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"*To the solid ground*
Of Nature trusts the mind which builds for aye."—WORDSWORTH

HAUPTBÜCHEREI D. TECHNISCHEN HOCHSCHULE
BRESLAU

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TECHNISCHEN HOCHSCHULE BRESLAU

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CAMBRIDGE STANDARDS OF VALUE.

Cambridge Essays on Education. Edited by Dr. A. C. Benson. With an Introduction by the Rt. Hon. Viscount Bryce. Pp. xix+232. (Cambridge: At the University Press, 1917.) Price 7*s*. 6*d*. net.

THESE essays, with one notable exception, constitute an appreciation and a defence of a classical education. They set forth all that is best in classical and literary studies, and abound in stimulating thoughts and provocative theories. But, with one exception, the writers have no great belief in scientific studies; though Cambridge essays, they do not represent Cambridge thought, of which Mr. Bateson assures us the dominant forces come from the scientific school. Even the Dean of St. Paul's, who has natural leanings towards science, pronounces scientific studies to be thin—like the air on the mountain-tops—whilst he admits that they are pure and bracing. But with all this fear of science there is in most of the essays the feeling of an unfulfilled hope, which is not allayed by the somewhat forced and artificial methods with which the writers seek to stimulate interest in literary studies. They have great possessions, but something is lacking; that something, students of science may claim, is the outlook of science.

It will be admitted that the advent of such mighty things as modern scientific discoveries might be expected to awaken a new curiosity and bring with it a new revelation. But unfortunately the outlook and aims of science are little understood and are confused with other motives. Mr. Paton, for example, declares science to be the embodiment of materialism. The last century, with all its brilliant achievement in scientific discovery, was, he tells us, spiritually a failure. He is probably mixing up science with what he sees around him in business. Sir John McClure, who writes on vocational training and is so distrustful of it, does the same. He quotes with approval from the speech which Mr. Hichens addressed to the Headmasters' Association. But Mr. Hichens is not thinking of science; he is thinking of "business." For high business capacity he does not want a man trained in science; he wants him trained in classics, to be a man of ability and of moral strength of character. This is one type. For research he will employ a man trained in science.

The difference arises from the existence of these two types of men; and these types, Mr. Bateson candidly tells us, scarcely know each other—their outlook and methods are diverse, and this diversity affects thought, ways of looking at things, and mental interests. One type is possessive, as Mr. Russell might say, the other creative. Mr. Hichens is, naturally enough, thinking of the conventional qualifications of the governing type; but in the changing order of affairs it is not so certain that this type will be able to deal with the new relationships which are in rapid process of development. At any rate, men of this kind are in full power in the State, in Government offices, and in many business affairs, and they have not prevented strikes, or wars, or revolutions; and at the moment their methods and aims and powers are in a fair way towards paralysis. Who can tell whether the men of research will not be called from their laboratory to save and reconstruct the State?

"The rapture of the forward view," which Dean Inge quotes as belonging to science more than to any other study, is much needed to-day if we are to be saved from disaster. Dr. Inge discusses many important educational problems. He reminds us that the aims of education should be the knowledge, not of facts, but of the relative value of them, and he insists on training the reasoning faculties, and not in placing faith in intuition. He even traces the instinct of acquisitiveness, so prevalent amongst the governing and possessive classes, to the absence of trained reason. No one, he says, who had formed any reasonable estimate of the relative values of life would devote his time to exploiting his neighbours. It is a question, however, whether too much reliance may not be placed on reasoning—for the value of things, which are the premises, may change.

Dr. Inge apparently does not believe in change of values, and is thereby led to distrust democracy and pin his faith to aristocraticism. Democracy in education, he tells us, is a leveller, and its tendency is to level down all superiorities in the name of equality and good fellowship. This may be the appearance of it under its present state of bondage, but it is not the true, effective democracy. Democracy in education means the opening of education to everyone, and it is along these lines that reconstruction of education must follow. At present the education and codes of the public schools are aristocratic. Democracy means the opening of education to every boy or girl, the raising of the weakest, the multiplying of educational opportunities to give scope for individual capacities; it means the introduction of scientific and technical studies, and the extension of the method to literature and to art. Democracy means change of values, and this change is at the root of science education. Mr. Bateson, in a fine passage, reveals the vital influence of science.

> Natural knowledge is destined to give man not only a direct control of the material world, but new interpretations of higher problems. Those who have grasped the meaning of science, especially biological science, are feeling after new rules of conduct.

He continues:—

> The general ignorance of science has lasted so long that we have virtually two codes of right and duty, that founded on natural truth and that emanating from tradition, which almost alone finds public expression in this country. Whether we look at the cruelty which passes for justice in our criminal courts, at the prolongation of suffering which custom demands as a part of medical ethics, at this very question of education, or indeed at any problem of social life, we see ahead and know that science proclaims wiser and gentler creeds.

The two essays of Dr. Inge and Mr. Bateson should be carefully studied.

Dr. Benson writes pleasantly and suggestively on imagination, or, strictly speaking, literary imagination, not the imagination which science provokes; and the Headmaster of Sherborne follows with an essay on the place of literature in education. Both essays are enjoyable reading. We wish, however, that Dr. Benson would add scientific and technical work to his curriculum, with workshops laboratory, agriculture, and his own methods of literary and artistic teaching; then he would have no need for hobbies, and the "way of play" would be transferred to the more delightful "way of work."

Space will only permit of brief reference to the other important questions discussed in these essays. The neglect of science, the alarming absence of the science outlook in the State services, the cramping effects of examinations, are the agitating questions of the day. Uninspired by the science outlook, the Consultative Committee of the Board of Education gives as a reason for reconstruction that men must continue to work in order that our great firms may make money, or wages will go down; and knowing that the Board itself had killed the people's higher grade schools, it makes the remarkable statement that the scholarship method of passing from the elementary to the secondary schools is too firmly rooted in the mind of the country to be dislodged. We believe that these opinions are due to the neglect of science and to the absence of men of the scientific type. But how can we get scientific ideas into the life of the nation? We agree with Mr. Bateson that to replace Greek by chemistry, or to force "science for all" into the public schools, is only playing with the question. What is wanted is that science on a large and comprehensive practical and technical scale should be taught in the schools, so that boys of scientific aptitude and tastes may revel in inspiring fields of research and study. The schools would then turn out a race of men with new ideals inspired by the "onward march." Such men would be able to govern, but in a different way.

WEBB'S "CELESTIAL OBJECTS."

Celestial Objects for Common Telescopes. By the Rev. T. W. Webb. Sixth edition, thoroughly revised by the Rev. T. E. Espin. Vol. i., pp. xx+253; vol. ii., pp. viii+320. (London: Longmans, Green, and Co., 1917.) Price 7*s*. 6*d*. net each.

WHEN the first part of the fifth edition of this book appeared in 1893 we were not alone in finding fault with the way in which, to avoid alteration of Webb's work, most of the correction, revision, and amplification was relegated to an irritating series of footnotes. Old readers probably had an earlier edition if they desired undiluted Webb; new ones could scarcely be attracted by such a cumbersome device. Yet, after an interval of nearly a quarter of a century, an interval as great as that between Webb's own second edition and the Espin-Webb fifth edition, we find the very same fault repeated with all the aggravation due to the increasing number and importance of these footnotes. We must attribute the blame to the editor or the publisher, as we may easily acquit Messrs. Denning and Phillips, who provide so many of these important additions and corrections, of any choice in the form of their presentation. We feel that a great opportunity has been lost. A book of the kind being wanted, the appearance of this "revision" may very well discourage the production of a more consistent work.

The main part of this edition is very similar to the last, with which we dealt some twenty-four years ago. Some of our objections have been met by correction, and others ignored. The second volume, for which Mr. Espin took responsibility in the fifth edition, in which for the first time it was printed separately, has certainly benefited by the adoption of some of the suggestions then made by Mr. Lewis, whose hints are acknowledged in the preface, inasmuch as more recent measures of binary stars are now incorporated; in fact, many were specially observed for this edition.

The second volume, however, is not on the same plane as the first. It is more ambitious, and aims at the inclusion of much that cannot by any stretch of imagination be considered applicable to the "common telescopes" for which the work was originally planned. The index still fails to reach Mr. Lewis's ideal, though that of the southern sky, thanks to Mr. Innes, is much more complete. Even in the first volume there is much to be found quite admirable in its advance upon the earlier edition. The out-of-date charts of Mars and the moon are replaced by the excellent drawings of Antoniadi and Goodacre, but the valuable additional notes on the lunar formations, instead of being incorporated with the body of this section, which is one of the best in the book, are put separately in an appendix.

The increasing size of instruments in the hands of amateurs, which provides the excuse for the expansion of the second volume, naturally accounts for the insertion of a section dealing with the micrometer, and Mr. Franks has given a fairly complete account of it. But we must take exception to a remark of his on the moving wire. It may happen that bad clock driving by confining one hand to the slow-motion rod may compel the observer to treat one of his moving wires as fixed. But surely we need not accept Mr. Franks's opinion that this is the best method in all cases.

There are some obvious misprints (*e.g.* nubulæ for nebulæ, and Melothe for Melotte), but we select as an example of a blemish in the original work uncorrected by footnote or otherwise the extravagant language on p. 233, where we find once more the expressions "inconceivable velocity" and "one of the greatest marvels of the universe" applied to the simple effect of perspective as the comet of 1843 passed from one side of the sun to the other as viewed from the earth.

W. W. B.

OUR BOOKSHELF.

Short Logarithmic and other Tables. By Dr. W. Cawthorne Unwin. Sixth edition. 43 pp. (London: E. and F. N. Spon, Ltd., 1917.) Price 1*s.* 6*d.* net.

These tables were compiled by Prof. Unwin to facilitate arithmetical calculations in cases where great accuracy is unnecessary, and are selected and so arranged as to be specially useful in the solution of engineering problems. That the book has been of service to many engineers is evident from the fact that it has reached its sixth edition. The first table gives five-figure logarithms (by use of proportional parts) of numbers up to 9999, and occupies four pages, being followed by antilogarithms. Trigonometrical tables for the natural functions of angles and their logarithms are given for intervals of one minute. Several tables follow, which are adapted for simplifying engineering calculations, such as squares, cubes, square roots, cube roots, hyperbolic logarithms, height of fall to produce a given velocity, and velocity due to falling from a given height. There are also included tables of areas and circumferences of circles, and a segment table, as well as tables of weights of engineering materials. In addition, the book contains a large number of factors for conversion from the British to the metric system, and *vice versa.* The usefulness of a set of mathematical tables depends very greatly upon the facility with which the information required can be obtained, and the arrangement of the present set leaves little to be desired in this respect.

Health in Camp. By Dr. A. T. Nankivell. Pp. ix+84. (The Chadwick Library.) (London: Constable and Co., Ltd., 1917.) Price 1*s.* net.

This little book is an amplification of a series of Chadwick Trust Lectures delivered by the author three years ago. It gives in simple language which can be understood by the veriest tyro an outline of camp sanitation and how to ensure health in camp. The author throughout emphasises the use of the simplest materials and those which are to hand. For example, a grease trap at a washing place may be constructed as follows: A large biscuit tin or oil-drum without a top has a few holes pierced at the bottom. The tin is then filled with heather, gorse, bracken, or wood shavings, and the soapy water is poured in at the top. The water passes through into an earth drain, leaving the fat behind. The bracken, heather, etc., are removed twice a day and burnt in the camp incinerator.

The empty food tins and incinerator ashes of the camp may be utilised for path-making, and bully-beef or biscuit tins may be built up one upon another so as to make a firm and well-acting incinerator. Final chapters deal with insect pests and the minor ailments of camp life, including the important item of the care of the feet. We feel sure that this book will be useful and interesting to all those who live a life in camp, whether they be soldiers, boy scouts, or the less pretentious dwellers in caravans.

Rustic Sounds and other Studies in Literature and Natural History. By Sir Francis Darwin. Pp. 231. (London: John Murray, 1917.) Price 6*s.* net.

A very real, if somewhat elusive, charm attaches to most well-finished works the creation of which is felt instinctively to have been a labour of love. "Rustic Sounds and other Studies" possesses this quality in a marked degree, and the essays themselves suggest the pleasant conversation of a friend who is drawing on the resources of ripened experience, which he desires to share with others. A certain note of personal intimacy seems to run through the whole volume, and even such debatable matters as the proper aims, means, and objects of education are discussed in such a way that even those who may differ from the author will scarcely seek to quarrel with him.

It is, however, when touching on those branches of plant physiology which he has himself so successfully cultivated that Sir Francis Darwin appears perhaps at his best. The ease with which he makes recondite matters plain and the living atmosphere with which he surrounds his subject can scarcely fail to excite a response in everyone who is not utterly dead to intellectual stimulus.

The volume is essentially one to possess, for every page can be read with interest, whilst its graceful style will surely commend it to a wide circle of friends.

J. B. F.

LETTERS TO THE EDITOR.

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

The Stimulation of Plant-growth by Electric Fields.

THE experiments on the electric stimulation of vegetable growth, initiated in this country by Sir Oliver Lodge and others, are generally held to have given a substantial result. But there does not seem to be any definite view among botanists and experimenters as to the way in which it is brought about.

It appears that present practice is to fix a horizontal network of wires ten yards apart at a height of five yards above the ground, and to maintain it at an electric potential of 120,000 volts. This gives a vertical field of about 200 volts per centimetre, which is not far from a hundred times the order of magnitude of the natural atmospheric gradient. The procedure suggests that it is the field of force that is expected to produce the stimulation. The comparatively trifling amount of electricity that leaks from the wires into the atmosphere could scarcely produce directly any sensible effect.

It has, of course, been surmised for a long time that one function of spicules and edges and hairs on vegetation may be to promote discharge into the atmospheric electric field. Although electrostatic discharge is a surface phenomenon, the growing points may thus be stimulated by the electric field, there very highly concentrated. A positive gradient might conceivably have a different effect from a negative one. The discharge would go on at the enhanced rate due to the increased field, even if the wire grating were protected entirely from leakage. In that case no motive power would be required to maintain its potential, notwithstanding the current that is produced. No paradox is thereby involved. If the atmosphere were absolutely still, the current would pass from the earth to the wires, and leakage would be an essential part of it. But actually the electric discharge from the spicules of the vegetation is mainly borne away on the breeze, and whatever power is needed to sustain the action is contributed from the energy of the wind. It would appear that effective observations might go on even in the limited space of an ordinary greenhouse, using a grating attached to a static source of potential.

J. L.

Cambridge, February 14.

Photographic Determination of the Altitude of the Aurora of December 16, 1917, in Christiania.

IT may be of interest to readers of NATURE to know that I succeeded in obtaining a series of simultaneous photographs of the aurora of December 16 last from two stations—Christiania and Aas, twenty-eight kilometres from each other.

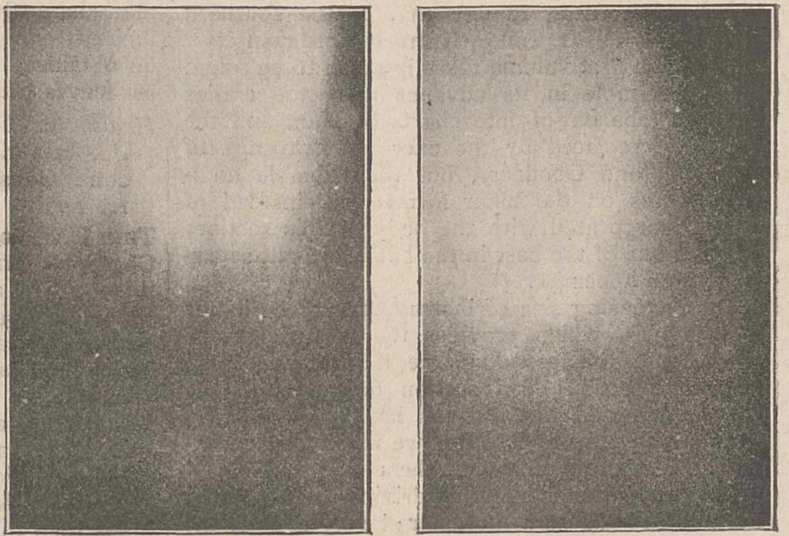

FIG. 1.—Aurora rays, December 16, 1917, 21h. 9m. G.M.T., photographed simultaneously from Christiania (left) and Aas (right). The rays reached down to a height of 100 kilometres above the earth. Stars of the Great Bear constellation are seen in the photograph.

The measures give altitudes of the *same* order as those obtained in Bossekop in 1913—that is, about 100 km. for the lower border of rays and curtains. This agrees with other measurements of the aurora

FIG. 2.—Corona, December 16, 1917, 21h. 10m. G.M.T. in Christiania. Exposure two seconds. Stars of the constellation Auriga are seen to the right.

of February 15, 1917, with the same base, Christiania-Aas.

It seems, then, that the cosmic rays causing the aurora have the same penetrability as those causing the aurora *in the aurora zone,* and that the southern situation is due to systems of corpuscular currents outside the earth, currents which are also the principal cause of the accompanying magnetic storms (see my Memoir in the *Archives des sciences physiques et naturelles,* Geneva, 1911–12).

The photographs were taken with plates only sensitive to blue and violet rays. As red rays occurred during the aurora, no measurements of these interesting phenomena were obtained. I have written to England for red sensitive plates, and if I succeed in securing them further important results may be obtained.

FIG. 3.—Corona, December 16, 1917, 21h. 11m. G.M.T. in Christiania. Stars of the constellation Perseus are seen near the centre, and Capella appears near the left border, though its image is deformed owing to the short focus lens used.

The illustrations represent a pair of photographic views of aurora rays, and photographs of the corona, showing that the rays are curved a little in their upper parts, which extend to about 400 km. above the earth.

CARL STÖRMER.

University of Christiania, January 28.

Eastern and Western Asymmetry of Solar Prominences.

REGARDING the suggested physical origin of a seeming predominance of solar prominences seen on the east limb as compared with the west limb, referred to in NATURE of January 31, p. 425, allow me to direct attention to numerous observations I have made which leave no doubt as to a predominance of deflection effects on and near the east limb being mostly to the violet, whereas west of the central meridian and on the west limb they are mostly towards the red. This feature is confirmed by the observations of M. Deslandres, and an illustrated account is given by him in the Paris *Comptes rendus,* tome 155, p. 1573 (séance du 30 décembre, 1912).

The deflection effects recently reported in the *Astrophysical Journal* by Mr. F. Ellerman are, in my opinion, the spectroscopic disc representation of the brilliant, and in most cases radially set, sharp "spikes" which an active area invariably exhibits when passing the limbs. I have seen the short-lived brilliant effects on the disc very often and their quick subsidence into dusky and dark forms, the brilliant initial outburst and its dusky sequence being distinctly punctuated by a very brief interval of partial or entire invisibility, owing to the luminosity passing the stage of that of the general disc itself. The life of the "spikes," when seen on the limb, is of the same brevity, and the identity of the two phenomena has long since been recognised by me from these observations and their interpretation.

ALBERT ALFRED BUSS.

22 Egerton Road, Chorlton-cum-Hardy,
Manchester, February 26.

A GRAHAM BELL TELEPHONE MEMORIAL.

THE Duke of Devonshire, Governor-General of Canada, on behalf of the Bell Memorial Committee, presented on October 24, 1917, to the town of Brantford, Ontario, a public park which will be known as the Alexander Graham Bell Gardens, the house in which the invention of the telephone was made, and a memorial monument to the inventor himself. For the accompanying photograph of the memorial we are indebted to the courtesy of Mr. G. H. Grosvenor, editor of the *National Geographic Magazine* of Washington. It is by the sculptor, W. S. Allward, and is allegorical. The figure on each side, one representing the speaker and the other the listener, is in bronze, and mounted on a granite pedestal. The panel on the crest of the memorial represents "Humanity in communication," the three shadowy figures being Knowledge, Joy, and Sorrow. They are bound together by lines representing telephone wires, the curved outline of the upper part of the monument representing the curvature of the earth. On the right and left are two circular panels inscribed as follows: "Opus Telephonica Patri Dedicatum Est" and "Mundus Telephonica Usu Recreatus Est." Underneath the central panel are the words: "To commemorate the invention of the telephone by Alexander Graham Bell in Brantford in 1874."

We congratulate the Canadians on having acquired such an interesting memorial of the great inventor. Dr. Bell's invention laid the foundation of a great and flourishing industry, which employs many hundreds of thousands of men and women, and in which many hundreds of millions of pounds are invested. He is one whom every man of science and engineer delights to honour.

It is interesting to remember that Dr. Bell's father, Mr. Alexander Melville Bell, the inventor of a well-known "visible speech" system, was for many years a lecturer on elocution in Edinburgh. His mother was a daughter of Surgeon Symonds, R.N. He himself was born in 1847, and educated at the Royal High School, Edinburgh. When fourteen years old he came to London, and was instructed by his grandfather, Alexander Bell, in elocution and the mechanism of speech. He was a teacher at Weston House Academy, Elgin, for a year, and then entered Edinburgh University, where he studied Latin under Sellar and Greek under Blackie. After being a schoolmaster again at Elgin

(m) x Water, Mineral
xx Springs

and also at Somerset College, Bath, he became assistant to his father, who was then lecturer on elocution in University College, London. In 1868–70 Dr. Bell matriculated at London University and attended medical classes at University College. As he was very delicate and as two of his brothers had died from tuberculosis, his father decided to emigrate to Canada in the hope of saving his life, and took a house at Brantford, near Tutela Heights, Ontario. In 1871 Dr. Bell gave instruction to the teachers of deaf-mute children in Boston, and in 1873 he was appointed professor of physiology at Boston University.

Dr. Bell began his career as an inventor very early. When sixteen years of age he invented a method of removing husks from wheat, and in conjunction with one of his brothers made a speaking automaton. In 1874 he invented a system of harmonic multiple telegraphy, and greatly improved his "articulating telephone." Amongst his later inventions we may mention the photophone, the induction balance, the telephone probe, the spectrophone, and, with C. A. Bell, the graphophone. In 1903 he invented tetrahedral kites, and in conjunction with the Aerial Experiment Association (1903–8) suggested numerous improvements in connection with aeroplanes. The outcome of their joint work was the "Red Wing," which made the first public flight in America at Hantsport, Mass., in March, 1908.

Memorial erected at Brantford, Ontario, to commemorate the invention of the telephone.

This country was in no hurry to honour Dr. Bell. It was not until 1906 that Oxford University made him a Doctor of Science, and not until 1913 that the Royal Society gave him a Hughes medal and the Institution of Electrical Engineers made him an honorary member. Surely never were honours better deserved. He is held in universal esteem by electricians the world over, and although his inventions have brought him fame and wealth, he is one of the most modest of men. As he is only seventy-one years of age, we hope that he will yet be spared for a long time, so that he may see the great expansion of the telephone industry which we anticipate in the immediate future.

A. R.

Radioactivity

THE RADIO-ACTIVITY OF SOME CANADIAN MINERAL SPRINGS.

DR. J. SATTERLEY, whose work on the radio-activity of the atmosphere, of river and well waters, and of the ocean is well known, and Mr. R. T. Elworthy, of the Canadian Department of Mines, in Bulletin No. 16, part i., issued by that department, report on the radio-activity of forty-seven mineral springs and twenty-three deep-well waters of the Dominion, the chemical character and composition of which are later to be dealt with in part ii. The examination was undertaken in view of the belief that the therapeutic value of mineral waters may be ascribed to their radio-activity, a hypothesis which, on account of the high radio-activity of many of the spas, celebrated from very early times, and the lack of virtue in the same water, transported from the spa, or waters artificially prepared to identical chemical composition, is certainly a plausible one.

The content of the water, both in radium emanation, which, of course, disappears spontaneously on keeping, and in radium itself, which acts as a permanent source of fresh emanation, has been investigated, the Canadian waters being characterised usually by the absence of dissolved radium, although frequently possessing relatively considerable amounts of the emanation. Fifty of the springs and wells examined were situated in eastern Ontario and western Quebec, a map of this district showing their location, but at a later date the well-known hot springs of Banff, at the eastern gate of the Canadian Pacific railway across the Rockies, were also included and found to be the most radio-active of those yet examined in Canada. Very full and clear descriptions and plates of the method of testing and apparatus employed are given, together with plates of twenty-one of the springs. The unit of measurement adopted is the scientific one, either 10^{-12} curie of emanation, or 10^{-12} gram of radium per litre of water, respectively.

The well waters contained from little or nothing up to 176 units of emanation, averaging 60 units for the twenty-three examined, dissolved radium not being detectable. For comparison may be cited the figures 130 and 196 units obtained by Satterley for two of the well waters of Cambridge (England). The springs, excluding those of Banff, contained on the average for forty, 120 units, 345 units being the highest. For these the dissolved radium was usually very small, rarely exceeding 5 or 10 units; but two springs were exceptional, the Philuder spring of St. Hyacinthe, Quebec, with 46 units—the highest recorded—and the Carlsbad "Magic" spring, eight miles from Ottawa, with 25 units. All the seven Banff springs examined were uniformly high in emanation content, from 220 to 640 units, with an average of 400 units, the radium content being 8·5 units, with the exception of the "Auto-road" spring, with 23·5 units, which also had the highest emanation content. Estimates of the flow are given, and in some cases the gases evolved were also examined both for emanation and by chemical analysis.

Compared with the most radio-active springs known, such as those of St. Joachimsthal, near the famous pitchblende deposits, at Plombières (France), Bath (England), and the hot springs of the Yellowstone Park and Arkansas, or of the majority of the spas celebrated for their medicinal powers, none of the Canadian springs are so radio-active. The water of the King's Well, Bath, for example, has an emanation content of 1730, and a radium content of 139. The Quebec and Ontario springs are, however, of the same order in emanation content as the group of springs at Saratoga, N.Y. The Banff springs are regarded as resembling closely the Bath springs both in mineral constituents and in the character of the gases evolved, with an emanation content about one-fourth or one-fifth as great. Banff being probably the chief Canadian health resort of the future, owing to its magnificent surroundings, it is suggested that the hot springs should be utilised in the manner now adopted at Bath. No results were obtained such as might indicate the existence of radio-active minerals in the neighbourhood of the springs, Canada being apparently exceptionally poor in such minerals, and the waters are in no case suited for bottling as radio-active waters, owing to their poverty in dissolved radium.

F. S.

PROF. E. A. LETTS.

Obituary

PROF. E. A. LETTS, of Queen's University, Belfast, died on February 19 in his sixty-sixth year as the result of a cycling accident in the Isle of Wight.

After a distinguished career at King's College, London, in Vienna and Berlin, Prof. Letts was appointed chief assistant at Edinburgh University in 1872 at the early age of twenty. Four years later he became the first professor of chemistry at University College, Bristol, and in 1879 he was appointed professor of chemistry at Queen's College, Belfast, in succession to the late Thomas Andrews, F.R.S., which position he held until failing health compelled him to resign early last year.

Prof. Letts was a man of singular personal charm, and inspired immense respect and affection in his students, to whom he was not merely the kindly teacher, but also the sympathetic friend who interested himself in all their affairs. He took a large part in establishing the Students' Union in Belfast, and was also prominently identified with the Better Equipment Fund, which aimed at raising 100,000*l.* locally for the provision of laboratories and other essential needs of the college. What this fund has meant to the college only those can appreciate who studied or taught under the conditions prevailing before its inception.

The scientific work of Prof. Letts covered much ground. He possessed great experimental skill, and an out-of-the-way problem, or one involving an unusual amount of manipulative dexterity, attracted his immediate interest. Early in his career he did much work upon the troublesome group of the phosphines. Later, he devoted some attention to the accurate determination of carbon dioxide in water and air, with the result that he was asked to devise the methods to be employed by the first Scott Antarctic Expedition in examining the atmosphere, and to report upon the results obtained.

Prof. Letts was best known, however, as an authority on questions connected with the pollution of rivers, especially of estuaries and tidal waters. During his thirty-seven years' tenure of the chair of chemistry at Belfast he had ample opportunity for the study of the problems associated with the rapid growth of the city and the insanitary conditions that afterwards developed in the upper reaches of Belfast Lough. These investigations, extending over many years, led to the publication of several papers on points of scientific interest, which were inquired into by Prof. Letts and his students. Perhaps the more interesting of these discuss the relation of the marine alga *Ulva latissima* to the nitrogen content of the water in which it grows. The decay of this seaweed on the foreshores of the Lough was found to be the cause of the nuisance rather than the direct pollution of the water by sewage. At the request of the Royal Commission on Sewage Disposal, Prof. Letts, in collaboration with Dr.

W. E. Adeney, made an extensive survey of the more important estuaries around the British coasts, in order to obtain data on the question of standards for tidal waters in relation to offensive putrefaction and injury to fish. The results of this inquiry, together with much other relevant matter, were published in 1908 as an appendix to the Fifth Report of the Commission, and form a document of first importance, which has become classic in this branch of work. As the recognised authority on estuarine pollution, Prof. Letts took part in many Local Government Board inquiries and legal proceedings connected with his subject.

NOTES.

The following fifteen candidates have been selected by the council of the Royal Society to be recommended for election into the society:—Charles Bolton, Henry C. H. Carpenter, Thomas A. Chapman, Gerald P. L. Conyngham, C. Clifford Dobell, Ernest Gold, Henry B. Guppy, Albert G. Hadcock, Archibald V. Hill, James C. Irvine, Thomas Lewis, Srinivasa Ramanujan, Arthur W. Rogers, Samuel Smiles, and Frank E. Smith.

The meeting of the British Association, which it was hoped would be held in Cardiff this year, has been cancelled. The Local Committee has reluctantly decided that satisfactory arrangements could not be made to ensure success for the meeting, and has sent a resolution to that effect to the council of the association. The council has accepted this view, so that for two years in succession the annual assembly of workers in all departments of science will not take place. Sir Arthur Evans has consented to occupy the office of president for another year, and there will be a statutory meeting in London on July 5 to receive reports of committees and transact other business, but otherwise the corporate life of the association will continue in a state of suspended animation, though there never has been a more favourable time than now to make the nation realise the debt it owes to science for the successful conduct of the war and the need for unceasing scientific activity to prepare for the industrial struggle which the future must bring.

For the last three years the Royal Society of Edinburgh has adopted a new method for electing new fellows. The date of election is the first Monday of March of each year, and all candidates recommended by fellows must have their forms of recommendation sent in before the end of the preceding November. Since this improved method was adopted the general interest in the election has greatly increased, the number of new fellows each year varying from sixteen to twenty-one. At the meeting held on March 4 the following were elected fellows of the society:—D. Ballsillie, F. J. Blight, A. Bremner, J. M. Campbell, A. S. Dodd, T. L. Galloway, W. F. Gray, P. S. Hardie, J. R. L. Kingon, G. J. Lidstone, J. D. McCulloch, W. Mackie, W. P. Paterson, G. W. Tyrrell, C. Whyte, and J. T. Wight.

The King has given orders for the appointment of Surgeon-General Sir Alfred Keogh, G.C.B., to the Order of the Companions of Honour for services in connection with the war.

We regret to see the announcement in the *Morning Post* that Prof. P. Blaserna, Vice-President of the Senate, and professor of experimental physics in the University of Rome, died on February 26, at eighty-two years of age.

Capt. J. C. McWalter, of Dublin, has been awarded the Carmichael prize of the Royal College of Surgeons in Ireland, value 100*l*., for an essay on the state of the medical profession.

The triennial Henry Saxon Snell prize of the Royal Sanitary Institute, consisting of a medal and the sum of fifty guineas, will be awarded this year for an essay on "Suggestions for Improvements in Apparatus and Appliances for Dealing with House Refuse."

The fourth Guthrie Lecture of the Physical Society of London will be delivered at 5 p.m. on Friday, March 22, at the Imperial College of Science, South Kensington, by Prof. J. C. McLennan, of the University of Toronto. The subject will be "The Origin of Spectra."

It is stated in the *Times* that Capt. Roald Amundsen intends to leave Norway this summer in his new Arctic vessel *Maud*, which has been specially built for his attempt to reach the North Pole. The vessel is provisioned and fitted out for a seven years' stay in the ice, but Capt. Amundsen hopes to be back again within four years.

We learn that last year the Imperial Museum of Natural History in Vienna began a new series of publications, the *Denkschriften*, to include larger works needing more extensive illustration than could be attempted in the well-known *Annalen*. The first volume is an important monograph by Dr. G. Schlesinger on the remains of Mastodon in the Vienna Museum, illustrated by thirty-five plates.

The Geological Department of the British Museum (Natural History) has received as a gift from Mr. S. L. Wood two portions of Ichthyosaurus showing the skin and other soft parts, from the Lias of Barrow-on-Soar, Leicestershire. The skin of the paddle seems to have been ornamented with rosettes of dark spots. Among the stomach contents are hooklets from the arms of cuttle-fishes which have been eaten.

The following officers and council of the Geological Society have been elected for the ensuing year:—*President*, G. W. Lamplugh; *Vice-Presidents*, R. M. Deeley, Dr. A. Harker, Prof. W. J. Sollas, and Sir J. J. H. Teall; *Secretaries*, Dr. H. H. Thomas and Dr. H. Lapworth; *Foreign Secretary*, Sir Archibald Geikie; *Treasurer*, Dr. J. V. Elsden; *Other Members of Council*, Dr. C. W. Andrews, Dr. F. A. Bather, Prof. J. Cadman, Dr. A. M. Davies, Prof. E. J. Garwood, J. F. N. Green, Dr. F. L. Kitchin, Major H. G. Lyons, Prof. J. E. Marr, R. D. Oldham, R. H. Rastall, Prof. H. H. Swinnerton, S. H. Warren, and Prof. W. W. Watts.

The officers and members of council of the Institute of Chemistry for the ensuing year have been elected as follows:—*President*, Sir Herbert Jackson; *Vice-Presidents*, H. Ballantyne, W. T. Burgess, C. F. Cross, Sir J. J. Dobbie, Dr. A. Harden, and Sir Robert Robertson; *Hon. Treasurer*, A. G. Salamon; *Members of Council*, E. C. C. Baly, C. O. Bannister, Dr. O. L. Brady, H. C. H. Candy, A. C. Chapman, C. H. Cribb, Dr. J. T. Dunn, E. M. Hawkins, Dr. G. G. Henderson, P. H. Kirkaldy, H. G. Lacell, Dr. A. Lauder, J. H. Lester, F. J. Lloyd, W. Macnab, Prof. G. T. Morgan, D. Northall-Laurie, G. H. Perry, F. M. Potter, W. Rintoul, H. Silvester, G. Stubbs, Dr. J. F. Thorpe, T. Tickle, L. E. Vlies, E. White, and W. M. G. Young.

An extension of the Fourth Northern General Hospital at Lincoln was opened on March 1 by

General Sir William Robertson, who, in the course of an address, pointed out the debt which the Army owes to medical science and skilful nursing. In past campaigns the mortality from sickness and epidemic disease was great, and was accepted as more or less non-preventable; but in the present war, with millions of men engaged in many different theatres of operations, some of them notoriously unhealthy, there has not been a single epidemic of any kind. The achievements of the Medical Service in this war constitute a bright spot on a picture which in many respects can be regarded only with sorrow and sadness.

A VERY important memorandum is issued by the Board of Agriculture and Fisheries as the second interim report of the Fresh-water Fish Committee. It deals with the economic value of the British eel fisheries, and deserves the widest publicity during the coming months. There are enormous runs of elvers in Great Britain and Ireland, so much so that many millions of these fish were formerly exported alive to Germany, for cultivation, from one catching depôt on the Severn. This depôt is now closed, and the Committee suggests that it should be taken over. The eel is the only popular fresh-water fish in these islands which is at the same time potentially highly abundant. The Committee is preparing schemes for intensive cultivation, now and after the war, and suggests the probability of a large export trade in the future. All persons interested in schemes of immediate eel culture should procure this report and advice from the Board of Agriculture and Fisheries (43 Parliament Street, London, S.W.1) or from the Fresh-water Fish Committee. The address of the secretary of the latter is the Hon. A. S. Northcote, 54A Parliament Street, London, S.W.1.

MANY of the accepted ideas regarding the electric arc seem to be undergoing some revision. At the meeting of the Illuminating Engineering Society held on February 26 Lt.-Com. Haydn T. Harrison mentioned several interesting respects in which some of the latest high-candle-power arc searchlights differ from the older and simpler types. In the new lamps the intrinsic brilliancy attained is as much as 250,000–300,000 c.p. per square inch, as compared with 80,000–90,000, which was formerly considered the limit likely to be attained. It was pointed out by Mr. A. P. Trotter so long ago as 1892 that the candle-power in any direction from a flat arc crater can be determined with fair accuracy from Lambert's law, and that the polar curve of light distribution (neglecting the shadow cast by the negative carbon) is approximately a circle. This law is so definite that if photometric measurements, when plotted, yield a different curve it is proof that the source of light is not a plane surface, but convex. In the high-candle-power searchlight lamp developed during the last few years this phenomenon occurs despite the fact that there is a very deep crater. It therefore appears that the gaseous contents of the crater actually boil over, and thus change the plane surface into a convex-shaped source of light.

DR. HUGO DE VRIES, professor of botany in the University of Amsterdam, has just completed his seventieth year. His long connection with the University has been marked by patient and successful investigations on "sporting" among plants, especially in *Oenothera Lamarckiana,* a plant which had become naturalised in Holland. His work with Œnothera began in 1895, and an article upon it appeared in NATURE of November 26, 1908 (vol. lxxix., p. 101), when the Hortus Botanicus at Amsterdam was the subject of a contribution to our series of "Scientific Centres." Out of the work and the experiments that had led up to it the "mutation theory" of evolution originated and developed. Prof. de Vries gave an account of this theory and of his researches in the Masters memorial lectures, which he delivered before the Royal Horticultural Society in 1909 (he was the first Masters memorial lecturer), and his great book, "Die Mutationstheorie," has been ably translated into English by Prof. J. B. Farmer and A. D. Darbishire. The fundamental idea of unit characters upon which the whole argument rests has been at the back of almost all recent research into heredity in plants, and the development of Mendel's work, which had been so long overlooked, was prepared for, and aided not a little by, the researches de Vries made with Œnothera and other plants. This work has had a profound effect upon our outlook towards, and knowledge of, the origin and development of horticultural varieties of plants. In order to mark its appreciation of the great value of this work the council of the Royal Horticultural Society has conferred upon Prof. de Vries one of the Veitch memorial medals—a gold medal awarded only to those whose researches have had, or are likely to have, great influence in the advancement of horticulture.

AN article in *La Nature* for February 16, under the title "Efficacité des Bombardements Terrestres et Aériens," is worthy of note. The writer remarks that the frequency of air raids has caused no little speculation as to the probability of personal danger during such raids. He proceeds to state the manner in which the laws of probability can be applied to estimate the chance of a shell falling at any particular spot near the target when the mean errors in range and direction are known. Turning to the question of bombardment from the air, figures are quoted from the *Aeroplane* giving the chances of a person receiving injury, and calculated on the assumption that a certain definite area surrounding the point of impact of a bomb is dangerous, and that bombs are equally likely to fall at any place in London. The results of these calculations were given in the *Aeroplane* as a table, which *La Nature* reproduces. The chance of danger is given as one in 150,000 in open spaces for each bomb dropped, while in a well-built house the chance is of the order of one in 50,000,000. These figures were based on the casualties during raids over London. One obvious weakness of the argument is that the bombs are not equally likely to fall anywhere, so that the danger is proportionately greater to those living near well-defined targets. The writer in *La Nature,* in applying these figures to Paris, expresses the opinion that the chances of injury are greater in that city than in London. He considers that the protection due to buildings has been over-estimated in the *Aeroplane,* especially if the buildings are not well constructed. The density of buildings is greater in Paris, and the houses are usually higher and more densely peopled. Making allowance for these facts, the French writer considers that the dangers in Paris are about twice as great as in London during an aerial bombardment.

SOME remarks made in the House of Commons on February 21 by Sir Watson Cheyne, dealing with the question of "The Medical Aspect of Flying," or, as it would be more correctly described, "The Physiology of the Airman," have attracted wide attention. While all men of science would doubtless support the institution of a special service to devote attention to the troubles which happen to the airman on account of his ascent to high altitudes, it cannot be too strongly pointed out that the problem is essentially one for the physiologist. Naturally, the airman is liable to the numerous other ailments that beset us all, so that the air medical service requires the inclusion of men with a certain knowledge of these. But the most important aspect by far is a thorough acquaintance with all the various forms of distress induced by deficient supply of oxygen. It would seem to the layman, and apparently to many medical men also, a rather extraordinary thing that something which appears to concern respiration alone should produce vomiting, whereas the excellent work of Dr. J. S. Haldane and his collaborators, and of other physiologists also, has shown beyond question that the multitude of diverse symptoms caused by high altitude are results, simply and solely, of low oxygen tension. Sir Watson Cheyne is scarcely explicit enough here, and his statement that the lungs are primarily affected may easily be misunderstood. What is needed is a regular and periodic testing of the reactions of the airman to reduced oxygen pressure, and this by the accurate methods of the physiological laboratory. The nervous factors referred to by Sir Watson Cheyne require investigation at regular intervals by the expert experimental psychologist. The length of the reaction time is so obviously important that it needs no further reference. The effects on the nerve centres of repeated exposure to deficient oxygen need more experimental investigation. It is, however, satisfactory to find that more attention is being given to the preliminary testing of men destined for the Air Service.

AN editorial article entitled "Gunfire in France, Rainfall in England," by Dr. H. R. Mill, in the February issue of *Symons's Meteorological Magazine*, comprises an analysis of the monthly rainfall returns for the south-eastern and north-western districts of the British Isles for the wet period 1909–17, considered in subdivisions of two three-year peace-periods and one three-year war-period. The rainfall for each month and for both regions is given in percentage of the thirty-five-year average, 1875–1909, the stations utilised being those employed in "British Rainfall," as specially representative of the districts. Without exhibiting the data, it is impossible in the space at our disposal adequately to deal with the salient features of the investigation; suffice it to say that, in Dr. Mill's words, "they bear very strong evidence to the effect that the abnormalities of the rainfall of the war-years are merely the natural development of changes which have certainly been at work for nine years, and in one case no less certainly for fifty years." This last reference is to the increasing dryness of September, shown by Dr. Mill to have been a feature of the climatology of the British Isles during the past half-century, and is, indeed, a matter of common observation. Attention is directed to the noteworthy fact that not one of the four war Septembers has had so much as average rainfall. It is important, moreover, to observe that while 1915 and 1916 had both an excess rainfall of 21 per cent. in south-east England, 1917 (which certainly witnessed no relaxation in the activity of artillery) was a year of nearly normal fall (+4 per cent.). In the same number Mr. F. J. Brodie replies to those who have criticised his treatment in the issue of December, 1917, of the same problem, and incidentally suggests a statistical process by which he considers it might be possible definitely to decide the point at issue.

AT the annual general meeting of the Institute of Chemistry held on March 1, Sir James Dobbie, the retiring president, said that the past three years have afforded unusual opportunities for demonstrating the utility of the institute, and the special services which it has rendered in connection with the war have been widely acknowledged. It has done valuable work in introducing suitable candidates for commissions in his Majesty's Forces where technical knowledge and experience are required, and in providing chemists for Government factories, controlled establishments, and laboratories engaged in war work. Every public department and every branch of the fighting services that requires the aid of the chemist has made use of its services. The institute may fairly claim to have been the chief agent in mobilising the chemists of the country for war purposes. Since the beginning of the war the institute has been unremitting in its efforts to ensure to chemists a supply of pure reagents, glass, and porcelain. The value of the glass research work carried out under its auspices has been recognised on all sides, and investigations originally undertaken for purely chemical purposes have been extended for the benefit of nearly every branch of the glass industry. The attention of the council has been largely devoted to the revision of the regulations for admission to the membership of the institute, with the view of promoting complete organisation of British professional chemists. Sir James Dobbie hopes the institute will undertake to maintain a register for persons engaged in chemistry, but not necessarily qualified for admission as members. Such an organisation would make it possible, when occasion demanded, for the chemists of the country to bring their whole weight and influence to bear on questions of national interest.

WE have lately received from Messrs. Wood Bros. Glass Co., Ltd., Barnsley, a copy of their new catalogue of scientific and laboratory glassware, covering a considerable variety of useful chemical apparatus. When we recollect that three years ago the difficulty of securing supplies of such articles seriously menaced many industries connected with the prosecution of the war, and when we realise the difficulties which had to be overcome to establish this entirely new branch of industry—so far as this country is concerned—we may well congratulate the enterprising manufacturers who have made such a noteworthy endeavour to provide our chemists with these essential requirements. The production of chemical glassware presented many unusual problems for solution. In devising the formulæ for batch mixtures, Messrs. Wood Bros. and other firms have been assisted by the Glass Research Committee of the Institute of Chemistry; but they have had to provide special plant, machinery, and moulds, to determine the conditions of working, as well as to secure the services of workers possessing the necessary technical skill for making many articles of intricate design. With the increasing appreciation of the value of science in industry and the extension of science teaching in our schools, the demand for laboratory glassware is likely to be far greater than it has been in the past, and we hope that every encouragement will be given to the British makers who have achieved such success in spite of the serious obstacles with which they have been confronted. We hope, too, that it is thoroughly recognised by this time that this country must be able to supply its own needs in this direction, and that the industry must therefore be properly protected in order that it may become so well established here that there will be no inclination or necessity to look to other countries to provide us with anything of the kind. We shall look forward to seeing future issues of Messrs. Wood Bros.' catalogue, and anticipate that in the course of the present year the range of production will be substantially extended.

IT is a matter of common experience in the fattening of cattle that the gain in live-weight secured per unit of feed consumed diminishes as the fattening progresses. Of the various causes that may contribute to this result the one that is perhaps most commonly regarded as being mainly responsible is the supposed less efficient utilisation of feed by the fattened as compared with the thin animal, the unit of a resorbed nutrient producing, according to this view, less fat in the latter case, while the heat production of the body should be correspondingly greater. In order to test this view by a direct comparison of the utilisation of feed energy by the same animal in ordinary condition and when well fattened an investigation has been carried out by Messrs. H. P. Armsby and J. A. Fries at the Institute of Animal Nutrition of the Pennsylvania State College, the results of which are published in the *Journal of Agricultural Research*, vol. xi., No. 10. No difference was found in the efficiency of digestion of the food by the animal in lean or fat condition, nor was there any measurable difference in the percentage of the gross energy of the feed which was metabolisable. The heat increment resulting from the consumption of a unit of feed was but little greater, and consequently the net energy value of the feed but slightly less, in the fattened than in the unfattened condition. The increased maintenance requirement of the fattened as compared with the lean steer was greater than corresponded with the increase in weight or in computed body surface. The lower economic efficiency of the fattened animal in this experiment was thus due chiefly to his higher maintenance requirement, and only to a small extent, if at all, to a difference in the utilisation of the surplus of feed above the maintenance requirement.

A NEW instrument for the determination of sea-water densities on board ship is described by Mr. A. L. Thomas in the Journal of the Washington Academy of Sciences for December 19, 1917 (vol. vii., No. 21). It is a modification of the total immersion hydrometer, and consists essentially of a test-tube containing the float, or bobbin, and the liquid to be measured, a stirred variable temperature bath, and a thermometer. The bobbin is about 5 cm. long and 12 mm. in diameter, and is made of Jena glass. The glass test-tube holds 15 to 30 c.c. of the water to be tested. The temperature bath, of copper and glass, holds about 270 c.c. of water, and can be rapidly heated electrically. The method of making a determination depends on noting the precise temperature at which the liquid to be tested is exactly of the same density as the bobbin, which is, of course, when the bobbin neither sinks nor rises. By taking the mean of the readings approaching the equilibrium temperature from a higher and a lower temperature the result may be obtained to 0·05° C. It is claimed that the apparatus is simple and rapid to work, requires a small amount of the water to be tested, and gives accurate results.

IN the paper on "Switchgear Standardisation" which Dr. C. C. Garrard read to the Institution of Electrical Engineers on February 21 many subjects were discussed which are of special interest at the present time. In connection with research, Dr. Garrard pointed out that while the Department of Scientific and Industrial Research expends a few hundred pounds on "switching and arcing," a single Berlin firm had recently expended about a hundred times as much in building a laboratory for the specific purpose of testing oil switches alone. He suggests that the electrical industry and the Government should cooperate for the purpose of providing a national high-tension research and standardising laboratory. We see no reason, however, why existing laboratories should not be utilised in the first place to the fullest possible extent. Several grandiose schemes on a similar scale have been discussed by various committees recently. They all start with the assumption that generous financial support will be given by the Government. In the discussion several speakers pointed out that standardisation has its limitations. It would be foolish, for instance, to standardise devices which are being improved from day to day. Such a procedure would simply mean the placing of an embargo on invention. Mutual co-operation is in every way desirable, but when interests are antagonistic it cannot be obtained. To force private firms to pool their information for the general good would in many cases simply amount to confiscation of capital; it is only human that manufacturers should desire to keep their trade secrets. The question also as to how far it is desirable to make devices "fool-proof" was discussed. The general opinion was that the great series of campaigns originated in America with the cry of "safety first" has now gone too far. To expend ingenuity in making devices "fool-proof" is desirable, but to try to make them absolutely "fool-proof" is in many cases pure waste of time.

FROM the specific gravities of certain substances, that of water at different temperatures, and those of the solutions of these substances in water, Mr. J. N. Rakshit has calculated the contraction of volume resulting when a fixed quantity of each substance is dissolved in increasing quantities of water. The results are tabulated in the Proceedings of the Indian Association for the Cultivation of Science (vol. iii., part iv.), the substances dealt with being hydrochloric, sulphuric, nitric, formic, acetic, and tartaric acids; stannic and sodium chlorides; ammonia, sodium, and potassium hydroxides; methyl, ethyl, propyl, *iso*butyl and *iso*amyl alcohols, glycerol, phenol, dextrose, lævulose, maltose, invert- and cane-sugars, acetone, chloral hydrate, acetonitrile, and nicotine. Study of the figures obtained shows that in some cases the contraction of volume increases with the increase in dilution, but in several others as the dilution increases a point of maximal contraction is observed. The maximum contractions are constants, and different for different substances. In the cases of sodium chloride and of acetic and sulphuric acids the contraction of volume at all dilutions diminishes as the temperature rises. It is not yet known whether this phenomenon is due to differences in the coefficients of expansion of water and of the solute.

A NEW book by Sir Ray Lankester is being brought out by Messrs. Methuen and Co., Ltd., entitled "Secrets of Earth and Sea," in which the following subjects will be dealt with:—The mammoth as drawn by those who lived with it; the "rostro-carinates"—the earliest works of man; Vesuvius in eruption; pond-life; gregarines and malaria; a mere worm (the earth-worm); what is meant by a species; the classification of animals; geological strata; about fishes (flying-fish, climbing-fish, blind-fish, cave-fish, deep-sea fish); the races of man; Darwinism and war; German culture; spider-sense and nonsense; belief and evidence; the Svastika. Other books in Messrs. Methuen's new list are:—"Glossary and Notes on Vertebrate Palæontology," the Rev. S. A. Pelly; "The Fisheries of the North Sea," N. Green; and "Food and Garden," H. A. Day.

CATALOGUE No. 71, just issued by Messrs. Dulau and Co., Ltd., 37 Soho Square, W.1, contains particulars of books and papers from the library of the late Dr. A. M. W. Downing, and other sources. It refers in the main to works on astronomy and astrophysics, but also gives the titles of books relating to engineering, geology, and mathematics.

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OUR ASTRONOMICAL COLUMN.

ENCKE'S COMET AND OTHERS.—Encke's comet was observed by Mr. R. Jonckheere at Greenwich Observatory on March 1. It appeared as a large diffused nebulosity of magnitude $8\frac{1}{2}$, without visible nucleus or tail. The position accorded well with the ephemeris lately given in NATURE. The brightness is now increasing, but the comet is drawing too near the sun for convenient observation.

A very interesting object, in appearance resembling a minor planet, but with an orbit of a cometary character, has been discovered by Prof. Wolf at Heidelberg. The following positions have been received:—

G.M.T. 1918				Appt. R.A.			Appt. N. Decl.			Place
	d.	h.	m.	h.	m.	s.	°	′	″	
Jan.	3	9	40·0	5	16	30	12	29	0	Heidelberg.
Feb.	5	8	37·5	6	56	9·47	34	19	19	,,
	11	18	28·1	7	17	43·22	35	55	21	Lick Obs.

The magnitude was 11 on January 3; 11·5 on February 3. The distance from the earth was about twenty-three million miles. The orbit appears to be a highly eccentric ellipse, with perihelion slightly outside the earth's orbit. The object will be below the 12th magnitude in March, so will only be observable by photography. Prof. Wolf announced a satellite of the 14th magnitude at a distance of 340″, moving through 13° per hour. It is impossible that the object could be massive enough to control a satellite at that distance, with such rapid motion, so it was probably a faint minor planet that happened to pass in the same line of sight.

Mr. Knut Lundmark, of Upsala Observatory, has deduced the following definitive orbit of the comet of 1802 (Pons) (*Arkiv för Matematik, Astronomi och Fysik*, Bd. 12, No. 13). It was under observation from August 25 to October 6 last.

$$\begin{array}{ll} T & 1802 \text{ Sept. } 9{\cdot}8619 \text{ Paris M.T.} \\ \left.\begin{array}{ll} \omega & 21^\circ\ 52'\ 7'' \\ \Omega & 310^\circ\ 14'\ 18'' \\ i & 56^\circ\ 59'\ 30'' \end{array}\right\} & 1802{\cdot}0 \\ \log q & 0{\cdot}0391162 \end{array}$$

A list is given of other comets with somewhat similar elements, including comet 1909 I. In no case, however, is identity probable.

NEBULOSITY ABOUT NOVA PERSEI (1901).—Photographs taken with the 60-in. reflector at Mt. Wilson have shown very clearly the nebulosity surrounding Nova Persei, which was discovered by Barnard in December, 1916 (Journ. R.A.S. Canada, vol. xii., p. 25). The strongest condensations are south preceding the nova, and give a fan-shaped appearance to the nebulosity on that side, somewhat resembling that which accompanied the original outburst. A negative taken by Mr. Ritchey on December 16, 1917, shows, in addition, a sharply defined continuous ring of nebulosity about 16″ in diameter, with the nova at its centre. If this ring be the result of the sudden increase in brightness of the nova ($1\frac{1}{2}$ magnitudes) reported by Belopolsky in August last year, it may be analogous to the expanding rings observed in 1901–2, but on a much smaller scale.

THE EGYPTIAN GOVERNMENT ALMANAC.—Owing to shortage of paper, the Egyptian almanac for 1918 has been issued in the form of a pamphlet, which is to be regarded as a supplement to the 1917 edition. The two pages assigned to each month give the Julian, Arabic, Coptic, and Jewish dates; fasts, festivals, and remarkable days; the times of rising and setting of the sun and moon at Cairo: and particulars of the phases of the moon and the visibility of the planets. The publication will doubtless be a great convenience to those for whom it is intended.

SIR ALFRED KEOGH AND THE ARMY MEDICAL SERVICES.

THE reception held at the Imperial College of Science and Technology on February 27, to welcome Sir Alfred Keogh back to the college of which he is rector, was entirely a domestic function. But the occasion made it, as Lord Crewe, who presided, said, a red-letter day in the history of the college. For three and a half years Sir Alfred Keogh, in response to Lord Kitchener's request, has refilled his former post of Director-General, and succeeded in getting this all-important Department into such working order that he is able to hand it over with safety to another; and the Imperial College has its rector back again. At this reception speeches were made by Lord Crewe, by Mr. Acland, and by Prof. Farmer, but by far the most important address was that made by the rector himself. One passage of this is of supreme importance, not only as embodying the result of his long and wonderful experience, but also as indicating the principles which have guided him in the work of the great Department over which he presided with such distinction and with such notable advantage to his country; it is, moreover, a writing on the wall for the admonition and guidance not only of the Army Medical Department, but also of all other departments. The rector said:—

"I hold, and always have held, that in this country, and perhaps in this country alone, administration has been absolutely divorced from science, that the administrator, as a rule, is ignorant of any particular branch of science, that he has had, as a rule, no scientific training, and neither thinks nor acts scientifically. I attribute many of our national shortcomings to this fact. If I have accomplished those things which you say I have in my official service, it has been because I have, from the first, both in matters of science and of administration, relied entirely upon scientific men, and have refused to take into my counsels other classes of administrators. To have done so would have been to have given the lie to the principles I have held for so many years."

It is devoutly to be hoped that these piercing words will not fall entirely upon stony ground, but that they will sink deeply into the nation's mind. Sir Alfred Keogh is, like all really great men, an artist, and is therefore possessed of imagination—one of the rarest of gifts; and, although in these words of his he modestly speaks of relying upon men of science, he has in him that scientific spirit which can guide and control the imagination or creative spirit. It is this union of imagination with the scientific spirit, coupled with his belief in the value of science, which has been the secret of Sir Alfred Keogh's notable success in the creation and direction of the Army Medical Services; for the R.A.M.C. of to-day is a new creation. The idea of bringing science to bear practically on such an unpromising thing as the military medicine and surgery of fifty years ago was a very bold conception, the value of which is now apparent to the lay mind through the publication of the numbers of cases of disease in this campaign as compared with any that have gone before.

It is worth while at the present moment to recall a few of the advances made by Sir Alfred Keogh; the real, detailed history of the steps will have to be written later. During the South African War he was placed upon the Committee for the Reorganisation of the Army Medical Service, which was created by Mr. Brodrick, and he afterwards became Deputy-Director-General and later Director-General. One of his early feats, of a more or less ethical kind, was the adjustment of the proper relations between the doctor of the regiment and its commanding officer, which altered the status of the doctor and placed responsibility in the right place. No advance was possible until this readjustment had taken place. He was associated with the scheme for the formation of the Advisory Board, consisting of military men and of civil and military medical men, upon a much broader basis than the system which the Board displaced. At this time there was an Army Medical School at Netley, where certain things only could be learnt, but there was no place where a man could go in order to brighten up rusty or deficient knowledge, or to learn what was new in medicine or surgery since he qualified. A scheme was then in progress, and money had been voted for the purpose of enlarging Netley, but Sir Alfred Keogh saw at once that such a place ought to be in London, and at his instigation the Netley extension was stopped and the Netley school boldly brought to London. At first it was housed temporarily in the laboratories of the Colleges of Physicians and Surgeons, but he saw that, as the Millbank Military Hospital was being built, the right place for his school would be near to it, and so the Royal Army Medical College was built with all the necessary arrangements for post-graduate teaching and training and for research work, and with facilities for acquiring new knowledge in any branch. Sir Alfred Keogh was also the first Director-General to encourage research among the better men of the R.A.M.C., and it was through his influence that such men as the late Major Fry and Capt. Ranken, V.C., were encouraged and permitted to undertake research work for the Royal Society, with results sufficient to justify publication in the Proceedings of the Royal Society.

When Sir Alfred Keogh became Deputy-Director-General there was no special sanitary service in the Army, and the knowledge of sanitation and hygiene, and of all that these words connote, which was possessed by the doctors was of the most elementary kind. He saw that if this were not rectified there would be a terrible and unnecessary loss of life in the next war, and he set himself to draw up a scheme by which a special branch of the Army Medical Service, devoted to sanitary science, should be created. He also insisted that the principles of sanitary science should be taught to the military students as a part of their ordinary course, as well as to the members of the R.A.M.C., and even to the combatant officers; a School of Army Sanitation was founded, and directors of Medical Sanitary Service were provided for the armies in the field, and a sanitary officer was placed on the staff of each command. This scheme had to wait years for its realisation, and it is to the credit of Lord Haldane that it was owing to his initiative and support that it became law. It is the application of science to sanitation which has helped in a very great measure to reduce the incidence of disease in the present war to the remarkable figures which have been published. Bound up with this is the question of water supply to the troops, and a branch of the Medical Service has had special instruction in the examination and disinfection of water, thus ensuring a safe and wholesome supply. Sir Alfred Keogh also initiated and superintended a long series of experiments on the kind and quantity of food necessary for soldiers, and as the result a system of food-rationing was arrived at which has, with but few modifications, borne the very severe test of the present war. His attitude towards vaccine therapy shows the same scientific perception. In the South African War many accidents happened owing to our incomplete knowledge of the subject, so he appointed a committee of experts, presided over by Sir W. Leishman, who wrote, as the result of the inquiry, the historical paper which has been the foundation of our present effective and safe methods.

In all these ways Sir Alfred Keogh prepared the way for the extraordinary results which have followed our treatment of typhoid fever and other diseases by vaccines in the present war; and during the war he has also exercised the same vigilant control by attacking two other diseases in the same scientific spirit—namely, tetanus and trench fever. Tetanus is a rare disease in peace-time, but during the war such numbers of cases occurred that he decided to form a committee for the *study* of this disease, which, as a result of its researches, would be able to advise as to better methods of treatment, and this has been followed with the best results. He has also formed a committee for the study of the problems of trench fever, which has already achieved important results. In both these cases, besides practical results, our scientific knowledge of the disease has been advanced: he has therefore, in all these instances, helped towards making medicine the possibly scientific pursuit which it is always becoming.

In addition, Sir Alfred Keogh had for two and a half years the direction of the work on poison gas and gas attacks, which work has been of no small advantage to us. But it is rather in the greater work of saving life that his devotion will be remembered, and the country can never forget what it owes to him in this respect. To have reduced disease to a minimum, so that men are more healthy in the field than at home; to have organised a medical service sufficient for our enormous Army, scattered all over the world; to have devised and insisted upon methods of sanitation which have borne the strain of most difficult conditions; to have encouraged and insisted upon research, even during the war, into diseases which have become prominent and about which we know little, forms a record which no mere words can appraise. It is not only that he has done these things, but also that he has done them in the face of great opposition, from both the military and the medical side. His power of imagination, however, controlled by the scientific spirit, has enabled him not only to overcome all the difficulties he has had to face, but also to hand over to another a living machine, which he knows will still act with the spirit he has infused into it, and be capable of answering any calls that may be made upon it.

It is not possible here to speak of Sir Alfred Keogh's work at the Imperial College of Science. There is no doubt that the college has caught something of his spirit, for it has given all its energies in every department to the service of its country, as Sir Alfred Keogh himself did.

His example will live; let us hope that his words, quoted above, may not be forgotten; may they be, as the Preacher said the words of the wise were, "as goads and as nails driven deep in." H. G. P.

THE DEPARTMENTAL REPORT ON SALARIES IN ELEMENTARY SCHOOLS.

IN view of the important changes that are foreshadowed in the sphere of education in the Bill now before Parliament, the question of a due supply of efficient teachers, especially for the elementary schools, assumes an aspect of high importance. We therefore welcome the carefully considered report, just issued, of the Departmental Committee for inquiring into the principles which determine the construction of scales of salary for teachers in elementary schools (Cd. 8939, price 6*d.* net).

The Committee, of which Sir Harry Stephen was chairman, was comprised of representatives of the various interests concerned—administrative and educational—and it received, either personally or by memorandum, the evidence of fifty-six witnesses representative of all shades of opinion and conditions of experience, with the result that a report of sixty-three folio pages of high value has been prepared, which will do much to enhance the position of the teacher. "For many years past," the report states, "it has not been possible to secure recruits in numbers adequate to the needs of the schools." The position will obviously be seriously aggravated should Mr. Fisher's Bill become law, and the children be required to remain at school until fourteen, and continued education be imposed within the usual hours of labour until the age of eighteen is reached. Not only will a much larger number of teachers be required, but also teachers of higher qualifications.

Already there are in the elementary schools 167,810 teachers of all grades, of whom 43,500 are men and 124,310 are women. Of this number 109,250 are trained certificated teachers. There is a constant pressure to induce a still larger number of teachers to go through a course of two or more years of college training with the view of securing either a certificate or a degree, which means that the future teacher will be at least twenty-one or twenty-two years of age before remunerative employment begins, and that on a scale not higher than that of an ordinary artisan.

It will be seen from the above figures how large a proportion of the elementary-school teachers are women, and yet it is clear that, at least for the older boy pupils, it is most desirable that their teachers should be men. The question of a more abundant recruitment is of vital moment, and its solution lies not merely in the establishment of a higher scale of salaries and an adequate pension scheme, but also in better prospects for the more able of the teachers, so that not only should head-teacherships be open to them, the average salary of which in England and Wales is about 176*l.* for men and 126*l.* for women, but also inspectorships and administrative posts with the central and local authorities.

It cannot be expected that men trained side by side in the same university with prospective lawyers, doctors, divines, men of science, and technologists in industry and commerce seeking degrees of equivalent standing will be content with the poor rewards the profession of teaching in the elementary schools offers to able men. If the nation desires that its children shall have a prolonged and satisfactory education in well-equipped schools, and also the best possible training at the hands of capable teachers, there is no course open to it but to pay the price for this essential service, and the reward of the nation will be great.

The report, in its interesting analyses and tables, exhibits an astonishing variety of scales of payments and of increments prevailing in the various areas, urban and rural, of England and Wales, but only in few cases can they be said to be liberal or attractive. There needs to be more uniformity than at present exists in the salaries of teachers, and where the produce of a 1*d.* rate per child is low, then it would appear desirable that the central authority, in order that the teacher may not suffer, should give the necessary financial assistance. Based upon the minimum initial salary which the President of the Board of Education stated that he had in mind, namely, 100*l.* for men and 90*l.* for women, the report offers, by way of illustration, five separate scales, according to the varying circumstances of urban and rural areas, for men and women certificated class teachers, ranging from 100*l.* and 90*l.* respectively to 300*l.* and 240*l.*, the maximum varying according to the conditions of the area, and for head-teacherships a like set of illustrative scales, rising to 400*l.* in the case of men and to 300*l.* in that of women, the maximum again to be determined by local conditions.

The principles insisted on in the report are that there should be a reasonable initial payment, and a scale of increment leading to a point representing an adequate salary; that this should be receivable as a matter of right, and as part of the contract, by every teacher whose service is not characterised by definite default or wilful neglect; and that, in order that the increment should be so adjusted as to meet the teachers' needs, the value of the teachers' services should be periodically recognised, so that good service may be encouraged. With respect to the payment of women teachers, the report states that in the opinion of the Committee the scale of salaries adequate for women is inadequate for men, and that in average circumstances the maximum for women should be three-fourths that for men, and finally suggests that the best method of recognising superior merit in teachers is by advancement to positions of greater responsibility and increased emolument, even if it means a departure from the normal scale.

The report is accompanied by a valuable memorandum, drawn up by its secretaries, giving a retrospect of methods and scales of payment since the Act of 1870, and a clear account, illustrated by elaborate comparative tables, of the common features of existing scales in various parts of the country.

METEOROLOGY AND EXACT THERMOMETRY.

IN the *Monthly Weather Review* for November, 1917, Prof. C. F. Marvin, Chief of the U.S. Weather Bureau, asks for a short word and corresponding symbol for the temperature on the hydrogen- or adjusted mercury-scale of Centigrade degrees measured from 273° C. below the normal freezing point of water in place of the word *absolute*. As he rightly points out, the use of the word in that sense is loose scientific language, because, to those who know, it means not quite the same thing as the absolute thermodynamic scale or true Kelvin scale.

Prof. Marvin's own suggestions for a descriptive name are *quasi-absolute, approximate absolute,* and *pseudo-absolute*, not one of which is likely to appeal to the general reader as the *mot juste*. The question is one of practical importance, because our own Meteorological Office uses the approximate absolute scale in many of its publications for expressing temperatures, together with the millibar scale for pressure, notably in its recent issue of data for the whole world with the title of *Réseau Mondial*. It has discarded the use of the degree sign for temperature and uses a small **a** immediately after the numeric, thus placing temperature on the same footing as an ordinary physical quantity like mass or length.

The practice of using absolute c.g.s. units for pressure and the approximate absolute scale for temperature dates from 1909 with the regular publication of data of the upper air in the *Weekly Weather Report*, and afterwards in the *Geophysical Journal*, the only change being the adoption of the millibar instead of the megadyne per square centimetre in 1914, a practice against which Prof. McAdie, of Harvard University, has raised protests on the ground that chemists had already assigned another meaning to the word *bar*. In the same year the U.S. Weather Bureau commenced the issue of a daily map of the northern hemisphere in the same units. The millibar was adopted in France for the *Bulletin International* in 1917.

The history of scientific progress justifies some looseness in the use of language. For example, the "boiling point of water" as a thermometric fixed point, like the "absolute" scale of temperature, is a loose expression, only understood by those who know; and unless some looseness be permitted the measurement of the "specific heat of copper" would have to disappear from the elementary course. With the two exceptions mentioned, the adoption of "absolute" units for atmospheric measurements, which was not "made in Germany," has been received with profound indifference in scientific circles. But the whole question of units and their nomenclature is of great importance to us at this juncture. Our practice of using one set of units in the laboratory and another set in practical life can only be described as stupid. Although the particular point raised is not a crucial one, it is much to be desired that Prof. Marvin's note may be the beginning of the serious consideration of this important subject by the exponents of the physical sciences.

GRAVITATION AND THE PRINCIPLE OF RELATIVITY.[1]

Principle of

THERE were many difficulties to encounter in entering the room just now. To begin with, we had to bear the crushing load of the atmosphere, amounting to 14 lb. on every square inch. At each step forwards it was necessary to tread gingerly on a piece of ground moving at the rate of twenty miles a second on its way round the sun. We were poised precariously on a globe, apparently hanging by our feet, head outwards into space. And this acrobatic feat was performed in the face of a tremendous wind of æther, blowing at I do not know how many miles a second literally through us. We do not claim much credit for overcoming these difficulties—because we never noticed them. But I venture to remind you of them, because I am about to speak of some other extraordinary things that may be happening to us of which we are quite unconscious.

Not to go too far back in history, the present subject arises from a famous experiment performed in the year 1887, known as the Michelson-Morley experiment. The apparatus was elaborate, but the principle of the experiment is not very difficult. If you are in a river, which will be the quicker—to swim to a point fifty yards up stream and back again, or to a point fifty yards across stream and back again? Mathematically the answer is, perhaps, not immediately obvious, because the net effect of the current is a delay in both cases. But I think that anyone who has swum in a river will have no hesitation about the answer. The up-and-down journey takes longer. Now we *are* in a river—of æther. There is a swift current of æther flowing through this room; or, if we happen to be at rest in the æther at the present moment, six months hence the earth's orbital motion will be reversed, and then there must be a swift current. Michelson divided a beam of light into two parts; he sent one half swimming up the stream of æther for a certain distance, and then by a mirror back to the starting point; he sent the other half an equal distance (as he thought) across the stream and back. It was a race; and with his apparatus he could test very accurately which part got back first. To his surprise, it was a dead-heat. Clearly the two paths could not really have been equal, the along-stream path must have been a little shorter to compensate for the greater hindrance of the current. That objection was foreseen, and the apparatus, which was mounted on a stone pier floating in mercury, was rotated through a right angle, so that the arm which was formerly along the stream was now across the stream, and *vice versa*. Again the two portions of the beam arrived at the same moment; so this time the other arm had become the shorter—simply by altering its position. In fact, these supposedly rigid arms had contracted when placed in the up-and-down stream position by just the amount necessary to conceal the effect which was looked for.

That is the plain meaning of the experiment; but we might well hesitate to accept this straightforward interpretation, and try to evade it in some way, were it not for some theoretical discoveries made later. It has gradually appeared that matter is of an electrical nature, and the forces of cohesion between the particles, which give a solid its rigidity, are electrical forces. Larmor and Lorentz discovered that this property of contraction in the direction of the æther current was something actually inherent in the formulæ for electrical forces written down by Maxwell many years earlier and universally adopted; it only waited for some mathematician to recognise it. It would be going too far to say that Maxwell's equations actually prove that contraction must take place; but they are, as it were, designed to fall in line with the contraction phenomenon, and certain details left vague by Maxwell have since been found to correspond.

We are then faced with the result that a material body experiences a contraction in the direction of its motion through the æther. According both to theory and experiment the contraction is the same for all kinds of matter—a universal property. One reservation should be made; the experiment has only been tried with solids of laboratory dimensions, which are held together by *cohesion*. There is at present no experimental evidence that a body such as the earth the form of which is determined by *gravitation* will suffer the same contraction; we shall, however, assume that the contraction takes place in this case also.

I am going to ask you to suppose that we in this room are travelling through the æther at the rate of 161,000 miles a second, vertically upwards. Let us be bolder and say that that *is* our velocity through the æther—because no one will be able to contradict us. No experiment yet tried can detect or disprove that motion; because all such experiments give a null result, as the Michelson-Morley experiment did. With that speed the contraction is just one-half. This pointer, which I hold horizontally, is 8 ft. long. Now [turning it vertically] it is 4 ft. long. But, you may say, it is taller than I am, and I must be approaching 6 ft. No, if I lay down on the floor I should be, but as I am standing now I am under 3 ft. The contraction affects me just as it did the pointer. It is no use bringing a standard yard-measure to measure me, because that also will contract and represent only half a yard. "But we saw that the pointer did not change length when it turned." How did you tell that? What you perceived was an image of the pointer on the retina of your eye, and you thought the image occupied the same space of retina in both positions; but your retina has also contracted in the vertical direction without your knowing it, so that your estimates of length in that direction are double what they should be. And similarly with every test you could apply. If everything undergoes the same change, it is just as though there were no change at all.

We thus get a glimpse of what, from our present point of view, must be called the *real* world, strangely different from the world of appearance. In the real world, by changing position you extend yourself like a telescope; and the stoutest individual may regain slimness of figure by an appropriate orientation. It must be something like what we see in a distorting mirror; and you can almost see a living-picture of this real world reflected in a polished door-knob.

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[1] Discourse delivered at the Royal Institution on Friday, February 1, by Prof. A. S. Eddington, F.R.S.

If our speed through the æther happens not to be so great as we have supposed, the contraction is smaller; but it escapes notice in our practical life, not because it is small, but because from its very nature it is undetectable. And because this real world is undetectable we do not as a rule attempt to describe it. Not merely in everyday life, but in scientific measurements also, we describe the world of appearance. We do this by imagining natural objects to be placed, not in the absolute space, but in a quite different framework of our own contriving—a space which corresponds with appearance. In the space of appearance a rod does not seem to change length when its direction is altered; and we use that property to block out our conventional space, counting the length occupied by the standard yard-measure as always a yard however its true length may vary. It is found also that in like manner our time is a special time of our own, different from the time we should adopt if our motion through the æther were *nil*. This is a perfectly right procedure; it introduces no scientific inexactness, and it is more in accordance with the ordinary meaning attached to space and time; the only thing to remember is that this space and time framework is something peculiar to us, defined by our motion, and it has not the metaphysical property of absoluteness, which we have often unconsciously attributed to it.

Now let us visit for a moment the star Arcturus, which is moving relatively to us with a velocity of more than 200 miles per second. Consequently its motion through the æther is different from ours, and the contraction of objects on it will be different. It follows that our conventional space would not be suitable for Arcturus, because it was specially chosen to eliminate our own contraction effects. There is a different space and a different time proper to Arcturus. We must then imagine each star carrying its own appropriate space and time according to its motion through the æther. The space and time of one star will not fit the experience of individuals on another star.

The exact relation between the appropriate space and time of one star and the space and time of another was first brought out clearly by Minkowski; it is a very remarkable one. We recognise three dimensions of space, which we may take as up-and-down, right-and-left, backwards-and-forwards. If we go over to Ireland we still have the same space, but Ireland's up-and-down no longer corresponds with ours. The directions are inclined; and what is vertical to them is partly vertical and partly horizontal to us. Now let us add a fourth dimension, imaginary[2] time, at right angles to the other three. There is no room for it in the model, but we must do our best to imagine it in four dimensions. In Ireland the three space-dimensions will have rotated, as I have said; but the time will be just the same. But if we go to Arcturus, or to any body moving with a velocity different from our own, the time-dimension also has rotated. What is time to them is partly time and partly imaginary space to us. It is a change in the space-time world of four dimensions just analogous to the change in the space-world between here and Ireland. That is Minkowski's great result; space-time is the same universally, but the orientation—the resolution into space and time separately—depends on the motion of the individual experiencing it, just as the resolution of space into horizontal and vertical depends on his situation. In Minkowski's own famous words—"Henceforth Space and Time in themselves vanish to shadows, and only a kind of union of the two preserves an independent existence."

From our original point of view it seems very remarkable that in the Michelson-Morley experiment the contraction should have been of just the right amount to annul the expected effect of our motion through the æther. Many other experiments, which seemed likely to show such an effect, have been tried since then, but in all of them the same kind of compensation takes place. It looks as though all the forces of Nature had entered on a conspiracy together with the one design of preventing us from measuring or even detecting our motion through the æther. It is still an open question whether one force, the force of gravitation, has joined the conspiracy. Hitherto gravitation has stood aloof from all the other interrelated phenomena in majestic isolation. We have become almost reconciled to leaving it outside every physical theory. A new model of the atom is put forward which accounts for a whole host of abstruse and recently discovered properties; but it would be considered unfair to suggest that it ought to account for the simple and universal property of gravitation. Dare we think that gravitation has so far forgotten its dignity as to join this conspiracy? There is certainly not enough evidence for a jury to convict; but yet I think we shall have to intern it on suspicion. Recently Sir Oliver Lodge, believing that gravitation was innocent of the conspiracy, showed that a very famous astronomical discordance in the motion of Mercury might be an effect due to the sun's motion through the æther, and might afford a means of estimating its speed. It is difficult in a brief reference to deal quite fairly with an intricate question, but it seems now that we should rather lay stress, not on this single discordance, which can perhaps be otherwise explained, but on the exact agreement of Venus and the earth with theory; for they also should show evidence of the sun's motion through the æther if gravitation had not joined in the conspiracy to conceal all such effects. It may be that the effects on Venus and the earth are not found because the sun's motion through the æther happens to be very small; but on the whole it appears more likely that the effect of the motion is null, just as in the Michelson-Morley experiment, because there is a complete compensation in the law of gravitation itself.

The great advantage of Minkowski's point of view is that it gets rid of all idea of a conspiracy. You cannot have a conspiracy of concealment when there is nothing to conceal. We cut Minkowski's space-time world in a certain direction, so as to give us separately space and time as they appear to us. We have been imagining that there exists some direction which would separate it into a real and absolute space and time. But why should there be? Why should one direction in this space-time world be more fundamental than any other? We do not attempt to cut the space-world in a particular direction so as to give us the *real* horizontal and vertical. The words "horizontal" and "vertical" have no meaning except in reference to a particular spot on the earth. So for a particular observer the space-time world falls apart into its four components, up-and-down, right-and-left, backwards-and-forwards, sooner-and-later; but no observer can say that this division is the one and only real one.

Our idea of a real space more fundamental than our own was, however, not entirely metaphysical; we had materialised it by filling it with an æther supposed to be at rest in it. We now deny the existence of any unique framework of that kind. We have failed to obtain experimental knowledge of such a framework since we cannot detect our motion relative to it. Whatever may be the nature of the æther, it is devoid of those material properties which could constitute it a

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[2] Imaginary in the mathematical sense, *i.e.* involving $\sqrt{-1}$. It is much simpler to consider imaginary time; and throughout the lecture I have ventured to omit reference to the complications which arise when our results are restated in terms of real time.

framework of reference in space. We can perhaps best picture the æther as a four-dimensional fluid filling uniformly Minkowski's space-time *continuum*, not as a material three-dimensional fluid occupying space and time independently.

The position we have now reached is known as the principle of relativity. In so far as it is a physical theory, it seems to be amply confirmed by numerous experiments (except in regard to gravitation). In so far as it is a philosophical theory, it is no more than a legitimate and useful point of view. I now pass on to a generalised principle of relativity, in which we must be content at first to be guided by a natural generalisation of these results, hoping later to be able to check our tentative conclusions by experiment.

If we analyse any scientific observation, distinguishing between what we perceive and what we merely infer, it always resolves itself into a *coincidence* in space and time. A physicist states that he has observed that the current through his coil is 5 milliamperes; but what he actually saw was that the image of a wire thrown by his galvanometer *coincided* with a certain division on a scale. He measures the temperature of a liquid, but the observation is the *coincidence* of the top of the mercury with a division on the thermometer. If then we had to sum up the whole of our experimental knowledge, we should have to describe it as consisting of a large number of coincidences.

A complete history of the progress of a particle consists of a knowledge of its path and the time at which it occupied each point of the path. The time may be regarded as an extra co-ordinate corresponding with a fourth dimension, and so the whole history may be summed up by a line in four dimensions representing the particle's progress through space and time. We call this four-dimensional line the *world-line* of the particle. Imagine that we have drawn the world-lines of all the particles, light-waves, etc., in the universe: we shall then have a complete history of the universe. It will be a rather dull history-book; the Venus of Milo will be represented by an elaborate schedule of measurements, and Mona Lisa by a mathematical specification of the distribution of paint; still they are there, if only we can recognise them. I have here a history of the universe—or part of it. Unfortunately I was not able to draw it in four dimensions, and even three dimensions presented difficulties, so I have drawn the world-lines in two dimensions on the surface of a football bladder.

A great deal is shown here which, properly speaking, is not history at all, because it is necessarily outside experience. As we have seen, it is only coincidences—the intersections of the world-lines—that constitute observational knowledge; and, moreover, it is not the place of intersection, but the fact of intersection that we observe. I am afraid the two-dimensional model does not give a proper idea of this, because in two dimensions any two lines are almost bound to meet sooner or later; but in three dimensions, and still more in four dimensions, two lines can, and usually do, miss one another altogether, and the observation that they do meet is a genuine addition to knowledge.

When I squeeze the bladder the world-lines are bent about in different ways. But I have not altered the history of the universe, because no intersection is created or destroyed, and so no observable event is altered. The deformed bladder is just as true a history of Nature as the undeformed bladder. The bladder represents Minkowski's space-time world, in which the world-lines were drawn; so we can squeeze Minkowski's world in any way without altering the course of events. We do not usually use the common word "squeeze"; we call it a *mathematical transformation*, but it means the same thing.

The laws of Nature in their most general form must describe correctly the behaviour of the world-lines in either the undistorted or the distorted model, because it is indifferent which we take as the true representation of the course of Nature. That is a very important principle; but, being almost a truism, it does not in itself help us to determine the laws of Nature without making some additional hypothesis. There is one law—the law of gravitation—which especially attracts our attention at this point, and we shall look into it more closely.

We know that one particle attracts another particle, and so influences the history of its motion. This evidently means that one world-line will deflect any other world-line in its neighbourhood. Apart from this influence, the world-line runs straight, bending neither to the right nor to the left, provided the bladder is in its undistorted state, *i.e.* provided we use Minkowski's original space-time. That is not so much a matter of observation as of definition. It defines what we are to regard as the undistorted state, though it is by observation that we learn that it is possible to find a space-time in which the world-lines run straight when undisturbed by gravitational or other forces. I must own that there is a certain logical difficulty in saying that a world-line runs straight when there are no others near it; because in that case there could be no intersections, and we could learn nothing about its course by observation. However, that is not a serious difficulty, though you may be reminded of the sage remark, "If there were no matter in the universe, the law of gravitation would fall to the ground."

(*To be continued.*)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE *Times* announces that Senator Dennis has given 12,000*l.* to Dalhousie University for a chair of political science in memory of his son, Capt. Eric Dennis, who was killed at Vimy Ridge; and that Major E. A. de Rothschild, who died at Cairo from wounds on November 17, aged thirty-one, has left the sum of 5000*l.* to Harrow School for a scholarship, the conditions of which are to be approved by his brother Anthony.

THE Department of Agriculture and Technical Instruction for Ireland has issued its programme of summer courses of instruction for teachers to be held this year. The courses will, with the exception of the courses of instruction in rural science (including school gardening) for National School teachers, begin on July 2, and close on July 26. The courses in rural science (including school gardening) will begin on August 6, and close on August 30. Teachers who attend the courses regularly will be allowed a sum of 3*l.* 10*s.* towards their expenses while living at the centre, and third-class railway fare for one return journey from the railway station nearest their school or centre. Among the subjects in which courses have been arranged are the chemistry of engineering materials, technology for teachers, experimental science, domestic science, and rural science. The courses are open only to those who are above twenty years of age, and, except in certain cases, only to teachers who are engaged (*a*) by local committees of technical instruction, or (*b*) in schools receiving grants either directly from the Department or under the provisions of an approved local scheme of technical instruction.

THE annual report of University College, London, shows that whereas in normal times the total number of students, day and evening, amounts to about 2200, the number last session was 1240. This number included 121 members of H.M. Naval and Military Forces, for whom special courses were provided, and 159 who attended special vacation courses, so that the actual number of ordinary students was 960, of whom 547 were women. The report points out that, while the normal fee revenue amounts to between 29,000*l.* and 30,000*l.* a year, the fee revenue last year was only 14,000*l.* Economies of every kind have been introduced, and all expenditure possible has been deferred. It is anticipated that, unless further help from the Treasury is forthcoming, there will be a deficit at the end of the current session of nearly 9000*l.* on the college establishment account. While the ordinary activities of the college have been maintained, all available energies have been directed towards war purposes, of which the report gives some account. Among the important developments of the year may be noted the admission of women to the faculty of medical sciences, the reorganisation of the department of Italian, the institution of a department of Scandinavian studies, and a movement for the institution of a department of Dutch studies. The *pro patria* list includes about 2500 names of past and present members of the college who are taking an active part in one or other of the Services connected with the war. Of these no fewer than 195 have already fallen. The list of honours and distinctions gained in the war is a long one.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 21.—Sir J. J. Thomson, president, in the chair.—Lord **Rayleigh**: The scattering of light by spherical shells, and by complete spheres of periodic structure, when the refractivity is small. The problem of a small sphere of uniform optical quality has been treated in several papers. In general, the calculations can be carried to an arithmetical conclusion only when the circumference of the sphere does not exceed a few wave-lengths. But when the relative refractivity is small enough, this restriction can be dispensed with, and a general result formulated. In the present paper some former results are quoted, but the investigation is now by an improved method. It commences with the case of an infinitely thin spherical *shell* from which the result for the complete uniform sphere is derived by integration. Afterwards application is made to a complete sphere of which the structure is symmetrical, but periodically variable along the radius, a problem of interest in connection with the colours, changing with the angle, often met with in the organic world.—Sir Joseph **Larmor**: The nature of heat as directly deducible from the postulate of Carnot. The germinal idea which developed, in the mind of Sadi Carnot in 1824, into the dynamical theory of heat was that heat can give rise to motive power only in the process of carrying through its effort towards an equilibrium. A proof is now offered that Carnot's principle regarding heat-engines follows from this basic idea by itself alone, without requiring the introduction of any hypothesis as to the physical nature of heat. It then further follows, from applying the same Carnot formula both to direct and to reversed working, that a scale of measurement of heat can be assigned, *i.e.* an ideal calorimetric substance can be chosen, so that the heat which disappears shall be the equivalent of the motive power that is gained, and conversely—that is, it follows that heat must itself be a form of energy. But a limiting case of this general result requires separate statement from the physical point of view, viz. the ratio of equivalence between heat and work may be so small that practically the heat is conserved as if it were a substance, and then the work may be said to be done by its fall to a lower potential, strictly after the analogy of the fall of water to a lower level. Finally, a second absolute scale of measurement, that of the potential or temperature of heat, may be chosen which reduces the thermodynamic relations to the standard simple form. It is also remarked that the original Carnot idea involves immediately the complete foundation of chemical physics as applied to isothermal processes; for under isothermal conditions it asserts that the interchanges of heat that occur during physical or chemical transformations do not enter at all into the interchanges of motive power—that is, of isothermal available energy. But physical knowledge was not wide enough for a dozen years after 1824 to enable any general survey of the energies of Nature to be thought of; and when the principle of the conservation and interchanges of total available energies came into the light through the theoretical explorations of Faraday, J. R. Mayer, and Helmholtz, and especially the practical experimental work of Joule, founded mainly on the relations of energy to heat, the Carnot restriction to uniform temperature was tacitly involved, though not overtly expressed until later. As a chapter in scientific method, it seems desirable to bring into view. even now, the full potentiality that was latent nearly a century ago in the single creative idea of Carnot.—J. J. **Guest**: Curved beams. Previous investigations upon the stresses produced in a curved beam by a bending moment have not resulted in solutions satisfying the necessary elastic relationships. The author first treats the case of a beam which is narrow in proportion to its depth, obtaining expressions for the displacements and principal stresses. The results are then thrown into forms suitable for calculation. For the case of a wider beam the author then shows that for the third principal stress to be zero, both the inner and outer surfaces of the beam section must curve in a definite manner, depending upon the value of Poisson's ratio for the material used. The rigorous solution for the case of a very wide beam compelled by restraints to preserve a cylindrical form as it bends is then given. The paper concludes with a semi-graphical method for estimating the maximum stress occurring in other cases, that of a beam of circular section being worked out for different values of the curvature.—Dr. A. E. H. **Tutton**: Monoclinic double selenates of the iron group. In this memoir are described the results of a complete investigation of the crystals of the potassium, rubidium, cæsium, and ammonium salts of the iron group of double selenates of the series $R_2M\left(\begin{smallmatrix}S\\Se\end{smallmatrix}O_4\right)_2, 6H_2O$. The outstanding result is to confirm the conclusions drawn from the previous study of three other groups of double selenates, and of eight groups (the complete set) of double sulphates. The general law of progression of the crystallographic properties, with the atomic weight and atomic number of the interchangeable alkali metals which form the group, is obeyed absolutely rigidly by the iron group.—Dr. A. E. H. **Tutton**: Selenic acid and iron. Reduction of selenic acid by nascent hydrogen and hydrogen sulphide. Preparation of ferrous selenate and double selenates of iron group. Some new properties of selenic acid have been observed. Instead of dissolving iron with evolution of hydrogen like sulphuric acid, selenic acid is without appreciable action on iron. After a very long time the latter becomes thinly coated with red selenium due to reduction of a trace of the acid by nascent hydrogen produced in the slight action which occurs. After attempts spreading over eight years the author has at last obtained $K_2Fe(SeO_4)_2,6H_2O$ crystals during four of the very cold nights of January, 1918, when the laboratory temperature fell to nearly 0° C. and never rose above 2° C. Above this temperature the salt is unstable. The crystals were pale green, well formed, and clear, but lasted at most only five hours after removal from the mother liquor, becoming opaque white, like porcelain.

Paris.

Academy of Sciences, January 28.—M. Léon Guignard in the chair.—The president read the decree authorising the creation of a new division of six members under the title "Application de la Science à l'Industrie."—A. **Blondel**: The experimental determination and applications of the vector representing the effects of the direct armature reaction and leakages in alternators.—M. de **Sparre**: The hammering in a pipe with wall of variable thickness, in the case of a progressive closing.—A. **Buhl**: Certain Abelian sums of double integrals.—S. **Lattès**: The repetition of rational substitutions with two variables.—G. **Julia**: Problems concerning the repetition of rational functions.—F. **Iversen**: The asymptotic values of meromorphic functions and the transcendant singularities of their inverse functions.—J. **Guillaume**: Observations of the sun made at the Lyons Observatory during the third quarter of 1917. Observations were made on ninety days, eighty of which, June 1 to August 19, were consecutive.—A. **Valeur** and E. **Luce**: The action of methylene iodide upon 1:4-dimethylaminopentene. A closed ring is not formed, as with iodine, but the addition of methylene iodide to nitrogen takes place, as with methyl iodide.—F. **Grandjean**: The step-like structure in certain anisotropic liquids.—P. **Russo**: Some peculiarities of the granitoid rocks of the Rehamna district (western Morocco).—R. **Chudeau**: The tectonic of western Africa.—G. **Lecointre**: The presence of the Cambrian and (possibly) Silurian at Casablanca (western Morocco).—Ch. **Dufour**: Value of the magnetic elements at the Val-Joyeux Observatory on January 1, 1918.—Ph. **Flajolet**: Perturbations of the magnetic declination at Lyons (Saint-Genis-Laval) during the third quarter of 1917.—C. E. **Brazier**: The diurnal variation of the velocity of the wind in altitude.—M. and Mme. F. **Moreau**: Cytological study of the development of the apothecium of the Peltigeraceæ.—A. **Lécaillon**: Some cytological data relative to the phenomena of natural parthenogenesis which occur in the silkworm.—A. **Sartory**: The tubercle bacillus associated with an Oospora. The Oospora was isolated from a sputum also containing typical tubercle bacilli. The two micro-organisms possess certain characters in common, but the Oospora proved to be non-pathogenic to the guinea-pig and rabbit.—F. G. V. **Miranda**: Biochemical researches on *Proteus vulgaris*. Comparison of the properties of a pathogenic strain and a saprophytic strain. The experimental work cited confirms Metchnikoff's view that the pathogenic and saprophytic forms of Proteus are identical; the small differences between the various strains result from the influence, more or less prolonged, of the culture conditions.—A. **Berthelot**: Ptomaines and war wounds.—MM. **Rousseaux** and **Sirot**: The soluble nitrogenous materials as an index of the baking value of flour.

Melbourne.

Royal Society of Victoria, December 13, 1917.—Prof. W. A. Osborne, president, in the chair.—Prof. W. A. **Osborne**: A contribution to the theory of gel structure. Investigations carried out in 1910 showed that bubbles formed in gels assumed lenticular forms, but without any dominant angle. The Struve-Baumstark phenomenon—*i.e.* the expression of the liquid phase on treatment with ether—points to the fact that in certain gels the liquid phase is held by capillarity.—A. J. **Ewart**: (1) Contributions to the flora of Australia, No. 26. Amongst the plants enumerated is a newly introduced St. John's wort, found in the Government House grounds, whilst the spread of *Erica arborea* as a naturalised alien is also noted. Interesting data are furnished regarding the depth at which sweet briar and furze can reproduce their shoots. (2) Chlorophyll, xanthophyll, and carotin, and the production of sugar from formaldehyde. A new and rapid method was described of producing sugar from formaldehyde, in which the products were glucose, lævulose, calcium, and sodium tartrates.—J. T. **Jutson**: (1) The influence of salt on rock-weathering in subarid Western Australia. It is suggested that the salt from the dry pans, during periods of moisture, impregnate the rock around the lake, causing marked disintegration, which sometimes produces cavernous structure in the rocks of the lake margin. (2) The formation of natural quarries in subarid Western Australia. Illustrations are given of circular, triangular, and vertically faced quarries due to the varying hardness and nature of the weathered rock.

Washington, D.C.

National Academy of Sciences, November, 1917 (Proceedings, vol. iii., No. 11).—G. A. **Bliss**: A necessary and sufficient condition for the existence of a Stieltjes integral.—L. P. **Eisenhart**: Transformations of applicable conjugate nets of curves on surfaces.—C. A. **Fischer**: Bilinear and N-linear functionals.—C. L. **Burdick** and J. H. **Ellis**: The crystal structure of chalcopyrite determined by X-rays. Chalcopyrite belongs to the tetragonal system of crystals, few of which have been examined for structure. The lattice is of the face-centred type.—W. M. **Davis**: The isostatic subsidence of volcanic islands. Darwin's primary theory of coral reefs holds good, although his supplementary theory of broad ocean-floor subsidence needs modification.—O. **Veblen**: The deformation of an N-cell.—G. D. **Birkhoff**: A theorem on series of orthogonal functions with an application to Sturm-Liouville series.—R. A. **Daly**: Low-temperature formation of alkaline felspars in limestone. A review of recent European literature and a discussion of American Rocky Mountain dolomite.—C. **Barus**: The interferometry of small angles, etc. Methods by direct and reversed superposed spectra.

December, 1917 (vol. iii., No. 12).—C. W. **Metz** and C. B. **Bridges**: Incompatibility of mutant races in Drosophila. The evidence from two cases of incompatibility in laboratory cultures, taken with evidence from apparently mutant forms and incompatible varieties of Nature, tends to remove a serious objection to the mutation hypothesis, and emphasises the possible evolutionary importance of mutations involving incompatibility.—H. D. **Curtis**: Absorption effects in the spiral nebulæ. Negatives of spiral nebulæ obtained with the Crossley reflector show that the phenomenon of dark lanes caused by occulting or absorbing matter is much more frequent than has been supposed. The results may bear directly on the explanation of the peculiar grouping of the spirals.—O. L. **Raber**: The synergetic action of electrolytes. Synergy is the opposite of antagonism; although antagonism is frequently reported, few cases of synergy have been noted.—W. **Craig**: Appetites and aversions as constituents of instincts. Although innate chain reflexes constitute a considerable part of the equipment of doves, few or none of their instincts are mere chain reflexes. On the contrary, each instinct involves an element of appetite or of aversion, or both.—A. R. C. **Haas**: Rapid respiration after death. The respiration of Laminaria may be much greater after death than in the normal condition.—Caroline E. **Stringer**: The means of locomotion in Planarians. The locomotion is essentially a muscular act in which the cilia play no necessary part.—J. F. **McClendon**: Diurnal changes in the sea at Tortugas, Florida.—C. **Barus**: Note on interferometer methods of measuring the elastics of small bodies.—W. M. **Davis**: Sublacustrine Glacial erosion in Montana. The Clark fork branch-glacier seems to have done its visible erosive work on the valley-side spurs

—and presumably a considerable amount of invisible work on the valley bottom—although it must have been wholly submerged in Lake Missoula for two or three score, if not for four score, miles.—J. F. **McClendon**: The effect of stretching on the rate of conduction in the neuro-muscular network in Cassiopeia. Apparently stretching the nerve does not change the rate.—B. M. **Davis**: A criticism of the evidence for the mutation theory of De Vries from the behaviour of species of Œnothera in crosses and in selfed lines. Although most of the genetical work on Œnotheras has not been interpreted by the Mendelian system of notation, there is clear evidence of order in the results in inbreeding and crossing; the difficulty has been to discover and to isolate simple material in the confusion of mixed and impure forms of these plants.—W. D. **Harkins** and L. **Aronberg**: The spectra of isotopes and the vibration of electrons in the atom. The spectra of isotopes have been previously reported as identical within the errors of measure. The authors find, however, a slight difference. The wave-length of uranio-lead was very slightly longer than that of the ordinary lead.—J. F. **McClendon**: The effect of oxygen tension on the metabolism of Cassiopeia.

BOOKS RECEIVED.

Cambridge Papers. By W. W. Rouse Ball. Pp. vi+326. (London: Macmillan and Co., Ltd.) 6*s*. net.

Infinitesimal Calculus. By Prof. F. S. Carey. Section I. Pp. xiii+144+v. (London: Longmans and Co.) 6*s*. net.

Mathematical Papers for Admission into the Royal Military Academy and the Royal Military College for the Years 1908–17. Edited by R. M. Milne. (London: Macmillan and Co., Ltd.) 7*s*.

The Science of Power. By B. Kidd. Pp. 306. (London: Methuen and Co., Ltd.) 6*s*. net.

DIARY OF SOCIETIES.

THURSDAY, March 7.

Royal Society, at 4.30.—Numerical Solution of Integral Equations: Prof. E. T. Whittaker.—(1) Cesaro Convergence of Restricted Fourier Series; (2) Non-Harmonic Trigonometrical Series: Prof. W. H. Young.—The Electro-magnetic Inertia of the Lorentz Electron: Prof. G. A. Schott.—Researches on Growth and Movement in Plants by Means of the High Magnification Crescograph: Sir J. C. Bose.

Institution of Electrical Engineers, at 6.—The Control of Large Amounts of Power: E. B. Wedmore.

Institution of Mining and Metallurgy, at 5.30.—The Application of Charcoal to the Precipitation of Gold from its Solution in Cyanide: H. R. Edmands.—Blast-furnace Smelting of Stibnite, with considerations on the Metallurgy of Antimony: W. R. Schoeller.—A "Responsive" Shaft Signal Device: B. Angwin.

Linnean Society, at 5.—(1) The Mimetic and Mendelian Relationships of the "White Admirals" of North America (with Lantern Slides). (2) A New Mimetic Form of *Pseudacraea poggei* (Dewitz) from ex-German East Africa, with other African Mimics of *Danaida chrysippus* (Linn.): Prof. E. B. Poulton.—Mimetic Species of the African Nymphaline Genus Pseudacræa and Lycænid Genus Mimacræa, together with their Acræine and Danaidine Models and Some of their Co-mimics: Lord Rothschild.

Chemical Society, at 8.—Atomic and Molecular Numbers: H. S. Allen.—The Subbromide and Subchloride of Lead: H. G. Denham.—Studies on the Phenylsuccinic Acid Series. VI., Racemisation Phenomena observed during the Investigation of the Optically Active Phenyl- and Diphenylsuccinic Acids and their Derivatives: H. Wren.—The Alkaloids of Ipecacuanha. III.: F. L. Pyman.—The Constitution of the Disaccharides. II., Lactose and Melibiose: W. N. Haworth and G. C. Leitch.

FRIDAY, March 8.

Royal Institution, at 5.30.—Vibrations: Mechanical, Musical, and Electrical: Prof. E. H. Barton.

Royal Astronomical Society, at 5.—Double Stars measured at the Cape Observatory: J. Voûte.—Planetary Motion in Space—Time of any Constant Curvature, according to the generalised Principle of Relativity: L. Silberstein.—The number of Stars of different Magnitudes in the Hyderabad Astrographic Catalogue. II., Zone −18°: R. J. Pocock.—Micrometrical Measures of Thirty-one new Double Stars: F. C. Leonard.—Errata in Van Biesbroeck's Third Series of Measures of Double Stars: E. Doolittle.—Solar Prominences, 1817: G. J. Newbegin.—The Early History of the Solar System: H. Jeffreys.—*Probable Papers* The Measurement of Time to the Thousandth of a Second: R. A. Sampson.—The Secular Acceleration of the Sun as determined from Hipparchus's Equinox Observations, with a note on Ptolemy's False Equinox: J. K. Fotheringham.

Physical Society, at 5.—The Asymmetrical Distribution of Corpuscular Radiation Produced by X-rays: E. A. Owen.—On "Air Standard" Internal-Combustion Engine Cycles and their Efficiencies: Prof. C. H. Lees.

SATURDAY, March 9.

Royal Institution, at 3.—Problems in Atomic Structure: Sir J. J. Thomson.

MONDAY, March 11.

Royal Geographical Society, at 8.30.—My Second Year's Journey in Kansu: Reginald Farrer.

Society of Engineers, at 5.30.—Concrete Mixtures for Ferro-concrete Work: T. J. Gueritte.

TUESDAY, March 12.

Royal Institution, at 3.—The Stifling of Children's Health: Dr. Leonard Hill.

Institution of Civil Engineers, at 5.30.—Kinematograph Films Illustrating Water-power Works in Canada: Prof. J. C. McLennan.

Royal Anthropological Institute and Prehistoric Society of East Anglia (Joint Meetings).—The Prehistoric Society of East Anglia, at 3.—Presidential Address: Our Neighbours of the Neolithic Period: R. A. Smith.—Royal Anthropological Institute, at 5.15.—The Age of Some Megalithic Structures in the Mediterranean Area: H. J. E. Peake.

WEDNESDAY, March 13.

Royal Society of Arts, at 4.30.—Ypres and other Flemish Cities Before and Since the War (in English): Paul Lambotte.

Institute of Metals, at 8.—Presidential Address.

British Association Geophysical Discussions (Royal Astronomical Society), at 5.—Auroræ and the Electrical State of the Upper Atmosphère: Dr. C. Chree, Prof. A. Fowler, the Hon. R. J. Strutt, and Others.

THURSDAY, March 14.

Royal Society of Arts, at 4.30.—English Commerce with India, 1608–1658: William Foster.

Institute of Metals, at 4.—The Relationship between Hardness and Constitution in the Copper-rich Aluminium-Copper Alloys: J. Neill Greenwood.—Aluminium-Bronze Die Casting: H. Whittaker and H. Rix.—On Grain Size: Dr. G. H. Gulliver.—Lead-Tin-Antimony Alloys: Owen W. Ellis.—An Investigation on Unsound Castings of Admiralty Bronze (88:10:2): Cause and Remedy: Prof. H. C. H. Carpenter and Miss C. F. Elam.

Optical Society (Imperial College of Science and Technology), at 8.—The Detection of Ghosts in Prisms: T. Smith.

FRIDAY, March 15.

Institution of Mechanical Engineers, at 6.

SATURDAY, March 16.

Royal Institution, at 3.—Problems in Atomic Structure: Sir J. J. Thomson.

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