THURSDAY, NOVEMBER 14, 1895.

THE EVOLUTION OF THE COSMOS.

Notes on the Nebular Theory in relation to Stellar, Solar, Planetary, Cometary and Geological Phenomena. By William Ford Stanley, F.R.A.S., F.G.S., &c. (London: Kegan Paul, Trench, Trübner, and Co., Limited, 1895.)

THE object of the present treatise is to establish in a modified form the nebular theory of Laplace, by the introduction of some original views which have long occupied the attention of the author. This is an ambitious scheme, and it is a little disquieting to read that authorities whose opinions carry weight did not recommend the communication of these views to the learned societies, whose duty it would have been to weigh and consider them. The reason assigned is, that the views were thought to be too speculative; and after studying them with great attention, we have no hesitation in saying that we hold the advice to have been sound.

Undoubtedly the nebular hypothesis as enunciated by Laplace is on its trial, and does not recommend itself unreservedly to those most capable of judging its merits. It may be admitted that a new working hypothesis would demand and receive great attention. But emendations, to be accepted, must come from those who have made a profound study of mathematical and physical science, and have proved themselves men of original genius. It may be that Mr. Stanley has qualified himself to speak with authority on this difficult subject, and undoubtedly the many references quoted in his volume display considerable reading and research; but the references are too frequently, not to original sources, but to the more popular writings and expositions to be found in the *Proceedings* of the Royal Institution, or in the pages of *Good Words* or the *English Mechanic*, and these authorities are quoted, apparently with as much satisfaction as the *Philosophical Transactions*. It is impossible to resist the impression that the author's scientific information is second-hand. The literary style of the work does nothing to remove this impression, and is incompatible with a complete mastery over the subject. Clearness of expression is wanting; obscure passages, that tax the patience of the reader, abound, and occasionally we come across sentences that defy interpretation altogether. As an example of these latter, we may give the following (p. 42):—"Assuming the pneuma to be a most perfect fluid and elastic system of matter, upon the meeting of two volumes of such matter, independently of any initial rotation it might possess, must have moved under pressure at the meeting plane in every or any direction, which at the time offered the least resistance to the continuity of its initial momentum." Obscurities such as these may possibly prevent the presentation of the author's views exactly as he would have wished. There are many statements which we cannot accept, if we have properly understood them, but which, expressed differently, might command a ready assent.

At the outset of his work, Mr. Stanley gives an historical account of the distinguishing features of the main cosmical theories, which have been elaborated by great minds in the past. The author's want of grasp and poverty of description are in this first chapter most conspicuous. Instead of a full and lucid account of these earlier ideas, which one would naturally expect in a work of this character, the reader must be content to find very meagre and obscure notes on the theories of Descartes, of Kant, of Laplace, or of more modern authorities, as Helmholtz, or of Faye. From this point onward to the end of the book, the author devotes himself to the description of his own views and theories. It has always been admitted, hitherto, by scientific men, that nothing more than a partial solution of the problem presented by the origin of the universe can possibly ever be expected, and, certainly, that our present state of knowledge is inadequate to the task. Laplace, for instance, based his hypothesis on the assumed existence of the sun, and sought to prove no more than the possibility of the formation of a system of planets, such as we see in existence. Mr. Stanley's theories are far more ambitious. Not only does he seek to account for a state of things existing prior to, and leading up to the formation of the sun, but he undertakes to explain such details as geological periods and the disposition of the materials of the earth's crust.

Following the theory which was first suggested by Wright of Durham, that the Milky Way forms one vast originally connected system, Mr. Stanley imagines immense districts in space filled with matter in its "original state." This is assumed to be of an attenuated gaseous character, and since the calculated size of the ultimate atom would leave less than a single specimen to the cubic metre, each one, for reasons which are not apparent, is divided into a large number of parts called "pneumites," which in a state of perfect atomic dissociation give rise to every line in the spectrum of light. The form of the "pneumites" is described in detail; but, inasmuch as our knowledge of the ultimate nature of the atom itself is confessedly imperfect, these speculations are obviously useless from a scientific point of view.

Having formed these arbitrary notions of the elementary condition of matter, existing at a high temperature, Mr. Stanley proceeds to explain the origin of the Milky Way as a vast agglomeration of pneumites, to which he gives the name "pneuma," moving in slow rotation. To account for the flattened form of the Galaxy, it is suggested that two such spheroidal "pneumas" drifted together at an early period, forming at their common surface a somewhat denser plane, over which the more distant parts of the pneumas would spread themselves by the action of their original momenta, while such parts as did not entirely combine would cause an apparent bifurcation. The division of this original "pneuma" system into nebulæ, and ultimately stellar systems, appears to be left to no more dignified cause than chance, aided by condensations brought about by heat radiation. The means by which it is suggested that these bodies kept distinct can only be described as obscure and unsatisfactory, and the attempt to cover with a false appearance of reasoning what must, by the nature of the case, remain matter for the vaguest speculation and assumption, is altogether to be regretted.

The author proceeds to discuss the behaviour of one of these separate condensations which is taken as the origin of the solar system. It is limited in every direction by the surface at which particles are in equilibrium under the influence of gravity of the solar nebula itself, and of the nearest stellar systems. Under the pressure of the outer portions, a centre of greater density would be formed, to which would be attracted all the matter in the inner parts of the nebula. The outer parts, on the other hand, condensing by radiation, as it is suggested, into comets and meteorites, will not reach the vicinity of the solar nucleus until a much later period, depending on their distances. Some of these will fall into and augment the nebulous sun, while others will become permanent members of the solar system. It is typical of the author's method that either event is left entirely to chance, and it is difficult to see where a line is to be drawn between the sun-forming matter and that which evades the nebulous envelope of the central attracting body. The abrupt disruption of the nebula, thus introduced, offers a most perplexing difficulty.

The process by which the planets come into existence presents precisely the question, to which an answer would be expected in the book before us. It must be said at once that the portion of the book dealing with this question is most unsatisfactory. In addition to the obscurity of style, to which allusion has already been made, the unfortunate arrangement of the subject-matter makes it quite impossible to gain any clear insight into the author's views as a connected whole. Mr. Stanley appears to adopt the theory of Laplace in its main features, not because he has any novel arguments to urge in its support, nor on account of the reasons which have hitherto led to its tentative acceptance, but because, in his opinion, no other theory heretofore offered possesses any reasonable probability. "Nevertheless," he says (p. 65), "it is not probable that our system was formed by any simple single mechanical effect of the action of forces upon surrounding universal matter, as generally assumed in special theories, but rather that all possible conditions were active, that may have conspired to produce the final results." Thus, for example, according to the theory of Laplace, the author thinks there should be a simple relation connecting the masses of the planets with their respective distances from the sun. He therefore attempts to explain the irregularities observed in the masses of the planets, by supposing them to be caused by the precipitation into the solar nebula of that matter, which at a much earlier period condensed by itself at the outermost parts of the solar "pneuma." Such a process implying the previous formation of masses, of variable amount, and operating irregularly and intermittently, may account for the existence of planets greatly differing in size; but, at the best, the difficulty is only removed from one place to another. It seems equally impossible to agree with the author that the plane in which the planets revolve, has been determined by the superior attraction of the two nearest stars. For both this plane and the equatorial plane of the sun should apparently preserve the direction impressed by the moment of momentum of the original solar nebula.

Space will not permit us to follow further Mr. Stanley's notions of the processes of planetary evolution or the effects which, it is suggested, the successive formation of planets had upon geological periods. It can only be said that the author toys with millions of years in a manner which possibly amused himself, but which can scarcely be edifying to the serious student. Unless the leading points of Laplace's theory can be placed practically beyond question, the consideration of details can have no scientific interest. And Mr. Stanley could hardly expect to rescue from its present position of doubt, and to place on a secure basis a theory, on the merits of which the ablest mathematicians and physicists have been unable to arrive at a definite conclusion. We have already intimated our opinion that the author's knowledge of mathematics and physics is slight. In confirmation of this view, we might draw attention to his treatment of the problem of finding the volume of a ring (p. 82), and to a bold assertion, on p. 190, concerning the increase of vapour tension in the atmosphere. We might, too, point to his contemptuous rejection of the theory, well supported by the highest authority, that the interior of the earth is not fluid. He is also singularly unhappy in refusing to accept Prof. G. Darwin's demonstration, that the earth formerly rotated at a much higher velocity than at present, because the study of the effects of tidal friction has always appeared to give direct evidence in favour of the probability of the nebular hypothesis.

W. E. P.

ELEMENTARY HIEROGLYPHICS.

First Steps in Egyptian: a Book for Beginners. By E. A. Wallis Budge, Litt.D., Keeper of the Egyptian and Assyrian Antiquities, British Museum. (London: Kegan Paul, Trench, Trübner, and Co., 1895.)

A REVIEW of a book dealing with the laws and structure of language may perhaps at first sight appear out of place in a journal devoted to science. A moment's consideration, however, will convince the reader that the book, the title of which stands at the head of this column, may be regarded as an exception to the rule. Very little was known of ancient Egypt until, at the beginning of the present century, the genius of Young and of Champollion led to the decipherment of the native inscriptions. Since that time, however, Egyptology has attracted many workers, and to the results that have followed the first decipherment the student of anthropology is perhaps even more indebted than the philologist; for while the language in itself proved unattractive in conquence of its somewhat chaotic structure, the subject-matter revealed was of the very highest importance. The key to the hieroglyphics, in fact, admitted the anthropologist and man of science to the study of the legends and beliefs, the daily life and customs of a people, whose history commences more than four thousand years before our era.

The truth of this statement is confirmed by the immense mass of literature that has within the last few years grown up around the records and remains of ancient Egypt. The man of science has made good use of his rich vein of fresh material, histories have followed quickly on one another's heels, while many of the Egyptian sacred texts and legends have appeared from time to time in the form of short stories and translations; in fact, the public has been amply provided with the means for acquiring a general knowledge of Egyptian science, history, and literature. But many people are not content to get their information entirely at second-hand. A winter spent in Cairo, or even a visit to a local museum, has perhaps tempted them to try to find out for themselves how the Egyptians recorded the legends and history of which they had read, or wrote down the prayers and ritual of which they had seen translations. Few, however, have found it easy hitherto to satisfy their curiosity, for the standard grammars and dictionaries of the language, with which the trained Egyptologist works, are either too costly or too stiff for the beginner, while editions of texts generally presuppose a knowledge of the language, and in many cases must be unearthed from the journals of learned societies. It is not surprising, therefore, to find that many a beginner has been discouraged by the great outlay, both of time and money, that must precede the commencement of his studies.

To any one who has had this experience, we would recommend Dr. Wallis Budge's "First Steps in Egyptian." Here the beginner who is anxious to tackle for himself the interpretation of Egyptian hieroglyphics, and to control the statements of scientific or popular writers, has the means placed at his disposal between the covers of a single book; and, should he subsequently wish to continue his studies, he will find himself enabled by its help to use with advantage the more advanced grammars he may come across in English, French, or German. A brief description of its contents will serve to indicate its general scope and character.

The book consists of two parts—the first containing an introduction, the second the texts. In the former, Dr. Budge begins by dismissing in a few paragraphs the external aspect of the subject, briefly referring to the history of Egyptian decipherment, and describing the manner in which inscriptions are written; he then passes to a detailed explanation of the twofold functions performed by the hieroglyphic signs, as ideographs and phonetics, and appends a list of the common signs with their phonetic values; the function of determinatives is next explained, and their use illustrated by a number of examples. The reader is then in a position to appreciate an analysis of an extract from a text, and an explanation of the methods by which its meaning may be ascertained. The rest of the introduction deals successively with pronouns, nouns, the article, adjectives, numbers, measures, divisions of time, the year, the verb, the adverb, prepositions and conjunctions, and particles, in each section of which any rule or statement is illustrated by a number of examples, and concludes with a list of common words and a list of the names of Egyptian gods and goddesses. Part ii. contains a series of some thirty texts and extracts, ranging from the Third Dynasty to the reign of Ptolemy V., and these are followed by a few untransliterated and untranslated texts, which the reader is intended to work out with the help of a short glossary at the end of the book.

In his selection of texts we think the author has been wise to look out for passages interesting in themselves, for by this means the reader's attention is secured. The translations of some of the shorter extracts are well worthy of quotation, some of the "Maxims of *Ani*," for instance, inculcating a lofty morality, while others show a shrewd knowledge of the world. "Take to thyself a wife while she is young, and she will make for thee thy son." "The time [once] past, one seeketh to grasp others [in vain]." "Enter thou not among the many, that thy name may not stink." "Answer thou not an angry master; speak that which is soft while he is uttering that which is of wrath." "Festal cries are abhorred by the sanctuary of God. Make thou supplication with a loving heart, its petitions being all in secret, and He will perform thy affairs, He will hear that which thou sayest, He will receive thy offerings." "Do not put thyself into the house of drinking beer. An evil thing are the words reported second-hand coming forth from thy mouth, thou not knowing they have been said by thee. Having fallen, thy members are broken, another giveth not the hand to thee. Thy companions [in] drink stand up, saying 'away with this drunkard.'" "Death cometh; it seizeth the babe which is on the breast of his mother as well as him that hath become an old man." "[When] thy messenger [of death] cometh to thee to carry thee off, be thou found by him ready." We have not space to do justice to the varied selection of historical and religious texts here collected, but may refer the reader especially to the quaint legend of "The Destruction of Mankind," and to *Tuauu-f-se-Kharthai's* humorous praise of the literary life and its rewards, in which he contrasts it with the unattractive trades of the blacksmith, "who stinketh more than the eggs of fish"; of the barber, "who worketh violently by his two arms to fill his belly"; of the weaver, "who is more wretched than a woman, whose legs are under him at the door of his heart, who breatheth not the air"; of the dyer, "whose fingers stink [with] the smell of the keeper of dead bodies"; and of the shoemaker, "who is the most unfortunate of all, for he chattereth everlastingly . . . [and] feedeth upon leather." We will conclude with a few lines from one of the untranslated texts, the touching address to the deceased lady *Ta-khert-p-uru-abtu*, which may be summarised as follows:—

"O thou triumphant one! thy soul liveth in heaven with the god Rā. Thy *double* has had offerings made to it among the gods. Thy beatified form is glorious among the shining ones. Thy house is filled with children and a husband, who as they follow thee weep. Thy children are rewarded by meeting thee for all they have done to thy *double*. Thou hast been buried rightly and gloriously, and they have placed thy *double* at the west of Thebes, opposite thy fellow-citizens. Thy tomb shall never be ravished, thy bandages shall never be stripped off, and thy body shall never suffer harm. Thy soul flieth towards heaven to meet the soul of the gods. . . . Thy life shall endure for ever, thy majesty shall be eternal, and thou shalt enjoy an endless number of festival-cycles, each of which shall endure for 120 years!"

It must not be supposed from what we have said that the book opens up a royal road to knowledge. No new language can be acquired without continuous work and perseverance, and Egyptian is far from being an exception to the rule. Hitherto, however, in addition to encountering the actual difficulties of the language, the beginner has been handicapped by a long and often unsuccessful search for his materials; his first steps, in fact, were unnecessarily arduous, and in making these more easy Dr. Budge will have deservedly earned his gratitude.

THE CLASSIFICATION OF ROCKS.

An Introduction to the Study of Rocks. By L. Fletcher. (British Museum (Natural History) Mineral Department, 1895.)

HAVING received from the facile pen of Mr. Fletcher a guide to the Mineral Gallery of the British Museum, and an introduction to the Collections of Minerals and Meteorites which it contains (works of a very high order from their simple lucidity as well as their thoroughness and accuracy) the student has looked forward to a companion work on the Rock Collection, from the same writer. This work has now made its appearance, and is no whit behind its fellows in outward aspect, being printed in clean, clear type, on good white paper, cheap, not too bulky, and attractive in its general appearance.

A large part of the work is taken up with an essay on classification, which will certainly tend to impress the student with the care that must be used in seizing on essential characters, the numerous pitfalls to be avoided, and the necessity of employing every instrument of research available in the study of rocks. After some preliminary paragraphs on the varied points of interest which rocks present; on the chief characters presented by the two constituents of rocks, minerals and amorphous matter; and on their ordinary modes of origin; the author observes that rock-masses vary so much from point to point, that "similarity, not identity" of characters can alone be aimed at in a classification. He strives to recognise the existence of "*petrical individuals*," but, owing to variation in different parts, to alteration, inclusion, and denudation, fails to reach the ideal, and is compelled to state that "petrical individuals have rarely, if ever, existed." We can hardly realise, however, that the inclusion of fossils or pieces of foreign rocks, which seem to trouble the orderly mind of the author, can have any real bearing on nomenclature; a boy is no less a boy if he happens to have swallowed a button. The outcome of this discussion is that "a rock-name is only required by the mineralogist for the purpose of indicating the *kind* of rock, not the particular rock-mass itself."

An admirable account is then given of "lithical characters" observed in hand specimens, both in relation to their individual constituents and to their aggregation or structure, and of the "petrical characters," which are only to be observed on a large scale in the field. A very useful term is here introduced—"merocrystalline," which is to be correlative with holocrystalline; all petrologists will be grateful for this substitute for semi-crystalline and the other unsatisfactory terms that they have been compelled to employ under protest. Taking the characters here specified, the author employs them to construct a tentative classification of a set of typical rocks, by linking into one group those which have several of these important characters in common. The first scheme attained by this method is in part natural, in that it brings together those "rocks which are composite in kind of material, holocrystalline, and without directional lithical characters," such as granite, syenite, diorite, dolerite, and euphotide. But it is also in part artificial, as, for instance, when it brings together gneiss, shale, and slate because they possess directional characters, and coal, clay, and phonolite because they are compact though composite. Mr. Fletcher points out that "directionality has been useful, however, in enabling us to bring together the rocks belonging to the several kinds"; but that things thus wedded are to be so quickly divorced is, we take it, his method of enforcing the necessity for most careful selection of essential characters in classification. The primary essential, when hit upon, turns out to be mode of origin.

From this point things go more smoothly, and the rocks fall into a grouping which is, for the most part, natural; want of complete knowledge on such subjects as the origin of the crystalline schists still, however, leaves us in difficulties in classifying these rocks, and we are compelled to place in an artificial group many which differ widely in their methods of origin.

In developing the natural grouping finally adopted, the history of the granite and basalt controversies is succinctly told, and a set of useful definitions and descriptions of the chief types of rocks is given. The work closes with a brief syllabus of these types, which have, through the devious course of trial and error, at last found rest in natural and fairly well-defined groups.

OUR BOOK SHELF.

Facts about Processes, Pigments and Vehicles; a Manual for Art Students. By A. P. Laurie, M.A., B.Sc. (London: Macmillan and Co., 1895.)

IN the majority of cases when a student of painting has seriously entered upon his work in a school of art, he has no wish, he makes no attempt to investigate the chemical and physical properties of the materials he employs. He is content to copy the practice of his teachers and fellow-learners; facility in working and immediate effectiveness are all he demands. He may even go so far as to resent the intrusion of science into the domain of art. To ask a painter to study exhaustively the chemistry of the materials and processes of painting would be unreasonable, for a whole-hearted devotion to the prime business of his life must be his first concern. Nor can an adequate grasp of the difficult and varied problems offered by pigments and vehicles and painting-grounds be acquired by listening to a few lectures, witnessing a few experiments, and reading a few chapters in a manual. The author of the little book before us makes a very modest demand upon the time and patience of the student of painting. Here are no symbols and formulæ to repel the uninitiated, no tables of constants, no complex theories of reaction and change. Mr. Laurie's readers are first furnished with a set of easy experiments which have been devised to show in an obvious way the nature and treatment of the chief pigments and vehicles. Then, in part ii., some notes on methods of painting in tempera, fresco, water, and oil are given, while the volume concludes with a glossary of pigments and a list of the chemicals and apparatus needed for carrying out the experimental work described in the earlier chapters of the book. There is one section of the volume which seems somewhat incongruous—a description of "drawing for process" and an endeavour to estimate the artistic value of the leading methods of photographic reproduction. Mr. Laurie will doubtless effect some improvements in a second edition—a little more attention to literary style is desirable. The late Mr. Gambier Parry of Highnam Court would have been surprised to find himself described as French. There are, indeed, very few slips or errors in this little volume—very few statements and explanations with which the writer of this notice does not agree.

A. H. CHURCH.

Practical Proofs of Chemical Laws: a Course of Experiments upon the Combining Proportions of the Chemical Elements. By Vaughan Cornish, M.Sc. (London: Longmans, Green, and Co., 1895.)

THIS small work is essentially a product of the modern efforts to teach science by a scientific method.

The author has endeavoured to give, in some ninety-two pages, clear and sufficient instructions for the experimental verification of the great quantitative laws upon which chemistry is based, and he has fully succeeded.

Nothing could be better calculated to lend interest to the work than the author's plan of quoting the results which were considered sufficient to establish these laws in the early days of our science; and the comparison of experimental data, obtained by the student, with the classical results of the great pioneers of chemistry, must lend a reality and zest to his efforts.

Used in its proper place, with students who have been well trained in general experimental science, and under the supervision of a capable teacher, there is no reason to suppose that the somewhat dogmatic statement of chemical laws will have any ill result.

The statement of the law of constant proportion given on p. 3—"this proportion remains constant in compounds which contain also other elements"—is so worded as to convey a wrong impression. It might be thought, for instance, that the proportion obtaining between potassium and chlorine in potassium chloride would remain the same in potassium chloroplatinate, which contains also another element platinum, and a reference to chapter v. would confirm this impression. It is evident that this statement requires remodelling.

Certain slips of a different type have found their way into the text. Thus, "*hollow glass-rod*" is mentioned on p. 52; and on p. 62, it is advised to treat silver with "pure strong hydrochloric acid" in order to convert it into silver chloride. Notwithstanding these minor defects, the book may be safely commended as embodying a well-thought-out and feasible plan of work. T.

Great Astronomers. By Sir Robert S. Ball, F.R.S. Pp. 372. (London: Isbister and Co., 1895.)

THE greater part of this book consists of *réchauffées* articles from *Good Words* and other publications. At the present day there is a large public curious to know biographical details, so no doubt the book will find many appreciative readers. The astronomers whose lives are portrayed are Ptolemy, Copernicus, Tycho Brahe, Galileo, Kepler, Newton, Flamsteed, Halley, Bradley, William and John Herschel, Laplace, Brinkley, the Earl of Rosse, Airy, Hamilton, Le Verrier, and Adams. It need hardly be said that the serious student of astronomy will find little in this book not already familiar to him; the volume is intended for the popular mind, and therefore much of it is small talk of the kind in which the general public revels. When the lives of eighteen astronomers are described in a volume of less than four hundred pages, as they are in this book, it is needless to say that only a few of the features characteristic of each can be presented. Sir Robert Ball has, however, selected the chief features in the lives and works of the great men who form his subjects, and his sketches, though verbose in parts, bring to light a few new facts in which astronomers generally will be interested. The book contains numerous illustrations, many of them new. The illustrations chiefly represent the astronomers described, and their houses, observatories, and instruments. We cannot understand, however, why some of them are in the book at all; for instance, with the sketch of the Earl of Rosse we find pictures of Birr Castle; The Mall, Parsonstown; and the Roman Catholic Church at Parsonstown. The connection of these views with "Great Astronomers" is much less reasonable than that between cats and clover.

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.*]

Sir Robert Ball and "The Cause of an Ice Age."

I SHOULD like to correct one statement in my long letter in NATURE of October 17. I there said that Sir Robert Ball had not withdrawn his claim to the discovery of the law of distribution of summer and winter temperature in each hemisphere, which had in fact been previously published by Wiener. I am reminded by Mr. Kendall that I had overlooked a second edition of the book in which credit is duly assigned to Wiener. Thereby hangs a tale. I have looked in vain through Low's well-known list for any trace of a second edition. I also looked through the British Museum Catalogue without any result, and inquired in the Copyright Office in that establishment, and was told that no such book had reached the Museum. Lastly, the Museum people tell me they have applied to the publisher for the book, and have received the reply that it is only a re-issue, and not a new edition with new matter in it.

I am further told by the Museum officials, that he has thereby incurred a penalty of £5 for non-compliance with the Copyright Act. It was by an oversight of his, therefore, that this second edition has been overlooked by myself and, probably, by others.

In this second edition, Sir R. Ball, after unwittingly wearing the nimbus for six years, gives up his oft-repeated claim to be the discoverer of the law in question, and attributes it to Wiener. As the publication of his discovery was the alleged reason for writing the book, he had now to find another excuse, and did so by reiterating the unjust accusation he had made against Croll of having ignored the disparity between the sun-heat of summer and winter, and thus necessitating the writing of a work to set the world right on the matter.

As long ago as 1891, Mr. Noble had called attention to this injustice, and shown that Croll had nowhere made the mistake attributed to him, and quoted passages from pages 55 and 86–7 of "Climate and Time," to show that he was perfectly aware of the real conditions. Although Croll nowhere cites the actual numbers 63 and 37, or 3·93768 and 2·34550 as Wiener gives them, it is odd that in calculating the amount of sunshine received at Edinburgh in summer and winter respectively, he does give the numbers 7 to 4, that is, 63 : 36, and "Climate and Time" was published four years before Wiener's "Memoir."

It is quite true that Croll does not use these figures in his calculations as Dr. Ball does. For him they would be mere academic numbers, since he knew, as we know, that the problem to be solved depends much on the proportions of the differential temperature of different latitudes at different seasons, and little or nothing on the proportions of the temperatures at different seasons of a whole hemisphere lumped together.

Since the above was written, Mr. Hobson has replied to my previous note, complaining that I have converged attention upon the now famous law, which was supposed to be Sir R. Ball's own child, and have not referred to the effects of varying eccentricity, which were everybody's property. He forgets that I was criticising Dr. Ball, who habitually claims the law in question as the *causa causans* of an Ice age, and especially refers to this invariable and constant factor as "the following theorem which constitutes *the essence of the astronomical theory of an Ice age.*"

The value of this essential factor of the problem being the matter in dispute, I presume Mr. Hobson wrote his letter to illuminate your readers, and not merely to engage in a profitless polemic. If so, perhaps he will do me the favour of meeting the following case.

(1) Wiener's law is not disputed. It represents the proportions between the *sum* of all the sun-heat received in either hemisphere in summer and winter respectively.

(2) Sir R. Ball makes it apply not only to the whole hemisphere, but to different zones in the hemisphere, and notably to Britain (see "A Cause for an Ice Age," new edition, pp. 127–131). Will Mr. Hobson support this astounding conclusion?

(3) In the zone between the tropics there is perpetual summer, and it absorbs one-half of the sun's heat received on the earth in equal proportions in the two seasons. Here, therefore, the proportions of sun-heat are not 63 : 37, but 50 : 50. There-

fore Wiener's law is not true of this zone taken apart. If we subtract the sun-heat received in this zone where glacial conditions never existed, we shall find that the proportions in the temperate and polar zones combined are not 63 to 37, but 38 to 12. So that Wiener's law is not true of these zones where glacial conditions alone existed. If, instead of taking the tropics, we take the area limited by the parallels of 45°, which is a better boundary for the district displaying glacial phenomena, the disparity is still greater. At Edinburgh, as Croll long ago said, the proportions are about 3 to 1. Does Mr. Hobson dispute this?

(4) Dr. Ball nowhere connects Wiener's law as a cause with the Glacial age as an effect *by proof of any kind*. He merely offers us certain *obiter dicta*, and argues that if the present proportions of sun-heat were distributed over a winter of 199 days and a summer of 166 days, we should have a glacial climate in Britain. Since the proportions of sun-heat actually recorded in Britain at this moment in our 199 coldest and 166 warmest days respectively show a far greater disparity than that represented by these figures, I may, I think, ask if Mr. Hobson admits this *reductio ad absurdum* of Sir Robert Ball's argument to be valid?

(5) Lastly. For the first time, Mr. Culverwell has applied numerical tests and methods to the problem of discovering the actual and not the hypothetical results on climate caused by a varying eccentricity of the earth's orbit. He has done so by comparing the actual sun-heat received by each latitude now, and contrasting it with the actual sun-heat received by the same latitude in the time of greatest eccentricity, and has shown that the limits of variation do not amount to more than can be measured by removing a parallel of latitude from 3½ to 4 degrees. This to some of us is absolutely conclusive, not only against Dr. Ball's arguments, but against all astronomical theories, including Croll's.

The real point and meaning of my letters is that in regard to the astronomical theory of an Ice age all the kind of reasoning employed by Sir R. Ball and its consequences are fallacious. They have been swept away and shown to be worthless by Mr. Culverwell's method of solving the problem, which is inductive and decisive, and which rigorously proves that Sir Robert Ball's results are as extravagantly baseless as his method is unfruitful. This being so, it is most clearly incumbent upon the Lowndean Professor either to answer his accomplished critic or to withdraw his book, which is only misleading the unwary by having its mistaken and shattered arguments sheltered under the Astronomical Chair at Cambridge. It ought certainly to have no place in a series entitled "Modern Science," where ascertained results and not ingenious fallacies ought to find a place. Nor ought Mr. Kegan Paul's name to appear on its title-page as a guarantee of its scientific soundness.

The Athenæum Club, October 29. HENRY H. HOWORTH.

Curious Aerial or Subterranean Sounds.

PROF. G. H. DARWIN, in NATURE for October 31, p. 650, asks for information as to the "Barisàl guns." The name is derived from Barisàl or Burrisal, a town in the eastern part of the Gangetic delta, and the best and most recent account of the sounds known as the "Barisàl guns" is to be found in the report of a sub-committee of the Asiatic Society of Bengal, published in the *Proceedings* of that Society for 1889, p. 199.

The great difficulty in the way of accepting the suggestions of Messrs. Meldola and Davison (NATURE, November 7, p. 4), that earthquake shocks are the cause of the sounds, is the restriction of the "Barisàl Guns," so far as is known, to a comparatively small area, where earthquakes are of rare occurrence, and to a particular season of the year.

W. T. BLANFORD.

[*Translated by Prof. G. H. Darwin.*]

AN article, by Prof. G. H. Darwin, on "Barisàl Guns and Mistpouffers" appeared in NATURE for October 31. Summarising a letter in which I drew his attention to this phenomenon, he mentions two sources for these mysterious sounds, which my friend M. Rutot and I have considered as possible, namely that the origin is entirely terrestrial, or that it is a special phenomenon of atmospheric electricity. It is as well, perhaps, also to point out another purely atmospheric source, viz. that it may arise from the abrupt displacement of a mass of superheated air in unstable equilibrium, which rises suddenly in the atmosphere.

This was the explanation given to M. Lancaster by the late M. Houzeau, the astronomer, on the former sending him my first notes on this phenomenon, in about 1881. M. Houzeau also stated that he had himself observed the noises, but that he could not suggest any more plausible explanation than the above.

In confirmation of this hypothesis, I would remark that *this year* the mysterious detonations were heard up to the end of September, and even up to the beginning of October, not only by me but by several of my friends and correspondents; this is much later in the year than usual. Now great and unusual heat prevailed this year during the whole autumn, and this coincidence affords a strong support to the theory of an origin arising from certain conditions of rise of temperature.

Sailors of the port of Ostend assert that "Mistpouffers" prevail over the whole of the North Sea as far as Iceland, and they consider them to be a sign of fine weather, with calms and heat.

The mysterious noises, mentioned to me by Mr. Clement Reid, which are heard on Dartmoor and in Scotland near the Highland Fault, are not perhaps exactly comparable with "Mistpouffers"; for Mr. Reid writes to me that these sounds are probably associated with those incessant tremors of the earth's crust, which are well known in these districts. With respect to sounds of this peculiar kind, readers of NATURE will find an interesting note by Mr. Charles Davison, entitled "On Earthquake Sounds," in the *Geological Magazine* for May 1892.

I might add many interesting data concerning "Mistpouffers," but I have promised to reserve them for the Belgian magazine *Ciel et Terre*, edited by M. Lancaster. In that journal, the readers of NATURE who are interested in this subject, will shortly find a complete account of the papers which have come to my knowledge; to which they will doubtless be able to add a number of facts and observations, which will prove of great service for the scientific study of the question.

ERNEST VAN DEN BROECK.

39 Place de l'Industrie, Brussels.

I HAVE heard many queer noises in lonely spots, and wish I had made note of the time and place and circumstances. But though I have few exact facts and figures, I have a very distinct recollection of many such observations, some of which are a direct answer to the question asked by Prof. Darwin in your number of October 31, while others seem to have a bearing upon it.

I have sometimes heard on the mountains north of the great Craven Faults, from which I looked over low ground towards Morecambe Bay, what I always took to be the sound of heavy guns somewhere out seaward. They were not, however, repeated at such intervals, nor for so long a time as to support the view that it was the sound of artillery practice; and, when I made inquiries from friends who resided in the district, I never learned that there was anything of the sort going on. The sound struck me as peculiar, but I could not find any satisfactory explanation of it. I considered many possibilities. First, there was the general question of the different transmission of such sounds according to the state of the atmosphere. Fog, for instance, affects it. In the particular case I have mentioned, I knew there were great quarries in various places within a few miles, and I had always before me the possibility of my having heard the sound of blasting echoed by some combination of cliffs to where I was.

The noises I heard were just such as are produced by the thud of the wave as it fills a cave. The muffled sound of the impact of water is heard a long way off. An idea of its force may be gained from cases in which the air, instead of being compressed in the hollow of the rock, finds an opening to the surface of the ground above, and rushes out, sometimes followed by a spout of spray. Its recurrence is irregular, and it lasts only for the short time when the rise and fall of the waves just fills and empties the cave. The direction of the transmission of this sound to long distances is still more uncertain.

In the case of the air-thuds on the Yorkshire Fells this explanation is extremely improbable, and the "guns of Barisàl," so named from the town and river of that name, boom across the flat delta of the Ganges, where there can be no cliffs or caves. What is really common to the two areas suggests another possible explanation.

The sound of the first blow of the curled wave upon the shore or on the sea, and of the outburst of the great volume of air included in its fold, is carried an immense distance. I have heard it much resemble heavy guns. It is exceptional and irregularly intermittent. It is only when the tide has reached one part of the long, flat shore, that the right combination occurs. For, when there is a ground swell on, the waves do not roll in continuously, but come in groups, and therefore we require the coincidence of the higher waves and the right minute on the shore.

Now, Morecambe Bay has a long flat shore, over which the tide comes in so fast that it has been known to overtake a coach-and-four. It is open to the south-west wind and the Irish Channel tide. The time when the "Barisàl guns" are heard is when the great tidal wave is rushing up the estuaries in the Bay of Bengal. This is a very suggestive coincidence.

Before we go further in our investigation of air-thuds, it would be of great help if we would get some exact data as to the distance at which the sound of great guns, of blasting, or of waves, can be proved to have been heard. So far I have endeavoured to explain such sounds by surface action. I believe, however, so strongly in the rapidity and constant recurrence of earth-movements which must produce sound, that I would add a few words upon that point.

To begin with small sounds. When the sun is setting and the shadows of the mountain climb up the screes or talus, each part rapidly passes from sunshine into shade, and often into very cold shade. In such circumstances it is not uncommon to hear a crepitation among the fragments. This is quite in accord with the view that the downward travel of the screes is largely due to diurnal changes of temperature affecting the fragments of which they are composed. More rarely bangs are heard among the crags in similar circumstances. The ticking of the firedogs and iron-work of a grate when the fire has gone out, and the sudden and terrifying crack of the oak-wainscoted room, are familiar examples of the same kind of thing. In frost, of course, such noisy ruptures are common.

Now as joints in rocks are surface phenomena, due to shrinkage, detonations accompanying such disruptions should be often heard. Under the artificially-produced conditions of mining they are frequently heard. In the limestone quarry, from which the black marble of Dent is procured, the workmen found that, when they were quarrying the lower beds, and struck the rock with a pick or bar, fragments flew up into the air with a greater force than could be due to the blow of the pick, and in an unexpected direction. Also, when the tunnel was being made above Ribble Head, and the workmen were engaged upon the bed of rock which formed the floor of the tunnel, pieces used to burst off with a loud noise, so that some of them thought that they had discovered a detonating shale. The explanation in both cases was that the hard thin bed which shelled off in that unexpected manner, rested on compressible shale, which, behaving as a fluid, transmitted the pressure due to the sides of the quarry or the wall of the tunnel, squeezed up the floor where the rock had been removed, and produced what in a coal mine would be called a "creep." The thin bed of hard rock above the shale rose in a slight arch over the upthrust shale, and was thrown into a state of tension, so that, when it was struck, chips, flakes, and sometimes larger pieces, would fly off. Phillips pointed out that "the removal of one side of a vein would leave the remaining side in a condition of strain resembling that of a strung bow, with a tendency to bulge outward into the workings," and it is known that from such a surface, especially when covered with a coating of crystalline vein-stuff, fragments fly off with cracks and explosions of various degrees of intensity. Earth-movements and the action of subterranean waters are continually opening out channels in which all these processes which produce strained surfaces and consequent explosions are going on. The widespread belief that fairy or goblin miners are heard working deep in the bowels of the earth probably arises from these natural rock-burstings, which are, from the nature of the case, more apt to occur along the line of lodes. I have myself been advised to go in for certain mining speculations because the sound of workmen's tools had been heard beneath the ground.

As on a small scale along lines of tension, artificially or naturally produced, so on a large scale along the lines of strain due to the great earth-movements, which are continually going on, analogous disruptions must repeatedly occur. When it is on a great scale, and the tremors and throws accompanying it have been observed, it is called an earthquake; when the noise only of the break is heard, it is unrecorded, because of the difficulty of distinguishing one air-thud from another. It must be a phenomenon of not uncommon occurrence along the lines of more rapid earth-movement, for we must bear in mind in all such inquiries that time is an element in the bending of rocks. In the cases I mentioned above, it is the rapidity of the action due to the artificial removal of the mass that causes the rock to break rather than to sag or bend, and retain its curved form. This last we see commonly among the contorted strata where nature has applied the pressure more gradually; but we also see evidence of more sudden movement in faults and slickensides and similar phenomena, all of which are going on still, and must be accompanied by sounds could we only detect them.

T. MCKENNY HUGHES.

Cactaceæ in the Galapagos Islands.

IN my notice (NATURE, p. 623) of Dr. Baur's botanical collections from the Galapagos Islands, I intended to add a few words respecting the Cactaceæ, but forgot it at the last moment. This natural order of plants forms the most conspicuous feature in the vegetation of some of the islands, as may be seen in the excellent views illustrating the cruise of the U.S. ship *Albatross*; yet Darwin, so far as I can discover, is the only naturalist who ever brought away any specimens, or contributed to any more exact knowledge than can be got from photographs on a very small scale. The presence and abundance of Cactaceæ in these islands is highly interesting, especially in relation to the age and origin of the flora, and to the fact that none exist in Juan Fernandez, though they abound in Chili. They are also of great importance to the animal kingdom during long droughts, as they are then the only source of water. As we learn from Darwin, the succulent branches are eagerly devoured by the large tortoises, lizards, and various other animals. He found that lizards four feet in length were easily enticed whenever he threw them a piece of a branch, and small birds would come within a few feet of him and peck at one end whilst a lizard was eating at the other.[1] Darwin also regarded the Cactaceæ as a source of food; and it is noteworthy that animals were mainly dependent on the branches broken off by wind. *Opuntia galapageia* was found by Darwin on James's Island, growing from six to ten feet high, with a trunk a foot in diameter, and so densely covered with strong spines as to be protected from destruction by predatory animals. The younger branches bear only long elastic bristles. Dr. N. J. Andersson, a Swedish botanist, who visited the islands in 1851, states (Eugenies Resa, "Botanik," p. 95) that this cactus grows in all the islands, and he adds that he observed at least four or five other species, but had not time to collect specimens or to sketch them. In another place ("Linnæa," xxxi., 1861–2, pp. 571–631) he particularly mentions the *Opuntia* growing in lava where nothing else would grow, forming huge candelabra-like objects with pretty red, shining fruits. It is evident, too, from the photographic views reproduced in the "General Sketch of the Expedition of the *Albatross*," that one (or more) species of *Cereus* attains a height of ten or twelve feet, and is equally prominent in the landscape. Perhaps the next botanist who visits the islands may find time to study the Cactaceæ. But when will any Government think it of sufficient importance to attach a really qualified botanist to such expeditions? I ought to add that Dr. Baur is not a botanist, but he appears to have done his best as a botanical collector.

W. BOTTING HEMSLEY.

Slow Lightning.

As far as I know, the first description of slow lightning occurs in your issue of November 7. It must be very rare, for I have never met any one who would readily believe in its existence. I write to testify to the accuracy of Mr. Crawford's description, though I have not seen it quite as slow as the flash which he timed. The best example that I ever saw was in a storm over London some eighteen years ago. A thick stream poured down, in the sort of curve which liquid takes from a kettle, and was then slowly joined by a similar stream from the opposite direction, the united stream then continuing its slow course downwards. I was not where I could see the end of it. The peculiarities—the breadth of the streams, and their deliberate motion—could scarcely be an optical delusion. The streams did not appear to me as "chains."

I have observed lightning all my life, and since it has begun to be photographed, I have been looking out for pictures of the various types. I hope we may get some picture of this, and

[1] See *Magazine of Zoology and Botany*, i. (1837), p. 467, where Prof. Henslow describes and figures *Opuntia galapageia*.

also of the sheaf form, which I have seen in storms directly overhead, the flash being like two brushes discharging in opposite directions, recalling the classical representations of the lightning in the hand of Jupiter. ROBERT BRIDGES.

Yattendon, Newbury, November 8.

An Early Reference to Hydractinia?

IN Swammerdam's letter to Thevenot on the anatomy of the Hermit Crab, there seems to be a reference to Hydractinia. The passage ("Biblia Naturæ," Leyden, 1737, i. 197) runs thus:—"Maximas tamen omnes [conchas] *Fuci marini quædam species, punctis vel apicibus minutis assurgens*, obtegebat eousque; ut tota nonnullarum figura obscurata & deformata esset; neque spiralium, quibus gaudent, convolutionum ulla posset conspici."

I venture to suggest that the words in italics fairly (though, of course, not literally) correspond to the "chitinous crust covered with numerous grooved and serrated spines" of Hincks ("Brit. Hydroid Zoophytes," i. 23, 24). The obliteration by Hydractinia of the whorls of shells tenanted by the Hermit Crab is well-known. Specimens showing such obliteration may be seen in the Natural History Museum, South Kensington.

Harringay, N. HENRY SCHERREN.

Rooks and Walnuts.

MR. REID'S remarks on rooks carrying off acorns, suggests my mentioning that they are great depredators of my walnuts. They come early in the morning, attack the walnuts on the trees, and carry them off to an adjoining field, where they punch a hole in the shell and extract the contents.

They build on several groups of elms in Ealing, and on one row of trees close to Christ Church they come regularly at Christmas to see what repairs are required; but one tree, which has an electric wire running through it, they now entirely avoid.

GEORGE HENSLOW.

A Substitute for Sulphuretted Hydrogen.

HAS "Rusticus" (see vol. lii. p. 597) heard of liquefied H_2S? I have tried it, and find it works admirably. Unlike ammonium thio-acetate, it can be obtained from any of the usual chemical dealers; a bottle containing a pound, = 11 cubic feet, can be had for a few shillings. It is always on hand when required, and entirely dispenses with the old H_2S apparatus and its abominations. A very great desideratum is the purity of the liquefied gas. CHEMICUS.

A GERMAN IMPERIAL INSTITUTE.

IN his presidential address to the British Association at Ipswich, reported in NATURE on September 12, Sir Douglas Galton referred to the efforts made by the German Government and Municipalities to advance scientific knowledge and promote research. In his statement that the "Royal Technical High School" at Charlottenburg "casts into shade the facilities for education in the various Polytechnics which we are now establishing in London," he scarcely appreciates the radical distinction between the German and London institutions, which accidentally bear the same name, but which are wholly different in purpose and organisation. But his remarks on the Reichsanstalt of Berlin are so suggestive and so full of interest, that I was eager to have the opportunity of visiting the Institute, and was glad within the last week or so to be able, during a brief stay in Berlin, to make myself better acquainted with its work.

The Institute, as its name implies, is an "Imperial Institute," as distinguished from the Polytechnicum, which is under the Government of the Prussian State. The Polytechnicum, or Technical High School, has been already described in NATURE, and is one of a number of technical universities situated in the several States which compose the German Empire. The Berlin Institute at Charlottenburg is by far the largest and the most completely equipped in Europe, and is already pronounced too small for the ever-increasing number of students, now exceeding 3000. In close proximity to this building in the Marsch Strasse, a turning in the leading avenue through the Thiergarten, the Physical-Technical Imperial Institute is now being erected. When complete it will consist of three detached buildings, in addition to separate residences for the Director and for some members of his staff. Two of these buildings are already finished, but the third is not yet erected, and pending its completion the work of this section of the Institute is carried on in a portion of the basement of the Royal Polytechnic.

The work of the Institute consists of two separate, but in some respects associated, sections. Section I. is devoted to pure scientific research, and Section II. to the testing and standardising of different kinds of measuring instruments. The Research Department is already housed in the main building of the new Institute, which has been planned especially for the purpose; whilst much of the testing work of the other department is still carried on in the Polytechnic building. The united Institute is under the general direction of Dr. Kohlrausch, and is maintained at an annual cost to the Government of about £15,000.

The Research Department of this interesting Institute is housed in a three-storeyed building, consisting of a basement, a main floor, and an upper storey. The construction is in many respects peculiar. The walls, instead of resting on separate concrete foundations, are built into a concrete flooring two metres deep, which covers the entire area of the building, so that the walls, basement, and flooring are closely bound together. The effect of this is that the building, if it vibrates at all, must vibrate as a whole, and no one part is separated from another. There is consequently no need for the isolated pillars which are found in some of our English laboratories. But even this arrangement does not appear to be perfect, and although the building is well set back from the road, in which there is some traffic, vibratory movements are not entirely avoided. The principal floor of the building consists of a central room, used mainly for experiments requiring constant temperature, surrounded by a corridor which leads into a number of other laboratories for experiments in electricity, magnetism, light, and heat. There are various interesting arrangements for maintaining the constant temperature of the central room, including the admission of light from the top through a series of separated glass roofs. The experimental work of the first section, or "Abtheilung," is under the direction of three heads of departments, Drs. Thiesen, Jaeger and Lummer, who occupy themselves respectively with investigations in heat, electricity, and light. They are aided by a number of permanent assistants, and by other workers who are admitted into the Institute for the prosecution of some special investigation. The members of the staff are engaged entirely in research, and have no teaching duties. The researches of the staff during the past year comprise numerous investigations connected with the determination of the expansion of bodies under heat; experiments with different kinds of thermometers, and pyrometers; electric and magnetic investigations; and photographic and photometric experiments. Short notices of these researches, giving the results as ascertained, are annually published.

Section I. is occupied exclusively with the testing of different measuring instruments. The makers of thermometers, manometers, and pressure gauges of all sorts, send their instruments to the Institute to be tested. Galvanic elements, accumulators, arc lights, ammeters, electric condensors, resistance coils, &c., are being tested in different parts of the building. No measurements connected with weight or mass are undertaken, and the testing of the strength of materials for builders and engineers is carried on in other buildings in no way connected with the Institute. The number of thermometers alone sent to the

Institute to be tested amounted last year to 11,656, of which 10,005 were clinical thermometers. A small charge is made for work done for the trade, but the receipts from this source of revenue do not exceed £1000. Incidentally, in connection with this work, there is a large amount of original investigation, and the staff employed are all men of proved scientific ability. New methods for obtaining more correct results and greater accuracy in measurement are constantly being investigated, and to this extent Section II. is equally with Section I. a laboratory of research. The experiments in Section II., however, are all directed towards the more accurate testing of instruments of precision. Some of the work done in this section is undertaken at the request of the staff of the Research Laboratory, and in connection with the experiments in pure science.

This Imperial Institute is under the immediate control of a Curatorium or Council, consisting of Professors of the University and Polytechnic, of engineering and technical experts, and of heads of industrial firms, presided over by a member of the Government. The selection of members of the staff, and permission to work at the Institute, rest with the Council. At first, applicants for admission were required to have obtained their Doctor's degree; but no such rule now holds. The ability to work, and the intention of prosecuting some original investigation previously approved by the Council, is a sufficient qualification. Each application for admission is considered on its merits. The Physical-Technical Imperial Institute is the crown of the series of coordinated Institutions which afford facilities for technical instruction in physical science, and opportunities for advanced research. In the city of Berlin are well represented the various educational agencies which have contributed so largely to the greatness of Germany; and the improvements which have been made of late years in the lighting and sanitation, in the postal and telephone arrangements of Berlin, are so many practical indications of the value of the education which the State and the city jointly provide. The Physical Institute is literally a temple dedicated to science, and its two divisions correspond with the twofold character of all scientific work—that which is undertaken with the sole object of widening the area of knowledge, and that which enables knowledge to be applied to the useful purposes of life. PHILIP MAGNUS.

THE PLANET JUPITER.

THIS bright planet now rises more than two hours and a half before midnight, and as his northern declination is about 18½°, he attains an altitude of about 57° when southing at about 5h. 15m. a.m. His apparent equatorial diameter this evening (Nov. 14) will be nearly 40″·5, and is increasing daily, so that by the end of the year it will be 45″·6, when the planet will be visible nearly all night, and remain above the horizon during a period of 15½ hours. He will arrive at opposition to the sun on January 24, 1896, and will then be displayed under the best conditions.

To those, however, who are disposed to study the complex and variable features exhibited by the belts, the present is an important time, for it is advisable that such markings should be watched during long periods, and that a large number of their transits should be recorded. Their individual rotation periods may then be ascertained, and the differences determined, together with the fluctuations of speed affecting the same objects. Details of this character can only be correctly derived when the observations are numerous and extend, at least, over a fairly long period of time. Materials of the kind alluded to, obtained in the early part of the opposition, are of special value for comparison with the observations made at the time of opposition, and with the terminal ones which may be secured in the evenings of June 1896, just before the planet leaves us for a season.

The features of Jupiter, though liable to certain changes, are yet, in some of their leading characteristics, remarkably durable. Like the spots on the sun, many of the markings on the planet disappear and reappear under very similar aspects. In fact, we are not without evidence that a certain degree of periodicity regulates the visibility of certain spots on the disc. In 1870 there was an eruption of dark spots along a belt in about 25° north latitude. In 1880 the phenomena appear to have recurred, for the same belt became studded with black spots, and in 1891 similar appearances were repeated. These markings are remarkable, as possibly indicating a periodical recurrence at intervals of about ten or eleven years. But it may be gravely doubted whether, in the present state of our knowledge, the materials exist for suitably investigating the question as to cyclical changes in the Jovian spots. The individuality of observers must affect the matter to a considerable degree, as their drawings and descriptions of the same features are seldom in agreement.

In recent years, the great red spot has not been so much observed as formerly. It has lost its striking character and its novelty, and planetary students have somewhat neglected it for newer objects more readily within reach. During the last ten years the mean rotation period of the spot has been 9h. 55m. 41s.; but it has shown some irregular variations. The slackening motion of the spot which operated so perceptibly between 1879 and 1885, and added seven seconds to the rotation period, appears to have been checked in the latter year, and the rate has been pretty evenly maintained since that time.

As to the visible aspect of the spot, it is now extremely faint, and can only be discerned on a good night of definition. Its feeble outlines are generally lost amid the very dark and well-marked boundaries of the belts in its immediate vicinity. But on a good night it is seen as a pinkish discolouration of the bright zone outlying the great southern equatorial belt, though its beautiful oval outline is distinguished with difficulty.

One of the interesting features of recent oppositions of Jupiter has been the series of dark and white spots plentifully arranged along the northern side of the great northern equatorial belt. These markings move swifter than the red spot, but not much so, for their period is 9h. 55m. 35s., or only six seconds less. They show changes, for sometimes one may be seen exceedingly dark, if not absolutely black, and just like a satellite-shadow in transit; but in a week or two a great decadence of tone may have affected it, and it appears scarcely darker than the belt on which it lies. These markings, so prominently fringing the northern belt, have certainly been visible during the last ten years. In 1885 I found their motion about eight seconds swifter than that of the red spot, but there were irregularities. Different spots, though in the same longitude and, probably, of the same character, do not yield coincident times of rotation, nor does any one object maintain exactly the same rate during a long period of time. The current in which they are situated, and by which they are transported to different longitudes, evidently suffers inequalities of speed, which are probably due to local disturbances underlying it.

These features of the northern belt are still very pronounced. On the morning of September 27, I observed two very dark spots projecting north from the belt and preceding the red spot at intervals of about four and two hours. The red spot follows Mr. Marth's zero meridian (System II.) by about seven minutes, but I have only obtained two observations since Jupiter has been visible as a morning star, and neither of these was very satisfactory.

During ensuing months it will be important to make as many drawings as possible, and to secure a large number of transits of the various markings. Among others the following may be specially mentioned :

(1) Light and dark spots near the equator (period 9h. 50m. 6s. in 1880, increased to 9h. 50m. 30s. in 1888).

(2) Dark spots on a belt in latitude 25° + (period 9h. 48m. in 1880, increased to about 9h. 49½m. in 1891).

(3) Dark spots and breaks in a very narrow belt in latitude 35° + (period 9h. 55m. 39s. in 1895).

(4) Light and dark spots in the region south of the red spot (period 9h. 55m. 18s., and apparently unchangeable between 1880 and 1891).

In the course of his work, the observer will also detect other features worthy of attention.

From eye-estimated transits the periods of the various objects can be very accurately ascertained, and Mr. Marth's valuable ephemerides for physical observations of Jupiter, published in *Monthly Notices* (June and supplementary numbers, 1895), will assist the student to reduce his own materials. W. F. Denning.

NOTES.

The Royal Society's medals have this year been adjudicated by the President and Council as follows:—The Copley Medal to Prof. Karl Weierstrass, For. Mem. R.S., for his investigations in pure mathematics; a Royal Medal to Prof. James Alfred Ewing, F.R.S., for his investigations on magnetic induction in iron and other metals; a Royal Medal to Dr. John Murray, for his services to biological science and oceanography in connection with the *Challenger* reports, and for his original contributions to the same; and the Davy Medal to Prof. William Ramsay, F.R.S., for his share in the discovery of argon, and for his discoveries regarding gaseous constituents of terrestrial minerals. Her Majesty the Queen has been graciously pleased to approve of the award of the Royal Medals. The medals will, as usual, be presented at the anniversary meeting on St. Andrew's day (November 30). The Society will dine together at the Whitehall Rooms on the evening of the same day.

The following is a list of those who have been recommended by the President and Council of the Royal Society for election into the Council for the year 1896, at the anniversary meeting on November 30:—President: Sir Joseph Lister, Bart. Treasurer: Sir John Evans, K.C.B. Secretaries: Prof. Michael Foster, the Lord Rayleigh. Foreign Secretary: Dr. Edward Frankland. Other members of the Council: Mr. William Crookes, Sir Joseph Fayrer, K.C.S.I., Mr. Lazarus Fletcher, Dr. Walter Holbrook Gaskell, Dr. William Huggins, the Lord Kelvin, Prof. Alexander B. W. Kennedy, Prof. Horace Lamb, Prof. Edwin Ray Lankester, Prof. Charles Lapworth, Major Percy Alexander MacMahon, R.A., Prof. John Henry Poynting, Prof. Arthur William Rücker, Mr. Osbert Salvin, Prof. Harry Marshall Ward, Admiral William James Lloyd Wharton, C.B.

The Trustees of the British Museum have decided not to fill up for the present the Keepership of Zoology, vacant by Dr. Günther's retirement, but to appoint two additional Assistant-Keepers from the existing staff, so that there will be one for each of the three sections into which the department will be divided for administration purposes, viz. insects, other invertebrates, and vertebrates. Sir William Flower will undertake the principal duties of Keeper of the Department, in addition to those of Director of the Natural History division of the Museum. A junior assistant will be appointed by competition, so as to keep up the numerical strength of the staff of the department. He will probably be attached to the entomological section, which although already the largest, still requires strengthening in order to cope with the arrangement of the vast number of specimens continually being added to the collection.

We notice the announcement that, on November 20, Mr. Balfour will receive a deputation from the Association of Chambers of Commerce, in reference to the adoption of the metric system. Our readers will remember that this subject has been considered by a Select Committee of the House of Commons, which has recommended that the metric system of weights and measures be at once legalised for all purposes, and, after a lapse of two years, be rendered compulsory by Act of Parliament. The deputation will present to the First Lord of the Treasury memorials which have been prepared by the Association and by the Leeds and other Chambers of Commerce, urging the Government to bring in a Bill next Session for the purpose of carrying out these recommendations. We trust that the need for the reform of our present cumbersome system will be forcibly impressed upon the Government.

A strong American Committee is being formed to act with the Huxley Memorial Committee. *Science* states that substantially all the American scientific men who have been thought of as possibly willing to serve have, so far as approached, signified their willingness to do what they can in the matter. The biologists are likely to be well represented, particularly, and the leaders in scientific work in every field will do their full share. It is hoped and anticipated by our contemporary that the contributions from the United States will rival those of Great Britain, and exceed those of any other nation.

The suggestion put forward by us, a fortnight ago, that the London County Council, or some other public body, should reciprocate the erection of a statue to Newton by the Paris Municipality, has not passed unnoticed in France. We indicated either Laplace or Lavoisier as a suitable subject for a statue in London; but the *Petit Journal*, in commending the idea, suggests that the right person to be honoured is Voltaire, who was an exile in England from 1726 to 1729, and who returned to France a great admirer of Newton. Voltaire was an enthusiastic exponent of Newtonian principles, and it was largely due to his support of them, in scientific and popular writings, that Descartes' vortex theory was rejected by the Paris Academy of Sciences.

The second International Congress of Applied Chemistry will be held in Paris next year. The Congress will be organised in ten sections, under the following heads: (1) Sugar and sugar-refinery; (2) Industries concerned with fermentation; (3) Agricultural industries; (4) Agricultural chemistry; (5) Official and commercial analyses of substances liable to duty; (6) Industrial chemistry; (7) Photography; (8) Metallurgy, mining, and explosives; (9) Biology, medical, pharmaceutical, and hygienic analysis; (10) Electro-chemistry. An International Exhibition of Chemical and Agricultural Industries will be held during the Congress, and for that purpose the Government has given the use of the whole of the Palais de l'Industrie.

A sign of advance in Africa comes to us in the shape of an announcement of the establishment of a monthly journal of South African science, arts, and crafts. The *Scientific African* (for that is the name of the new periodical) will contain popular scientific articles, written by experts, on South African animals, plants, rocks, and minerals, and giving information as to the habits, uses, and occurrences of organic and inorganic matter in South Africa and elsewhere. All the industries of South Africa, in the Colony, Transvaal, Free State, Rhodesia, &c., will be described, with photographic illustrations of the interiors of factories, the workings of mines and collieries, bridges, harbour works, special processes in agriculture, and other industries by which the wealth and comfort of South Africa is being enhanced. It is intended to give the latest scientific news, and the columns of the paper will be open to the discussion of scientific matters. The *Scientific African* may thus do good service in collecting and publishing observations on the natural history of Africa, and we extend to it a hearty welcome.

THE death is announced of Dr. P. Bertkau, Professor of Zoology in the University of Bonn; and of Dr. Gustav Wilhelm, Professor of Agriculture in the Technische Hochschule of Gratz.

AT the commencement of this month, a Laboratoire d'Études et de Recherches, connected with the École de Physique et de Chemie industrelles, was opened at Paris. By paying a nominal monthly sum to the Paris Municipal Council, any one desiring to work in the laboratory will have placed at his disposal the materials required for his experiments. On the face of it, this seems an ideal means of furthering scientific research.

THE opening meeting of the new session of the Institution of Civil Engineers was held on Tuesday, in the new premises of the Institution, and Sir Benjamin Baker delivered his presidential address. The Emperor of Germany was elected an honorary member at the same meeting. This brings the number of honorary members up to twenty, out of a total membership of 6730.

A BRILLIANT display of aurora was observed in many parts of the British Islands on Saturday night, the 9th inst., following an exceptionally fine day during the recent unsettled and rainy period. But this temporary improvement was succeeded on Sunday by a barometrical disturbance of considerable intensity which reached our western coasts from the Atlantic, causing strong gales over the kingdom generally, and accompanied with heavy rainfall in the northern and western districts. The barometer fell as low as 28·05 inches in the Hebrides, and the changes of pressure generally were very considerable. The gale was characterised by heavy gusts, and these were at times very violent in the south and west; at Greenwich Observatory, a pressure of 19 lbs. on the square foot was recorded at midnight on the 10th.

THE Quarterly Summary of the *Weekly Weather Report* for July to September last, furnishes valuable means for the comparison of temperature, rainfall, &c., for the summer quarter of the last thirty years, in the principal wheat-producing and grazing districts of the British Islands. The tables show that the highest mean temperature for the three months was 61°·7 in the south of England, and the lowest 55°·4 in the north of Scotland; the mean excess over the whole of the country was 1°. During the last thirty years, the greatest mean excess was 2°·8 in the year 1868, and the greatest deficiency 2°·5 in 1888; there have only been four years with an excess of temperature since 1881. The mean rainfall for the whole of the British Islands during the quarter was 9·1 inches, being a deficiency of 0·3 inch on the average of thirty years. The average fall during this long period was largest in the west of Scotland, 11·8 inches, and lowest in the east of England, 7·5 inches.

THE third International Congress of Psychology will be held at Munich, August 4–7, 1896. The International Committee of Organisation is constituted as follows:—President, Prof. Dr. Stumpf; vice-president, Prof. Dr. Lipps; general secretary, Dr. Frhr. von Schrenck-Notzing; and twenty-five members, including, as representatives of British Psychology, Prof. Bain, Prof. Ferrier, Mr. F. W. H. Myers, Prof. Schäfer, Prof. Sidgwick, Prof. Sully, and Dr. Ward. The Congress will be opened on the morning of August 4, 1896, in the great "Aula" of the Royal University. All who desire to further the progress of psychology, and to foster personal relations among the students of psychology in different nations, are invited to take part in the meetings. The following is the provisional programme of work:—Section I. Psychophysiology. (*a*) Anatomy and Physiology of the brain and of the sense-organs (somatic basis of psychical life). Development of nerve-centres; theory of localisation and of neurons, paths of association and structure of the brain. Psychica functions of the central parts; reflexes, automatism, innervation, specific energies. (*b*) Psychophysics. Connection between physical and psychical processes; psychophysical methods; the law of Fechner. Physiology of the senses (muscular and cutaneous sensibility, audition, light-perception, audition colorée); psychical effects of certain agents (medicines). Reaction times. Measurement of vegetative reactions (inspiration, pulse, muscle-fatigue). Section II. Psychology of the normal individual. Scope, methods, and resources of Psychology. Observation and experiment: Psychology of sensations: Sensation and idea, memory and reproduction: Laws of association, fusion of ideas: Consciousness and unconsciousness, attention, habit, expectation, exercise: Perception of space (by sight, by touch, by the other senses); consciousness of depth-dimension, optical illusions. Perception of time. Theory of knowledge. Imagination. Theory of feeling. Feeling and sensation. Sensuous, æsthetic, ethical and logical feeling. Emotions. Laws of feeling: Theory of will. Feeling of willing and voluntary action. Expressive movements. Facts of ethics: Self-consciousness. Development of personality. Individual differences. Hypnotism, theory of suggestion, normal sleep, dreams: Psychical automatism: Suggestion in relation to pædagogics and criminality; pædagogical psychology. Section III. Psychopathology. Heredity in Psychopathology: Statistics: Can acquired qualities be transferred by inheritance? Psychical relations (somatic and psychic heredity), phenomena of degeneration, psychopathic inferiority (insane temperament): Genius and degeneration; moral and social importance of heredity Psychology in relation to criminality and jurisprudence. Functional nerve-disease (hysteria and epilepsy). Alternating consciousness; psychical infection; the pathological side of hypnotism; pathological states of sleep. Psychotherapy and suggestive treatment. Cognate phenomena; mental suggestion, telepathy, transposition of senses; international statistics of hallucinations. Hallucinations and illusions; imperative ideas, aphasia and similar pathological phenomena. Section IV. Comparative Psychology. Moral-statistics. The psychical life of the child. The psychical functions of animals. Ethnographical and anthropological psychology. Comparative psychology of languages; graphology. Forms of application may be obtained from the General Secretary, or from Prof. Sully, East Heath Road, Hampstead, N.W.

THE new quarterly number of the *Journal of the Royal Agricultural Society* (third series, No. 23) is largely occupied with reports of the Society's country meeting, held this year at Darlington. Among the novelties exhibited was a milking machine capable of milking ten cows simultaneously in about twelve minutes. The ingenious part of the apparatus appears to be the teat-cups, which are made of india-rubber of varying thickness, so as to reproduce as nearly as possible the kind of pressure exerted in the operation of hand-milking; a small steam-engine and a vacuum pump are the adjuncts. Papers of scientific interest include one by Prof. Brown, late Director of the Veterinary Department, on "Sheep-Scab in its Relation to Sheep Husbandry," in which the acari of scab are described and illustrated. Sir John Thorold explains the value, as food for calves, of the meat meal which is a by-product in the making of essence of beef. Mr. C. G. Roberts advocates the modification of threshing machines in such a way as to deal with the ears only, thereby avoiding the great waste of power which has been proved to occur when the entire straw is driven—and uselessly driven—through the machine. Dr. E. J. McWeeney contributes an illustrated paper on *Phoma Betæ* (Frank), a fungus that injures mangel. A lengthy paper on village water supplies deals with a subject of increasing importance in rural districts. In the statistical section of the journal it is stated that the wheat crop in Great Britain has this year suffered an unprecedented diminution to the extent of over half a million acres, or 26·5 per cent., and a table is given to show that the wheat area diminished in every county in England, without exception, the greatest decrease being one of 40,890 acres in Lincolnshire.

The papillary ridges on the hands and feet of monkeys and men form the subject of a paper received from Dr. D. Hepburn, and communicated by him to the Royal Dublin Society, from the *Transactions* of which (vol. v. series ii., 1895) it has been taken. Galton has shown that the great variety in the designs of the patterns among human finger-prints admit of classification under a small number of primary forms. It seemed probable, therefore, that among monkeys the primary forms of the patterns of human finger-prints might be found in conditions sufficiently simple to afford a key to the production of the more elaborate human patterns. With the idea of throwing light upon this point, Dr. Hepburn has prepared and examined a considerable number of impressions from the hands and feet of living Primates. In the chimpanzee and orang-utan, patterns were found similar to those commonly seen in man, whereas among lower monkeys the patterns approximated more closely to those found in the palm or sole. The conclusions arrived at are as follows: (1) The papillary ridges and their intervening furrows are adjuncts to the prehensile function and power of the hands and feet *as well as* arrangements associated with increased sensibility and discrimination of the sense of touch. (2) The eminences on which papillary ridges form designs or patterns are specially developed areas raised above the general level of surrounding parts. They are also special developments in relation to the prehensile function. This accounts for their constancy in the hands and feet of animals which have these organs modified for prehension. (3) The "design" which covers each of these eminences has its character determined by the position, shape, and dimensions of the particular eminence.

An improved calorimeter, for the application of the method of mixtures in determining specific heats, is described by Mr. F. A. Waterman in the current number of the *Philosophical Magazine*. Mr. Hesehus's ingenious suggestion is acted upon, to maintain the calorimeter, after the introduction of the heated body, at a constant temperature by means of cold water, instead of measuring the rise of temperature of the calorimeter. This arrangement gets rid of the radiation error, and eliminates the "water equivalent" of the vessel. By dropping the cold water in, stirring is also made unnecessary. The method has been placed by Mr. Waterman upon a footing of equality at least with other methods, but his success may be partly due to other improvements. The body experimented upon is heated by a coil of wire conveying a current, and surrounded by ice. The initial temperature of the body may thus be regulated by simply maintaining the current at a certain strength, and this temperature can be kept constant for five or six hours together to within 0°·1 C. The body is then plunged into a silver calorimeter surrounded by the bulb of a delicate air thermometer indicating a difference of temperature of 0°·01 C. The cold water is contained in a copper vessel having the shape of an inverted cone surrounded by ice. In this manner the ice cannot melt away and leave a free space round the vessel. The water-dropping arrangement and the electric heater are mounted on vertical axes in such a manner that they can be quickly swung into position just over the calorimeter. After the heated solid or liquid has been dropped in, the water-dropper is set to work, at first rapidly, and then slowly until the body has assumed the original temperature of the calorimeter. For bodies of the same weight and the same initial temperature, the specific heat is then simply measured by the amount of ice-cold water necessary to cool them to the temperature of the room.

A very useful summary of the results so far obtained by the new treatment of diphtheria with antitoxin has just been issued in pamphlet form by Dr. Welch, Professor of Pathology in the Johns Hopkins University, Baltimore. It is reprinted from the *Transactions* of the Association of American Physicians, and is an expansion of an address recently delivered by the author before the Association. Statistics have been carefully collected from all parts of the world, and the reduction in the case mortality for diphtheria by serum treatment is brought out in a very striking manner. Perhaps the best testimonial to the efficacy of the new treatment is furnished by the experience of Baginsky and others, who record the results obtained during an involuntary pause in the serum treatment caused by failure in the supply of serum. Thus Baginsky states that between March 1894 and March 1895, 525 children were treated with antitoxin with a fatality of 15·6 per cent. During the period when the supply of serum was exhausted, 126 children were treated without antitoxin with a fatality of 48·4 per cent. Similarly, Körte noted a rise in fatality from 33·1 per cent. during the serum period to 53·8 when no serum was procurable, and during an epidemic of diphtheria at Trieste the fatality rose from 18·7 per cent. to 50 per cent. when the supply of serum failed. The *Deutsche medicinische Wochenschrift* has instituted a collective investigation of all the cases of diphtheria treated with serum, and the second provisional report was published last August. Such statistics should prove of inestimable value in assisting the formation of a correct official judgment of the therapeutic value of the antitoxin; meanwhile, Dr. Welch states that "the study so far of the results of the treatment of over seven thousand cases of diphtheria by antitoxin demonstrates beyond all reasonable doubt that anti-diphtheritic serum is a specific curative agent for diphtheria surpassing in its efficacy all other known methods of treatment for this disease," whilst "the essential harmlessness of the serum has been demonstrated by over a hundred thousand injections."

The second part of the new ethnological journal, *Ethnoligsches Notizblatt*, has just appeared. Amongst other articles may be noted a short paper on two old carved canoe prows from New Zealand, by Dr. von Luschan, illustrated by a photographic plate. Prof. Grünwedel writes on representations of Gautama from Upper Birmah and other Indian notes. Dr. F. W. K. Müller describes a Japanese picture of the World-Mountain Meru. Some antique clay tablets from Guatemala are described and illustrated by Dr. E. Seler. Prof. W. Grube gives a list of the Chinese gods of the lower classes in Amoy. Some of the specimens collected by Count von Götzen, during his rapid journey across Africa, are described by Dr. Weule; the Count gave the whole of his valuable collection to the Berlin Museum. Under the title of "Anthropological Anniversary" in reference to the twenty-fifth anniversary of the Berlin Anthropological Society, Prof. Bastian gives an eminently characteristic review of anthropological research from his own point of view; he also has a notice on three quipus collected by Dr. Uhle: these are figured. The last half of the journal is occupied with notes and reviews of recent anthropological literature, most of which are signed, and to which Prof. Bastian largely contributes. While dealing with ethnographical matters in a way common to other similar journals, the editorial committee is evidently paying special attention to the philosophical aspects of anthropology, apparently under the guidance of Prof. A. Bastian, and thus the journal will appeal to a wider circle of readers, and tend to advance ethnological studies.

VOL. III. No. 4 of *Contributions from the U.S. National Herbarium* consists of a "Flora of the Sand-hills of Nebraska," by Mr. P. A. Rydberg. The district consists almost entirely of sand-hills formed by the action of the wind, and still constantly altering their configuration from the same cause. The production of soil is only rendered possible by the holding together of the sand by the roots of grasses.

DR. GEORGE KING, F.R.S., Director of the Botanical Survey of India, has forwarded his report for the year 1894-95. Much work has been done during the year in the botanical survey of Northern India by Mr. J. F. Duthie. Mr. G. M. Woodrow has discovered that the tree from which the "date" matting so common in Poona is made, is *Phœnix robusta*, Hook. f.

WE have received, from Messrs. Baillière, Tindall, and Cox, a slender volume, in which is described the Tallerman-Sheffield Hot-Air Bath, with notes on its use in various hospitals. The invention is for the treatment of rheumatism, gout, rheumatic arthritis and similar complaints, by the local application of superheated dry air.

A PAMPHLET entitled "Clouds and Weather," written by Capt. D. Wilson-Barker, and illustrated from twenty-four photographs of clouds taken by him, has just been published at the office of the *Shipping World*. The pamphlet has been prepared for navigators, and is intended to show the interdependence of cloud and weather, so that "they who go down to the sea in ships" may know what relations between the two appear generally to hold good.

AMONG Mr. Murray's announcements of forthcoming works is one entitled "The Great Rift Valley: an Account of a Journey to Mount Kenya and Lake Baringo," by Dr. J. W. Gregory. It will contain a narrative of the journey, and chapters giving some account of the geology and ethnography of the eastern half of British East Africa, and notes on its flora and fauna. One chapter discusses "The Problems of the Distribution of the East African Flora and Fauna." The work will be illustrated by numerous maps and illustrations.

THE current number of the *Journal* of the Chemical Society contains an inset with reference to the Collective Index of the Transactions, Abstracts, and Proceedings, which the Society has determined to publish. The Index will be in two volumes, vol. i. extending from 1873 to 1882, and vol. ii. from 1883 to 1892. Both volumes will be sent to those who have been members of the Society since the end of 1882. Vol. ii. will be sent to Fellows who have joined the Society between January 1, 1883, and December 31, 1892. Fellows who are ineligible to receive gratis copies, and those who neglect to apply for them before the end of this year (or March 1, 1896, for Fellows resident abroad), may obtain them by purchase.

THE ninth edition of Müller-Pouillet's "Lehrbuch der Physik und Meteorologie," enlarged and revised by Dr. L. Pfaundler and Dr. Otto Lummer, is being published in parts by Herren Friedrich Vieweg und Sohn, Brunswick. We have previously announced the publication of several sections of this elaborate work (which, as a whole, makes three volumes, illustrated by no less than two thousand figures), and now notice the issue of the part of the second volume dealing with spectrum analysis, polarisation, double refraction, and the wave-theory of light. The complete second volume will take in both light and heat, but the optical section is itself divided into two parts, published separately, and it is the second of these parts that has just appeared. The treatment of the subject is full, and the value of the text is increased to the student by copious references to optical memoirs, papers, and reports.

WE have on our table several recently-published volumes referring to the proceedings of different learned societies, but limits of space prevent us from giving more than a passing mention of a few of the papers in them. In vol. xxviii. of the *Proceedings* of the Royal Society of New South Wales, Prof. Anderson Stuart's presidential address, and the communications to the Society in the latter half of last year, are printed. Among the papers we notice: "From Number to Quaternion," in which M. G. Fleuri shows how mathematicians may pass quite naturally from the idea of number to that of quaternion; an account of an aboriginal Bora held at Gundabloui in 1894, by Mr. R. H. Mathews; Mr. H. A. Hunt's essay on "Southerly Bursters," which gained the Abercromby prize of £25; the timbers of New South Wales, by Mr. J. V. de Coque; note on Australasian and other stone implements, by Prof. A. Liversidge; and an account of the distribution and collection of current-papers sent adrift to indicate the direction of the coastal currents around Australia, Tasmania, and New Zealand, by Mr. H. C. Russell. The volume contains forty-six plates illustrating the papers in it.

IN the *Mitteilungen* of the Berne Naturforschenden Gesellschaft for 1894 (Nos. 1335-1372), edited by Prof. J. H. Graf, Dr. J. G. Glur has a long paper on the fauna of lake-dwellings; Prof. G. Huber describes shooting-stars and meteorites, and the part these celestial bodies play in the universe, his paper being a good historical account of what is known about them; Dr. F. Stähli discusses the foci of cylinders; Dr. E. Baumberger gives a contribution to the geology of the Bieler Lake; and Dr. C. Wagner gives an analysis of Bessel's function of the first order. The volume containing these papers was received through Messrs. Williams and Norgate, who sent at the same time the *Compte rendu* of the seventy-seventh meeting of the Société Helvétique des Sciences Naturelles, held at Schaffhouse last year, and the *Verhandlungen* containing the reports of committees, and obituary notices of the late Dr. Rudolf Wolf, de Marignac (whose portrait forms a frontispiece), Louis de Coulon and B. Schenk.

THE November number of *Science Progress* contains several very good articles. Prof. W. Stirling contributes to it a detailed account of the life, personality, and work of the great physiologist and teacher, Carl Ludwig, and Dr. Sims Woodhead give a similar notice of Pasteur. Mr. F. H. Neville writes on the chemical nature of alloys and Dr. John Beddoe, F.R.S., on anthropometric research in India, his paper chiefly referring to the investigations made by Mr. H. H. Risley, with Governmental authority and support, into the anthropometry of the Bengal Presidency. One of the inferences which Mr. Risley drew from his investigation was that the castes in India are really ethnological, and not merely social divisions. Referring to a comparison of the size of head in the several provinces, Dr. Beddoe remarks: "Here the brachykephals surpass the dolichos, the Aryans the aborigines, the upper surpass the lower castes. But the Brahmans, despite their claims to be considered a kind of intellectual aristocracy, do not seem to surpass other high-caste men, unless it be in the dimensions of the forehead; and the Kaysaths, or writers, almost all of whom live by their brains and their pens, do not stand very much above the average. The differences are not inconsiderable; they exceed probably those which obtain between the superior and inferior classes in our own country; but I do not think they yield any evidence in support of the inheritance of acquired characters." Other papers in our contemporary are: "The Present State of Floral Biology," by Mr. J. C. Willis, and "Present Knowledge of the Mechanical Testing of Iron and Steel," by Prof. Hudson Beare.

The additions to the Zoological Society's Gardens during the past week include a Western Slender-billed Cockatoo (*Licmetis pasinator*) from Western Australia, presented by Mrs. Halford Stephens; a Crossed Snake (*Psammophis crucifer*), a Hoary Snake (*Coronella cana*), two Ring-hals Snakes (*Sepedon hæmachites*) from South Africa, presented by Mr. J. E. Matcham; a Common Wombat (*Phascolomys wombat*), a White-backed Piping Crow (*Gymnorhin leuconota*) from Australia, deposited; wo Pennant's Parrakeets (*Platycercus pennanti*) from Australia, purchased; a Rufous Rat Kangaroo (*Hypsiprymnus rufescens*), a Red Kangaroo (*Macropus rufus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

The Temperature of the Sun.—Ebert's recent estimate of the solar temperature (Nature, vol. lii. p. 232), based upon Langley's energy curves for heated solid bodies, is called in question by Dr. Paschen (*Astrophysical Journal*, vol. ii. p. 202). It appears that certain precautions have not been taken in formulating the law derived from experimental data, and that consequently the law does not hold even for the limits of temperature between which direct observations can be made. The chief defects of the former evaluations is that the prismatic energy curves have not been transformed into those for the normal spectrum; and when this is taken into account, the supposition that the wave-length of maximum energy is inversely proportional to the square root of the absolute temperature falls to the ground.

From a series of experiments made with the object of furthering theoretical investigations, Dr. Paschen considers it extremely probable that "the wave-length of the maximum of energy in the spectrum of an absolutely black body is inversely proportional to the absolute temperature." Assuming provisionally as the quantitative results of his observations, wave-length of max. energy × absolute temp. = 2700, and adopting Langley's value of $0\mu\cdot5$ (μ = ·001 mm.) for the position of maximum energy in the normal solar spectrum, Dr. Paschen finds the solar temperature to be 5400° on the absolute scale, or 5130° C. This means that the sun gives an energy spectrum which is the same as that of an absolutely black body at 5130° C.; and this would be its temperature if its light were entirely a consequence of its heated condition, and if its surface possessed no selective reflection. Attention is drawn to the fact that as our experimental methods are improved, our estimates of the magnitude of the sun's temperature are reduced. Dr. Paschen's value is more than a thousand degrees lower than that of Messrs. Wilson and Gray.

The Double Star OΣ·285.—Dr. See, to whom we are indebted for the revision of the orbits of so many double stars, has lately given us another in the case of OΣ·285 (*Ast. Jour.* No. 356). We are almost tempted to ask whether any practical good results from the premature attempt to determine an orbit where insufficient observations exist, or where the chance errors of observations mask the apparent path of the star. Of course, one very practical value such inquiries may have, especially in the case of a close double star, is to point out the times when observations are likely to prove possible and effective. But the question arises, whether an elaborate interpolation formula or real elliptic elements are dealt with. We are the more concerned to put this question, because Dr. See himself points out that Mr. Gore has, from practically the same observations, given elements strikingly at variance with those to which he has been conducted. The more conspicuous differences between the two sets of elements are shown below.

	Gore (1845-1892).		See (1845-1895).
Period ...	118·57 years	...	76·67 years
Excentricity ...	0·58 ,,	...	0·470 ,,
Node ...	106°·58′ ,,	...	62°·2 ,,
Inclination ...	45·42 ,,	...	41·95 ,,

The difficulty of deciding which of the two orbits is the more probable representation of the motion is increased by the fact, that the position angle computed from both is very similar. Previous to 1865 and subsequent to 1887 (in the interval 1865–87, the observations were very uncertain, owing to the close approach of the components) the position angles computed from the two orbits for the same date are rarely separated by a degree, while occasionally the observations differ from the computed place by as much as ten degrees. Dr. See gives an ephemeris for the next five years, and if trustworthy observations can be made of stars separated by about 0″·3, additional light will be thrown on the motion of this interesting pair.

The Spectrum of α Aquilæ.—The fact that the lines in the spectrum of α Aquilæ are much broader than the corresponding lines in the majority of stellar spectra, was first noticed by Prof. Pickering, who suggested that this appearance might be due to a very rapid rotation of the star. Photographs taken at Kensington and Potsdam have also shown this haziness of the lines.

The spectrum of this star has formed the subject of a somewhat extended research by M. Deslandres at the Paris Observatory, and by the use of a comparison spectrum enabling him to determine the velocity in the line of sight, he has obtained results of great interest (*Comptes rendus*, Nov. 4, p. 629). He finds that very frequently there are fine double bright lines running through the middle of the dark lines of hydrogen, and even sometimes through those of iron and calcium; the brightness of these lines varies with respect to the general intensity of the spectrum, and M. Deslandres attributes them to the chromosphere of the star.

Measurements of the radial velocity are given for fifty-six dates, and they clearly indicate periodic but complex variations. The maximum velocity of approach with respect to the sun was 38·4 km. per second on September 19, 1892, and of recession 11·4 km. per second on July 25, 1895. There appears to be a great oscillation with a maximum velocity every forty-three days, and superposed on this are one or more secondary oscillations, one of which has probably a period of about five days. M. Deslandres believes his results to indicate that Altaïr is at least a spectroscopic triple star; but he states that for a more complete knowledge of the phenomena, better apparatus and a less variable sky than that of Paris will be necessary.

β Ursæ Minoris also exhibits rapid fluctuations of velocity, and M. Deslandres' results in connection with this star will form the subject of a future paper.

Variability of Red Stars.—In the current number of *Knowledge*, Dr. Brester gives a general account of his theory as to the cause of variability in red stars (see Nature, vol. xxxix. p. 492), and extends it a step in order to account for the appearance of bright lines. It is assumed that the stars in question are cooling bodies, and that the atmospheres are sufficiently cooled down to permit the existence of chemical compounds. When some of the vapours are cooled to the dew point, they will condense in obscuring clouds, and produce a minimum without any reduction of temperature. In addition to saturated vapours, if we follow Dr. Brester, the atmospheres will also contain molecules of dissociated matter, which will only combine after the condensation of the saturated vapours has rendered the mixture sufficiently concentrated. The combination of the dissociated molecules produces heat enough to vapourise the clouds, and the maximum is restored by the opening to view of the constantly glowing interior. The presence of bright lines in the spectrum of a variable star near maximum is ascribed to "luminescence" produced by the chemical combination of the dissociated molecules. Thus, the bright lines at the maximum, according to Dr. Brester, are not the effect of heat, but rather of cooling. Dr. Brester finds some justification for this supposed origin of bright lines in the fact that carbon bisulphide gives a discontinuous spectrum at no higher a temperature than 150°; but it must be remembered that the bright lines in question are usually those of hydrogen, and there is no experimental demonstration that these lines can be produced except at a high temperature. To us it seems easier to regard the bright lines of hydrogen as being produced by true elevations of temperature about the time of maximum, such as are explained by the meteoritic hypothesis.

TYPHOID FEVER EPIDEMICS IN AMERICA.

The factors which control the dissemination of disease are so numerous, and in many cases so complicated, that it is often only after long and patient searching that an epidemic is successfully tracked to the original nidus from which it has sprung.

By the careful record of data of this description, compiled with accuracy and care, we shall gradually become possessed of trustworthy material out of which an historical survey may be built up, and the task of deciphering the course and conduct of epidemic diseases materially lightened.

As a contribution to the history of typhoid fever epidemics, we warmly welcome the able report of some outbreaks of this disease in Massachusetts, made by, as well as under the direction of, Prof. W. T. Sedgwick.

The work before us was included, in the first instance, in the Twenty-fourth Annual Report of the State Board of Health of Massachusetts, but has been, and we think wisely, issued also as a separate pamphlet. No less than nine outbreaks of typhoid fever were investigated, but perhaps the most interesting and important is that which occurred in Lowell, one of the largest cities in the Merrimack Valley, and depending mainly for its water supply on the Merrimack River. Public attention was first called in December 1890 to the serious character of the epidemic of typhoid fever in the city, when it became known that in the preceding month 122 cases had been reported, and twenty-eight deaths from this disease had taken place. After a long and exhaustive investigation, the river water supply became suspected of being the vehicle of the specific infection to which the epidemic must be attributed. Prof. Sedgwick set to work, therefore, to find if there had been any special or unusual infection of the river *above* Lowell, and the discovery was made that an outbreak of typhoid fever, "such as had not been known for forty years," had occurred during the previous August, September, and October in a small village only three miles above Lowell, and situated on a small stream running into the Merrimack River. Four at least of the cases of typhoid fever were proved to have directly infected this small brook, which joins the river only two and a half miles above the intake of the Lowell Waterworks. Dr. Sedgwick states in his report that "the Merrimack River is regularly polluted above Lowell, not only by Stony Brook, but very extensively by the large cities of Nashua, Manchester, Concord, and Fitchburg, the sewers of all of which pour their raw contents directly into the Merrimack River or the Nashua. This they had been doing for months and years; and to the fact that Lowell has been willing to drink this regularly polluted water, *totally unpurified by filtration*, is chargeable the fact that typhoid fever has annually been excessive in that city. But the conditions were no worse than usual in these cities in September and October 1890. There was, however, as has been shown, an infection of a small and seemingly insignificant feeder of the Merrimack only two and a half miles above the intake of the Lowell Water Works, such as is not known to have occurred there for forty years." With respect to the chemical and bacterial examinations of the water, Dr. Sedgwick writes as follows:—

"These were made in the hope of discovering some unusual condition of the river, or of possibly detecting the Eberth bacillus itself. But, as usually happens in typhoid fever epidemics, the worst was over before the examinations began. The chemical examinations showed nothing that was not already known. The bacterial analyses revealed a noteworthy excess of *Bacillus coli communis*, confirming the chemical evidence of the presence of sewage in the city water as drawn from the river, but no Eberth bacilli were found."

We do not, however, attach perhaps the same importance as Dr. Sedgwick to the detection of the *B. coli communis* in the water, as we believe that this organism, or forms closely allied to it, may be found far more frequently present in pure peaty or other upland surface waters than is usually surmised, and that such microbial forms are not *necessarily* indicative of the access of sewage to a given water-supply.

The epidemic of typhoid fever, which apparently started above Lowell, infecting the Merrimack River, supplying that city with water, subsequently extended to Lawrence, situated on the same river, nine miles below Lowell, and a so using its waters for drinking purposes. In this connection Dr. Sedgwick remarks: "Inasmuch as there is good reason to believe that this unusual epidemic was caused by the unusual infection of the river at North Chelmsford and at Lowell, it is interesting to observe that some of the infectious material was apparently able to survive the comparatively unfavourable conditions imposed by the long and slow passage through the Lawrence reservoir and the service pipes." [The "unfavourable conditions" here referred to are the processes of sedimentation to which the microbial contents of the water would be exposed under these circumstances.] "It would seem therefore that, while much of it must have perished *en route*, some of it did not; and, as the time of year was November and December, we are safe in concluding that during these months, under certain conditions, some of the infectious material of typhoid fever may be conveyed nine miles by a river, may slowly travel through a distributing reservoir, and still remain effective to a very dangerous extent if swallowed in drinking water." During the four years preceding 1891, the average mortality from typhoid fever in Lowell is stated to have been 8·44 per 10,000, whilst in 1890-91 it rose to 19·54 per 10,000. Thus the average death-rate from typhoid fever is considerably higher than we experience in London, but it sinks into comparative insignificance when we contrast it with the statistics of typhoid fever in Chicago compiled by Dr. O. M. Huff, of that city. In 1891 the deaths directly attributed to typhoid fever in Chicago amounted to no less than 16·64 per 10,000. In 1892 the condition of things was somewhat improved, although the death-rate, says Dr. Huff, still remained three times as great as in New York, five times as great as in London, and more than six times the rate of Berlin. Dr. Huff has made a minute study of the relation of typhoid fever to the water supply of Chicago, and has come to the conclusion that the contamination of the drinking water supplied to the city with sewage is the "efficient cause" of this alarming mortality. It is stated that Lake Michigan "serves both as a water-bucket and a cesspool for Chicago." An American scientific journal, in reviewing this report, reasonably suggests that every resident of Chicago ought to be advised of the fact that there is death in the water-pipe.

It is to be hoped that the attention now being bestowed in America on subjects both directly and indirectly connected with public health will lead to beneficial practical results, and that the distribution of water openly contaminated with sewage in its raw, unfiltered condition for drinking purposes, will be summarily prohibited by law in all countries before such grave consequences have again to be met as attended the distribution in Hamburg of raw, unfiltered river Elbe water for dietetic purposes.

G. C. FRANKLAND.

AN ACCOUNT OF THE CONSTRUCTION AND STANDARDISATION OF APPARATUS, RECENTLY ACQUIRED BY KEW OBSERVATORY, FOR THE MEASUREMENT OF TEMPERATURE.

THE accuracy of the measurements made at Kew Observatory may, without exaggeration, be regarded as a matter of national concern. It is right, therefore, that the scientific public should be made acquainted with the principles involved and the methods of comparison employed in any series of measurements conducted at the Observatory; more especially when a new departure is made, either in the apparatus used or in the nature of the observations.

In the absence from England of Prof. Callendar, F.R.S., the writer, at the request of the Kew Committee, undertook the responsibilities connected with the preparation and standardisation of the apparatus, recently installed at Kew, for the accurate measurement of temperatures—particularly of high temperatures.

It would be impossible, without unduly trespassing upon these pages, to give a full description of the principles on which the measurements of temperatures by platinum thermometers are founded, or of the methods of standardisation adopted. I will, however, endeavour to briefly indicate reasons for our faith in the principles involved and the accuracy of the methods employed.

I make this communication with the (unofficial) consent of the Kew Sub-Committee, to whom the oversight of this matter was delegated; at the same time it should be understood that the writer alone is responsible for the statements, or opinions, advanced in the following pages.

Sir Douglas Galton in his address at Ipswich remarked that "British students of science are compelled to resort to Berlin or Paris when they require to compare their more delicate instruments and apparatus with recognised standards." We may now hope, however, that, at all events as regards temperature measurements, his statement will ere long require modification.

I. *Brief Explanation of the Terminology and of the Principles involved in the Measurements of Temperature by Platinum Thermometers.*

A platinum temperature scale is one so constructed that a rise of one degree on that scale at any temperature would cause the electrical resistance of a platinum wire to increase by onehundredth of the difference between its resistance at 100° and 0° C.

Hence, if R be the resistance at any temperature, R_1 the resistance at 100° C., R_0 at 0° C., and pt the temperature on the platinum scale, then

$$pt = \frac{R - R_0}{R_1 - R_0} \times 100.$$

The investigations of Prof. Callendar[1] established the relation between pt and t (where t is the temperature on the air scale) over the range 0° to about 600° C. for a particular sample of platinum wire.

This relation is given by the following equation.

$$d = t - pt = \delta \left\{ \left(\frac{t}{100} \right)^2 - \frac{t}{100} \right\} . \quad . \quad . \quad . \text{ Eq. } (d)$$

the value of δ for Callendar's wire being 1·57.

If it was at all times possible to obtain platinum wires of *exactly* the same degree of purity as Callendar's, we could at once establish a standard platinum scale, which could be used for purposes of reference independently of any assumptions as to its relation to the air scale. The impossibility of securing uniformity in this respect, however, would, at first sight, appear to be an insuperable impediment to the adoption of such a proposal.

Subsequent experiments by Callendar and myself led, however, to the following conclusion.[2]

That, although the value of δ varies greatly according to the purity of the sample of platinum, the relation given by the equation (d) holds true, provided the percentage of impurities is small (this condition is sufficiently fulfilled by ordinary commercial samples).

This conclusion is an exceedingly important one, for (the $t - pt$ curve in every case being a parabola) it is only necessary to determine the resistance at three different temperatures in order to ascertain the appropriate value of δ, and thus to completely standardise the thermometer.

Much experimental work had to be accomplished before we could venture to regard the above proposition as established; but I think that any impartial reader, who cares to study the original papers[3] dealing with this matter, will admit that the evidence is sufficient.

The three temperatures selected for the purposes of standardisation were the melting-point of ice, steam at a pressure of 760 m.m., and the vapour of sulphur at the same pressure.

Certain discrepancies between thermometers thus standardised and others standardised by direct comparison with the air thermometer, led to a redetermination (by means of an air thermometer) of the boiling-point of sulphur, when we found that Regnault's value (448°·34) was too high, our experiments leading to the conclusion that 444°·53 was the correct value.[4]

Subsequent investigations by different observers have confirmed the accuracy of the above conclusions, which may now be regarded as experimentally established over the range 0° to 600° C.

There is, however, a large amount of indirect evidence which indicates that formula (d) holds true over a far more extended range.

For example, the results obtained by Messrs. Heycock and Neville (*Chem. Soc. Trans.*, 1895) are entirely dependent on the validity of the above conclusions. They find the freezing-point of copper as 1080°·5 C., whereas Holborn and Wien, using a platinum rhodium couple standardised by direct comparison with the porcelain air thermometer, find 1082° as the value of the same constant.[1]

As illustrating the identity of the results obtained by the use of thermometers having a very different value of δ, I quote the following numbers from Table XII. of Heycock and Neville's paper:—

Pyrometer.		Value of δ.		Freezing-point of gold. °
13	...	1·500	...	1061·9
15	...	2·040	..	1061·2
18	...	1·574	...	1061·4
13A	...	1·553	...	1061·9
14	...	1·511	...	1062·0

Results of this kind prove that even if the reduction does not express the temperature accurately in the air scale, it at all events gives us a *constant* scale in which all high temperatures can be expressed, and it is further evident that this constant scale differs but little (even at these high temperatures) from the true air scale.[2]

Indications are not wanting that the same relations hold true at very low temperatures.[3]

Finally, a very careful comparison of the platinum and air thermometers over the range 0° to 100° C., and also of the platinum thermometer with the nitrogen standard of the Bureau International, establishes the validity of the methods of observation and reduction at ordinary temperatures.

As regards the constancy of platinum thermometers there should now be little uncertainty. The prevailing doubt (amongst those who have not used them) may be traced to the adverse report of a British Association Committee in 1874, on another form of the instrument, and I would refer those who may be influenced by that report to a letter by Prof. Carey Foster, F.R.S., in NATURE, August 23, 1894.

An inspection of the voluminous tables given in Heycock and Neville's paper (*supra*) will show, however, that when the thermometers are repeatedly exposed to temperatures above 900° or so, a slight permanent increase in FI (the Fundamental Interval = $R_1 - R_0$) is observable. It is probable that this change is due to a permanent thickening of the mica plates by which the wire is supported, and thus, on cooling, the wire is slightly strained. The change is small, and can always be traced by repeating the determinations of R_1 and R_0, and does not appear to appreciably affect the values of δ.

To show the order of magnitude of the change, I give the following illustration, compiled from Table VIII. of Heycock and Neville's paper.

History of Pyrometer 13.

On August 3, 1894, the fundamental interval was 100·64. During the next few months this pyrometer was used for the determination of the freezing-points of the following substances:—

Substance.	Number of determinations.
Silver	10
Aluminium	12
Potassium sulphate	5
Sodium sulphate	4
Sodium carbonate	3
Magnesium	5
Antimony	2
Tin	3
B.P. of sulphur	6

Also the pyrometer had been raised to a bright red heat in a muffle furnace some scores of times, and the exterior porcelain

[1] *Phil. Trans. Roy. Soc.* A, 1887.

[2] A summary of these experiments is given in *Science Progress*, September 1894.

[3] Callendar, *Phil. Trans. Roy. Soc.* A, 1887; Griffiths, "Report of Electrical Standards Committee, B.A. 1890; Heycock and Neville, *Chem. Soc. Journ.* 1890; Griffiths, *Phil. Trans. Roy. Soc.* A, 1891; Callendar and Griffiths, *Phil. Trans. Roy. Soc.* A, 1891; Callendar, *Phil. Mag.*, July 1891; Griffiths and Clark, *Phil. Mag.*, December 1892; Griffiths, *Phil. Trans. Roy. Soc.* A, 1893; *ibid.*, *Proc. Roy. Soc.* vol. lv. 1894; *ibid.*, *Science Progress*, 1894; Thorpe, "Dictionary of Applied Chemistry," article "Thermometry"; Heycock and Neville, *Trans. Chem. Soc.* 1895.

[4] In the last edition of Watts's "Dictionary of Chemistry," article "Sulphur," I find that some doubts are expressed (by Mr Pattison Muir) as to the validity of this determination, owing to uncertainty as to the purity of our sample of sulphur. I subsequently investigated the boiling-point of a specially pure sample by means of one of the platinum thermometers (thermometer E) used during the original comparison of the air and platinum thermometers in sulphur vapour, and I found no evidence of any difference in the boiling-point of the two samples. We may assume, therefore, that if any impurities were present, they were not of such a nature as to influence the temperature of the vapour.

[1] The following example illustrates the importance of the alteration in the boiling-point of sulphur. In Table VI. of Heycock and Neville's paper (*supra*) are given the details of an observation on the freezing-point of Cu determined by pyrometer No. 8. They are as follows: $pt_s = 421·29$, $\delta = 1·517$, $d = 159·3$, $t = 1080·7$. If we assumed the validity of Regnault's boiling-point of sulphur (448°·34), the above value of pt_s would change the value of δ to 1·729; this would give $d = 181·6$; hence $t = 1103°·0$. In this case the discrepancy between the results of Holborn and Wien, and Heycock and Neville would be very marked—a difference of 21°·0 as against the present difference of 1°·3.

[2] Messrs. Heycock and Neville, in Table XVI. (*Chem. Soc. Trans.*, 1895, p. 195), give Violle's value for the freezing-point of gold as 1035° C., and the discrepancy between this number and that found by them (1061°·7) is considerable. A redetermination, however, by Violle in 1892 (*Comptes rendus*, 92, p. 866) raised his number to 1045°. Some recent experiments by Le Chatelier (*Comptes rendus*, August 12, 1895) lead that observer to the conclusion that Violle's later value should be further raised by about 15° (or at all events by a number "not exceeding 20°"), *i.e.* to about 1060° C., a very close approximation to the 1061°·7 found by Heycock and Neville in December 1894.

[3] Griffiths and Clark, *Phil. Mag.*, December 1892.

tube had on three occasions been removed and replaced by a new one.

At the close of these operations (December 19, 1894) the value of FI had risen to 101·003, an increase of 0·36 per cent.

It should be remembered that in each determination the substances were raised to 50° or 100° above their freezing-points before the observations were taken; for example, the freezing-point of potassium sulphate is given as 1066° C., but it is certain that when determining this point the pyrometer was previously raised to a temperature considerably exceeding 1100°. A study of the original table will show that the rate of increase in FI diminishes with use.

As this question of constancy is of vital importance, Messrs. Heycock and Neville have given me permission to state that they have used only one pyrometer during a continuous series of high-temperature determinations extending over two months of the past summer. When the account of their work is published, it will be found that although the number of the observations on the freezing-points of alloys exceeds some hundreds, the pyrometer is as efficient now as at the commencement of their work. Its FI on July 28 was 100·148, on August 20, 100·357, and on nearly all the intervening days it had been immersed in molten metal at temperatures between 900° and 1000° for five or six hours at a time. A determination of the freezing-point of copper, made at the close of the above series of experiments, gave a value practically identical with that previously published.

Apart from the slight change in FI, above illustrated, there is abundant evidence that when *completely protected from the action of furnace gases* the platinum wire undergoes no change. Space does not permit the accumulation of further evidence, but full information will be found in the papers already referred to.

II. *Description of the Apparatus.*

The facts dwelt upon in Section I. show that if the methods of platinum thermometry are adopted, the measurement of temperature becomes a question of the measurement of electrical resistance, and there are few physical quantities which can, if due precautions are taken, be measured with greater accuracy than the resistance of a conductor. The Kew apparatus, therefore, may be regarded as designed for the accurate measurement of the resistance of a platinum wire, and some of the contrivances introduced with the object of securing greater accuracy are, I believe, peculiar to this apparatus.

The designs were drawn up by Prof. Callendar and myself, after consultation with Mr. Horace Darwin, and the apparatus was constructed by the Cambridge Scientific Instrument Company, Ltd., under the personal direction of Mr. Pye.

Fig. 1 is a diagrammatic view of the connections.

The coils S_1 and S_2 are of equal resistance (about 5 ohms), Q is a set of resistance coils, A B a bridge-wire, and K a thermo-electric key. When the resistances between C_1 and C_2 and P_1 and P_2 are equal, the bridge is balanced if the resistance at Q is zero, and the contact-maker H is at the mark O near the centre of the bridge-wire. The scale of this wire is so graduated that if the reading to right or left of O be added or subtracted from r (the resistance at Q), the result gives the value of P – C where P is the resistance between P_1 and P_2, and C the resistance between C_1 and C_2.

Now $P = p + C_p$, where p is the platinum coil resistance, and C_p the resistance of the leads to that coil, including the thick platinum wires which run down the thermometer stem. An equal pair of leads run from C_1 C_2 to similar thick platinum wires in the thermometer stem, which are connected together at the lower extremities, but have no contact with the coil.

Thus $r \pm OH = p + C_p - C$; and therefore if $C_p = C$, we get $p = r \pm OH$.

The leads C_p and C are everywhere bound together except in the thermometer stem, where they are parallel and adjacent, being held in position by their mica discs, hence changes in C_p and C caused by changes in temperature do not affect the resulting value of p, and thus the readings are independent of the thermometer stem-temperature—a matter of great importance at high temperatures.[1]

A certain amount of stem immersion is, however, necessary, for the lower extremities of the leads must be heated to the bulb temperature, otherwise they would, by conduction, cool the extremities of the coil; this is an additional reason for forming the leads of platinum, which has a low thermal conductivity.

A preliminary series of experiments led to the conclusion that a certain quality of white marble had superior insulating properties to ebonite—the material generally used for the tops of resistance-boxes. This superiority was partially due to its non-hygroscopic properties; for example, I placed slabs of the best ebonite, black marble, and this white marble in an ice-safe for some time. I then removed them one by one to the warm laboratory, and tested them under similar conditions with a "pressure" of 100 volts. The insulating powers of the ebonite and black marble fell off alarmingly, while the white marble was but little affected.

Some difficulty was experienced by the makers in devising a satisfactory method of attachment between the marble and the many brass connections, &c., but this difficulty was at length overcome. The coil and bridge-wire were constructed from one sample of platinum silver. The coil of a platinum thermometer was replaced by a specimen of the wire (diameter ·008 in.) from which the coils were formed, and which had been subjected to the same process of annealing. Its temperature coefficient was then determined with great care over the range 15° to 25° C. (nitrogen scale), and was found to be ·000260 in terms of the

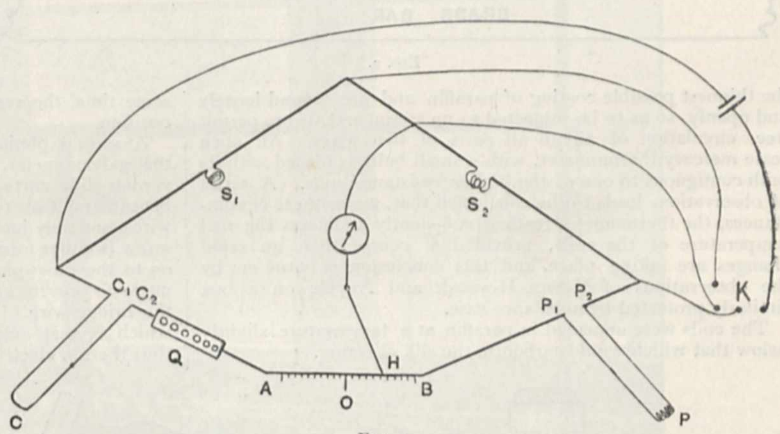

FIG. 1.

resistance at 20° C. I proposed to keep the box when in use at a temperature near 20° C., for it is wise, when feasible, to maintain all measuring instruments at a temperature exceeding that of an ordinary room, for two reasons: (1) it is generally easy to raise the temperature of the apparatus above that of the air, whereas it is extremely difficult to keep it at a lower temperature; (2) when the temperature of the apparatus exceeds that of the room, all its surfaces are kept dry, and also more dust-free than would otherwise be the case.

The greatest difficulty encountered in resistance measurements is (according to my experience) uncertainty as to the actual temperature of the coils. If a resistance-box is placed in a tank, it is true that five sides of it can be maintained at a constant temperature, but the top is necessarily exposed; and since all the coils are ultimately connected with the top, their temperature at times differs considerably from that of the tank.

[1] The *absolute* equality of C and C_p is not essential; both are small as compared with p $\left(\frac{c}{p}\text{ is always less than }\frac{1}{50}\right)$, thus $C_p - C$ is a very small fraction of p, and it is only the temperature change in $C_p - C$ that affects the measurements. The total resistance of the thick copper leads from the box to the thermometer is so small, and they are subject to such comparatively slight changes of temperature, that the temperature change of their difference may almost certainly be neglected. The greater part of C_p and C is the resistance of the platinum stem leads, which are certainly exposed to considerable temperature changes. If, however, they are made of the same platinum as the coil, then any irregularity has nearly the same effect as an alteration in the original length of the coil, and does not appreciably affect the ratio $\frac{R_1}{R_0}$ or the values of pt. In all carefully constructed thermometers the value of $C_p - C$ may be regarded as zero.

Again, the thick coating of paraffin, and the solid core, which are almost universally prevalent, increase the uncertainty, for if any temperature change is taking place the lag is considerable.

These sources of error were diminished as follows: the sides and bottom of the box are the inner walls of a double copper tank, holding about eight gallons of water maintained at a temperature near 20° C. by a regulator. Over the top of the box and tank is fixed a case similar to that of an ordinary balance, the front glass of which is only raised when adjustment of plugs and contact-maker is necessary, all connecting screws being exterior to the case. The silk-covered coils (which are double in all cases to reduce the effects of current heating) are suspended from an ebonite rack within the box. They received the thinnest possible coating of paraffin and are wound loosely and openly, so as to be subjected to no strain, and also to permit free circulation of air to all parts of the wires. An open scale mercury thermometer, with a small bulb, is placed with its bulb contiguous to one of the higher resistance coils. A series of observations leads to the conclusion that, under these circumstances, the thermometer-reading sufficiently indicates the real temperature of the coils, provided of course that no rapid changes are taking place, and this conclusion is borne out by the observations of Messrs. Heycock and Neville on a box similarly protected by a balance case.

The coils were annealed in paraffin at a temperature slightly below that which would carbonise the silk covering.

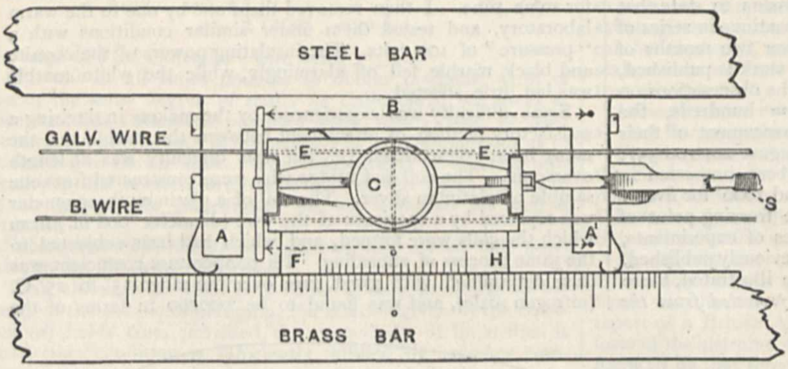

FIG. 2.

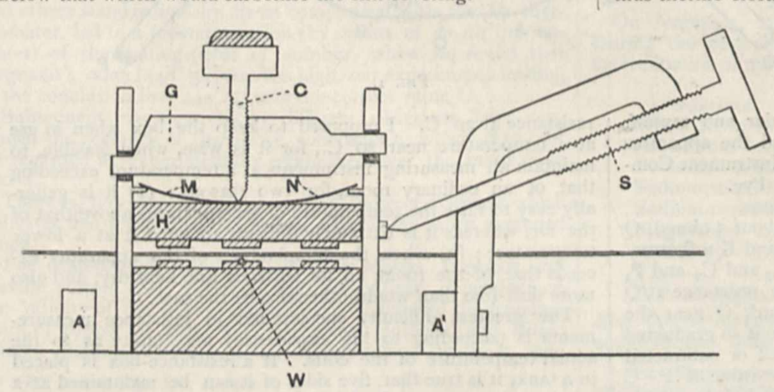

FIG. 3.

The box-unit is (approximately) $\frac{1}{100}$th of a Board of Trade ohm. The coils have the following nominal values in terms of this unit.

A	B	C	D	E	F	G	H	FI
640,	320,	160,	80,	40,	20,	10,	5,	100,

and the bridge-wire has such a section that a change of 1 c.m. in the reading indicates (approximately) a change of 1 unit in p (in reality 1 c.m. = ·9957 box units), and the resistance of the thermometers, with one exception, is such that a change of one box unit corresponds to 1° on the platinum scale.

The whole length of the bridge-wire is 30 c.m.; thus any resistance exceeding 40 units can be measured in three or four different ways by changing plugs and bridge-wire contact. Thus the accuracy of the various corrections can at any time be exposed to a severe test.

Great attention was given to the drawing of the bridge-wire, for, although the effect of irregularities would be eliminated by the subsequent calibration, it was desirable to make it as uniform as possible. In this matter the Scientific Instrument Company were very successful, for it was ultimately ascertained that if the wire was assumed as uniform, the greatest resulting error would not exceed 0·005 units.

Before its final attachment to the box, the wire was hung from a conductor, and had a small weight fastened to the lower end, which communicated with a cup of mercury; it was then raised to a bright red heat by means of an electric current, after which the cells were gradually switched off, so that the cooling was slow. The annealing was thus very perfect, and the wire on being released remained quite straight. The coefficient of expansion of this platinum-silver alloy lies between that of steel and brass. A narrow parallelogram was formed, whose longer sides consisted of brass and steel bars respectively—the shorter sides of ebonite. The steel and iron bars were connected at their centres to the marble box top, and the wire placed between, and parallel to, them, its ends being fixed to the ebonite cross-pieces and connected by flexible brass strips to the remainder of the bridge. By this arrangement the tension of the bridge-wire is kept constant when the temperature of the box alters, and, at the same time, the zero-point at the centre remains unchanged in position.

A second platinum-silver wire, permanently connected with the galvanometer, lies alongside the true bridge-wire. The vernier-slide carries a small cross-bar of the same wire placed beneath and at right angles to the bridge and galvanometer wires, and only just clearing them (Fig. 3). When the contact-screw is either forced, or screwed down, both wires are pressed on to the cross-piece by means of pads, and arrangements are made to prevent any pressure being exerted which could injure the bridge-wire. This method has several advantages, one of which is that only similar metals are brought in contact, and thus thermo-electric effects at this junction are avoided.

The vernier reads directly (by means of a microscope) to $\frac{1}{20}$th m.m., thus $\frac{1}{100}$th m.m. can be estimated; *i.e.* approximately 0·001 box units, or 0·00001 ohms.

Great difficulty has hitherto been experienced in constructing a fine adjustment for a bridge-wire contact. It must be of such a nature that it will permit the free movement by hand of the contact-maker to any position. Again, if, owing to an oversight the contact-maker is screwed down, and any of the ordinary means of fine adjustment are used, the bridge-wire is subjected to a scraping action which may affect its section. These difficulties have been overcome by an ingenious device designed for this apparatus by Mr. Horace Darwin.

Fig. 2 is a plan, and Fig. 3 a vertical section of the contact-maker.

A B A' (Fig. 2) is a brass framework which slides between the steel and brass bars previously referred to. An inner block F E E' H stands within the brass framework with a play-space at its ends of about 1 c.m. Springs at A and A' press the brass frame against the steel bar, and springs at E, E' press the inner block against the front brass bar. Thus the pressure of the brass frame against the steel bar is the sum of the pressures of the springs at A, A', E and E', whereas the pressure of the inner block on the front bar at F H is the sum of E and E' only; if, therefore, the screw S is rotated the inner block alone is moved. As the screw S recedes the inner block is made to follow it by means of long springs indicated in the plan by the dotted lines with arrow-heads. If by inadvertence S is turned when the bridge-wire has not been released by the screw C

(Fig. 3), then the outer framework A B A′ moves instead of the inner block.

The arrangement by which the pads in the block H can be either pressed down for temporary, or screwed down for more permanent, observations is shown by the section in Fig. 3. The spring M N lifts the pads off the bridge and galvanometer wires, which therefore do not touch the cross-wire (whose section is shown at W) unless a downward pressure is exerted on the block H.

By holding the head of the screw S the whole contact-maker can be pushed to any desired position.

The vernier is shown at F H (Fig. 2).

The box contains coils of 20 and 100 ohms, which can be thrown into the battery circuit by means of a switch, and also a galvanometer shunt of about $\frac{1}{10}$ the galvanometer resistance.

With the exception of the points to which I have drawn attention, the resistance-box resembles those ordinarily in use.

The galvanometer has a resistance about 5 ohms, and is sensitive and "dead-beat." A fixed scale is placed before the mirror, and the image viewed through a microscope. Very small deflections can thus be observed, and observations can be taken in bright daylight.

This last has a coil whose resistance is 2·5 times as great as he preceding ones.

All these thermometers have been annealed at a temperature of about 1000° C., Nos. 5 and 6 being temporarily placed in porcelain tubes for that purpose.

The apparatus for the standardisation in ice, steam, and sulphur-vapour presents certain distinctive features, most of which, however, are described in *Phil. Trans. Roy. Soc.*, vol. 182 A.

Messrs. Heycock and Neville were so kind as to undertake the design and arrangement of the furnaces, &c., for the high temperature work, which are, in the main, similar to those used during this summer for the purposes of their investigations into the behaviour of alloys. As an account of their work will shortly be published, I shall not venture to anticipate it by any description. Arrangements have been made for (1) the standardisation of thermometers by observations on the freezing-point of silver when placed in a reducing atmosphere;[1] (2) the comparison of the Kew standards with other thermometers over the range 100° to 300° C. by means of a well-stirred bath of a fusible metal covered with paraffin or oil; (3) the comparison over a range 300° to 1200° C. in a bath of melted tin placed in a reducing atmosphere.

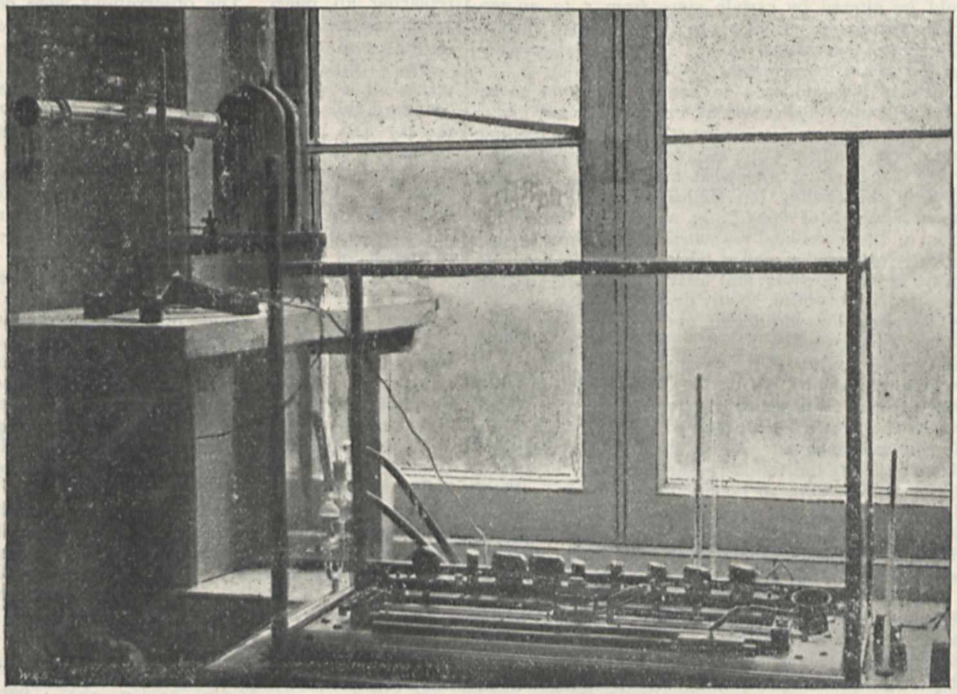

FIG. 4.

Thermo-electric effects (which at high temperatures are occasionally considerable) are eliminated by the use of a special key described in *Phil. Trans. Roy. Soc.*, vol. 184 A, p. 397.

The leads from the box to the thermometer are about five yards in length, and are each composed of 136 strands of copper wire carefully insulated. The thermometers can thus be used in any part of the room.

Six thermometers have been supplied, all of whose coils are formed from the same sample of specially pure platinum wire—diameter 0·006 inches. The length of wire in Nos. 1 to 5 is about 18 inches, the mica framework which supports the coil is from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length, and this portion is termed the bulb.

Nos. 1 and 2 are contained in porcelain tubes 1·2 c.m. in diameter, 40 c.m. long.

Nos. 3 and 4 are contained in porcelain tubes 1·5 c.m. in diameter, 36 c.m. long.

No. 5 is contained in a glass tube 1·4 c.m. in diameter, 40 c.m. long.

No. 6 is contained in a glass tube 1·7 c.m. in diameter, 40 c.m. long.

The whole of the apparatus is placed in a special building erected for this purpose by the Kew Committee, according to designs by Mr. W. N. Shaw, F.R.S., and myself, after consultation with Messrs. Heycock and Neville. The building is found to admirably fulfil its purpose, the only drawback being the defective gas supply, which will, however, shortly be remedied by the insertion of a larger main between the Observatory and the outbuildings.

Fig. 4 (a copy of a photograph by Mr. Hugo) gives the relative positions of box and galvanometer. It will be seen that the observer can manipulate the contact-maker without removing his eye from the galvanometer-microscope, a great advantage when observing small temperature changes. Immediately to the right of the resistance box, but exterior to the limits of this plate, is a large draught-chamber containing the furnaces, &c.

III. *The Standardisation of the Apparatus.*

The necessary operations were as follows:—

No. 1. Determination of the temperature coefficient of coils and bridge-wire.

[1] See letter to NATURE, October 17, 1895.

No. 2. Calibration of bridge-wire and determination of error due to the position of the scale zero mark.

No. 3. Determination of the coil errors.

No. 4. Value of the mean box-unit in terms of the Board of Trade ohm. (This was *not* a necessity for the temperature measurements, but it appeared advisable to ascertain it.)

No. 5. Determination of R_1 R_0 and δ for each thermometer.

It is impossible to give any full description of the operations—I can but indicate the methods adopted.

No. 1 has already been described *supra*.

No. 2. A length of 4 c.m. of an unused portion of the bridge-wire was soldered across the thick posts supporting the coil marked FI; thus if balance was obtained with the plug FI in, its withdrawal would compel a movement of about 2 c.m. in the contact-maker to restore equilibrium. As the constitution of both wires was the same, and as they were included in the glass case, the length moved by the contact-maker was unaltered by changes in temperature.

C_1 C_2 (Fig. 1) were connected by a thick copper strip, while p_1 and p_2 were connected with the terminals of a resistance-box (r_1) having a slightly larger unit than the Kew box, and the extremities of r_1 were connected with two other boxes (r_2, r_3), of which r_2 could be altered by certain steps from 5 to 20,000 ohms, and r_3 by any quantity from 0·1 to 10,000 ohms; thus r_2 and r_3 may be regarded as shunts to r_1. All three boxes were maintained at a constant temperature.

This arrangement was adopted to enable a balance to be obtained when the contact-maker was at, or very near any given position; for example—suppose contact desired at reading + 15, r_2 and r_3 were made as large as possible, and r_1 adjusted until the bridge-wire reading somewhat exceeded 15; r_1 was then reduced until the reading but slightly exceeded 15. Reductions of some hundreds of ohms in r_3 would now cause but small alteration in the combined resistance of the three boxes, provided r_3 greatly exceeded r_1 and r_2 when in parallel arc. It was thus always found possible and easy to balance so that contact was nearer than 0·5 m.m. to any desired position.

The plug FI was now withdrawn, and the corresponding movement of the contact-maker noted. Repeated observations throughout the whole length of the wire were thus taken, not only by the writer, but also by Mr. G. M. Clark, who performed an independent series. Denote the resistance of the wire across FI by U, then the reciprocals of the observed lengths give in terms of U the effective resistance per c.m. of the wire at the middle point of each range. By means of the arrangement described above, the observations were so conducted that these middle points fell almost exactly on the integral numbers of the scale, and, by plotting, the exact values at the integers were obtained.

By repeating the process with the plug H the value of U in terms of H could be accurately ascertained, and a check was also obtained on the previous observations. The value per c.m. for the whole wire could thus be found in terms of H. Later in the operations, when the value of H was known in terms of the mean box unit, the b.-w. values were expressed in terms of the mean unit and integrated on each side of the zero mark.

No. 3. The effect of any inequality in the bridge arms of S_1 S_2 (Fig. 1) could not be eliminated by means of the Correction Tables, nor could such an error be easily detected by means of the box itself, as is the case in the remaining coils. Great attention was, therefore, devoted to securing equality. It is certain that they do not differ by 1 in 100,000.

The errors of coils A to H and FI (the temporary connection across FI having been removed) were now determined by a method originally adopted by Prof. Callendar. No great efforts were made to secure the identity of these coils with their nominal values, for it was certain that some small corrections would in any case be necessary, and as the magnitude of the correction in no way increases the labour of calculation, the time and energy expended in any exact adjustment would have been wasted.

The procedure was as follows:—

All plugs were inserted, and the balance obtained with the contact-maker at any convenient position by adjusting r_1, r_2, r_3, as previously described. H (5) was then removed, and the change in reading required to readjust balance observed. Let Z_1 be the consequent change in reading; r_1, r_2, r_3 were then altered until the contact-maker was brought back to about the same position as it occupied when H was in. H was then inserted, and G (10) removed. Let change = Z_2; contact was again brought to first position, D (20) removed, and G and H replaced. Let change = Z_3, &c.

When the process is completed we thus get a series of equations

$$A - (B \text{ to } H) = Z_8$$
$$B - (C \text{ to } H) = Z_7$$
$$C - (D \text{ to } H) = Z_6, \text{ \&c.}$$

By subtraction we then get

$$A - 2B = Z_8 - Z_7$$
$$B - 2C = Z_7 - Z_6, \text{ \&c.}$$

Now the values of Z_1 Z_2, &c., *in terms of H* are already known from the previous operations, hence A, B, &c., in terms of H can be found.

As the right-hand extremities of the intervals Z_1 Z_2, &c., were approximately in the same position, nearly the same portion of the bridge-wire was used throughout; thus any errors in the previous calibration would but slightly affect the results.

Knowing the values of all the coils in terms of H, it is then easy to express them all in terms of the mean coil, and hence in terms of the mean box unit, a corresponding correction being made in the integrations of the bridge-wire.

The zero error of the scale was next determined by reducing the resistances between C_1, C_2, and P_1, P_2 (Fig. 1) to zero, and replacing all plugs. The observations were checked by reversing all the connections. The displacement was found to be + 0·005 c.m.

No. 4. Finally the sum of all the coils was determined by means of a dial box, of whose comparison with the B.A. Standard full particulars are given in *Phil. Trans.* A, 1893, pp. 407–410. The result was that the mean Kew box unit at 20° C. = 0·0099993 Board of Trade ohms.

At the conclusion of the standardisation a large number of readings of the same resistance were taken by different observers with different combinations of coils and b.-w. readings. The accuracy of all the corrections was thus exposed to a crucial test, the results of which were satisfactory.

No. 5. The standardisation of the thermometers was performed after the installation of the apparatus at Kew, the previous observations having been made in my own laboratory.

I find that many misapprehensions are prevalent as to the nature of the operations, and it may therefore be of assistance to observers who standardise their own thermometers, if I give a complete example of one set of the observations as taken at Kew, together with their reductions. I select thermometer K_2, as several observers took part in its standardisation, and it therefore well illustrates the order of accuracy obtainable.

The numbers in italics show the corrections resulting from the standardisations of which an account has been given. The times are always entered, since the observations of the barometer cannot be taken simultaneously with the temperature measurements, and it is necessary, therefore, when working with steam and sulphur, to form a time-chart by which to ascertain the correct pressure at the moment of observation.

Thermometer K_2. *Determination of* R_0.

Date and observer.	Time.	Coils and correction.	B.-wire and correction.	Temp. box and correction.	R_0
Oct. 2, 1895					
C.T.H.	11.47	C.D.F. = + 260 + *·035*	− 2·302 + *·004*	21·38 + *·092*	257·829
E.H.G.	11.50	,,	− 2·306 + *·004*	21·36 + *·091*	257·824
W.H.	11.57	C.D.F.H. = 265 − *·023*	− 7·260 + *·022*	21·33 + *·089*	257·828
C.T.H.	12.6	,,	− 7·263 + *·022*	21·33 + *·089*	257·825
W.H.	12.13	C.D.H. = 245 + *·014*	+ 12·784 − *·059*	21·32 + *·088*	257·827
			Mean ...	...	257·827

The separate determinations were entirely independent, and taken by three different observers; the coils were so changed that the b.-w. readings altered from − 7·263 to + 12·784, while the sum of the corrections varies from + 0·131 to + 0·043, yet the greatest departure from the mean = 0·003.

Thermometer K_2 *in Steam.*

Date and observer.	Time.	Coils and correction.	B.-wire and correction.	Temp. box and correction.	Bar. and temp. F.	R^1
Oct. 2, 1895						
C.T.H.	12.37	C.D.F.FI. = 360 − *·008*	− 2·820 + *·007*	21·30 + *·121*	29·602 at 61·2	357·300
E.H.G.	12.42	,,	− 2·824 + *·007*	21·30 + *·121*	29·600 at 61·2	357·296

The barometer reading at 12.37 corrected for temperature, and for *g* to sea-level, lat. 45° = 750·12 m.m., and at 12.42 = 750·06 m.m. (This difference of ·06 m.m. corresponds to a decrease of 0·002 in R.)

Hence mean pressure = 750·09 m.m., and temperature of steam at this pressure = 99°·634 C.

$\therefore \frac{347{\cdot}298 - 257{\cdot}827}{99{\cdot}634}$ = *mean* change in R per 1° C. over this range.

Now $\frac{\delta pt}{\delta t} = 1 - \delta \frac{2t - 100}{10{,}000}$. We may assume δ for this wire as approximately 1·50.

Hence

$$\frac{\delta pt}{\delta t} = 0{\cdot}985, \quad \therefore \frac{\delta R^1}{\delta t} \text{ at } 100° = {\cdot}9982 \times {\cdot}985 = {\cdot}983,$$

$$\therefore \delta R^1 \text{ for } 0{\cdot}366° \text{ C.} = 0{\cdot}360.$$

Hence

$$R_1 = 357{\cdot}298 + {\cdot}360 = 357{\cdot}658.$$

Thermometer K_2 *in Suiphur-vapour.*

Date and observer.	Time.	Coils and correction.	B.-wire and correction.	Temp. box.	Mean bar. and temp. F.	R.
Oct. 2, 1895						
E.H.G.	1.50	A.F.G.H. = 675 − *·207*	+ 2·789 − *·013*	21·15 + *·203*	29·610 at 61·5	677·772
E.H.G.	1.53	,,	+ 2·796 − *·013*	21·14 + *·201*		677·777
E.H.G.	1.58	A.E. = 680 − *·089*	− 2·343 + *·004*	21·13 + *·201*		677·773
W.H.	2.20	,,	− 2·322 + *·004*	21·04 + *·183*		677·776
					Mean	677·775

Here, again, changes in coils and b.-w. readings do not appreciably affect the results. It is interesting to notice that the change in box temperature between 1.58 and 2.20 p.m. almost exactly accounts for the difference of 0·021 in the b.-w. readings by the different observers. As the apparatus had but just been installed, we had not got the regulator properly under control; thus the temperature changes were greater than would usually be the case.

Barometer, corrected as before = 750·30 m.m.

Now, b. p. of sulphur

$$= 444{\cdot}53 + (p - 760) \times {\cdot}082 = 443{\cdot}73,$$

and

$$pt_s = \frac{677{\cdot}775 - 257{\cdot}827}{357{\cdot}658 - 257{\cdot}827} = 420{\cdot}66.$$

Hence, Eq. (*d*),

$$443{\cdot}73 - 420{\cdot}66 = \delta(4{\cdot}437^2 - 4{\cdot}437),$$

$$\therefore \delta = 1{\cdot}512.$$

Thermometer K_2 is now completely standardised.

Constants

$$R_1 = 357{\cdot}658 \quad \frac{R_1}{R_0} = 1{\cdot}3872$$

$$R_0 = 257{\cdot}827$$

$$FI = 99{\cdot}831 \quad \delta = 1{\cdot}512.$$

The most simple manner of obtaining the value of *t* for any given value of *pt* is to proceed as follows. Construct, by means of Eq. (*d*), a table giving corresponding values of *pt* and *d* for regular increases in *t* or *pt*, assuming the value of δ as 1·500. (For convenience of those using these thermometers, I give such a table, as an appendix, for values of *pt* up to 1000.) Plot the numbers thus obtained on a large scale with *pt* as abscissa and *d* as ordinate. Having experimentally found *pt* in a certain case with a thermometer whose value of δ is δ^1, ascertain from the chart the corresponding value of *d*, then $t = pt + \frac{\delta^1}{1{\cdot}500} \times d$, and thus the same chart can be used for different thermometers.

The above example will suffice both to illustrate the general method and the standardisation of the Kew thermometers.

IV. *Concluding Remarks.*

I understand that the Kew Committee had two objects in view when they sanctioned the acquisition of this apparatus and undertook the task of directing a course of observations.

(1) To submit the methods and principles of platinum thermometry to an exhaustive trial, and especially to ascertain how far the apparatus would stand the test of time and use. Such a series of observations can only be undertaken by a department similar to that at Kew, where records are properly kept, and where the continuation of the experiments is not dependent on the life or inclination of individual observers.

(2) To establish some recognised system of standardisation for instruments intended for the measurement of high temperatures.

With regard to the latter object, I would venture to add a few remarks. If high-temperature mercury thermometers (such as those of Niehls, of Berlin) are sent for comparison, it must be remembered that the readings of these instruments are greatly influenced by the stem temperature, especially when the range is large, and it is impossible, under the conditions usually prevalent in high temperature measurements, to secure complete immersion of the stem. The observers at Kew will be able to state the length of the portion actually immersed, &c., and those who afterwards use such thermometers must endeavour, if they wish for accurate results, to reproduce the conditions as nearly as possible. The experience of Messrs. Heycock and Neville in their earlier work (when they used for their experiments mercury thermometers standardised by platinum ones)[1] shows that it is possible to reproduce the original conditions with sufficient accuracy.

Again, it is useless to standardise glass thermometers unless previous experience has shown that they are not subject to the zero rise usually characteristic of such instruments after exposure to high temperatures.

Another matter, to which I trust the attention of Dr. Chree will sometime be directed, is the suitability of platinum standards for the calibration of mercury thermometers *at ordinary temperatures*. The greatest value of *d* over the range 0° to 100° (*i.e.* near 50° C.) is with these standards less than 0°·4 C.; now an error of 1 per cent. in δ (and I do not believe that any such error is probable, or I may say possible) would mean an error of but 0°·004 in *t* at 50° C., and less at other temperatures. The readings are independent of changes in internal or external pressure, of position or of stem immersion, and are directly expressed in terms of the air thermometer. It was with a view to such comparisons that I designed K_6, which on account of the large value of FI would cause an error of ·003 in the readings to affect the resulting value of *t* by only 0°·001 C.

1 *Chem. Soc. Jcurn.*, July 1890.

In conclusion, I may be permitted to express my gratification that the efforts made by Prof. Callendar and myself to demonstrate the accuracy and convenience of the methods of platinum thermometry are, although progress has been slow, at length awakening the attention of scientific inquirers. We believe (and that belief is founded not only on our own experience, but more especially on the work of Messrs. Heycock and Neville) that it is by means of the platinum thermometer that the many difficulties attendant on thermometric measurements, either at high or low temperatures, can be most easily surmounted.

Although the acquisition and installation of the apparatus has involved a considerable expenditure of both time and money, I am confident that, under the able direction of Dr. Chree, the results will justify the action of the Committee.

APPENDIX.

The following table gives the relation between the platinum temperature scale and the air temperature scale, when the value of $\delta = 1·500$.

Platinum temperature scale.	Correction.	Air temperature scale.	Platinum temperature scale.	Correction.	Air temperature scale.
− 100	+ 2·9	− 97·1	450	+ 27·0	477·0
− 50	+ 1·1	− 48·9	500	+ 34 9	534·9
0	0·0	0	550	+ 44·0	594·0
50	− 0·4*	49·6	600	+ 54·4	654·4
100	0·0	100·0	650	+ 66·2	716·2
150	+ 1·2	151·2	700	+ 79·4	779·4
200	+ 3·1	203·1	750	+ 94·2	844·2
250	+ 6·0	256·0	800	+ 110·7	910·7
300	+ 9 8	309·8	900	+ 149·4	1049·4
350	+ 14·5	364·5	1000	+ 197·0	1197·0
400	+ 20·2	420·2			

* More accurately = − 0·375 and 49·625.

E. H. GRIFFITHS.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—It is announced that the electors to the Waynflete Professorship of Mineralogy will proceed to the election of a Professor in the course of the present year. Candidates are required to send to the Registrar of the University, on or before December 7, their applications and testimonials.

The University having accepted a bequest of £900, given by the will of the late Mrs. Fielding, for the purpose of providing for the payment of a Curator of the Fielding Herbarium, it has been decreed that there shall be a Curator of the Herbarium, appointed by the Fielding Curators, and under the direct control of the Sherardian Professor of Botany. Besides the income derived from the bequest of £900, the Curators shall have the power to apply a part of the funds at their disposal to the increase of the stipend of the Curator of the Herbarium.

The following Examiners have been approved by Convocation:—For the first examination for the degree of Bachelor of Medicine, W. R. Dunstan, G. W. S. Farmer, and Dr. R. Stockman; for the second examination for the degree of Bachelor of Medicine, Dr. C. W. Mansell Moullin, Sir William Stokes, G. E. Herman, and Dr. S. H. C. Martin. In each case the appointments are for the examinations of 1896, 1897, and 1898.

CAMBRIDGE.—Mr. T. W. Bridge, Professor of Zoology in the Mason College, Birmingham, and Mr. G. H. Bryan, F.R.S., of Peterhouse, have been approved for the degree of Doctor of Science.

Mr. C. T. R. Wilson, of Sidney Sussex College, has been elected to the Clerk Maxwell Studentship in Experimental Physics.

The late Miss Jane Saul has left her collection of shells, and the cabinet containing the same, her "Conchologia Iconica," and other conchological works, to the University.

MR. J. GAD, Extraordinary Professor of Physiology in Berlin University, has been appointed Ordinary Professor of the same subject, and Director of the Physiological Institute in the German University at Prague. Dr. M. von Lenhossek, of Wurzburg, has been appointed Prosector in the Anatomical Institute at Tübingen. Other recent appointments are: Dr. Mark W. Harrington to be President of Washington State University; Mr. H. Landes to be Professor of Geology in the same University, and Dr. H. C. Myers to be Professor of Chemistry.

DR. C. M. LUXMORE has been appointed to a Research Fellowship of the Pharmaceutical Society.

MR. JAMES WILSON, Lecturer in Agriculture, University College, Aberystwyth, has been appointed to the Fordyce Lectureship in Agriculture in Aberdeen University.

FROM the *Journal* of the Society of Arts it appears that the great advances made by Swiss national industry during the last fifteen or sixteen years, both in the technical and artistic character of its products, are attributed by the *Deutsches Handels Archiv* to the beneficial influences of State and Municipal establishments for technical education. It is very remarkable how much is done in the cantons of Geneva and Neuchatel to encourage and improve local industries, especially in finer classes of goods, for the manufacture of which a considerable amount of skill and artistic knowledge is required. In these two cantons, numbering little more than 220,000 inhabitants, there are five schools for watchmakers, and in Geneva, Neuchatel, and Chaux de Fonds there are schools for instruction in the fine arts and in artistic handicrafts. Besides the institutions there are commercial schools in Geneva and Neuchatel, and the professional schools in which instruction in various industries is given to persons of both sexes. In the watchmaking school at Geneva a class for girls has recently been established, where certain operations peculiarly suitable for female labour are taught. Considerable assistance is also rendered to the watch industry by the astronomical observatories at Geneva and Neuchatel, both by testing chronometers, and by their co-operation in the annual trade competitions.

SCIENTIFIC SERIALS.

Internationales Archiv für Ethnographie, Band viii. Heft iv.—This well-illustrated journal is steadily increasing in value and interest, as it is wider in its scope than it was at the commencement. Baron van Hoëvell, of Amboina, has a paper on a few notes on the kinds of the worship of gods in the south-western and south-eastern islands of the Malay Archipelago. Amongst other interesting information is a legend of the origin of two fetiches which are said to have fallen from heaven; one, which is called a sword, is probably a piece of old hoop-iron, and the other, a supposed spear-point, appears to be a piece of meteoric iron. There are also traces of a virginal conception through divine influence.—"Dogs and Primitive Folk" is the title of a comprehensive essay by Dr. B. Langkavel, in which he deals with dogs in folk custom and belief, the name as a term of reproach, ornaments derived from dogs, &c.—Dr. O. Frankfurter writes on dreams and their significance according to a Siamese dream-book.—J. D. E. Schmeltz has three communications on Papuan ethnography, of which the first, on objects from the Tugeri, is the most interesting. We are now beginning to learn something definite about these ruthless pirates that harass the western coast population of British New Guinea. A bow, tobacco-pipe, drum, and two remarkable dance ornaments are figured; the latter are slabs of wood carved to represent a flying bird (?), and several lizards or crocodiles. He also describes a wood-carving of what appears to be an echidna and some ceremonial objects. The rest of the journal is occupied with the usual notes and notices.

IN addition to articles specially interesting to Italian botanists, the *Nuovo Giornale Botanico Italiano* for July contains the following:—A study of the action of certain alkaloids on plants in darkness and in light, by Signor A. Marcacci. While quinine arrests the transformation of starch into saccharose, and of dextrose into levulose, both in the dark and in the light, strychnine does so only in the light, from which the conclusion is drawn that these changes are not simply chemical processes, but are dependent on other unknown forces.—On certain contrivances for dissemination in Angiosperms; in which more stress is laid than is generally the case on the action of water in the dispersion of seeds; as, for example, in the production of mucilage, to which the rupture of capsules is often due.—On the fruit of *Aucuba japonica*, by Signor L. Pampaloni.—On the affinities of the *Sphenophyllaceæ*, by Prof. G. Arcangeli. The author regards this group of fossil plants as having no near affinity with any other, either palæontological or recent. While the structure of the stem resembles that of the *Calamarieæ*, the mode of formation of the spores is analogous to that of the *Lycopodiaceæ*.—On the development of *Tricholoma terreum*, by Signor P. Voglino.

SOCIETIES AND ACADEMIES.

London.

Physical Society, November 8.—Prof. A. W. Rücker, Vice-President, in the chair.—Mr. W. H. Everett read a paper on the magnetic field of any cylindrical coil or plane circuit. The method of treatment is based on the formula for the force due to an element of current. A single integration applied to one component of this force gives for any point in the field due to a plane circuit the force perpendicular to its plane; and a double integration gives the longitudinal force at any point due to a cylindrical coil of any cross-section, the depth of winding being supposed inconsiderable. For coils in which the latter condition does not hold, an approximate solution can readily be found. The force parallel to the plane of a circuit and the transverse force due to a coil are investigated in a similar manner. The general results are of a very simple form, and admit of easy approximate calculation. Special formulæ are deduced for coils of rectangular cross-section, the general expressions being in this case integrable. Appended to the paper are some numerical results giving the values of the forces at different points due to coils of various dimensions. Prof. Perry said he considered the paper to be a valuable one, particularly as illustrating a practical mathematical method of integrating. Mr. Trotter said the paper was of interest to him, as he considered that several of the author's results might be applied to the solution of problems on illumination—for instance, the illumination of a room by a circle of lamps. Mr. Rhodes regretted that it had not been possible to supply a proof of the paper before the meeting. The method in which the author obtained the force outside a solenoid as the difference of the forces due to two solenoids, reminded him of the method employed in calculating the attraction of, say, a truncated pyramid. Prof. Silvanus Thompson said the author had mentioned several previous papers on the subject, but had not referred to one by Prof. Viriamu Jones, in which the force due to a solenoid is obtained in terms of elliptic integrals. Another method of attack was to calculate the work done when a unit pole is carried through the solenoid and back outside to the starting-point. Prof. Ayrton said he also regretted the absence of a proof of the paper. He considered it of great importance to have exact and simple methods of calculating the forces due to a solenoid. The Chairman (Prof. Rücker) said he had made a somewhat similar calculation in connection with the magnetic effect of sheets of basalt below the surface of the earth.—Mr. E. H. Griffiths read a paper, by himself and Miss Dorothy Marshall, on the latent heat of evaporation of benzene. The method employed is similar to that used by one of the authors in the determination of the latent heat evaporation of water (*Phil. Trans.* 1895). The loss of heat due to the evaporation is balanced by (*a*) the heat supplied by an electric current; (*b*) a secondary supply due to the work done by the stirrer; (*c*) a slight gain or loss due to small unavoidable changes in temperature of the calorimeter. The comparative values of the various sources of heat (if we denote the supply due to the electrical current by 1000) is approximately:—Electrical = 1000; stirring = 11; changes in calorimeter temperature ± 5. The electrical supply could be measured with extreme accuracy, and the above table shows that small errors in the determination of the remaining thermal quantities are of little importance. The results may be summed up in the formula

$$L = 107{\cdot}05 - 0{\cdot}1981\,\theta$$

where θ is the temperature and the thermal unit at 15° C. is used. The discussion on this paper was postponed till after the reading of the paper by Prof. Ramsay and Miss Marshall, on a method of comparing the heats of evaporation of different liquids at their boiling points. The method employed has already been described before the Society (January 11, 1895). The liquid to be experimented on is put into a glass bulb enclosed in an outer jacket filled with the vapour of the same liquid. An open tube is attached to the top of the bulb, so that there is free communication between the interior and the vapour jacket, and no loss of material. Inside the bulb is a spiral of fine platinum wire, attached to stout platinum terminals which are sealed into the glass. The temperature of the liquid in the bulb is raised to the boiling point by the vapour jacket; thus when a current is sent through the wire, the whole of the heat developed is spent in converting a portion of the liquid into vapour. Two such bulbs are connected in series, and the ratio of their losses of weight is the inverse ratio of the heats of evaporation of the liquids. A correction is made for the inequality in resistance of the spirals, and the ratio of the differences of potential between the ends of the spirals, when the current is passing, is determined in each experiment by Poggendorff's method. Results are given for fourteen liquids. Prof. Ramsay drew special attention to the table giving the values of the quotient ML/T, where M is the molecular weight, T the absolute temprature, and L the latent heat. Very curious differences are noticeable in the case of water, alcohol, and acetic acid. Prof. Carey Foster expressed his admiration for the method, since it obviated the necessity of knowing the specific heat of the liquid vapour. Prof. Silvanus Thompson said the difficulty experienced in the case of water due to electrolysis might be obviated by the employment of a spiral of lower resistance and a larger current, so that the difference of potential between the ends of the spiral should be less than 1·7 volts. The Chairman said Captain Abney had asked him to inquire to what extent the temperature of the liquid was affected by radiation. Mr. J. W. Rodger asked if any direct experiment had been made to determine if the temperature of the liquid was not above its true boiling point. In some cases differences of as much as 2° might exist between the temperature of the liquid and that of the vapour given off. The differences in the value of ML/T in the case of water, alcohol and acetic acid might be due to the fact that the vapours of alcohol and water were simple, while the vapour of acetic acid was complex. Mr. R. Appleyard suggested that the differences obtained in the case of water might be due to the presence of dissolved air. Mr. Griffiths said that the objection to the adoption of Prof. Thompson's suggestion was the fear that with short wires an excessive difference in temperature between the wire and the liquid might exist. Mr. Rhodes asked if Mr. Griffiths could trust his determinations of temperature to $\frac{1}{80000}$th of a degree. Mr. Griffiths, in reply, said that he thought there was no limit to the accuracy with which a difference of temperance could be measured; the absolute temperature, however, he only relied upon to $\frac{1}{1000}$th of a degree. Prof. Ramsay said the fact of superheating existing would not affect the results, since near the temperatures at which they were working the latent heat did not vary appreciably with the temperature. In reply to Captain Abney, he said some previous experiments by Dr. Young and himself had shown that the vapour jacket was quite impervious to radiant heat from without

Paris.

Academy of Sciences, November 4.—M. Marey in the chair.—Action of silicon on iron, chromium, and silver, by M. Henri Moissan. By heating silicon with soft iron, chromium, or silver in the electric furnace or otherwise, compounds having the composition Fe_2Si and Cr_2Si are produced by the two former metals, and silver dissolves a notable proportion of silicon, but deposits it again on solidification in the crystalline state. The silicides of iron and chromium are produced at temperatures below the melting points of either constituent, probably owing to the vapour tension of silicon at the temperature of formation; the whole process much resembles cementation. These silicides are readily attacked by hydrofluoric acid or aqua regia, slowly acted on by hydrochloric acid and unacted on by nitric acid. Fused potassium nitrate and chlorate do not act on these compounds, but they are easily decomposed by fusion with a mixture of nitrate and carbonate.—M. de Freycinet describes the aim of his book, "Essays on the Philosophy of the Sciences," of which a copy is presented to the Academy.—Elements of Swift's comet (1895 II), by M. L. Schulhof. These elements are compared with the elements for Lexell's comet given in Le Verrier's table (for $\mu = +\,0{\cdot}9$), and show very near agreement.—Spectroscopic researches on the star Altaïr. Recognition of an orbital movement and of an atmosphere, by M. H. Deslandres. (See our Astronomical Column.) On the binomial differential equation of the first order, by M. Michel Petrovitch.—New method for the extraction of roots of numbers, by M. Manuel Vazquez Prada.—Expression of the pressure supported by the shaft of a hydraulic turbine at work. Theorem concerning the dynamical effect of the water. Note by M. Bertrand de Fontviolant. It is concluded that: The dynamical effect is equal to the geometrical variation of quantity of movement suffered by the volume of water delivered per second in its passage across the turbine.—On the time distribution of rain at Athens, by M. D. Eginitis.—On the process of attacking the emerald and the preparation of pure glucina, by M. P. Lebeau.—On a group of mineral waters containing ammonia (bituminous waters), by M. F. Parmentier.—On the estimation of tannins in wines, by M. E. Manceau.—Action of chlorine on normal propyl alcohol, by M. André Brochet. Two of the products of chlorination in the cold are α chloropropionic aldehyde, $CH_3.CHCl.COH$, and dipropyl chloropropional, $CH_3.CHCl.CH(OC_3H_7)_2$.—On ozotoluene, by M. Adolphe Renard. Ozotoluene resembles the ozobenzene previously described. It is a white opaque mass, commencing to decompose at about 8°. It detonates on heating or by shock, but less easily than ozobenzene. Its composition is represented by the formula $C_7H_8O_6$.—Study on the nitration of menthone, by M. Konovaloff. By heating with nitric acid at 100° in a sealed tube menthone yields nitromenthone $C_{10}H_{17}(NO_2)O$. The alcoholic solution of the latter with sodium ethoxide gives a salt, undecomposed by boric, carbonic, or hydrosulphuric acids, corresponding to the acid $C_{10}H_{19}NO_4$ set free by sulphuric acid. The nitromenthone is reduced with formation of a basic substance. It is probably a tertiary nitromenthone of the composition

$$CH_3.CH\left\langle\begin{matrix}CH_2-CH_2\\ CH_2-CO\end{matrix}\right\rangle C(NO_2).C_3H_7.$$

—On the fermentation of cellulose, by M. V. Omelianski. The specific ferment destroying cellulose has been isolated by the author, and is described in the paper.—Anatomy of the digestive apparatus of the Orthoptera of the family of the *Forficulidæ*, by M. Bordas.—On the application of the experimental method to the orogenic history of Europe, by M. Stanislas Meunier.—Experiments relative to the direct manufacture of pure ethyl alcohol, by the fermentation of *Asphodelus ramosus* and *Scilla maritima* with cultivated pure wine yeasts, by M.M. G. Rivière and Bailhache.—On the reclamation of the heath-lands of the Dordogne, by M. Raoul Bouilhac. It is shown that the reclamation of these sandy barrens is possible by the use of a lime phosphatic manure.—Experimental congenital deformities, by MM. Charrin and Gley.

AMSTERDAM.

Royal Academy of Sciences, September 28.—Prof. Van der Waals in the chair.—Mr. Jan de Vries read a paper on addition theorems for elliptic integrals.—Prof. Kamerlingh Onnes communicated measurements, made in the Leyden laboratory, and already published in Dr. Lebret's dissertation (July 1895) on the variation with temperature of the Hall effect in bismuth, the temperatures ranging from −74° to +240°. Two samples of pure bismuth were experimented upon. The temperature curve of one of the specimens showed a maximum point at −20°; that of the other was not examined far enough. The latter specimen was melted up into a glass tube, and the variation in the electrical resistance measured between −76° and +240°.—At the request of Prof. Cohn of Strassburg and of Dr. Zeeman of Leyden, Prof. Onnes gave an account of experiments, made partly at Strassburg and partly at Leyden, on the propagation of electrical waves in water. The result was: (1) there is no dispersion for waves of the oscillation frequency of 27 to 97 millions per second; (2) the refractive index for waves of which there are a hundred millions a second, is equal to the square root of the specific inductive capacity as measured by the statical method.—Prof. Onnes further communicated: (1) a measurement on the refractive index of glowing platinum, made by Dr. Zeeman in the Leyden laboratory. With Babinet's compensator it was impossible to establish a variation with temperature of the principal incidence and the principal azimuth, even when the platinum mirror was heated to 800° C. Hence within the limits of the errors of measurement the refractive index does not change; (2) a chart, showing the secular variation of magnetic declination, by Dr. W. van Bemmelen; (3) photographs of vibrating strings made by a new method, that of intermitting photography, by Dr. H. J. Oosting.—On behalf of Messrs. C. A. Lobry de Bruyn and W. Alberda van Ekenstein, Prof. Franchimont presented a paper on the reciprocal conversion of glucose, fructose and mannose into one another under the influence of alkalis.—Mr. van Diesen called attention to a copy, now in the library of the Academy, of the second edition of the map of North Holland, made in 1575, by order of the Duke of Alva, by Joost Jansz. Beeldsnÿder. Of the first edition no copy seems to be extant in Holland. The copy shown is the edition published in 1610 by H. A. van Warmenhuysen. Though the map seems to have been prepared with care as regards local details, the triangulation is not correct. The "mile," given as scale, probably the Spanish mile, has on this copy a length of 73 m.m.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—The Story of the Earth in Past Ages: Prof. H. G. Seeley (Newnes).—Birds from Moidart and Elsewhere: Mrs. H. Blackburn (Edinburgh, Douglas).—Zoological Record, Vol. xxxi. (Gurney).—Histoire de la Philosophie Atomistique: L. Mabilleau (Paris, Alcan).—Geological Survey of Canada, various Maps, (Ottawa).—An Introduction to the Algebra of Quantics: Prof. E. B. Elliott (Oxford, Clarendon Press).—The Reliquary and Illustrated Archæologist, new series, Vol. 1 (Bemrose).—Analyse des Alcools and des Faux-de-Vie: X. Rocques (Paris, Gauthier-Villars).—Applications Scientifiques de la Photographie: G. H. Niewenglowski (Paris, Gauthier-Villars).—Fourth Volume of Reports upon the Fauna of Liverpool Bay, &c. (Liverpool, Dobb).—A Primer of the History of Mathematics: W. W. R. Ball (Macmillan).—Science Readers: V. T. Murché, Books v. and vi. (Macmillan).—The Natural History of Eristalis Tenax, or the Drone Fly: J. B. Buckton (Macmillan).—Studies in Economics: Dr. W. Smart (Macmillan).—The Life of Joseph Wolf: A. H. Palmer (Longmans).—Stanford's Compendium. Africa, Vol. 2: South Africa: A. H. Keane (Stanford).—Elementary Physical Geography: Prof. R. S. Tarr (Macmillan).—Elementary Physiography: J. Thornton, 8th edition (Longmans).—The Intellectual Rise in Electricity: Dr. P. Benjamin (Longmans).

PAMPHLETS.—De la Double Réfraction Elliptique et de la Tétraréfringence du Quartz: Prof. G. Quesneville (Paris).—The Rutherfurd Photographic Measures of Sixty-two Stars about η Cassiopeiæ: H. S. Davis (New York).—Clouds and Weather: Captain D. Wilson-Barker (*Shipping World* Office).

SERIALS.—Princeton Contributions to Psychology, September (Princeton, N.J.).—Zeitschrift für Wissenschaftliche Zoologie, lx. Band, 2 Heft (Leipzig, Engelmann).—Geographical Journal, November (Stanford).—Bulletin of the American Mathematical Society, October (New York, Macmillan).—L'Anthropologie, tome vi. No. 5 (Paris, Masson).—Zeitschrift für Physikalische Chemie, xviii. Band, 2 Heft (Leipzig, Engelmann).—Scribner's Magazine, November (S. Low).—Geological Magazine, November (Dulau).—Journal of the Chemical Society, November (Gurney).—History of Mankind: F. Ratzel, Part 2 (Macmillan).—Mathematical Gazette, October (Macmillan).—Science Progress, November (Scientific Press, Ltd.).—The Evergreen, Autumn (Unwin).—Journal of the American Public Health Association, October (Concord).—Proceedings of the Physical Society of London, November (Taylor).—Journal of the Franklin Institute, November (Philadelphia).—American Naturalist, November (Philadelphia).—Engineering Magazine, November (Tucker).

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