for semi-colons.

The ingenuity with which various effects are analysed and alternative hypotheses tested is extraordinary; Sir Joseph Thomson possesses scientific imagination in the highest degree, combined with the power of mathematical presentation and wonderful experimental skill. Take the following passage:—

"We can form an estimate of the magnitude of the attraction between a neutral atom and a corpuscle. From the measurement of the plates we find that there are negatively electrified atoms of hydrogen with a velocity as large as 2×10^8 cm./sec. This means that a neutral atom of hydrogen is able to capture a corpuscle even though it is moving past it with this velocity. This capture, however, would not take place unless the work required to remove a corpuscle from the surface of a neutral atom of hydrogen were greater than the kinetic energy of a corpuscle moving with the velocity of 2×10^8 cm./sec. This kinetic energy is equivalent to the fall of the atomic charge through 11 volts; hence we see that it must require an ionising potential of more than 11 volts to liberate the corpuscle from a negatively electrified atom of hydrogen. The same considerations show that to liberate the corpuscle from a negatively electrified atom of carbon would require at least 0·9 volt, while for oxygen the corresponding ratio would be 0·7 volt. It must be remembered that these are merely inferior limits; the actual values may be much larger."

It is interesting to note that evidence has been obtained of the transitory existence of such groupings as CH_3, CH_2, and CH, as well as of

groupings of two and of three carbon atoms; the last are produced only when the vapours of complex carbon compounds are induced to form "positive rays."

The question of multiple charges carried by an atom is discussed at considerable length; it would appear that a mercury atom may carry as many as 8 charges; an atom of krypton, 4 or 5; one of argon, 3; one of neon, 2; of nitrogen and of oxygen, 2; and of helium, also 2; no hydrogen atom with more than one charge has been observed. The larger the number of charges carried, the fainter the line. But the intensity of the parabolic line, whether seen on a Willemite screen or photographed, is by no means proportional to the amount of element producing it. The hydrogen parabola, for instance, is always much more intense than would be accounted for by the relative amount of hydrogen present. To prove this, a most ingenious device was adopted; a parabolic slit in the screen was interposed between the source of the rays and a metallic box, connected with an electrometer; by altering the intensity of the magnetic field, the parabolas were made to fall on the slit, and the rays passed through into the box, and registered their intensity on the electrometer. In this way the relative quantity of the gaseous elements present was estimated with fair accuracy.

Proof was also obtained that helium is a monatomic gas, while oxygen and hydrogen are diatomic; for in the discharge-tube, besides detachment of a corpuscle from a molecule, the splitting up of a molecule into its constituent atoms takes place.

Chapters follow on retrograde and on anode rays; and Stark's interesting observations on the Doppler effect are described and amplified; also a short account of the spectra produced by bombardment with positive rays.

Next follows a chapter on the use of positive rays for chemical analysis; the preface states that "one of the main reasons for writing this book was the hope that it might induce others, and especially chemists, to try this method of analysis." I fear that it will not have this result. It is a pity that Sir Joseph Thomson in this chapter had not given a more detailed account of his methods, with more elaborate diagrams of the apparatus. Even to one skilled in work of this nature, what appear no doubt commonplaces to him require elucidation. For example, how many amperes are necessary to incite his magnets? What is the size of the magnets? What electric field is required? What voltage must be applied to the plates giving an electrostatic field? One would require to visit the Cavendish laboratory, or to trouble its director with correspondence before one could set up an apparatus in working order.

A discussion then follows of Mr. Aston's interesting investigation of neon, with the object of ascertaining whether neon, which has the atomic weight 20·2, contains a gas of atomic weight 22; the existence of the latter is indicated by positive rays in neon. To my mind it is scarcely credible that a mixture of gases, separable by diffusion, as Mr. Aston finds, cannot be separated by distillation and yet neither Mr. Watson, who determined the atomic weight of neon, nor Mr. Aston, who repeated Mr. Watson's experiments, have been able to effect any separation by fractionation. Further work, however, will no doubt settle the question. The existence of "X_3" is next treated of; and the reasons for believing it to be a hydrogen "ozone" appear to be cogent.

Finally, Sir Joseph Thomson deals with the continuous production of helium when certain substances are bombarded with kathode rays. Again, he does not inform us what gas was present. He is rightly very cautious in drawing any definite conclusions from his experiments; but at present his bias is in favour of the possibility of disintegration; that the matter bombarded disintegrates into helium, and some other "elementary" form of matter. He says:—"The view that helium can be got from other chemical elements raises questions of such a fundamental character that few will be prepared to accept it until every other explanation has been found to be untenable." The production of helium from radium, from niton, from thorium, and from actinium is now accepted as an undoubted fact; questions of "a fundamental character" have been raised and answered; and it appears to me to need a very small stretch of imagination to suppose that while some "elements" spontaneously undergo exothermic changes with evolution of helium, others require external sources of energy before disruption takes place. W. R.

GEOLOGY AND MINERALOGY.

(1) *The Earth: Its Genesis and Evolution considered in the Light of the most recent Scientific Research.* By A. T. Swaine. Pp. xix + 277 + xi plates. (London: C. Griffin and Co., Ltd., 1913.) Price 7*s.* 6*d.* net.

(2) *Grundzüge der geologischen Formations- und Gebirgskunde.* By Prof. A. Tornquist. Pp. iv + 296. (Berlin: Gebrüder Borntraeger, 1913.) Price 6.80 marks.

(3) *Determinative Mineralogy.* With Tables for the Determination of Minerals by means of their Chemical and Physical Characters. By Prof.

J. Volney Lewis. Pp. v+151. (New York: John Wiley and Sons; London: Chapman and Hall., Ltd., 1913.) Price 6*s*. 6*d*. net.

(1) MR. SWAINE'S book represents extensive reading in geological reports and journals, some of which are not easy to procure. The references to authors require some correction —T. C. Chamberlin, for instance, is consistently quoted as "Chamberlain"—but they are well chosen and are thoroughly suggestive to the student. Thanks to this free acceptance of the results obtained by field observers in many lands, a great deal of stratigraphical information is to be found within these pages. The author, however, is possessed by an idea, which forms the undercurrent of the book, and must appear somewhat startling to petrologists, if not also to biologists. He holds that the "globes of condensed vapour" (p. 9) that occur in nebulæ pass into a liquid state, producing, if we read aright, globes of water in which certain elements are dissolved.

Through the development of protoplasm in this water, and the withdrawal of the elements from solution by organisms seeking to form hard parts, a rain of mineral matter descends, and a stony nucleus is built up from the centre outwards. Calcium carbonate cannot exist in great oceanic depths, and consequently the first deposits were siliceous, and were followed by calcareous matter, similarly arising from the tests of organisms. The red clays of deep seas represent material intermediate between these types; but the chemical actions required to produce them from shells are admittedly obscure. Wherever deep oceanic basins existed during geological times, the same order of deposition has been followed (pp. 19—21); the quartzites and sandstones in such cases, which in reality mark the first sediments in a sinking area, are regarded as formed from radiolaria in a great persistent hollow which has gradually become infilled. The calcareous oozes thus represent the latest and shallowest stage.

The application of this theory to the Upper Cretaceous series of Europe (p. 22) leads to a very confused argument. Terrigenous deposits are recognised at the base, and yet these are used to support the statement that "the $CaCO_3$ decreases with the depth." Petrological examination would have kept the author from many unjustified suggestions, such as that in regard to laterite (p. 198), which is treated, in spite of an abundant literature, as an oceanic ooze. The book is obviously not a safe one for beginners, though its illustrations and mode of production go far to commend it to the reader.

(2) Prof. Tornquist's introduction to geology is of a very different order. He also reaches a description of oceanic sediments on his tenth page, and interestingly refers to Philippi's suggestion that in past times, when no polar ice-caps existed to produce unfavourable coldness, calcareous organic deposits could be formed over the deep-sea areas in general. As is fitting in a work emanating from Königsberg, the rocks of the "Eozoicum" find their type in the admirable exposures of Fennoscandia; but the absence of many formations from eastern Prussia enables the author to be wisely eclectic. Due prominence is thus given to the Silurian strata of Wales and of Bohemia; the Permian and Triassic systems receive far more adequate treatment than is usual in English text-books; and we have a good account of the Jurassic rocks of central Germany. On the other hand, we may feel that four lines (p. 222) form an insufficient reference to the Cretaceous beds of northern France and England. The earth-movements in the Harz area in Cretaceous times are illustrated on p. 227, and are shown to be forerunners of the "Saxon folding" that accompanied the formation of the Alps. On p. 263, the essentially modern nature of Europe is well expressed. The illustrations are excellent, and include the skeleton of *Allosaurus agilis* from the American Museum in New York. We should have liked some reference to the gnawed bones of the prey in this most terrible of zoological reconstructions.

(3) Prof. Lewis's manual may be regarded as convenient by those to whom the well-known work of Brush and Penfield seems unduly large. It follows similar lines and covers a wide field, and such recently discovered minerals as benitoite and purpurite are introduced. In every case references are given to the two text-books by J. D. and E. S. Dana. G. A. J. C.

OCEANOGRAPHIC RESEARCHES.

Scientific Papers. By J. Y. Buchanan, F.R.S. Vol. i. Pp. xii+15 papers. (Cambridge: University Press, 1913.) Price 10*s*. 6*d*. net.

THE numerous expeditions which have explored the depths of the sea since the voyage of H.M.S. *Challenger* during the years 1873–76 have added much to our detailed knowledge of the conditions occurring in various seas and oceans, and in certain cases have given some idea of the periodic and irregular physical changes which take place. But the great pioneer voyage remains the only one which has surveyed the whole world of waters, and it is remarkable how little the work of more recent years, with all its advantages of previous experience and more adequate

resources, has modified the broad outlines of the *Challenger* results. It is of fundamental importance to the history of oceanography that the record of these early investigations should be made accessible once for all by the best authorities; those authorities, to wit, to whom the researches themselves were originally due. This has, of course, been done in great measure in the published narrative and reports of the *Challenger* Expedition; but, as in all other undertakings of the same order of magnitude, there is a sort of aftermath of result, the fruit of incidental inquiries into special methods or of special subsequent opportunities arising from the original main enterprise. These collateral results are necessary to complete the historic picture, both of the work and of the men who carried it out.

It is, therefore, a matter for much satisfaction that this has now been done, in so far as the physical and chemical work is concerned, by the chemist and physicist of the expedition himself. Mr. Buchanan entered upon his work with nearly everything to plan and invent, both as regards what was to be done and how it was to be done, and he has continued and expanded it in many directions since, along lines similar in many ways to those followed on the *Challenger*. We welcome this volume of reprints of his original papers, both for historical reasons and for the permanent value of the results obtained.

Of the fifteen papers reprinted in this book, two deal with the distribution of temperature under ice in Linlithgow Loch, describing observations showing the fallacy of the belief that the temperature of the water of a frozen lake is always that of the point of maximum density. With these exceptions, they are all concerned with oceanographical matters; either describing methods and results of experiment, as in the papers on absorption of carbonic acid by saline solutions, on the composition of sea-water ice, on determinations of specific gravity, or on apparatus for deep-sea investigation generally; or else giving the results of observations in special regions of the ocean. The lectures on "Laboratory Experiences on Board the *Challenger*," and "Deep-sea Investigation and the Apparatus Employed in it," are of special historical value, as they describe in full detail the instruments and methods employed in deep-sea work from the time of Columbus up to and including the *Challenger* expedition itself.

Mr. Buchanan's work after the *Challenger* expedition was largely carried on in the cable ships of the Silvertown Company, which afforded him special opportunities for research in connection with lines of soundings on the west coast of Africa. The results are embodied in important papers on the "Dacia" shoal, on the land slopes separating continents and oceans, and on the exploration of the Gulf of Guinea. The remarkable submarine valleys running out from the mouths of the Congo and other West African rivers are described.

OUR BOOKSHELF.

Cabinet Timbers of Australia. By R. T. Baker. Pp. 186+lxviii plates. (Sydney: Technological Museum, 1913.)

THIS work directs attention to a section of Australian timbers which is especially suitable for cabinet work, furniture, and interior decoration.

More than sixty species, belonging to twenty-one different natural orders, are described and illustrated, the natural colour and graining of each wood being depicted by the aid of colour photography. There are also excellent illustrations in black and white of furniture and interior fittings made from several of the woods.

The coloured illustrations are the feature of the book. At first sight many of them give one the impression of being thin veneers, an impression only removed by fingering the surface of the picture. The very texture of the wood is so well brought out by this process that its working qualities can almost be predicted. We have placed actual specimens alongside the prints in several cases, and the majority of them match very closely. The text is not equal to the illustrations. Each plate is accompanied by a popular description of the timber and the uses to which it can be applied, but the information given is very meagre. This is followed by a condensed description of the tree in technical language which will only be understood by the trained botanist. The geographical range of each tree is given, but little is said about the supply available, which is one of the most important points for the trade.

The main object of the author, however, is to interest Australians themselves in their native timbers and bring home to them the necessity for taking steps to prevent these valuable timber trees being exterminated in the process of clearing the land for settlement. The book certainly brings out the fact that Australia possesses a rich assortment of beautiful cabinet woods exhibiting a wide variation in figure, texture, and colour, and the Empire, no less than the Commonwealth, will suffer an irreparable loss if steps are not taken to stop the present waste of this valuable heritage of natural wealth.

Marsh's Mathematics Work-book. Designed by H. W. Marsh. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1913.) Price 3*s.* net.

THIS book consists of about 250 blank unruled sheets of writing-paper of good quality, divided into two sections. Each section is fastened to the book-cover by two strong paper fasteners, so that the sheets may be removed as required. The cover is of substantial quality, having leather

corners and back. Several daily record sheets are provided, and the student is expected to fill these up, giving particulars of date, portion of the text-book or work studied, remarks, as well as particulars of the time which he has spent at other subjects. The student is expected to certify this record by his signature. Pasted to the interior of the cover are elaborate instructions regarding methods of entering work done, for filling up the record sheet, excuses, collection and distribution of work-books, inspection, and corrected work. Some of these instructions are distinctly good, and might be taken to heart by many teachers of mathematics in this country. For example—"as soon as possible learn to draw a light, smooth, draughtsman's line." Those who have had the opportunity of examining the British average mathematical home-work will appreciate this quotation. No doubt the designer of this book has found that it meets perfectly the needs of his own institution and students, but we question whether it will meet with much favour in this country, where it is well known that every teacher prefers to develop his own methods as regards style of home-work, examination, and so on.

The Celebration of the Two Hundred and Fiftieth Anniversary of the Royal Society of London, July 15–19, 1912. Pp. 128. (London: Humphrey Milford, 1913.) Price 5*s*. net.

THE interesting events in connection with the celebration of the 250th anniversary of the Royal Society in July, 1912, were reported in these columns at the time, and the contents of this volume consequently cover ground familiar to our readers. This permanent record of the proceedings contains a full list of delegates and verbatim accounts of the addresses, speeches, telegrams, and letters addressed to the Society from learned societies and other bodies throughout the world. With the new edition of the "Record" of the Society, and the facsimile reproduction of the pages of signatures of the fellows in the Charter book, from that of the Royal founder down to those entered in the summer of 1912, it will form an appropriate and lasting memorial of a noteworthy celebration.

Who's Who in Science: International, 1914. Edited by H. H. Stephenson. Pp. xx+662. (London: J. and A. Churchill.) Price 2*s*. net.

THIS excellent work of reference contains, in addition to its 9000 biographies of men of science of all nationalities, other useful information. Especially convenient are the tabular statements, arranged alphabetically, of particulars about the universities of the world, which include the names in each case of the head of the university and the senior occupants of the various scientific chairs. A valuable list of the "World's Societies" is also included, and from it the name, address, number of members, the name of the secretary, and other facts can be seen at a glance. An exhaustive classified index adds greatly to the value of the volume.

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.*]

The Pressure of Radiation and Carnot's Principle.

I GATHER from a letter on this subject which appears in your last issue that Lord Rayleigh endorses the opinion that the partial pressure p of any particular frequency in full radiation may properly be deduced from the intrinsic energy-density E/v of the same frequency by Carnot's principle.

The other point to which I wished to direct attention is that, in the case of a steady stream of radiation of constant frequency, the heat quantity measured is the total heat of formation per unit volume, $E/v+p$, and not the intrinsic energy-density E/v as commonly assumed. The disagreement with experiment of Wien's well-known formula for the partition of energy in full radiation, is readily explained if we assume that it represents only the intrinsic energy. The corresponding value of the pressure is very easily deduced by reference to Carnot's principle, as Lord Rayleigh has indicated. The formula which I have proposed (*Phil Mag.*, October, 1913) is simply the sum of the pressure and energy-density thus obtained, and gives very satisfactory agreement with experiment, both for radiation and specific heat. I prefer it to Planck's formula (among other reasons) on the ground that the latter cannot be reconciled with the classical thermodynamics, and involves the conception of a *quantum*, or indivisible unit of action, which is unthinkable. The corresponding physical magnitude on my theory, which I have elsewhere called a molecule of caloric, is not necessarily indivisible, but bears a very simple relation to the intrinsic energy of an atom, which is all that is required to explain the fact that radiation may in special cases be emitted in atomic units which are multiples of a particular magnitude.

H. L. CALLENDAR.
Imperial College of Science and Technology, South Kensington.

Atomic Models and X-Ray Spectra.

IN his letter to NATURE of January 1 on "Atomic Models and X-Ray Spectra," Dr. F. A. Lindemann deals with the approximate agreement between the recent experiments of Mr. H. G. J. Moseley on "The High-frequency Spectra of the Elements" (*Phil. Mag.*, December, 1913), and the calculations given in my paper, "On the Constitution of Atoms and Molecules" (*Phil. Mag.*, July, September, November, 1913).

In Dr. Lindemann's opinion a theoretical explanation of Mr. Moseley's results can be obtained in several ways; and he therefore concludes that the agreement in question cannot be considered to support the assumptions used in my paper. By the help of a consideration of dimensions he seeks a relation between the five quantities, v, r, Nne^2, m, and h. He shows that an infinite number of different expressions can be obtained for v in terms of r, Nne^2, m, and h; and he indicates how several of these expressions may be brought in approximate agreement with the experimental results.

This procedure does not appear to me to be justified. Just as little as the five quantities v, r, Nne^2, m, and h, the four quantities, r, Nne^2, m, and h, may be considered as independent of each other. By a consideration of dimensions we can obtain a relation

between r, Nne^2, m, and h; and if we introduce this relation in Dr. Lindemann's expressions for ν, all the different expressions become identical.

By a consideration of dimensions only, we cannot calculate the numerical factors which determine the exact values for the frequencies of the spectrum of an element; in order to do this, we must introduce more detailed assumptions as to the constitution of the atom and the mechanism of emission of radiation. A discussion of the special assumptions used in my calculations will be found in a paper on the influence of electric and magnetic fields on spectral lines, which will appear shortly in the *Philosophical Magazine*.

N. BOHR.

The University, Copenhagen, January 5.

DR. F. A. LINDEMANN (NATURE, January 1) disagrees with the theoretical interpretation of my recent work on X-ray spectra (*Phil. Mag.*, December, 1913). He objects to my statement that the results so far obtained strongly support the views of Bohr, and considers that they yield no information about the structure of the atom beyond confirming the views of Rutherford and van den Broek. My work was undertaken for the express purpose of testing Broek's hypothesis, which Bohr has incorporated as a fundamental part of his theory of atomic structure, and the result of the test certainly confirms the hypothesis. In my opinion, however, further definite conclusions can be drawn from the results, and these conclusions strongly support other features of Bohr's theory. Moreover, I cannot accept the alternatives which Dr. Lindemann offers to my formula representing the values of the principal frequencies observed.

Dr. Lindemann's arguments are based on the principle of dimensions. This method of treatment is of historical interest, as we owe to it the introduction of Planck's quantum h into the discussion of atomic structure. So long as the only factors, common to all atoms, on which this structure was known to depend, were e, m, the charge and mass of an electron and Ne the charge of the nucleus, it was impossible to obtain a quantity of the dimensions of a frequency. In an electromagnetic system the introduction of c, the velocity of light, might get over this difficulty, but it has proved more profitable to treat the problem as electrostatic and make definite calculation possible by using h.

We will call the assumption that h is a fundamental factor in the atom the h hypothesis. It then follows from the principle of dimensions that the frequency of an atom, $\nu = f\frac{e^4 m}{h^3}$, where f is a numerical constant which depends on N, and also on the arrangement of the electrons in the atom.

The reason why Dr. Lindemann arrives by the same argument at an indefinite result is that he takes r, the distance of the electron from the nucleus, or else rN to be an independent factor in the calculation. No independent natural unit of length, which would apply to an electrostatic problem, is known, and the separate introduction of r or rN appears to me to be unwarranted. Bohr has pointed out that the fundamental frequency ν_0 of ordinary series spectra is obtained by putting $f = 2\pi^2$ in the formula given above, while my work shows that the frequency of the principal line in the X-ray spectrum of elements from Ca, N = 20 to Zn, N = 30 corresponds with

$$f = 2\pi^2 . \tfrac{3}{4}(N-1)^2 .$$

The simplicity of the expression f in these two cases is itself an argument in favour of the h hypothesis. It is, however, more strongly supported by the fact that the frequencies in the X-ray spectrum are proportional to $(N-1)^2$. Two alternative explanations can be given for the occurrence of $(N-1)$ and not N. It is just possible that two of the elements which precede calcium have the same atomic number. A mistake would then have been made each time in reckoning N, and ν would really be $\propto N^2$. It is much more likely that the repulsion of the other electrons cannot be neglected compared with the attraction of the nucleus, and then N must be replaced by $(N-\sigma_n)$. In either case we conclude that as we pass from atom to atom $\nu \propto (Fr^2)^2$, where F is the resultant electrostatic force on the vibrating electron. In other words, a quantity of dimensions $T(ML^3T^{-2})^2$ remains constant, and since the mass is always the mass of an electron $M^p L^2 T^{-1}$ remains constant. By putting $p = 1$ a quantity is obtained of the same dimensions as h. For these reasons I conclude that the experiments support the h hypothesis, which has been put forward in three distinct forms, first by Nicholson, then by Bohr, and recently by J. J. Thomson.

I have not succeeded in obtaining agreement between my results and the vibrations considered by Nicholson. Bohr's theory, on the other hand, explains why there is a general spectroscopic constant, ν_0, given by $f = 2\pi^2$, and at the same time demands that the principal X-ray frequency should be given by $f = 2\pi^2 . \frac{3}{4}(N- \ )^2$. This agrees with the experimental result if the vibrating system is a ring of four electrons, all vibrating together; since $\sigma_4 = 0{\cdot}96$. Two things, however, suggest that either Bohr's theory or my interpretation of it requires modification. In the first place, it fails to account for the second weaker line found in each spectrum. In the second place it is difficult to see how a ring of four electrons can store up enough energy to vibrate as a whole. Perhaps the examination of the spectra of other groups of elements will suggest a solution of these difficulties.

H. MOSELEY.

Oxford, January 5.

"Atmospherics" in Wireless Telegraphy.

WITH reference to Prof. Perry's letter on "atmospherics" in NATURE of January 8, a description of some experiments made by us in the summer of 1912, and continued last summer, may be of interest. A receiving station was erected near Rothbury, in Northumberland, with an antenna consisting of two horizontal wires stretched about 3 ft. from the ground. The receiving apparatus consisted of a galena-tellurium detector and telephone circuit coupled to two inductances connected to the antenna wires and having a variable condenser in circuit between them. The length of the antenna was varied during the experiments, but for most of the time was about 500 yards each way, the direction of the wires being approximately north-west and south-east. No earth connection was used.

The antenna was laid on a slight slope, the receiving hut being situated in a field, but in each direction the antenna wires passed through extensive woods, the whole district in the vicinity being thickly wooded. During the observations of 1912 the ground was nearly always very wet owing to the excessive rainfall.

According to the views put forward by Prof. Perry, it would naturally be expected that atmospherics would be either absent or greatly diminished in intensity with an antenna such as we used. So far from this being the case they were both numerous and loud, so much so that we adopted this form of antenna as being suitable for investigating the direction from which atmospherics emanate. For this purpose we used crossed horizontal wires connected to a form of radio-goniometer, the well-known directive effect of

horizontal antennæ being thus utilised. The observations were not sufficiently numerous to justify definite conclusions being drawn, but so far as they went they tended to support Mr. Marconi's results as to the southerly origin of these disturbances.

The aërials of many stations are, of course, to some extent directive, and this may account for the comparative immunity of one station from atmospherics while another in its vicinity is more disturbed by them, although both might be affected equally by local thunderstorms.

WILFRED HALL.
H. MORRIS-AIREY.

9 Priors Terrace, Tynemouth,
Northumberland, January 12.

A Recently Discovered Stone Circle, near Matlock, Derbyshire.

ON the summit of "Bilberry Knoll," in the district of Matlock, latitude 53° 7′ 1½″, and longitude 1° 32′ 15″ W., there are remains of what I believe to have been an important station in prehistoric times, dedicated to the sun-worship cult.

The highest point of the hill is crowned by a mound, obviously artificial, built up of large boulders and earth, and, although much disturbed, many of the stones occupy positions in which they were originally placed. Some of them appear to form part of the circumference of a circle with thirty-six bays, or divisions, of 144 ft. diameter. Near the centre there are two chambers, one in horse-shoe form, and the axis through these chambers is in line with the "Nine Ladies," a well-known circle, on Stanton Moor.

The range of hills (of which Bilberry Knoll forms the highest point, 928 ft. above O.D.) occupies a very strong natural position, and the summit was apparently further protected by ramparts, remains of which may be seen about 200 yards south of the circle mound.

The circle commands an extensive view in every direction, and there are in sight more than thirty positions which bear distinctive names.

To discover the significance of some of these positions I have taken observations of the sunset on those days usually regarded as sacred in the "Druidical," or sun-worship cult, more particularly of the May Eve and June Solstice festivals. But sunsets down to the horizon are rare, and I had no data by which to determine the true date of *May Eve*. I ultimately decided on May 11 as being consonant with May Eve (old style), and this year, on that date, the *full disc* of the sun rested upon a distant horizon (altitude 10′), exactly over the intersection of intervening hills, on an alignment N. 58° 00′ W.

At the June solstice the results were more decisive, the sunset being almost exactly over the "*Nine Ladies*." This well-known circle lies a little more than five miles away, N. 46° 30′ W., and the height of horizon is about 13′. And N. 46° 00′ E., with a similar altitude, stands "Blakelow Hill"; this hill would thus indicate the rising sun, and, conjointly with the "Nine Ladies," provides irrefutable evidence of purpose. For, whereas "Blakelow Hill" is a distinctive natural feature, the "Nine Ladies" occupies a *chosen* site, slightly below the highest ground, on a broad plateau. And, whilst it is in sight, and indicates the sunset from "Bilberry Knoll," it is not in sight from a circle only 1¾ miles away on Harthill Moor, nor from "Arbor Low," which is within 5½ miles, though a difference of very few yards in position, on higher ground, would have placed it in sight of all three. It was therefore clearly established as an adjunct to "Bilberry Knoll."

Comparing these results with data which I have since obtained from Sir Norman Lockyer's valuable work on "Stonehenge," I find the alignment for sunset on May 6 to be about N. 61° 00′ W., but the date actually observed appears to be subject to local variation, the Roman calendar being May 9 (the date of a fair day at Matlock). Making allowance for this, and for variation in obliquity of the ecliptic, it seems probable that this hill intersection would indicate the sunset on the eve of the May year festival.

The alignment for the June solstice I make N. 47° 15′ W., which is so near as practically to confirm my conclusions.

Investigations on the various sites would, I believe, prove that the better-known Derbyshire circles, "Arbor Low," the "Bull Ring" at Dove Holes, and "Wet Withins" on Eyam Moor, were also established with alignments to distinctive features that would indicate the rising and setting sun on these dates.

JOHN SIMPSON.

Spring Mount, Bank Road, Matlock,
January 5.

Trepanning among Ancient Peoples.

A NOTE in NATURE of October 30, 1913, p. 273, referring to the late Dr. Lucas Championnière's paper on prehistoric trepanning, which was read at the last annual public meeting of the Five Academies in Paris, contains this observation :—

"It is remarkable that the operation was not practised among highly civilised races like Greeks, Egyptians, Arabs, Hindus, and Chinese. . . ."

But the subjoined quotations would seem to militate with the soundness of this expression so far as it concerns the ancient peoples of Greece and India :—

"In surgery his (Hippocrates's) writings are important and interesting, but they do not bear the same character of caution as the treatises on medicine; for instance, in the essay 'On the Injuries of the Head,' he advocates the operation of 'trephining' more strongly and in wider classes of cases than would be warranted by the experience of later times" ("Encyclopædia Britannica," 1910, vol. xiii., p. 518).

"The next most elaborate chapter (of the Hippocratic collection) is that on wounds and injuries of the head. . . . Trephining was the measure most commonly resorted to, even where there was no compression" (*ibid.*, vol. xxvi., p. 125).

"Jīvaka (afterwards termed the King of the Physicians) had learnt the whole art of healing with the exception of the operation of skull-opening. Now a man who was afflicted by a cerebral malady came to Atreya (Jīvaka's master) and asked him to treat him. Atreya replied that the man must dig a pit that day and provide it with dung. . . . When Atreya came, he placed the man in the pit, opened his skull, and was about to seize the reptile with his pincers (when Jīvaka advised him how to take it away). . . . When all this had been done the man was cured" (E. A. von Schiefner, "Tibetan Tales," trans. Ralston, 1906, p. 98). The same book, p. 100, relates how Jīvaka cured a man whose head itched greatly by drawing out of his skull a centipede through the same operation. In the "Lives of Jīvaka and Amrapālī (his mother)," translated into Chinese in the second century A.D., he is said to have used a golden knife in skull-opening.

"Les Saniassis sont enterrés jusqu'au col; un Religieux du même ordre casse des cocos sur la tête du mort jusqu'à ce qu'elle soit brisée; ensuite on la couvre de terre. On ignore aujourd'hui le motif de cette pratique singulière, à moins que ce ne soit pas pour faciliter à leur âme le moyen de sortir par une ouverture plus honnête que la bouche, les oreilles et

d'autres issues du corps, qu'on regarde comme impures et souillées" (Pierre Gonnerat, "Voyage aux Indes Orientales et à la Chine," à Paris, 1782, vol. i., p. 93).

KUMAGUSU MINAKATA.

Tanabe, Kii, Japan, December 13, 1913.

Systems of Rays on the Moon's Surface.

A GREAT deal has been said, and a great many theories have been put forward, as to the cause of these marvellous systems of rays on the surface of the moon. I now venture to put forward an explanation which has occurred to me, and should like the opinion of some of your readers upon it.

It is generally admitted that the volcanic action of the moon was of an enormous character, "even when the low force of lunar gravity is taken into consideration," and from our knowledge of the amount of lava emitted from one of our own small craters, we can conceive what a huge volume must have been thrown out from such gigantic craters as Clavius, Ptolemäus, or Copernicus. Now, from what we can see even to-day, the lunar surface is exceedingly mountainous, and I suggest that when these craters were in their full power huge volumes of lava were thrown out, and in many cases practically filled up valleys, or cañons between the mountains. We know the rays are from five to ten miles broad, even up to twenty miles, and from the action of the volcano there would always be the tendency for the lava to run away from the crater itself, thus forming these rays, like spokes from a hub. Some of the rays are, however, apparently of a prodigious length, up to 2000 miles long, but Prof. Pickering tells us that this length is an illusion, the long rays being made up of rays from different craters, which appear to form one long continuous ray, which satisfies the question of length.

Then many of these rays apparently run right across and almost obliterate (at full moon) such craters as Clavius and Maginnus. Now I think it is generally admitted that the ray systems from Tycho, Copernicus, and Kepler are the largest on the moon, and they are also three of the very largest craters. This points to the fact that they were the first eruptions on the lunar surface, and being the first, threw out the greatest volume of lava. This filled up the valleys in their neighbourhood, but afterwards other craters were erupted through the lava-covered rocks, though without breaking up the "lava valleys." It is highly probable that in these circumstances most, or all, the craters have their rays, though too small to be detected through even the largest glass. Their brilliance would, of course, be accounted for, by the sun shining directly upon them, through no atmosphere at all, or none worth mentioning. It seems, therefore, to me, that these rays must be geologically old remains of eruptions, dried up now, but still showing themselves on the lunar surface, though it is doubtful if the matter will ever be satisfactorily cleared up.

C. HUBERT PLANT.

49 Lichfield Road, Walsall, December 16, 1913.

THE CAPE OBSERVATORY.[1]

IN the preface to this work Sir David Gill relates that when, as a young astronomer, he was connected with Lord Crawford in the design and erection of the observatory at Dun Echt, he turned for assistance to Wilhelm Struve's "Description de l'Observatoire Astronomique Central de Poulkova." Remembering the help and pleasure which Struve's work had given him, he resolved, in humble imitation, to write a description of the Cape Observatory.

"Struve," in the words of Gill, "had the true genius and spirit of the practical astronomer, the love of refined and precise methods of observation, and the inventive mechanical and engineering capacity."

Struve had the rare opportunity of building an observatory after his own heart, regardless of expense, which should fulfil the highest requirements of the astronomy of his time. Gill, animated by the same spirit as Struve, and with similar qualifications, greatly extended and remodelled an historic observatory. Thanks to his grasp of the trend of astronomy, his skill in the design and construction of instruments, and his administrative ability and energy, he left the Cape Observatory, at the close of his directorate, one of the best equipped and most efficient observatories in the world.

The volume, as its title indicates, is divided into two parts. The first consists of a history of the observatory from its foundation to the present time, with brief biographical notices of those who have filled the position of H.M. Astronomer, and an appreciative criticism of their work and their contribution to the development of the observatory. Following this is a brief account of the past and present instrumental equipment, and a comprehensive survey of the important astronomical and geodetic results which have proceeded from the Cape Observatory. The second part of the book is devoted to a detailed description, illustrated by many photographs and diagrams, of the important instruments which have been erected at the observatory during Sir David Gill's directorate.

The value of the Cape as a site for the extension of astronomy and geodesy to the southern hemisphere was first appreciated by Lacaille, who in a brief visit in the middle of the eighteenth century made observations of the positions of more than 10,000 stars, and measured an arc of the meridian.

After the British occupation, the establishment of a permanent observatory at the Cape was considered by the Board of Longitude in February, 1820; the appointment of an astronomer was recommended, and estimates were obtained from Troughton, Dollond, and Jones for suitable equipment. The Board of Admiralty expressed its concurrence with this proposal, and the observatory was established by Order in Council on October 20, 1820, the staff to consist of one astronomer, one assistant, and one labourer.

The Rev. Fearon Fallows, fellow of St. John's College, Cambridge, was appointed H.M. Astronomer, and directed to make observations so far as possible similar to and complementary to those at Greenwich. He fixed the site of the observatory on part of a bare, rocky hill, covered with thistles and infested with snakes, but tolerably free from the sandy dust prevalent near Cape Town, and commanding a good view of Table

[1] "A History and Description of the Royal Observatory, Cape of Good Hope." By Sir David Gill K.C.B. F.R.S. Pp. cxc+136+plates. (London: H.M. Stationery Office, 1913.)

Bay, so that ships anchored there might be able to observe the time-signals. The order to commence building was signed in 1822, but did not reach Fallows until 1825. After a change of Government in 1827, 10,000*l.* was cut off the estimates for building, so that when completed the observatory was a mere block of masonry on a desolate hill, without protection, an adequate water supply, or roads. The instruments were, however, installed, and some valuable observations made.

Fallows died in 1831, after eleven years' work, full of anxiety and disappointment, and was succeeded by Henderson, who remained at the Cape only one year, but crowded into that time an enormous number of observations of various kinds. His most permanently valuable work is his catalogue of positions of the principal southern stars, obtained with similar accuracy to that of the northern stars at the same epoch, but his most striking discovery and that which his name invariably calls to mind, is his determination of the parallax of α Centauri.

Henderson's successor was Maclear. He remained director of the observatory from 1833–70. Maclear was a man of great energy and practical ability. He faced the difficulties which had disheartened Fallows, and from which Henderson had shrunk, and succeeded in making the barren hillsides into fertile grounds, in obtaining a pure water supply, in breaking the force of the south-east winds by planting trees, and establishing a communication with the main road to Cape Town. At the same time the scientific work of the observatory was carried on untiringly, both with the meridian instruments and equatorials. Owing to the smallness of the staff, the observations were not all reduced and published at the time, but Maclear's successors, Stone and Gill, were able to publish these valuable observations. In addition, he found opportunities to extend help and infuse enthusiasm into the educational and scientific projects of the growing colony.

Maclear was succeeded by Stone. He had been trained at Greenwich in the systematic school of Airy, and left as a lasting monument of his nine years at the Cape (1870–79) a catalogue of 12,881 stars.

Gill was appointed H.M. Astronomer on February 19, 1879, and retired on February 19, 1907, after completing twenty-eight years of service. At the University of Aberdeen he had the good fortune to come under the influence of Clerk Maxwell, and gain inspiration from his teaching. His interest in astronomy began with the installation of a time service for Aberdeen, which he carried out with the assistance of David Thomson, professor of natural philosophy. Shortly afterwards he purchased a 12-in. mirror, mounted it equatorially, and used it in measuring double stars, taking photographs of the moon and other observations. In 1872 he was offered charge of the observatory which Lord Lindsay was erecting at Dun Echt; he relinquished his business career, and accepted without hesitation the opportunity thus presented of devoting his whole time to science.

Gill now entered on the congenial task of assisting in the design and erection of Lord Lindsay's magnificent private observatory, and the testing, mounting, and adjustments of its numerous instruments. Soon afterwards he accompanied Lord Lindsay to Mauritius to observe the transit of Venus, and in this connection made several important determinations of longitude. In 1877 he made an expedition to Ascension, and from observations of Mars with a 4-in. heliometer, determined the solar parallax as $8{\cdot}78''$, with a probable error of $\pm 0{\cdot}012''$.

Thus fitted by his training and experience, Gill found at the Cape Observatory ample scope for his energy and for his mechanical and observational skill. In 1879 the only instruments at the Cape were the non-reversible transit-circle, the 7-in. equatorial, and the photoheliograph. During his tenure of office a 7-in. heliometer, an astrographic equatorial of 13 in., the Victoria telescope, presented by Mr. McClean, consisting of a 26-in. photographic telescope for spectroscopic work, with an 18-in. guiding telescope, and a new reversible meridian circle were all added to the equipment, and from all these instruments important results have already been obtained. With the non-reversible transit instrument observations of fundamental stars, bright southern stars, and stars the positions of which were required as comparison stars for heliometer observations were carried on systematically, and particular mention may be made of a catalogue of 8650 reference stars for the astrographic work at the Cape.

From the commencement of his tenure of office Gill urged the necessity of a reversible instrument for fundamental work. The project was not sanctioned, however, until 1897. The greatest care was lavished on the instrument, the building and the foundations. The full description, occupying one hundred pages of the book, and illustrated by many photographs and drawings, cannot be summarised in a short review, and only a bare mention can be made of the most striking and interesting features. Besides being reversible, the object-glass and eye end of the instrument are interchangeable, so that flexure may be eliminated, except for the sagging of the wire, in the mean of opposite positions. The microscopes are carried on iron piers, which are covered externally by non-conducting material, and are filled with water so that their temperature may be uniform in horizontal layers, and no tendency to twist be introduced. To detect any shift of the telescope in azimuth, stable meridian marks are obtained by connecting optically the marks and collimator lenses N. and S. of the instrument, with points fixed on the solid rock at the bottom of deep iron cylinders. These have proved so successful that the movement of the pole in azimuth corresponding to the variation in latitude has been observed. The instrument is furnished with an impersonal micrometer for the elimination of magnitude equation from the observations of

right ascension. To save the strain on the observer this is moved at approximately the right rate by an electric motor with suitable mechanism for giving the rate corresponding to the declination of the star. The great success of this instrument is attested by the results already published by Mr. Hough.

A full description is also given of the Victoria telescope, presented to the observatory by Mr. Frank McClean. It is furnished with a spectroscope for the determination of velocity in the line of sight, and with two large objective prisms of 24 in. aperture and refracting angles of 8° and 12° respectively. These can be used singly or together. Excellent results, including a determination of the solar parallax by Dr. Halm, have been already obtained with the line of sight spectroscope. The Cape Observatory is therefore, thanks to the generosity of Mr. McClean, admirably equipped for astrophysical work.

While the reversible transit-circle and the Victoria telescope are probably the instruments which will be most valuable to Sir David Gill's successors, it is with the 7-in. heliometer that most of his own personal observing work has been done. This instrument was obtained in 1887 to supersede the 4-in. used at Ascension. With it (partly in cooperation with Dr. Elkin) he made the well-known determinations of the parallax of the sun and of the brightest stars of the southern hemisphere, remarkable alike for the smallness of their accidental error and the care with which causes of systematic error were eliminated. In addition, the 7-in. heliometer has been used in other important investigations, particularly in the determination of the mass of Jupiter and the orbits of its satellites, researches in which two young astronomers, Mr. Bryan Cookson and Mr. de Sitter cooperated.

Sir David Gill includes an account of the Cape Photographic Durchmusterung. Knowing that this survey of the southern sky was proposed, Prof. Kapteyn volunteered to undertake the arduous work of measuring the photographs and discussing the results. From this cooperation, a catalogue containing the magnitudes and approximate positions of 450,000 stars resulted, giving a complete survey of the southern skies; it is noted that the preparation of this work first directed Kapteyn to the study of the problems of cosmical astronomy.

A very interesting account of the Geodetic Survey of South Africa is supplemented by an appendix by Dr. Wilhelm Bahn (translated from the *Beiträge zu Geophysik*) on the South African arc of meridian. Arcs of meridian were measured by Lacaille and Maclear, and between 1859 and 1862 the triangulation of the southern coast of Cape Colony was taken in hand. Soon after Gill's appointment, he pointed out to Sir Bartle Frere the advantage to be gained by a comprehensive survey, and recommended a gridiron system of chains of principal triangulation extending over the Cape Colony, the Orange Free State, Natal, and the Transvaal. This work has been carried out under the direction of Sir William Morris in the field, with Sir David Gill as scientific adviser, who kept constantly in view the service to geodesy which would be derived from the measurement of a large arc on the 30th meridian of east longitude. This was afterwards continued through Rhodesia, and the extreme arc measured extends over nearly 22° from 31° 36′ S. lat. to 9° 41′ S. lat. There are six base-line determinations along the arc, and sixty determinations of astronomical latitude. The measures of the South African arc of meridian indicate a somewhat larger terrestrial spheroid than that of Clarke, and are in accordance with the results obtained by Hayford in the United States. The extension of this arc to join the Egyptian arc, and the connection round the eastern end of the Mediterranean to join the Russian arc measured by Struve is of great scientific importance, and, as Sir David Gill points out, offers no very formidable difficulty if international cooperation is secured.

In this article only portions of the volume have been touched upon. Sir David Gill is to be congratulated on the production of a work the historical and narrative portions of which are of interest to all men of science, while the technical portions are of the greatest value to astronomers. He may be assured that others will find guidance and inspiration in this history of the Cape Observatory, as he himself did in Struve's account of Pulkova. F. W. DYSON.

SCIENTIFIC METHODS OF IDENTIFYING PICTURES.

UP to the present time the identification of works of art has been entrusted entirely to the art expert, who brings to bear upon the problem his wide experience and artistic training; and, in addition, it is probable that among those engaged in buying and selling pictures, many devices kept as trade secrets are useful in identifying pictures. While not for a moment denying that the final word should lie with the trained art expert, it is of interest to see how far scientific methods can be brought to bear upon this problem. The first step in this direction is a careful study of the history of pigments. By the examination of ancient documents, such as the illuminated manuscripts of the monks, Venetian Ducali, and the Coram Rege Rolls, it has been possible to plan out the history of pigments probably with sufficient accuracy for practical purposes, and to fix the dates approximately of certain pigments which appear and others that disappear from the artist's palette. This method, where applicable, may be regarded as infallible, as the presence of a pigment of a date more modern than the date at which the picture is supposed to be painted proves either forgery or repainting, and a careful microscopic examination make it quite possible to tell whether the picture has been repainted or not.

This, however, does not settle the authorship

of the picture, and there are certain periods in the history of art during which for a considerable length of time there was no change in the artist's palette. It is necessary, therefore, to bring other methods as well to bear upon the problem. One of these is the study of mediums used at different dates, and in this study sufficient progress has been made to prove it of use for dating purposes. But, as will be obvious to a chemist, the analytical difficulties here are much more serious.

The microscopic study of pictures by magnifying under low powers revealed remarkably distinctive characters in the artists' brushwork; and the more pictures examined, the more valuable did the method appear as a trustworthy means of determining the authorship of a picture. There are probably certain schools of art to which the method does not apply. A great deal of the sixteenth-century Italian work, for instance, is handled in a very similar way, and it may be very difficult to apply this method successfully to some of these painters. But there is a wide field in which the artist has left his individual mark upon his paint, and has so drawn for the future a signature which it is impossible to forge. One of the most interesting revelations is that many of these touches are so fine as to be really beyond the limit of unaided sight. For instance, the brushwork of Teniers and of Watteau can be magnified up to four or five diameters, revealing an accuracy of touch and a delicacy of modelling and a drawing of lines which are themselves in some cases not more than one-tenth of a millimetre in diameter, and yet are put in with perfect certainty. The study of foliage is also of special interest, as each man's method of handling foliage is characteristic.

Among the large number of photographs taken it is difficult to know which to select as examples of the method, but probably those will be of most interest which illustrate an actual problem. Such a problem is offered by the picture in the National Gallery known as "The Old Gray Hunter," which is signed "Paul Potter," and has been stated by no less authority than Dr. Bredius to have been painted by Verbeecq, a contemporary artist. There is another Paul Potter in the National Gallery (No. 849), the authenticity of which has never been questioned, and which a comparison of photomicrographs with photomicrographs of a pedigree Paul Potter in The Hague Museum shows to be genuine.

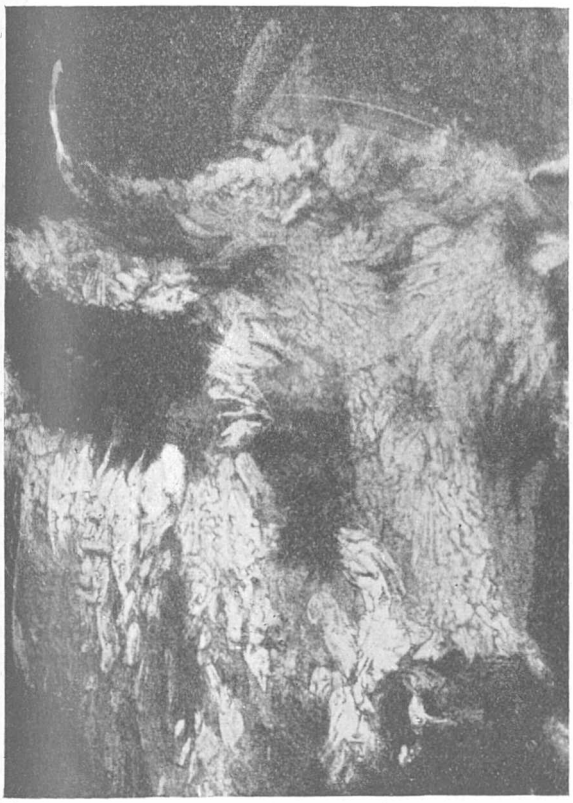

FIG. 1.—Brushwork of the head of a cow in an undoubted picture by Paul Potter in the National Gallery.

FIG. 2.—Brushwork of the head of the horse in "The Old Grey Hunter," shown by the touch not to be by Verbeecq, and inferior to Paul Potter's best work.

The first photograph here reproduced (Fig. 1) is the head of a cow in this genuine Paul Potter for the comparison with the head of the horse (Fig. 2) in "The Old Gray Hunter." It is at once obvious that, while there are certain similarities in the brushwork, the painting of the horse's head is by a very inferior hand to that of the painting of the cow. The probability is, then, that it is not Paul Potter's work, although this cannot be considered as absolutely proved.

The method of photomicrography has been applied to the examination of pictures by other artists. One example examined was in a private

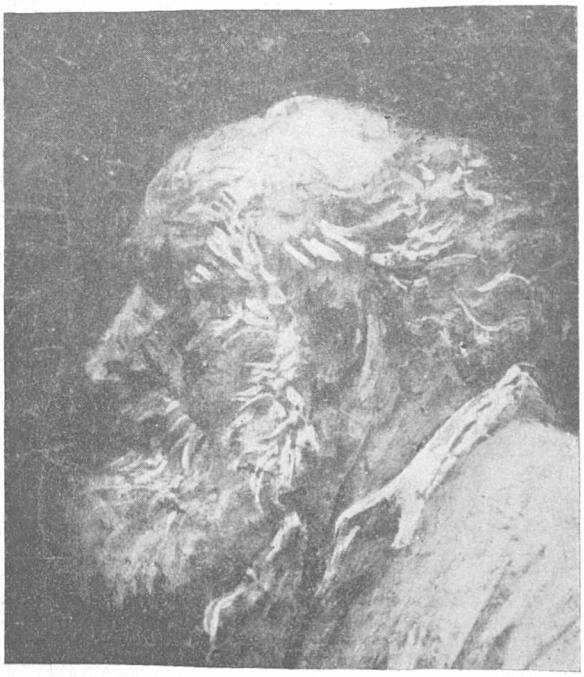

FIG. 3.—Brushwork of the head of an old man, from a picture in the National Gallery known to be by Teniers.

collection, and it had every appearance of being by Teniers. Curiously enough, there appeared in it an old man who is to be seen in more than one

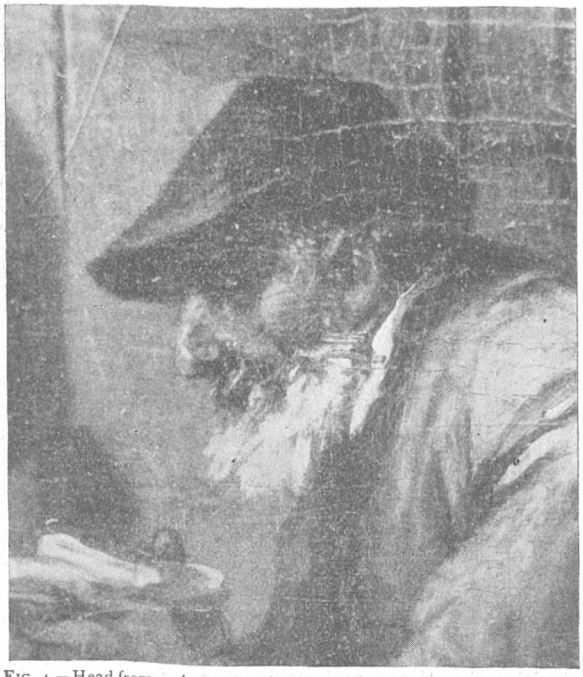

FIG. 4.—Head from a picture described in a private collection as by Teniers but shown by the brushwork not to possess Teniers's touch.

of Teniers's genuine works. The picture, therefore, had come from Teniers's studio, as the same model was to be found in it, or it was a copy and a forgery. The two photographs reproduced in Figs. 3 and 4 show the old man as painted by Teniers in the well-known picture in the National Gallery of Teniers's "Chateau," and the face painted in the private picture. The difference of brushwork in the modelling of the face is at once apparent, while the careless painting of the beard, when compared with Teniers's, is clearly revealed.

A. P. LAURIE.

AMERICAN AND GERMAN INVESTIGATIONS ON SOIL FERTILITY.[1]

THERE is always a refreshing novelty about the publications of the American Bureau of Soils that makes an irresistible appeal to the student of agricultural science on this side of the water. We may not always agree with the conclusions reached, and we may sometimes think that the facts might be interpreted otherwise, but we cannot deny the ingenuity and freshness of the work done.

Of all difficult problems connected with the soil, few are more promising than the investigation of the remarkable carbon compounds produced during the decay of plant residues in the soil. It is known in a general way that cellulose and protein (two important plant constituents) are broken down in the soil to ammonia and carbon dioxide, but the intermediate products have scarcely been investigated in spite of the great biochemical interest of the process. Dr. Schreiner and his colleagues have recently attempted the problem, and their results are set out in a series of bulletins issued from the bureau.

Examination of the soil has shown that numerous nitrogen compounds can be obtained from it as the result of applying certain methods of extraction; among them are hypoxanthine, xanthine, guanine, adenine, cytosine, as well as the split-products of the proteins. There can be little doubt that these arise from the decomposition of decaying plant residues and other substances added as manure. The fact of their existence in the soil is of considerable interest, but it is still more interesting to inquire whether they serve any useful purpose in relation to plant growth. The current view is that they decompose to form nitrates, which are then absorbed by the plant, and built up once more into complex proteins, nucleoproteins, &c. Messrs. Schreiner and Skinner suggest that some of them at any rate are absorbed as such, and utilised direct for the formation of protein. One is accustomed to this view in animal physiology, but hitherto it has not been commonly held among plant physiologists. Experiments are here described, showing that histidine, creatinine, and asparagine caused increases in green weight in wheat, even when a

[1] "Nitrogenous Soil Constituents and their bearing on Soil Fertility." By Oswald Schreiner and J. J. Skinner. U.S. Department of Agriculture, Bureau of Soils, Bull. No. 87.

"Occurrence and Nature of Carbonised Material in Soils." By O. Schreiner and B. E. Brown. *Ibid.* Bull. No. 90.

"Studies in Soil Catalysis." By M. X. Sullivan and F. R. Reid. *Ibid.* Bull. No. 86.

"Pflanzenwachstum und Kalkmangel im Boden." By A. Wieler. (Bornträger, Berlin). Price 14 marks.

culture solution was present, and that a mixture of the three constituents gave better results than either separately. Maximum results were obtained when 150 parts of the substance per million were present. Evidence is presented to show that the organic compounds are absorbed as such by the plant, and are not decomposed to form ammonia, nitrites or nitrates in the solution.

The development of this new view will be watched with interest, not only by plant physiologists, but by soil students as well.

In another bulletin Messrs. Schreiner and Brown investigate the black soil material insoluble in alkalis, and find lignite particles, coal particles, and other materials, some of which suggests intermediate stages of formation. The coal-like material seemed to be present in every soil, and is considered to be formed during the decomposition of the organic matter. If this turns out to be the case it will add one more to the remarkable reactions going on in the soil.

Messrs. Sullivan and Reid have investigated the power of soils to decompose hydrogen peroxide, and they suggest that this catalytic power is due not to an enzyme, but to the inorganic and organic matter in the soil. The subject is of some interest because it is important to study the conditions under which the reactions go on in the soil.

An entirely different problem is attacked by Prof. A. Wieler in his monograph on the effect on plant growth of removing calcium carbonate from the soil, especially when this removal is brought about by smoke. This is a continuation of the author's earlier work on the effect of sulphur dioxide on plants, which led him to conclude that the injurious result was due not only to an action on the leaf, but to one on the soil. The Claustal (the region investigated by the author) has, like parts of our own Lancashire, lost its trees, and the author concludes that this has come about because the soil has become too depleted of lime for tree growth to be possible. This thesis is developed at considerable length, and a section is added on the injurious effect of metallic salts on plant growth.

NOTES.

THE council of the Royal Geographical Society has made a grant of 1000*l.* towards the expenses of Sir Ernest Shackleton's Transantarctic expedition. Mr. Rudyard Kipling is to lecture before the society on February 17 upon "Some Aspects of Travel."

THE Geological Society of London will this year award its medals and funds as follows:—Wollaston medal, Dr. J. E. Marr, F.R.S.; Murchison medal, W. A. E. Ussher; Lyell medal, C. S. Middlemiss; Wollaston fund, R. B. Newton; Murchison fund, F. N. Haward; Lyell fund, Rev. W. Howchin and J. Postlethwaite.

AN Institution of Petroleum Technologists has been formed, with Sir Boverton Redwood, Bart., as president. Dr. D. T. Day, of the United States Geological Survey, and Prof. C. Engler have been elected honorary members of the institution. Form of application for mebership may be obtained from the secretaries, 17 Gracechurch Street, E.C.

THE council of the Royal Anthropological Institute has made arrangements for an address by Prof. Baldwin Spencer, C.M.G., F.R.S., on the life of the Australian tribesmen, to be given in the theatre of the Civil Service Commission, Burlington Gardens, W., on Tuesday, January 27, at 8 p.m. The address will be illustrated by means of kinematograph films and phonograph records.

ON Tuesday next, January 20, Prof. W. Bateson will deliver the first of a course of six lectures at the Royal Institution on animals and plants under domestication, and on Thursday, January 22, Mr. W. McDougall will begin a course of two lectures on the mind of savage men. The Friday evening discourse on January 23 will be delivered by Sir James Dewar on the coming-of-age of the vacuum flask.

THE volcanic Mount Sakurashima, which forms an island situated at the head of Kagoshima Bay, south of Kiushiu, after being dormant for a century and a quarter, burst into eruption on Monday, destroying the villages on the island and affecting the ancient city of Kagoshima on the mainland a few miles away. It is reported that from Sunday morning to Monday more than two hundred shocks were felt in Kagoshima. When the eruption began, enormous columns of illuminated dust and vapour burst out from the sides of the volcano, and soon enveloped the whole island of Sakurashima. Forty minutes later an eruption began from the summit. The heat from the volcano was intense, and could be felt in Kagoshima. The city of Nagasaki, a hundred miles from Sakurashima, has been covered with a fine deposit of volcanic ash.

THE death is reported, in his eighty-fourth year, of Mr. John Phin, the author of many popular scientific text-books, and a former editor of several New York papers, including *The Manufacturer and Builder, The Technologist,* and *The American Journal of Microscopy*. He was born in Melrose, Scotland, and was educated at the parish school, and the Musselburgh Academy, subsequently studying civil engineering in Edinburgh. He went to the United States in 1851, and afterward became professor of chemistry and technology in the People's College, Havana, N.Y., and professor of agriculture in the Pennsylvania Agricultural College. In addition to his scientific interests, he was a devoted Shakespeare student, and compiled a Shakespeare cyclopædia and glossary.

MR. GRIFFITH TAYLOR, in a paper read before the Royal Geographical Society on Monday last, described at length the topographical and geological features of the Australian federal territory, which forms an enclave in New South Wales. It is an area of considerable physiographical interest, and though only of some 900 square miles' area, participates (with the surrounding country) in four well-marked divisions, namely the Lake George plains, an undissected country of recent surface-form, the Murrumbidgee scarp and

Cullarin scarp, with "youthful" features, the Gourock highlands, &c., with their mature valleys and rounded ridges, and the Canberra plains, in a "more mature stage of erosion." Mr. Taylor dealt not only with the geography but briefly with the political considerations which dictated the choice of the site. It fortunately happens that political and geographical considerations coincide, for Mr. Taylor showed how the federal territory is situated on "a line joining the centre of population with the nearest good port," namely Jervis Bay, where the seaport of the new city will be situated. Mr. Taylor described the physical environment of the territory, and incidentally mentioned conditions affecting south-eastern Australia as a whole; he drew an effective comparison between this country and the United States of America, having regard to the points in the history of their settlement and development which each has reached.

DURING the Christmas holidays the Lawes and Gilbert Centenary Fund Committee ceased work so as not to interfere with the ordinary Christmas appeals; it has now begun work again to collect the last 1600*l.* needed to complete the scheme. The object of the centenary fund is to build and equip a satisfactory laboratory for the prosecution of researches in agricultural chemistry, a subject largely founded on the experiments of Lawes, who was born just 100 years ago, and of Gilbert, who was born three years later. These investigators founded the Rothamsted Experimental Station, the oldest, and for many years the best-equipped agricultural experiment station in the world. Rothamsted has maintained its high position in respect of its staff and its field plots, but it has fallen behind in laboratory accommodation, and a serious effort is now being made to remedy this defect. The committee has ascertained that a satisfactory laboratory can be erected and equipped for 12,000*l.*, and it has decided to collect the money, and to put up the laboratory this year in commemoration of the centenary of the birth of the founders. Its efforts have been so far successful that only 1600*l.* is now required; and an urgent appeal is addressed to all interested in agricultural science to aid the committee in closing the list so that the work can be put in hand at an early date. Subscriptions should be sent to the secretary, Rothamsted Experimental Station, Harpenden, Herts.

SIR HERBERT MAXWELL, in a letter to *The Times* of December 10, throws doubt upon a cherished belief of fly-fishermen. Great care is taken by salmon-fishers in the selection of their flies, which are formed by tackle-makers with rare and bright feathers supposed to be particularly attractive to the fish. As a fisherman with more than fifty years' experience of the habits of salmon in many rivers, and as an observant naturalist, Sir Herbert states that he has failed to detect the slightest preference on the part of salmon for one pattern of fly over another. He adds: "I should be perfectly willing, during the few angling seasons which may remain to me, to use no flies except those composed of the feathers of native game birds or barndoor fowls, dyed or undyed, with silk and tinsel to smarten them up to human, if not to piscine, taste." It has been stated that a large number of beautiful birds are sacrificed every year to the demands of fishermen for brilliantly coloured artificial flies. The demand is based upon the assumption that a salmon is capable of discerning details of form and colour in a small object passing between its eye and the high light; although a human eye, in a similar relative position, could perceive nothing but a dark silhouette. According to Sir Herbert's observations, the colour and material of the lures used are of little consequence; and if this be the case, the destruction of numerous brightly plumaged birds in order to provide feathers for artificial flies is not only useless, but also a waste of beauty.

COMMENDATORE BONI has made another notable discovery in the course of his excavations on the Palatine Hill at Rome. He has found the famous *mundus*, or pit, leading to the infernal regions, sacred to Dis and Proserpine. This was covered by the *lapis manalis*, a square, rough-hewn slab of tufa pierced by two round holes. It was the innermost shrine, the most holy centre of the Roman religion, consecrated to the ancient mysteries, whence germinated and spread forth the fundamental energies of the Roman people. The later Romans had lost the site of this sacred spot, and the Emperor Augustus, in his desire to re-establish the ancient usages, searched for it in vain. A shaft, filled with débris, discovered in the course of recent digging, may well represent the exploration by Augustus.

A JOURNAL dealing with Egyptian antiquities has long been needed. We are glad to welcome the appearance of a new quarterly magazine, having the title, *Ancient Egypt*, which, under the editorship of Prof. Flinders Petrie, promises to supply the want. The first issue is well printed and illustrated, contains much interesting matter, and is procurable at the modest cost of 7*s.* per annum. Prof. Petrie notices an interesting fact about early glass manufacture. Sir Gardner Wilkinson ("Manners and Customs," ed. 1878, Fig. 380) published a drawing supposed to represent men blowing glass bulbs on the end of rods. But though examples of early glass, especially about 1500–1400 B.C., are abundant, not a single piece of blown glass can be dated before Roman times. The men are really using reed blowpipes for a jeweller's furnace, and as these blowpipes would soon be burnt at the end, a lump of mud was put on as a nozzle to the pipe. The new journal is published by Messrs. Macmillan and Co., Ltd.

IT will be remembered that the eighteenth International Congress of Americanists was held in London during May, 1912. Two articles appeared in NATURE dealing with the congress; one on April 18, 1912 (vol. lxxxix., p. 169), gave the outstanding items of the programme, and the other on June 6, 1912 (vol. lxxix., p. 379), summarised the proceedings. The editorial committee has now issued in two volumes running to 570 quarto pages (London: Harrison and Sons, 2*l.* 2*s.* net) the full proceedings of the session. Full lists are included of the names of the officers, organising committee, delegates, members, and associates. The

presidential address of Sir Clements Markham and the papers read in the various sections are given in full, and many of the latter are handsomely and profusely illustrated. The success of the congress must be very gratifying to Sir Clements Markham, Dr. A. C. Haddon, and Mr. A. P. Maudslay, to whom the organisation and arrangements were entrusted.

IN the number of *Biometrika* issued in October, 1913, Dr. H. S. Stannus describes cases of albinism or deficiency of pigment in natives of Nyasaland. He classifies them into several groups, ranging from complete albinism to a condition in which the skin is light brown, the hair yellow, and the irides hazel, and also separates off three distinct groups of piebalds and "spotlings." He also describes cases of pathological leucoderma, and discusses its relation with albinism. The descriptions indicate that there is considerable grading between the different classes; the examples classed as complete albinos have some pigment in the fundus and iris, and there seems to be no sharp line of distinction between these and cases with pigment in the skin. The more extreme cases are often associated with bad teeth. The short pedigrees given show no instance of direct transmission from parent to child, but several of more than one case in a family.

IN *The Field* of December 13, 1913, Mr. Lydekker adduces evidence to show that the Circassian goat may be a domesticated derivative from the markhor (*Capra falconeri*), which it resembles in the direction of its horn-spirals, and thereby differs from other domesticated goats—the offspring of the wild *C. hircus aegagrus*.

IN the Proceedings of the U.S. National Museum, vol. xlv., pp. 651–57, Dr. F. W. True describes a new species of beaked whale from the Californian coast, under the name of *Mesoplodon mirum*, a preliminary diagnosis having been given in an earlier note. The species is related to Sowerby's beaked whale (*M. bidens*), and also to *M. europaeus*, from the latter of which it differed by the form of the beak and of certain other elements of the skull.

THE new generic and specific name, *Leurospondylus ultimus* is proposed by Mr. Barnum Brown (Bull. Amer. Mus. Nat. Hist., vol. xxxii., pp. 605–15) for a plesiosaurian from the Upper Cretaceous Edmonton beds of Alberta, Canada, which is of special interest on account of being the latest member of its order at present known. It was a relatively small species, the vertebral column measuring about 7 ft., and related to Elasmosaurus, among its distinctive features being the medium length of the neck, the shortness and width of the centre of the vertebræ, and the single-headed ribs.

IN an article on the inheritance of left-handedness in the *American Naturalist* for December, 1913, Prof. F. Ramaley points out that the peculiarity, in its true form (*i.e.* when not acquired), seems to be connected with an unusually high development of the right cerebral hemisphere. As the result of the record of 1740 cases, of which 610 were parents, it is concluded that as regards inheritance, left-handedness is a Mendelian recessive. Out of 305 families there were only two in which both parents were left-handed, and in one of these one of the three children was right-handed, whereas if the inheritance were recessive all should have been left-handed. A possible explanation of the anomaly is that one of the parents was naturally right-handed.

TO the large number of extinct bisons from the superficial formations of North America already described as distinct species, Dr. O. P. Hay, in a paper published in the Proceedings of the U.S. National Museum, vol. xlvi, pp. 161–200, adds a new one, under the name of *Bison regius*. It is typified by a skull discovered in 1902 near Hoxie, Sheridan County, Kansas, and appears to be nearly related to *B. latifrons*, of Ohio, from which it differs by the greater length, slenderness, and curvature of the horns, and also by the folding of the enamel of the central pits in the crowns of the upper molars. The latter feature is the one on which the author chiefly relies in distinguishing the new species from *B. latifrons*, as the difference in the horn-cores might be merely sexual. The paper, which is illustrated by eleven plates, also contains a synopsis of all the other species, with a "key" to their distinctive features. In a second paper the same author (*op. cit.*, pp. 267–77) recognises seven species of the North American Pleistocene genus Camelops, and at the same time discusses the characters distinguishing this genus from the existing Lama (Auchenia), with which it has been regarded by some writers as identical. Among the more important differences are the absence of a vertical ridge at the antero-external angles of the last two lower molars of Camelops, the longer and narrower skull, the more elongated grinding surfaces of the upper molars, the more procumbent lower incisors, and the narrower upper portion of the nasal bones of the skull.

WE have received a reprint of a paper from *The Salmon and Trout Magazine*, July, 1913, by Mr. J. Arthur Hutton, on Wye salmon (results of scale reading, 1908 to 1912), in which the author gives numerous statistics of the length, girth, weight, &c., of a considerable number of salmon caught each year, together with some information as to age and spawning, as shown by examination of the scales of the fish. Work of this character is most valuable from the point of view of the study of the life-history of the fish, and it would lead to a considerable increase of our scientific knowledge of the salmon if fishermen would make similar observations on the fish of other British rivers. One of the most interesting results brought out by Mr. Hutton's figures is that the proportion of girth to length of Wye salmon, which may be regarded as a measure of the condition of the fish, is highest (0·523) in fish netted at the mouth of the river, whilst it gradually decreases in fish taken in the higher waters, until it sinks to 0·497 in those salmon caught above Builth, which is 115 miles from the sea.

MISS DORIS MACKINNON contributes to the *Quarterly Journal of Microscopical Science* (vol. lix., part 3) some interesting notes on certain flagellate Protozoa found

in the intestine of the common leather-jacket, or larval crane-fly. It appears that no fewer than eight kinds of flagellates and two amœbæ are found in this situation, feeding upon a rich bacterial flora. The author suggests that the term "parasite" is scarcely applicable to such organisms, which appear to fulfil a useful function in keeping down the bacteria, and points out that the richest intestinal fauna was generally found in the largest and healthiest looking grubs. She believes that totally different species of animals, when they frequent the same feeding grounds, may serve as hosts to the same species of protozoan parasites. The beautiful form known as *Rhizomastix gracilis* was described by Alexeieff in 1912 from the Axolotl, and Miss Mackinnon now records and figures it from the crane-fly larva, filling in certain particulars as to its life-cycle. A new subgenus and species, *Tetratrichomastix parisii*, is proposed for another flagellate from the same host, the subgeneric name being chosen on analogy with Tetratrichomonas. It is true that Tetratrichomonas possesses an undulating membrane which may represent a fifth flagellum, but the fact that five separate flagella are actually present in the new subgenus makes the proposed name distinctly misleading.

THE rust-fungi (Uredineæ) of Nova Scotia are dealt with in detail by W. P. Fraser in vol. xii., part 4, of the Proceedings of the Nova Scotian Institute of Science. The author gives an excellent introductory account of the structure and life-history of the group, followed by detailed descriptions of the ninety-two species known from Nova Scotia, including several not hitherto found in any other part of North America. In the descriptions the terminology proposed by Arthur in his well-known work on North American Uredineæ is followed, though it is doubtful whether botanists in general will perceive any special advantage in the new terms adopted for the various pore-forms in place of those which have become familiar by long usage.

A VALUABLE contribution to our knowledge of soil gases and the complex conditions surrounding the growth of crops in swamp rice soils has been made in the Memoirs of the Department of Agriculture in India, vol. iii., No. 3, chemical series, by Mr. W. H. Harrison and Subramania Aiyer. The results obtained show that the normal fermentation of green manure in swamp paddy soils leads to the production of a relatively large quantity of methane, a smaller amount of nitrogen, together with some carbon dioxide and hydrogen. This in itself is not surprising when one considers the anaerobic conditions obtaining in the flooded soil, but it has been further observed that the introduction of a crop greatly modifies the composition of the soil gases, either by directly retarding the rate of fermentation and restricting the formation of methane and hydrogen, or by a portion of the intermediate products of decomposition being removed out of action by absorption by the roots. The latter has been experimentally demonstrated in various recent investigations, and the nutrition of paddy rice would appear to consist in the assimilation of nitrogen either in the form of ammonia or of organic compounds produced by the decomposition of the proteids of the green manure, since nitrification is impossible under the anaerobic conditions that obtain in these soils.

THOSE who desire to keep pace with modern views on crust-displacements and mountain-structure, whether as an aid to geographical or geological studies, will find a well-illustrated summary in Otto Wilckens's "Grundzüge der tektonischen Geologie" (Jena: G. Fischer; price 3.50 marks), which covers matters that are not to be found in every text-book.

THE Government Printing Office at Kingston, Jamaica, has issued a coloured geological map of Jamaica, which may be found generally useful, on the scale of one inch to twenty miles. It is published separately as Publication No. 420, with an explanation by Maxwell Hall, but might be overlooked by geologists, since it officially forms part of the memoir on "The Rainfall of Jamaica from about 1870 to end of 1909."

THE Cotteswold Naturalists' Field Club maintains its reputation for original publication in its eighteenth volume (1913). L. Richardson and C. Upton describe new species of brachiopods from the Inferior Oolite, and the former author, with E. T. Paris, publishes a supplement to previous work on the echinoids from the same formation. The photographs of important species are in both cases admirable. The country where William Smith found such welcoming friends as Benjamin Richardson and Joseph Townsend will never forget the principles of stratigraphical geology.

"A BIBLIOGRAPHY of Russian Ethnographical Literature" forms vol. xl., No. 1, of the *Zapiski* of the ethnographical section of the Russian Geographical Society. It covers the years 1700 to 1910, and is compiled by M. D. K. Zelenin on behalf of the Commission for the Construction of an Ethnographical Map of Russia.

PROF. KUZNETSOF, whose historical sketch of the flora of Daghestan has already been referred to in these pages (vol. lxxxviii., p. 600), gives an account of his investigations and results in the *Izvestiya* of the Russian Geographical Society, Nos. i.–iii., 1913. At the end of the number is a map showing the distribution of the most distinctive forms, and a full list, compiled by M. P. P. Popof, of the plants collected.

THE narrative of M. Zhitkof, who explored the Yamal Peninsula, in 1908, is published in the *Zapiski* of the Russian Geographical Society, vol. xlix. The name Yamal, meaning "end of the earth," in the Samoyed language, is more correct than the usual Yalmal, which signifies "mouth of the river" (Ob). The country is low, especially in the north, where it slopes down to the Malygin strait, and the watershed is there inconspicuous. In the south it is more marked, rising at the Yarro-to lakes to 300 ft. above sea-level. The eastern and western coasts often rise in steep cliffs of clay and sand. Lakes and basins partially filled up are numerous in the central part. The work includes chapters on the fauna and flora, the Samoyeds and reindeer grazing. M. Rudovits contributes a report on the meteorological observa-

tions, and General Shokalski on the hypsometrical determinations. The volume contains numerous illustrations, a map of the peninsula, and one of the lakes Noi-to and Yambu-to, from a survey by Captain Vvedenski.

IN the last annual report of the Meteorological Committee it was stated that, at the request of H.M. Treasury, the committee had entered into negotiations with the Scottish Meteorological Society with the object of placing the finances of the latter upon a satisfactory footing as regards the supply of information to the public generally, and of securing a closer cooperation with the Meteorological Office in respect of climatological stations in Scotland. The Journal of the society (vol. xvi.), and the last report of the council to the general meeting of the society, show that the financial position of the latter had long caused great anxiety, the only additions to its ordinary income (derived chiefly from decreasing voluntary sources), being small annual payments for observations by the Registrar-General (Scotland) and the Meteorological Committee. A strongly supported appeal to the Treasury ultimately resulted in the action above referred to, and we are glad to find that the deliberations between the various authorities interested have been crowned with success. The amount hitherto paid by the Meteorological Committee is very materially increased (from April 1, 1913), and that paid by the Registrar-General will be continued. A Meteorological Office has been established in Edinburgh, the organisation of the supply of information on the lines above-mentioned has been secured, and the arrangements are considered to be "in the best interests of meteorology and of the society." The public funds will be administered by a representative committee (including several members of the society), with Dr. W. N. Shaw as chairman.

A CAREFUL examination of the effects of temperature on the physical properties of a number of minerals has been undertaken by the geophysical laboratory of the Bureau of Standards. The first communication dealing with the results obtained, appears in the Journal of the Washington Academy of Sciences for December 4, and is devoted to the measurements of the change in the crystal angles of quartz made by Mr. F. E. Wright at temperatures between 0° C. and 1250° C., with a special two-circle goniometer constructed for the laboratory. The author finds that the polar angle for the unit rhombohedron (1011) decreases from 51° 47·5′ at 0° C. to 51° 37′ at 575° C., the quartz then changes from the α to the β form, and the angle becomes 51° 35′ and remains constant up to 1250° C. The agreement between these observations and those of Randall on the expansion of quartz, those of Sosman on its specific volume, and the tabulated values of its birefringence is very close over the range 0° C. to 550° C.

WE have received copies of Nos. 5 and 6 of the *Publications de la Société de Chimie-Physique*, issued by the Librairie Scientifique A. Hermann et Fils, Paris. No. 5 is entitled "L'Etude physico-chimique des sels chromiques," by M. A. Sénéchal (pp. 28, price 2 francs), and No. 6 "L'additivité des propriétés diamagnetiques et son utilisation dans la recherche des constitutions," by M. Paul Pascal (pp. 26, price 1 franc). These form part of the useful series of monographs issued by the society, and were originally delivered as lectures before the members.

IN the *Sitzungsberichte* of the Imperial Academy of Sciences, Vienna (vol. cxxii., class ii. b, p. 75), Messrs. V. Rothmund and A. Burgstaller describe a method for the estimation of ozone and hydrogen peroxide in presence of each other, for which purpose no accurate method is yet known. Advantage is taken of the fact that, by the addition of a trace of molybdic acid, it becomes possible accurately to determine hydrogen peroxide iodometrically. Difficulties are encountered in estimating ozone directly in a similar manner, but by adding potassium bromide under certain defined conditions, and subsequently potassium iodide, iodine is liberated quantitatively, and the two methods can be combined so as accurately to estimate both substances.

THE presidential address delivered to the American Chemical Society at Rochester, N.Y., by Mr. A. D. Little, is reprinted in *Science* (vol. xxxviii., No. 984), under the title, "Industrial Research in America." Mr. Little points out that although Germany has long been regarded as pre-eminently the country of organised research, a new competitor is arising in the United States, "that prodigal among nations, still justly stigmatised as the most wasteful, careless, and improvident of them all." Within the last few years enormous funds have been allotted to the organisation of research in a large number of the principal industrial concerns of the United States, and a very striking account is given of some of the most important achievements of this new system. "Research has firmly established itself among the foundation-stones of our industrial system, and the question is no longer 'What will become of the chemists?' It is now, 'What will become of the manufacturers without them?'" There are in the United States at least fifty notable laboratories engaged in industrial research for private companies, in several of which the expenditure is more than 300,000 dollars a year. An interesting summary is given of the activities of Government departments, such as the Department of Agriculture, the Bureau of Mines, and the Bureau of Standards of the Department of Commerce, which alone devotes about 700,000 dollars annually to scientific work.

The Engineer for January 9 has an illustrated article on the motor ship *Fionia*, the largest and highest powered ship of this kind in service. This vessel is the ninth motor ship built by Messrs. Burmeister and Wain, of Copenhagen, and is 395 ft. long, with a dead-weight capacity of 7000 tons. She is propelled by two sets of Diesel engines, having a combined horse-power of 4000. Each set has six cylinders as compared with eight in earlier ships, and the cylinder sizes have been increased from 530 mm. diameter and 730 mm. stroke to 740 mm. diameter and 1100 mm. stroke. The speed has been reduced from 135 to 100

revolutions per minute. The *Fionia* ran her official trials in Copenhagen Sound on December 18 with uniformly favourable results.

AN article in *Engineering* for January 9 directs attention to the waning supply of petroleum. Although a continually greater supply of petroleum is being placed on the market, this increased output is secured only by sinking more wells and boring to a greater depth, showing that the surface supply is becoming exhausted. At the beginning of this century the wells touched 1100 ft., and to-day the average level of the oil may be placed at 2000 ft.—an ominously rapid rate of sinking. Dissatisfaction with existing methods and acute appreciation of the necessity for increased effort to keep up the yield have induced the United States Bureau of Mines to issue a warning, and to suggest improved methods of working. It cannot but be regarded as a happy augury that the authorities are alive to the extent of the drain made on the stores of oil, and of the necessity of husbanding the resources of the future. America, by reckless expenditure of her resources, has increased her annual output to 200 million barrels, yet the demand for oil for special purposes has become so great that the rise in price is considerable—so great, indeed, that competition with coal for ordinary purposes has become impossible. The entire production of petroleum from all sources is only about one-fifth of the coal produced in England alone, and already schemes are on foot for obtaining a motor fuel from other sources.

THE issue of "Willing's Press Guide" for 1914 is the forty-first to appear. The first 297 pages are devoted to an alphabetical list of newspapers and periodicals. Among other useful contents may be mentioned the classified list of the periodical Press of the United Kingdom according to the interest or subject dealt with, and the lists of metropolitan newspapers, the provincial Press, and American newspapers.

OUR ASTRONOMICAL COLUMN.

COMET 1913*f* (DELAVAN).—This comet is gradually creeping up in north declination and getting brighter. The following is an ephemeris for intervals of four days :—

Berlin Midnight.

	R.A.	Dec.
	h. m. s.	° ′
Jan. 12	2 53 25 ...	−2 1
16 ...	2 54 58 ...	−0 36
20 ...	2 57 30 ...	+0 59
24 ...	3 1 3 ...	+2 43
28 ...	3 5 40 ...	+4 36

THE CROSSLEY REFLECTOR AND NEBULÆ.—Mr. Heber D. Curtis contributes to the Lick Observatory Bulletin, No. 248, a second list of nebulæ and clusters photographed with the Crossley reflector, being a continuation of that which appeared in Bulletin No. 219. It comprises photographs secured between September 26, 1912, and November 1, 1913. The exposures were practically all of two hours' duration, but the author states that longer exposures and counts limited to a radius of 15′ from the optical axis might easily show larger number of nebulæ per square degree. The present list comprises descriptions of 109 nebulæ and clusters, and many uncatalogued nebulæ which present features of interest are included. The list is striking in that on some plates such a large number of nebulæ was photographed. Thus under N.G.C. 20 it is stated that there are forty-one nebulæ on this plate; under N.G.C. 68 eighty-seven were counted in an area of 45′ × 55′; on other plates we find 30, 31, 37, 31, 36, 28, 47, 69, 28, 17, nebulæ recorded.

GALACTIC COORDINATES.—The *South African Journal of Science* for November last (vol. x., No. 3) contains a communication from Mr. R. T. A. Innes, advocating the use of galactic coordinates for star positions. The adoption of fixed instead of moving coordinates is an object much to be desired, and it would eliminate a great amount of labour if such a system could be adopted. Regarding the adoption of the galactic plane as a point of departure for measurement the galaxy is so irregular that estimates of the great circle which most truly represents it do not agree among themselves. Mr. Innes thinks, however, that such criticism is superficial. Mr. Crommelin (*Knowledge*, January) points out that both the galactic circle and the suggested starting point, the longitude of the sun's apex, are arbitrary, and that "it would be exceedingly difficult to get the astronomers of all nations to agree on points of this kind." Further, he suggests that it is likely that for a long time to come meridian instruments will be the chief means of obtaining the places of at least the brighter stars, so that the R.A.'s and declinations will still have to be found. Mr. Innes's paper is nevertheless an interesting and suggestive contribution.

THE ARC SPECTRUM OF IRON.—Lick Observatory Bulletin, No. 247, is devoted to an investigation on the arc spectrum of iron carried out by Mr. Keivin Burns at the Physical Institute at Bonn at the suggestion of Prof. Kayser. The object was to measure with reasonable accuracy all the lines of the arc spectrum of iron which can be readily photographed. It was proposed to measure the stronger lines on four plates each and the fainter on two plates. This programme has been completed for the region 3206–7800 A, but for various reasons shorter and longer wave-lengths than the above are excluded. The apparatus used was a Rowland concave grating mounted according to Abney's method—that is, the slit is the only movable part of the apparatus. The author describes the plates used, the standards employed, and the method of measurement and reduction, and accompanies his communications with the long list of wave-lengths derived. In comparing his results with those of Goos, he finds that the differences, Burns minus Goos, are usually less than 0·004 A, limiting the comparison to lines about equal in intensity to the standards. Other lines, he says, do not agree so well. Referring to the Mount Wilson measures, he writes :—"My measures are in good agreement with the values of St. John and Ware, in the case of lines for which these observers find the same wave-length on Mount Wilson as in Pasadena. In cases where they find a difference between the mountain- and sea-level, my measures are in excellent agreement with the wave-lengths found on the mountain, although my observations were made at sea-level." The author again directs attention to the systematic differences of wave-lengths or displacements with regard to the lines of impurities, a subject referred to in this column on August 7 of last year (vol xci., p. 592). He here asks the question : "Will the wave-length of a line in the carbon arc be different from the wave-length of the same line at the same pressure in the iron arc?" The answer may not be so easy to give correctly as it appears to be.

EDUCATIONAL CONFERENCES.

THE annual Conference of Educational Associations just concluded at the University of London was a strenuous business spread over eight days. The inaugural address by Mr. James Bryce contained a plea that the strongest and finest minds should be pushed forward. In reference to this key to national success, it was noted that the tide runs now towards scientific studies just as fifty years ago it ran towards humanistic studies, and it was pertinently asked: What subjects and what sort of teaching of those subjects, are best calculated to train men to think, to enable the mind to see facts as they are, to analyse them, to draw just conclusions from them, to rise above prejudices, to play freely round the phenomena of life? Are mathematics and physics or chemistry sufficient for this purpose? The note of caution here applied in one direction was also sounded in connection with the additional expenditure of public money on education, with a single exception, that concerning the payment of higher salaries to the teachers.

This same note of caution was noticeable in many of the speeches made both at the London conference and at the North of England Education Conference. The London paper, by Sir H. G. Fordham, on the problem of rural education opened with the reminder that so great has been the effect of modern methods of locomotion upon the movement of population, "there is nothing to be gained by attempting to make an educational distinction between the town man and the country man." Agriculture, he asserted, can, in no circumstances, be usefully introduced as a subject of instruction in elementary schools, and can only very indirectly be utilised as a subject of instruction in secondary schools.

Sir Robert Baden-Powell dealt with character building in schools, and, after asserting that the Scout movement had captured the boys, truly laid his monitory finger on one of the defects of the Scout movement; it has not captured the teacher. Theoretically, the movement is good; how often does it fail because the teachers are not scout-masters?

Mr. H. Holman warned us that manual teaching was not going to transform education, however much it would reform it. It was not going to do away with reading, writing, and arithmetic, but it would deprive them of their usurped and false pre-eminence. These subjects would be better taught.

In the north of England Dr. M. E. Sadler reverted to the review of education made by Principal Griffiths in his presidential address to the Educational Science Section of the British Association. In Dr. Sadler's opinion English education is at the moment torn asunder by hesitancy as to ideals. It is puzzled, self-critical, harried by doubts. It is frightened of making a venture. But there is encouragement in this condition; for the hesitation is the outcome, not of palsied will-power, but of harrassed fair-mindedness; and there are signs that a clear purpose is taking the place of this uncertainty.

Consequently, the Geographical Association can be congratulated upon its definite successes. This year the association attained its majority, and Dr. Scott Keltie has become the president of the association thirty years after his issue of the famous report on geographical education. Dr. Keltie's *résumé* of thirty years' progress was distinctly exhilarating. Geography has a definite place in education, and its sphere of labour is by no means circumscribed; the plan is in being, and the stately edifice is being erected.

A definite aim in education emerges from these conferences in reference to examinations. On many occasions expression was given to the opinion that the written examinations, which Dr. Rouse labelled as the fetish of the British people for sixty years, required the definite addition of a face-to-face test. In connection with the examination of modern languages, a rough equivalent of the face-to-face test, viz. free composition, was stated to be showing beneficial results.

The meeting of the Private Schools Association in London was notable for the severe criticism levelled at the Board of Education. The Rev. G. H. Moore said that the Board had displayed such despotism that at times it might seem to be anxious even to deprive the parent of the choice of school for his own children. A single inspector's opinion came with the whole weight of the Board behind it. The reputation of a teacher could be ruined in an hour by his inability to satisfy the standard of the Board's inspector of the moment.

The Montessori system was treated cautiously in the north and ambitiously in London. The title of the paper read in London is significant, "The New Hopes Due to Scientific Investigation of the Child's Natural Development." The London speakers revelled in their proclamation of a new scientific method, and, therefore, of a new science of experimental psychology. The Montessori system was claimed as the application, for the first time in the world's history, of science to the problems of education. The system applies the laws of environment which are more powerful than the laws of birth; no more than 1 per cent. of young children are hopelessly inefficient from birth; on the basis of an experience of a few brief years and in reference to these young children, it was claimed that a class of forty children trained on the Montessori system became a class of forty efficient children without a single backward or stupid scholar. The caution which was absent on this occasion from the speeches in London must have risen to the minds of the teachers present as they heard acclaimed as new those methods of pedagogy which most good teachers have long practised, *e.g.* waiting until the pupil is ready before giving a lesson on a new subject. Teachers know they must so wait; but owing to the fact that they teach classes, they cannot wait for all individuals; hence the novelty lies solely in individual instruction.

In the north stress was laid on the need for caution in regard to the Montessori apparatus. There seems to be a very real danger in the overbalance of minute, isolated sense training, against the minimum of story-telling, of play, and happy dancing and singing. In relation to the Montessori principle of auto-education, of freedom, it was asked with due reason, "But should not the apparatus give scope, so that it helps him at five years old to become aware of his neighbour? For this apparatus offers little, if any, scope for neighbourliness." Similarly, the system demands that the child shall not be made aware that he has made a mistake. Is it not wise to realise that an intelligent failure is more hopeful for the future than an unintelligent success? There is some hope in class-teaching after all.

RHEOSTATS.

AN example of the great attention given to details nowadays in connection with apparatus for the laboratory and lecture-room use, and general experimental work, is afforded by a 104 pp. list which a firm of electrical instrument makers (Messrs. Isenthal and Co.) have sent us, devoted entirely to rheostats. It is not within the scope of the present article to indicate all the various patterns and modifi-

cations of these, but we may mention that we notice among the designs some convenient "twin" and "universal" patterns which enable a large range of resistance and accurate regulation to be obtained with apparatus of smaller dimensions than a simple rheostat would have for the same requirements. The catalogue contains a diagram of the "Ruhstrat" winding, designed to eliminate, so far as possible,

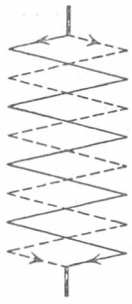

FIG. 1.—Ruhstrat winding.

FIG. 2.—Ordinary double winding.

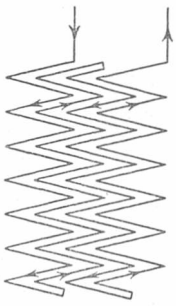

FIG. 3.—Chaperon winding.

capacity and safe induction. Two wires are wound in parallel in opposite directions and symmetrically, as shown in Fig. 1, which may be compared with the ordinary double winding shown in Fig. 2, and the Chaperon winding in Fig. 3.

The idea used to prevail that practically anything would "do" to insert as a resistance for reducing the voltage of the supply mains for experimental work or various miscellaneous purposes. This has resulted in trouble from time to time, and more care is now exercised in the selection of suitable pieces of apparatus. One form of rheostat, for instance, which was at one time extensively used in connection with medical applications of electricity, has a particular element of danger. It was customary to use a coil of very fine wire wound on slate connected as a potentiometer between two supply mains, as shown in Fig. 4; an apparently small and easily adjustable difference of potential is thus obtained between the points A and B, but the danger is that if the part of the rheostat wire between these two points should burn out, the pressure between A and B will suddenly rise to the full 220 volts. Another method of applying such a rheostat is shown in Fig. 5 in connection with an electric bath. The bath, of course, is porcelain. The main resistance in the circuit in this case is the lamp B, so that the current passing through the bath can be adjusted with considerable accuracy by moving the slider along the rheostat, and in ordinary circumstances the potential difference between the two electrodes in the bath is not high. It must be remembered, however, that if the two points A and D are connected across the supply mains, one of these will be at earth potential. If this is the point A it is evident that the point D, which is directly connected to one of the electrodes, is actually at 220 volts potential, and a patient sitting in the bath and touching a water tap would immediately receive a 220-volt shock. If the connections between the rheostat board and the electric lighting mains are made through an ordinary two-pin plug, as shown in the diagram, it is an even chance whether this wrong connection is obtained or not. A similar shock could be obtained, no matter what was the polarity of the connections if the lamp were to become short circuited.

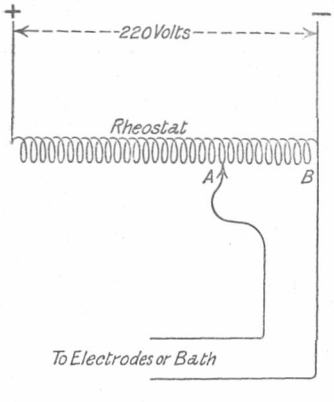

FIG. 4.

For heavy currents proper precautions must also be taken in the construction of rheostats. If, say, a 20-ampere arc lamp for a high-power lantern projector is used from a 220-volt main, it necessitates the use of a resistance which shall cause a drop of about 170 volts, *i.e.* the consumption of power of $170 \times 20 = 3400$ watts, or about $4\frac{1}{2}$ h.p. If wire of sufficient thickness is not used, this will rise to a very high temperature, and, no matter what the gauge of the wire, it is clear that if the lamp is used for a long period at a time a very large amount of heat has to be dissipated. The wiring rules of the

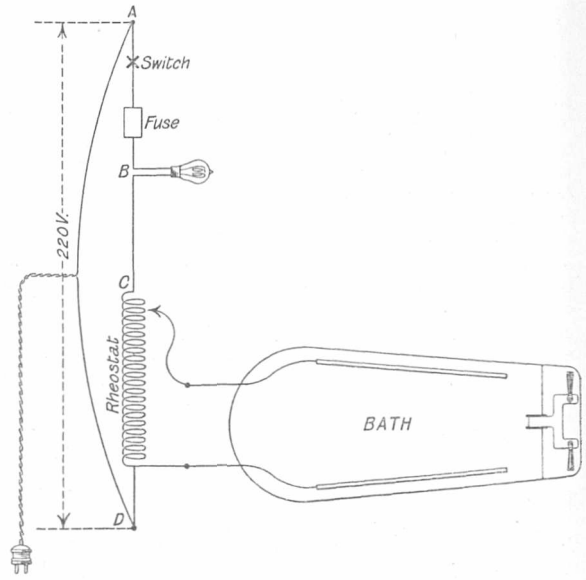

FIG. 5.

Institution of Electrical Engineers, which unfortunately are not always observed in such cases, limit the maximum temperature of the case containing the resistance to 176° F. (80° C.). The rules also specify that the resistances must be enclosed in cases of incombustible material, or protected by wire gauze or perforated sheet metal, and fixed so that no unprotected combustible material is within 24 in. vertically above the case, or within 6 in. in other directions.

Largely owing to the development of apparatus for electric cooking, considerable progress has also been made in recent years in the composition of the wire itself. For cases in which large currents are employed, wires made of special alloys have been produced which will stand a very high temperature without oxidising or becoming brittle. It is true that when a constant resistance, practically independent of temperature, is required, such alloys may not always be suitable, but for heavy current work, such as indicated above, they can naturally be used with considerable advantage. In the mechanical construction of resistances, great progress has also been made.

MODERN METHODS OF MEASURING TEMPERATURES.[1]

THERE are few manufacturing processes in which the question of temperature is not involved, and it may be of use to review briefly the methods now available for the measurement of temperatures.

As a result of the work of Guillaume,[2] Chree,[3] the Physikalische Technische Reichsanstalt, and others, the mercury thermometer has become an instrument of considerable precision. Hard glasses such as the French *verre dur* and the Jena glasses 16^{iii} and 59^{iii}, are now used almost universally for making at least the bulbs of the best thermometers. In all mercury thermometers intended for accurate work the two fundamental points (0° and 100° C.) are introduced whatever may be the range of the thermometer; this is done by making small enlargements in the capillary.

Assuming that such a thermometer has been properly constructed and its corrections determined at one of the National Physical Laboratories, it is possible to measure temperatures with it to an accuracy of 0·001° C., throughout its range.

For nearly all engineering work an accuracy of 0·001° C. is not required,[4] and the recent developments in mercury thermometers have been in the direction of making them easier to read[5] and more robust. The introduction of an inert gas under pressure above the surface of the mercury in the tube of the thermometer raises the temperature at which the mercury boils, thus permitting the thermometer to be used up to a temperature of 540° C., this limit of temperature being due to the softening of the glass envelope.

Thermometers of various kinds have been developed in which metal tubes have been substituted for the glass envelope, and gases, saturated vapours, or liquids for the mercury. Mercury-in-steel instruments are proving themselves very practical instruments in engineering work. They consist of a steel bulb to which a steel capillary tube is attached, the latter being connected to a form of Bourdon pressure-gauge. The whole system is filled with mercury and hermetically sealed. The hand, attached through some simple mechanism to the pressure gauge, is arranged to point over a dial or to carry a pen which writes on a circular sheet of paper rotated by clockwork. The recording or indicating mechanism may be placed at distances up to 75 ft. from the bulb of the thermometer.

Thermo-electric Thermometers.

Expansion thermometers have a limited range of temperature over which they may be employed, and some of the other physical properties of materials must be used for the determination of high temperatures. The most valuable for this purpose is the property by which a thermo-electric force is set up when a junction of two dissimilar metals is heated when this heated junction forms part of a closed circuit, the magnitude of the current and its direction depending on the metals employed. Le Chatelier showed that platinum, platinum-rhodium (10 per cent. Rh) was the most satisfactory of all thermo-elements, and this has been generally adopted as the standard couple. Owing to the high price of platinum many attempts have been made to find satisfactory thermo-couples made of comparatively inexpensive wires.

The most satisfactory of these so-called "base" metal couples is silver-constantan (the latter being an alloy wire sold commercially as a resistance material, and consisting of copper 60 per cent., nickel 40 per cent.), and it may be employed up to 700° C. Copper is frequently used instead of silver as one element of this couple, but in practice it will not be found so trustworthy as silver for temperatures above 500° C.

For temperatures from 700° C. to 1100° C. the Hoskin's couple, which consists of nickel used in conjunction with nickel-chromium (10 per cent. Cr) may be employed.

The electromotive forces given by various thermo-couples differ very much, as the following table will show. In each case the cold junction temperature is 0° C.

Name of thermo-couple	Approximate electro-motive force in milli-volts at 500° C.
Platinum-platinum, 10 per cent. rhodium	4·4
Platinum-platinum, 10 per cent. iridium	7·4
Nickel-nickel, 10 per cent. chro-mium (the Hoskin's couple) ...	10·0
Iron-nickel	12·0
Iron-constantan	26·7
Silver-constantan	27·6
Copper-constantan	27·8

The relation between temperature and the E.M.F. produced by a thermo-couple when the cold junction is maintained at 0° C. is given by Holman's empirical formula[6]:—

$$\log E = A \log t + B,$$

when E = E.M.F. of the thermo-couple in microvolts; t = the temperature of the thermo-couple in degrees Centigrade, and A and B are constants depending on the wires employed. For the chief thermo-couples in general use at the present time this equation is as follows:—

Platinum, platinum-rhodium, approximately $\log E = 1{\cdot}19 \log t + 0{\cdot}52$.

Platinum, platinum-iridium, approximately $\log E = 1{\cdot}10 \log t + 0{\cdot}89$.

Silver-constantan, approximately $\log E = 1{\cdot}14 \log t + 1{\cdot}34$.

In accurate thermo-electric work the universal practice is to immerse the cold junction of the thermo-couple in melting ice and to adopt the potentiometric method of measuring the electromotive force given. In industrial practice the E.M.F. is measured directly by a galvanometer, which should be placed in a spot which is not subject to great variations in temperature. It is only necessary, therefore, to run the wires from the hot end of the thermo-couple straight to the galvanometer, and this is the course generally followed in the case of the base metal couples. Owing to the costliness of the material, it is impossible to do this with platinum couples, and several proposals have been made to overcome this difficulty. The most satisfactory method is one originally due to Bristol,[7] but suggested independently by Peake,[8] in which an inexpensive alloy is substituted for the platinum wires, the alloy being so chosen as to give the same E.M.F. against copper as that given by the platinum, platinum-alloy couple. The resultant E.M.F. generated by this compound couple is the same as if the

[1] Abridged from a paper read before the Institution of Mechanical Engineers by Robert S. Whipple.

[2] Traité Pratique de la Thermométrie de Précision, C. E. Guillaume.

[3] *Philosophical Magazine*, March and April, 1893, C. Chree.

[4] As an instance where engineers have been keenly interested in temperature measurement to this degree of accuracy, mention must be made of the work of Prof. Barnes, on frazil ice. He has shown that differences in the water temperature of 0·001° C. may bring about the formation of frazil ice which may throw out of action a complete hydro-electric plant. In his case all the measurements were made with resistance thermometers. See "Ice Formation, chap. v., H. T. Barnes. (London: Chapman and Hall, Ltd.)

[5] *E.g.* the lens-front thermometer invented by Luigi Peroni.

[6] *Phil. Mag.*, xli., p. 465, 1896.

[7] British Patent Specification, No. 14514, A.D. 1904.

[8] *Ibid.*, No. 370, A.D. 1909.

entire couple were of platinum, platinum-alloy. For accurate work it cannot be assumed that variations in the temperature of the vicinity of the galvanometer are of no importance. Corrections must be applied to reduce the readings to the correct values at 0° C. In practice it will be found that the simplest way of maintaining the cold junction at a constant temperature is to use a Dewar vessel or thermos-flask filled with oil (see Fig. 1) into which the cold junction of the thermo-couple, or of the composite thermo-couple, is placed.

A simple form of potentiometer in conjunction with a direct moving-coil galvanometer, has largely increased the usefulness of the direct-reading instruments by opening out the scale to any desired extent. For the autographic recording of temperature the photographic arrangement originally due to Le Chatelier is still the only way of recording very small and

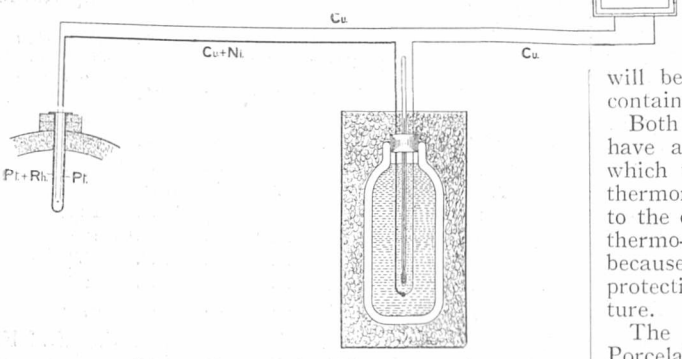

FIG. 1.—Thermos-flask cold-junction control.

rapid changes in temperature. In the majority of recorders now in general use the galvanometer pointer is depressed intermittently by clockwork, or some electrical mechanism on to either an inked thread or typewriter ribbon which is pressed on to a chart mounted on a rotating drum (clock-driven), the resulting record being a series of ink marks. The thread recorder (Fig. 2), designed by Mr. Horace Darwin, may be taken as a typical example of one of these recorders. The action of the clockwork in depressing the galvanometer boom on to the paper is so rapid that the boom is only under control by the chopper-bar for less than two seconds out of the minute. The figure illustrates a double recorder in which two galvanometers connected to two separate thermo-couples are recording on the same drum.

Resistance Thermometers.

Sir William Siemens was the first to suggest, in 1871, that the change in the electrical resistance of a wire with temperature might be employed as a means of measuring temperatures. In the hands of Callendar and Griffiths this has become the most accurate method of measuring temperatures up to 1200° C. Callendar pointed out that if R_0 denoted the resistance of the thermometer coil at 0° C. and R_1 its resistance at 100° C., a temperature scale could be established for that particular wire which might be called the scale of platinum temperatures, such that, if R were the resistance of the coil at any temperature t on the gas scale, the temperature on the platinum scale would be $R-R_0/R_1-R_0 \times 100$. For this quantity he employs the symbol pt, its value depending on the sample of platinum chosen.

In order to reduce the temperatures on the platinum scale pt to the gas scale, it is necessary to know the law connecting t and pt. They are, of course, identical at 0° and 100° C., and experiment has shown that the formula :—

$$t-pt=\delta\left\{\left(\frac{t}{100}\right)^2-\frac{t}{100}\right\}$$

when δ is a factor depending on the purity of the wire for making the thermometer, expresses the relationship between them in other parts of the scale.

The $t-pt$ curve being a parabola, it is only necessary to determine the resistance at three different temperatures in order to ascertain the value of δ, and thus to standardise the thermometer completely. The three temperatures usually employed are 0°, 100°, and 444·70° C. (the boiling point of sulphur).

The resistance of the thermometer is usually measured by the ordinary Wheatstone Bridge methods, and several instruments have been designed for this purpose.

The methods of measuring temperature to a very high degree of precision are outside the scope of this paper, but reference to them will be found in Dr. Burgess's book,[9] which also contains a full bibliography of papers on the subject.

Both thermo-electric and resistance thermometers have a distinct upper limit of temperature beyond which they should not be employed. The resistance thermometer cannot be used beyond 1200° C., owing to the disintegration of the mica frame, and even the thermo-couple can rarely be used above 1400° C., because of the impossibility of finding a gas-tight protecting envelope that will last above this temperature.

The porcelain tubes made by the Royal Berlin Porcelain Manufacturing Co. are on the whole the most satisfactory. This firm have comparatively recently introduced a tube made of a new material called "Marquardt," which will resist temperatures

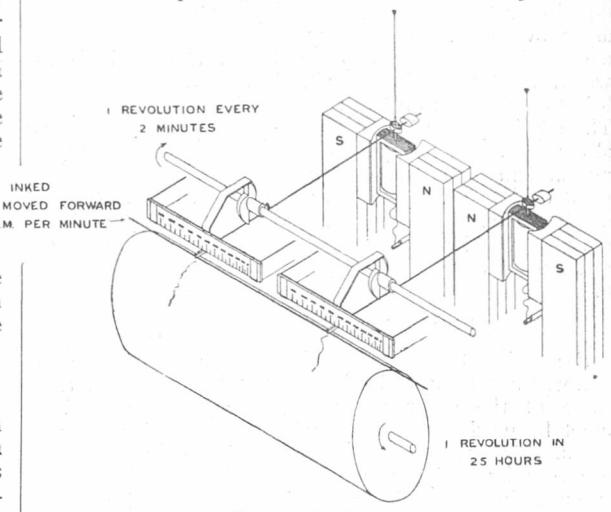

FIG. 2.—Diagram of double-thread recorder.

up to 1700° C. (approximately the melting point of platinum). Unfortunately tubes made of this material are very brittle, and great care must be taken in handling them, especially in allowing them to cool slowly. Tubes made of fused quartz are also employed, but it will be found that these tubes soon devitrify and become brittle if used continuously at a temperature of 900° to 1000° C.

[9] "The Measurement of High Temperatures," pp. 212–218, 470–471. By G. K. Burgess and H. Le Chatelier. (London: Chapman and Hall, Ltd.) In this connection it may be mentioned that Principal E. H. Griffiths successfully made differential temperature measurements between the freezing points of two liquids to one-millionth of a degree Centigrade by means of resistance thermometers and a sensitive bridge.

Optical and Radiation Pyrometers.

The temperatures reached in many modern manufacturing processes are so high that the temperature can only be measured by optical or radiation methods. It was not, however, until Le Chatelier[10] invented his optical pyrometer in 1892 that any really satisfactory attempt was made to determine the temperature of a hot body by measuring the radiations emitted by it.

The intensity of the light emitted by a hot body

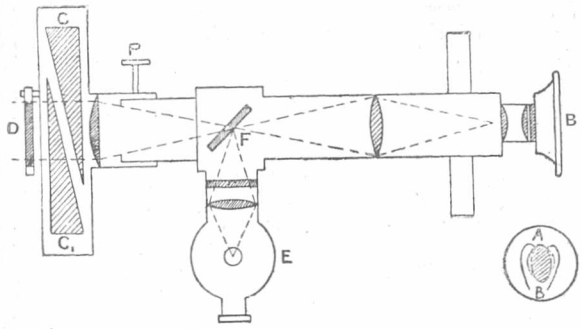

FIG. 3.—Diagram of Féry absorption pyrometer.

varies immensely with the temperature,[11] and therefore, at the first glance, one would assume that the easiest way to measure a temperature would be to compare photometrically the light emitted by the hot body with that emitted by a second hot body at a definite temperature. This would be the simplest way of doing so, if all bodies at the same temperature emitted the same amount of light, but unfortunately such is not the case, the light, for example, from incandescent iron and carbon is much greater than that of porcelain or platinum at the same temperature.

Kirchoff first propounded the idea of a "black-body" as being a body which would absorb all radiations falling upon it, and would neither reflect nor transmit any. He also showed that the radiation from such a black-body is a function of the temperature alone, and was identical with the radiation inside an enclosure, all parts of which are at the same temperature. All substances, if they are heated inside a black-body, will emit the same radiation, and if looked at through a small opening in the furnace will appear of uniform brightness. Stefan was the first to state that the energy radiated was proportional to the fourth power of the absolute temperature. Boltzmann later deduced the same law from thermodynamic reasoning. This law has since become known as the Stefan-Boltzmann radiation law, and may be stated as follows :—

The total energy radiated by a black-body is proportional to the fourth power of the absolute temperature, or $E=\sigma(T^4-T_0^4)$, where E is the total energy radiated by the body at absolute temperature T to the surroundings at absolute temperature T_0 and σ is a constant depending on the units used.[12]

This law has received ample experimental verification throughout the range over which temperature measurements can be made.

As previously mentioned, the first satisfactory radiation pyrometer was that designed by Le Chatelier.

The instrument is really a form of photometer, in that it is arranged to match the luminous radiation obtained from an incandescent body against that obtained from a standard lamp. This instrument in the form modified by Féry is illustrated in Fig. 3. It consists of a telescope DB, which carries a small comparison lamp E attached laterally. The image of the flame of this lamp is projected on to a mirror, F, placed at 45° to the axis of the telescope, the mirror being silvered only over a narrow vertical strip. The telescope is focussed on the object the temperature of which it is desired to measure, the object being viewed on either side of the silvered strip. A coloured glass in the eyepiece ensures monochromatic conditions. A pair of absorbing-glass wedges, C and C_1, are placed in front of the objective of the telescope, and these wedges are moved laterally by means of a screw until the light from the object under observation appears of equal brightness to that emitted by the standard lamp. A table provided with the instruments converts the readings obtained by the scale into degrees centigrade.

The Holborn-Kurlbaum pyrometer is shown diagrammatically in Fig. 4; it is a photometric instrument of rather a different character. A small incandescent lamp L is mounted in the focal plane of the objective and eyepiece of a telescope. The lamp circuit is provided with a battery, rheostat, and sensitive ammeter. The

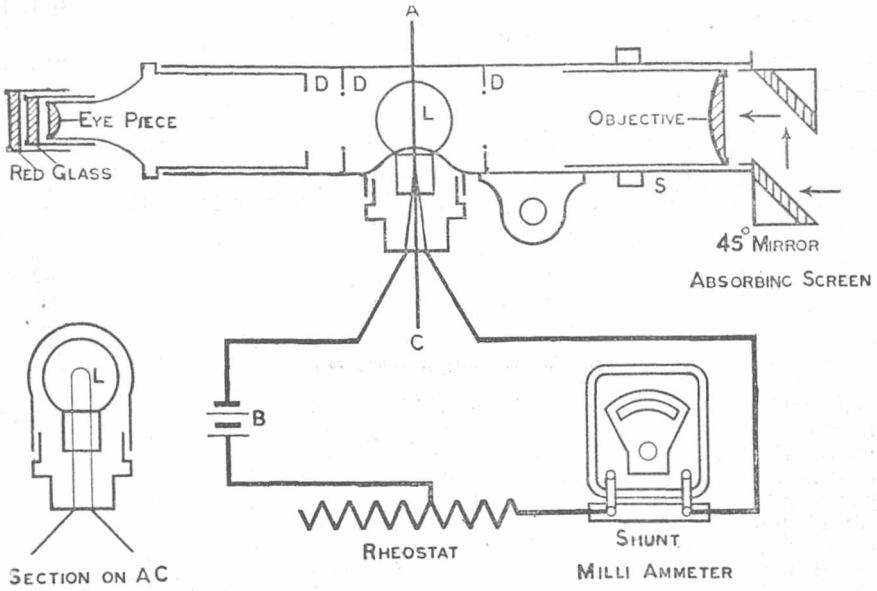

FIG. —The Holborn and Kurlbaum optical pyrometer,

[10] "On the Measurement of High Temperatures," H. Le Chatelier (*Comptes rendus*, vol. cxiv., pp. 214-216, 1892).

[11] If the intensity of red light $\lambda=0{\cdot}656\mu$ emitted by a hot body at 1000° C. is called 1, at 2000° C. the intensity will be 2100 times as great (see C. W. Waidner and G. K. Burgess, "Optical Pyrometry," Bulletin No. 2 of the Bureau of Standards).

[12] The laws of radiation and the various forms of optical and radiation pyrometers are fully discussed in Dr. Burgess' book, *loc. cit.* Two other good *résumés* will be found—(1) "Optical Pyrometry," C. W. Waidner and G. K. Burgess (Bulletin No. 2 of the Bureau of Standards; and (2) "The Black Body and the Measurement of Extreme Temperatures," A. L. Day and C. E. van Ostrand (*Astrophysical Journal*, vol. xix., 1-40).

telescope is focussed on the incandescent body, thus bringing its image into the plane AC. The current is then adjusted by means of the rheostat until the filament is of the same colour and brightness as the object. A previous calibration of the current for the particular lamp used, in terms of temperature, will then give the temperature of the hot body.

Radiation pyrometers differ from the optical types previously discussed in that they employ all the radiation received from the hot body. The first practical form of pyrometer making use of total radiation was invented by Féry. The instruments is shown in section in Fig. 5. The radiation from the hot body is focussed by means of the concave mirror on to a sensitive thermo-couple mounted at D; the electromotive force generated by the couple is indicated on a galvanometer connected to the terminals, B, B In another form of the instrument Féry has replaced the thermo-couple by a bi-metallic spiral placed in the focus of the mirror. When heated the spiral uncoils and carries an aluminium pointer over a dial divided in degrees of temperature.

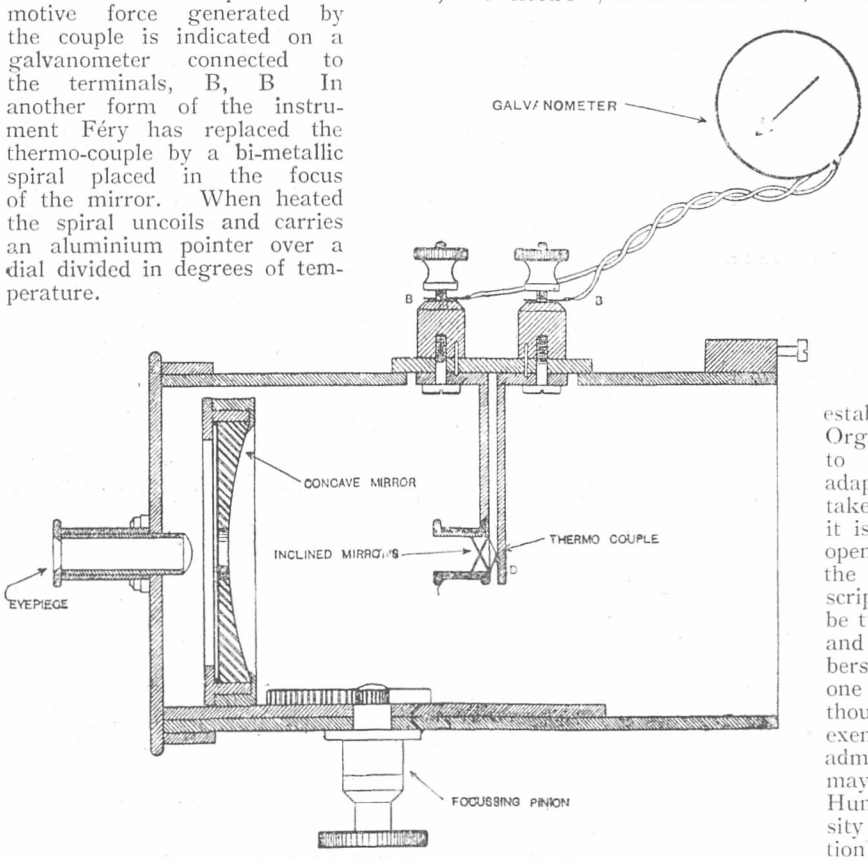

FIG. 5.—Diagram of Féry radiation pyrometer.

The author discussed briefly the capabilities and limitations of the optical and radiation pyrometers with the view of assisting observers in their use. He also threw out suggestions as to the best forms of pyrometer to be used in various industrial operations.

In discussing the question of the standardisation of pyrometers, the author pointed out that unless pressed for time the observer would find it advisable to send his instruments to the National Physical Laboratory, when they would be examined and their corrections determined for a moderate fee. In a works where there are a large number of instruments, it is advisable to keep a set of instruments which have been examined at the National Physical Laboratory as standards of reference. If this is not possible, corrections at one or two points in the range of the thermometer can generally be determined. The author mentioned the boiling points of some liquids and the freezing points of some pure metals and salts which would be found useful as standardisation points.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. H. F. Baker, F.R.S., fellow and lecturer of St. John's College, and Cayley university lecturer in mathematics, has been elected Lowndean professor of astronomy and geometry in succession to the late Sir Robert Ball.

DR. LIVINGSTON FARRAND, professor of anthropology at Columbia University since 1903, became president of the University of Colorado on New Year's Day. A native of Newark, New Jersey, he graduated at Princeton in 1888, and, after completing a medical course in America, studied for two years at Cambridge and Berlin, before receiving an appointment as instructor in psychology at Columbia in 1893.

IT is proposed to establish a club for graduates, teachers, and officers of the University of London. The proposal has been approved by the Senate of the University and by Convocation. Negotiations are in progress for the lease of 19 and 21 Gower Street, W.C., and, subject to a satisfactory assurance as to the number of members joining the club if established in these premises, the Organisation Committee is willing to continue negotiations. The adaptation of the premises will take some time to carry out, but it is hoped that the club may be open to members immediately after the Easter vacation. The subscriptions in the first instance will be two guineas for town members, and one guinea for country members. The entrance fee will be one guinea, except that the first thousand original members will be exempt. A form of application for admission to original membership may be obtained from Mr. T. Ll. Humberstone, secretary, University of London Club Organisation Committee, University of London, South Kensington, S.W.

SOCIETIES AND ACADEMIES.

LONDON.

Society of Chemical Industry, January 5.—Dr. W. R. E. Hodgkinson in the chair.—J. L. **Stevens**: The viscosity of oils. The author, after emphasising the importance of the determination of absolute viscosity and its relation to temperature for any particular lubricant, proceeds to correct certain figures previously published.—L. T. **Wright**: The oxygen content of the gases from roasting pyrites. The author on examining a number of analyses of "burner" gas from various sources noticed that the oxygen "deficiency" is the greater the greater the dilution of the gas, and this suggests that there is in addition to the well-known production of SO_3 and metallic sulphates some other cause, such as a constant error in the analyses, which influences these. In any case, the evidence of these gas analyses shows that the manner in which the oxygen is disposed of would prevent the "burner"

gas containing more than about 12 per cent. of SO_2 as a maximum when all the oxygen of the air supplied was used up, and the author states that his various attempts to obtain more than this in practice by keeping burner gas long in contact with incandescent pyrites have failed.—L. C. **Jackson**, L. **McNab**, and A. C. H. **Rothera**: The electrical conductivity of milk during the concentration, with suggestions for a practical method of determining the end point in the manufacture of sweetened condensed milk. Although the measurement of electrical conductivity is of no value in determining the degree of concentration of a separated unsweetened milk, it can be made the basis of a working process for watching the concentration of sweetened whole milk. A device in which the resistance of sweetened milk in the vacuum pan is compared with that of an approved sample of condensed milk maintained at exactly the same temperature is described.—S. J. **Johnstone**: Monazite from some new localities. Wide variation may occur in the quantity of thoria present in samples; notable amongst these are ranges shown by those from Ceylon, the thoria percentage of which varies from 9·5 to 28·2; from Malaya, 3·4 to 9·4; and from northern Nigeria, 2·3 to 8·0.

PARIS.

Academy of Sciences, January 5.—M. P. Appell in the chair.—L. **Lecornu**: A project of "Monument de l'heure." Suggestions for the erection of a monument at Villers-sur-Mer on the meridian of Greenwich.—R. de **Forcrand**: Ferrous sulphate and its hydrates. Methods are given for preparing the hepta-, tetra-, and mono-hydrates of ferrous sulphate in a pure state. The pure anhydrous salt could not be prepared, some basic sulphate being always present. The heats of solution of these four salts are given.—M. **Coggia**: Observations of the comet 1913*f* (Delavan) made at the Observatory of Marseilles with the comet-finder. Positions are given for December 21 and 22.—Ch. **Platrier**: A characteristic property of surfaces of constant negative total curvature.—E. **Goursat**: Certain extensions of Stokes's formula.—Emile **Borel**: Some problems of geometrical probabilities and hypotheses of discontinuity.—Pierre **Weiss**: The molecular field and the magnetising action of Maurain. Maurain has studied experimentally the magnetic properties of iron deposited electrolytically in a magnetic field; it is shown that the law of variation with distance (inversely as the sixth power) previously deduced by the author holds in this case.—Marcel **Boll** and Victor **Henri**: The non-influence of oxygen on certain photochemical reactions. Two reactions were studied, the decomposition of tetrachloroplatinic acid, and of oxalic acid in presence of uranyl nitrate, and the reaction velocities in absence and presence of air compared. It is shown that Bodenstein's theory is inapplicable to these two photochemical reactions.—L. **Gay**: The relations between the covolume b and the critical constants. The critical constants of substances not strongly polymerised can be determined with fair accuracy from the constancy of the ratios V_c/b and $R\theta/\pi b$.—Paul **Pascal**: The magnetic properties of the alkali metals in their compounds.—Manuel **Veres**: Researches on cadmium Description of the preparation and properties of the double sulphate, $2CdSO_4.(NH_4)_2SO_4$.—A. **Bouzat** and Ed. **Chauvenet**: The heat of formation of some compounds of cupric chloride with ammonium chloride.—H. **Taffanel**: The combination of gaseous mixtures and reaction velocities.—A. **Sartory**, J. **Gratiot**, and F. **Thiébaut**: The rejuvenation of the potato. Experiments on raising potatoes from seed. The plants raised were vigorous and free from disease.—Marcel **Dubard**: General remarks on the place and characters of classification of the Mimusopeæ.—J. **Magrou**: Symbiosis and tuber formation in the potato. It has been found by experiment that with the potato growing on poor soils, comparable with soil in which the wild potato is found, symbiosis exercises a decisive influence on the formation of the tubers. These results are in agreement with views of Noël Bernard on symbiosis and evolution.—Etienne **Rabaud**: The experimental study of an instinct. A study of the conditions governing the migration of *Myeloïs cribrella* in its larval state, from the head to the stem of the plant serving as its host.—M. **Lécaillon**: Rudimentary parthenogenesis in the golden pheasant (*Phasianus pictus*).—Max **Kollmann** and Louis **Papin**: The chondriome of the Malpighi body of the œsophagus; the signification of Herxheimer's filaments.—P. **Masson**: The endocrinal gland of the intestine in man.—H. **Bierry** and Mlle. Lucie **Fandard**: The sugar of the blood plasma.—Ch. **Dhéré**: The photographic determination of the fluorescence spectra of the chlorophyll pigments.—Charles **Lepierre**: Zinc and Aspergillus. The experiments of M. Coupin and M. Javillier.—Em. **Bourquelot** and A. **Aubry**: The influence of the alcoholic strength on the biochemical synthesis of α-ethylglucoside and α-propylglucoside.—F. **Garrigou**: The utilisation of phreatic sheets by towns built on alluvial terraces of valleys.—Emile **Haug**: The zone of the Jurassic hills of Nans.—Alfred **Angot**: Value of the magnetic elements at the Val-Joyeux on January 1, 1914.

BOOKS RECEIVED.

Das Kaiser-Wilhelm-Institut für Chemie, Berlin-Dahlem. By E. Fischer and E. Beckmann. Pp. 68. (Braunschweig: F. Vieweg und Sohn.)

Das Tierreich. 40 Lief. Tunicata. Salpae ii. Cyclomyaria et Pyrosomida. By Dr. G. Neumann. Pp. ix+36. (Berlin: R. Friedländer und Sohn.)

Einführung in die Erdbeben- und Vulkankunde Süditaliens. By A. Sieberg. Pp. vi+226+plates. (Jena: G. Fischer.) 4 marks.

Cours de Physique Générale. By H. Ollivier. Tome Premier. Pp. 716. (Paris: A. Hermann et Fils.) 18 francs.

Le Système du Monde. By Prof. P. Duhem. Tome Premier. Pp. 512. (Paris: A. Hermann et Fils.) 18.50 francs.

Uganda Protectorate. Annual Report of the Department of Agriculture for the Year ended March 31, 1913. Pp. 41. (Kampala: The Uganda Co. Press.)

Egyptian Government Almanac for the Year 1914. Pp. vii+216. (Cairo: Government Press.) P.T.5.

The Manuring of Market Garden Crops. By Dr. B. Dyer and F. W. E. Shrivell. New edition. Pp. 149+plates. (London: Vinton and Co., Ltd.) 1*s*.

Astronomy. By E. Hawks. Pp. 120+iii plates. (Manchester: Milner and Co.) 1*s*. net.

Lessons in Elementary Tropical Hygiene. By H. Strachan. Pp. xi+116+vi plates. (London: Constable and Co., Ltd.) 1*s*. net.

The Influence of the Gold Supply on Prices and Profits. By Sir D. Barbour. Pp. xii+104. (London: Macmillan and Co., Ltd.) 3*s*. 6*d*. net.

The Biology of the Blood-cells, with a Glossary of Hæmatological Terms. By Dr. O. C. Gruner. Pp. xii+392+plates. (Bristol: J. Wright and Sons, Ltd.) 21*s*. net.

The Nature of Enzyme Action. By Prof. W. M. Bayliss. Third edition. Pp. viii+180. (London: Longmans and Co.) 5*s*. net.

The Chemistry of Cattle Feeding and Dairying. By J. A. Murray. Pp. xii+343. (London: Longmans and Co.) 6*s*. net.

Willing's Press Guide for 1914. Pp. xii+474. (London: J. Willing, Ltd.) 1s.

The Cultivation of the Oil Palm. By F. M. Milligan. Pp. xiv+100+plates (London: Crosby Lockwood and Son.) 2s. 6d. net.

Behaviour Monographs. Audition and Habit Formation in the Dog. By H. M. Johnson. Pp. iv+78. (Cambridge, Mass.; New York: H. Holt and Co.)

Studien zur Pathologie der Entwicklung. Edited by Dr. R. Meyer and Dr. E. Schwalbe. I. Band. Heft 2. (Jena: G. Fischer.) 10 marks.

Memoirs of the Geological Survey of India. Vol. xxxix. Part 2. Geology of the Northern Shan States. By T. H. D. La Touche. Pp. iv+379+xli+27 plates. Vol. xl. Part 1. The Oil Fields of Burma. By E. H. Pascoe. Pp. x+269+xxxix+54 plates. (Calcutta: Geological Survey of India; London: Kegan Paul and Co., Ltd.) 4s. and 6s. 8d.

The Art of Dying. In two parts. Pp. 356. (Stratford-on-Avon: The Tapestry Studio.) 3s. 6d.

Waves of Sand and Snow and the Eddies which Make Them. By Dr. Vaughan Cornish. Pp. 383. (London: T. Fisher Unwin.) 10s. net.

Studies in Water Supply. By Dr. A. C. Houston. Pp. xii+203. (London: Macmillan and Co., Ltd.) 5s. net.

A Junior Geography of the World. By B. C. Wallis. Pp. ix+310. (London: Macmillan and Co., Ltd.) 2s. 6d.

National Defence v. Channel Tunnel. By Admiral Sir A. de Horsey. Pp. 15. (London: Longmans and Co.) 3d. net.

Lehrbuch der Meteorologie. By Dr. J. Hann. Dritte Auflage. Lief 2 und 3. (Leipzig: C. H. Tauchnitz.)

The Curious Lore of Precious Stones. By Dr. G. F. Kunz. Pp. xiv+406+plates. (Philadelphia and London: J. B. Lippincott Co.) 21s. net.

DIARY OF SOCIETIES.

THURSDAY, JANUARY 15.

ROYAL GEOGRAPHICAL SOCIETY, at 5.—Some Scientific Results of Captain Scott's Antarctic Expedition: G. Taylor.

ROYAL SOCIETY OF ARTS, at 4.30.—Indian Museums: A Centenary Retrospect: Col. T. H. Hendley, C.I.E.

INSTITUTION OF MINING AND METALLURGY, at 8.—The Bereozovsk Gold Deposit, Ural District, Russia: C. W. Purington.—The Outlook for the Mineral Industry in Canada: J. M. Bell.

LINNEAN SOCIETY, at 8.—Lantern Slides Illustrating the Fauna and Flora of the Interior of Vancouver, from her last journey: Mrs. Henshaw.—Some Observations on the Tentacles of *Blennius gattorugine*: H. A. Baylis.—(1) Some Recent Additions to the British Flora; (2) A Note on Article 45 of the Vienna Code; (3) The Abridgment of Miller's "Gardener's Dictionary" of 1754, and Hill's "British Herbal" of 1756: G. C. Druce.

ILLUMINATING ENGINEERING SOCIETY, at 8.—Discussion on Mr. C. J. Waldram's Paper: Some Problems in Daylight Illumination, with Special Reference to School Planning."

MATHEMATICAL SOCIETY, at 5.30.—(1) A Generalisation of the Euler-Maclaurin Sum Formula; (2) The Deduction of Formulæ of Mechanical Quadrature from the Generalised Euler-Maclaurin Sum Formula: S. T. Shovelton.—Binary Forms: A. Young.

FRIDAY, JANUARY 16.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Commercial Tests of Internal Combustion Engines: W. A. Tookey.

MONDAY, JANUARY 19.

VICTORIA INSTITUTE, at 4.30.—Japan, and some of its Problems, Religious and Social: Rev. Prebendary H. E. Fox.

ROYAL SOCIETY OF ARTS, at 8.—The Relation of Industry to Art: Sir Charles Waldstein.

TUESDAY, JANUARY 20.

ROYAL STATISTICAL SOCIETY, at 5.—The Fertility of Marriage in Scotland: A Census Study: Dr. J. C. Dunlop.

INSTITUTION OF CIVIL ENGINEERS at 8.—*Further Discussion*: Superheating Steam in Locomotives: H. Fowler.

WEDNESDAY, JANUARY 21.

ROYAL SOCIETY OF ARTS, at 8.—The Modern Poster, its Essentials and Significance: W. S. Rogers.

AËRONAUTICAL SOCIETY, at 8.30.—The Stability of Aëroplanes: L. Bairstow.

ROYAL METEOROLOGICAL SOCIETY, at 7.30.—Annual General Meeting.—Address on Upper Air Research: C. J. P. Cave.

ROYAL MICROSCOPICAL SOCIETY, at 8.—Presidential Address: The Microscope and Medicine: Prof. G. Sims Woodhead.

GEOLOGICAL SOCIETY, at 8.—Geology of the Country round Huntly (Aberdeenshire): W. R. Watt.—The Glaciation of East Lancashire: Dr. A. Jowett.

THURSDAY, JANUARY 22.

ROYAL SOCIETY, at 4.30.—*Probable Papers*:—On the Heat Production Associated with Muscular Work. (A Note on Prof. Macdonald's Paper, Proc. R.S., B, vol lxxxvii.): Dr. R. T. Glazebrook and D. W. Dye.—The Chemical Interpretation of some Mendelian Factors for Flower Colour: M. Wheldale and H. L. Bassett.—The Determination of the Minimum Lethal Dose of various Toxic Substances and its Relationship to the Body Weight in Warm-blooded Animals, together with considerations bearing on the Dosage of Drugs: Prof. G. Dreyer and Dr. E. W. A. Walker.—Experiments on the Restoration of Paralysed Muscles by means of Nerve Anastomosis. Part ii., Anastomosis of the Nerves supplying Limb Muscles: Prof. R. Kennedy.—Variations in the Sex Ratio of *Mus rattus* following an Unusual Mortality of Adult Females, based on an Analysis of Weight Frequency Distributions: Dr. F. N. White.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—The Fifth Kelvin Lecture: Sir Oliver Lodge.

FRIDAY, JANUARY 23.

PHYSICAL SOCIETY, at 5.—Some Characteristic Curves and Sensitiveness Tests of Crystals and other Detectors: P. R. Coursey.—Exhibition of a Water Model of the Musical Arc: W. Duddell.—Further Experiments with Liquid Drops and Globules: C. R. Darling.—A Note on Aberration in a Dispersive Medium and Airy's Experiment: J. Walker.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Testing of Materials for Use in Engineering Construction: F. W. Monkhouse.

CONTENTS.

	PAGE
Applications of Positive Rays. By W. R.	549
Geology and Mineralogy. By G. A. J. C.	550
Oceanographic Researches	551
Our Bookshelf	552
Letters to the Editor:—	
The Pressure of Radiation and Carnot's Principle.—Prof. H. L. Callendar, F.R.S.	553
Atomic Models and X-Ray Spectra.—Dr. N. Bohr; H. Moseley	553
"Atmospherics" in Wireless Telegraphy.—Wilfred Hall; H. Morris-Airey	554
A Recently Discovered Stone Circle, near Matlock, Derbyshire.—John Simpson	555
Trepanning among Ancient Peoples.—Kumagusu Minakata	555
Systems of Rays on the Moon's Surface.—G. Hubert Plant	556
The Cape Observatory. By Dr. F. W. Dyson, F.R.S.	556
Scientific Methods of Identifying Pictures. (*Illustrated.*) By Prof. A. P. Laurie	558
American and German Investigations on Soil Fertility	560
Notes	561
Our Astronomical Column:—	
Comet 1913*f* (Delavan)	566
The Crossley Reflector and Nebulæ	566
Galactic Coordinates	566
The Arc Spectrum of Iron	566
Educational Conferences	567
Rheostats. (*Illustrated*)	567
Modern Methods of Measuring Temperatures. (*Illustrated.*) By Robert S. Whipple	569
University and Educational Intelligence	572
Societies and Academies	572
Books Received	573
Diary of Societies	574

Editorial and Publishing Offices:
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.

Advertisements and business letters to be addressed to the Publishers.

Editorial Communications to the Editor.
Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.