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"To the solid ground
Of nature trusts the Mind that builds for aye."—WORDSWORTH.

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NATURE

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Science and International Policy

IN a thoughtful study of the international problems poised by the growth of economic nationalism*, F. H. Simonds and Brooks Enemy argue that the price of peace is economic liberty. The implications of this thesis were discussed in the Richard Cobden lecture "The Price of Peace" delivered by H. E. Señor Don Salvador de Madariaga in May of last year (London: R. Cobden-Sanderson, Ltd., 1935). This lecture merits some attention from scientific workers by reason of the scientific and impartial manner in which it examines the question of peace. More detailed attention was directed to the matter in a conference recently held in London under the auspices of the National Peace Council on "Peace and the Colonial Problem".

In these discussions, the scientific worker will find much material to assist him to find his way to a reasoned opinion on the matter which may have some claims to be considered unbiased. The need for a scientific study of such matters is unfortunately only too apparent in recent actions or discussions bearing on peace. To take only two examples, the publications thus far issued by the Air Raid Precautions Department indicate little appreciation of the way in which air-conditioning might be used as a safeguard in the event of gas attack, and there has been little evidence that authority appreciates the way in which an extension of air-conditioning methods might form not only an additional safeguard in the event of emergency, but also an immediate contribution in the sphere of industrial or public health.

Similarly in the discussions on sanctions, little regard has been paid to the suggestions outlined by Sir Thomas Holland in his presidential address at the South African meeting of the British Association in 1929, on "International Relationships of Minerals", and more recently in "The Mineral Sanction as an Aid to International Security", regarding the significance of minerals for munition purposes and the effect of treating minerals as munitions or arms in cases of aggression. The value of a considered scientific exploration of these possibilities at the present time cannot easily be over-emphasised, and, were it available, the application of sanctions to arrest the present conflict might well be made much more rapid and effective.

That there is need of much scientific thought in these matters before we can hope even to outline a policy which holds out some real promise of eliminating the causes of international friction and promoting international co-operation in the development and use of world resources for the

* The Price of Peace: the Challenge of Economic Nationalism. By F. H. Simonds and Brooks Enemy. (London: H. Hamilton, Ltd., 1935.)

world community as a whole, and not in the interests of merely a section or sections, however powerful, can scarcely be gainsaid. This, however, is only the starting point. Even when we are able to outline such a policy, there remains the difficult task of securing its adoption by public opinion in those countries where free expression of opinion is still possible, and of teaching dictatorship elsewhere that it is highly dangerous to themselves to hinder the development of that policy.

The difficulty of this task is apparent when we recall that a radical change in the outlook of nations is required. The true cause of war is the prevalence of the national point of view, and the difficulties which have beset the putting into operation of economic sanctions against Italy illustrate the way in which sectional and national points of view continually threaten and hinder co-operate action, even against the most undisguised acts of aggression.

The discarding of such national selfishness is an essential part of the price which has to be paid for peace, and the whole course of events in the recent months strangely underlies the points made by Señor de Madariaga so long ago as last May. We have seen the nations reluctantly admitting the necessity of sacrificing the free shaping of the aims of foreign policy, struggle though some of them still do to retain their wonted freedom. The Abyssinian dispute has emphasised too the necessity of treating international affairs, before they have become conflicts, by a small group of experienced men, assisted by an organised staff of experts. These things are essential if the policy of mutual assistance, so tardily shaping itself for Abyssinia, is to become part and parcel of living international politics.

It is in fact only when the pooling of policy is accepted that the armament question can be treated on rational lines, because national sovereignty over armaments has been sacrificed. Until this stage has been reached, no matter how sincerely and genuinely a country may protest that its armaments need expanding in order to meet its possible obligations on behalf of the League, any steps so taken to increase its armed forces are just as likely to promote suicidal competition as the most blatant expansion of a militarist nation. Between a national armament policy and the adjustment of armaments on an international basis by an international authority there is no alternative, and only the latter policy in the long run can ensure peace.

When we consider how much is involved in this policy—the surrender of the national right to use armaments as we please and the acceptance of obligations only to use them for the aims of commonly agreed policy, the abandonment of our right to decide alone what should be our armed strength, and the disclosure to the world of the secrets of our armed forces—we begin to appreciate the immensity of the task of educating public opinion for these changes, and the insistence with which Señor de Madariaga pleaded that of all the requirements of peace none was more urgent and more imperative than the organisation of means of objective and impartial information. Co-operation in the organisation and use of a genuine international news agency is one of the first and most fundamental tasks in the organisation of peace.

One of the most difficult problems of civilisation is in fact how to eliminate the war spirit fostered by commercial competition without depriving the world of the zest and stimulus of private initiative. The fear of monopoly, of the withholding of essential colonial raw materials, is already causing alarm, and the desire for a guarantee that the distribution of raw materials will not be unfairly impeded is stimulating the demand for further inquiry. It is because the mandatory system provides expression for the point of view of the world community that demands for strengthening and generalising this system are growing. Once we admit the existence of a world community, the unfettered domination of any race or tribe by any one nation can no longer be justified, and the least that must be granted to the requirements of peace is that all colonial possessions should be held as trusts on behalf of the world community. This alone would calm down unsatisfied colonial ambitions, and, by opening the doors to international trade, would do much to ease the tension between the world powers.

At the conference on peace and the colonial problem, Sir Arthur Salter advocated the extension of the mandatory principle in this way to British non-self-governing colonies, and was supported by Mr. Norman Bentinck, who pointed out that such a development would involve abandoning the system of imperial preference in such colonies, which by closing or reducing the market in these colonies to foreign countries was one cause of the present trouble. Once again we are brought to realise the immense complexities of the problem of peace and of international

relations, and the impossibility of isolating factors or problems in exactly the same way as in the physical sciences. Prof. Julian Huxley's plea for the development of an appropriate technique, which is capable of dealing with multiple causation and multiple effect as an essential step in the evolution of a true social science, could scarcely be more emphatically endorsed. The study of peace, the scientific determination of the price which has to be paid and the organisation which has to be developed or created to ensure peace, is one in which the scientific worker as such, and not only as a citizen, is called to play a part. Nowhere is it more essential than here that science should become a real brain for society and not a series of isolated nerve centres, and the first step to that end is taken only when the scientific citizen gives his own mind to this great and urgent problem.

Natural Gas

Geology of Natural Gas

Edited by Henry A. Ley. Pp. xii + 1227. (Tulsa, Okla.: American Association of Petroleum Technologists; London: Thomas Murby and Co., 1935.) 6 dollars; 26*s*.

THE efforts of forty-seven authors working to an accepted plan have produced a most comprehensive geological account of the occurrence of natural gas on the North American Continent. The subject is one of increasing interest as more and more use is being made of natural gas both by industrial and domestic consumers. The potentialities for the future are immense, as is evidenced by the fact that the present combined daily open flow capacity of commercial gas wells in the important proved and producing areas exceeds 55 billion cubic feet per day, of which less than 10 per cent was consumed in 1933: there is still great waste of gas. The reservoirs for the future are thought to be infinitely greater, and there is said to be no known geological reason why the present levels of production cannot be maintained for many years.

Gas has as great a range as petroleum in the geological age of the rocks in which it is found, but an unsolved problem is the presence of gas only without associated oil in extensive areas: the same is true of other parts of the world. One suggestion is that gas migrates ahead of oil; others relate its presence to the critical permeability value of the rocks.

The papers on the various gas-yielding areas in the volume under notice are arranged in a north to south sequence beginning with Alberta and Ontario in Canada and ending with West Virginia and the Mexican oilfields. These are full of geological and production details with sections and maps, and scarcely lend themselves to comment, though it is soon apparent under what diversity of conditions gas is found and how its composition varies. In Alberta, for example, there is an increase in the proportion of higher hydrocarbons to methane.

Some of the fields yield gas rich in helium and nitrogen, the percentage of helium in the richest gases ranging between 1·0 and 8·0 per cent. A gas rich in helium has been found in Ontario, but in small supply and at a low pressure. Elsewhere in the world natural gases are poor in helium. There is some evidence that it is derived from the radioactive elements in the crystalline basement rocks.

In the western part of the United States the gas is rich in carbon dioxide, whereas in the 'sour gas' from western Texas hydrogen sulphide is a constituent and must be removed before the gas can be put to domestic uses.

It is of interest that the wide use of natural gas began about 1891 when compressors were first designed for its transmission by pipe-line: such gas contains about 72·5 per cent of methane and 15·4 per cent of ethane.

The problem of wasted gas is receiving more attention, though probably not more than half of that lost could be economically conserved. The surplus is sometimes stored underground in depleted gas reservoir rocks. In the Zoar field near Buffalo, as much as two hundred million cubic feet are seasonally stored each year in this way without loss.

As is well known, the higher hydrocarbons are separated from the methane and ethane before these latter are transmitted by pipe-line often as much as 1,000 miles to replace retort gas made from coal. The propane is being sold compressed to a liquid in steel bottles in yearly increasing quantities for household purposes in places where there is no town's gas available. The butane is used for industrial heating and for enriching petrol which is deficient in the low-boiling fractions. By pyrolysis it can be converted into higher

hydrocarbons, that is, back to petrol, and there are signs that in the near future large amounts may be so treated.

In the past, the oil industry in all its forms has been most wasteful of natural resources, but this is being rapidly altered and if the above eventuate, the enormous amount of natural gas available will also be turned to good use. At the present time there are few more interesting developments than those connected with natural gas: the complete information furnished in this book is therefore very timely. E. F. A.

The Data of Seismology

(1) International Seismological Summary for 1930

Prepared and edited by J. S. Hughes and Ethel F. Bellamy for the International Union of Geodesy and Geophysics, the British Association Seismological Committee, the University of Oxford. Pp. ii+426. (Oxford: University Observatory, 1935.) n.p.

(2) Catalogue of Earthquakes, 1925–1930: being a digest of the International Seismological Survey (1925–1930). (London: British Association for the Advancement of Science.) 2*s*.

(3) The Brunner Focal Depth—Time—Distance Chart

By C. J. Brunner and J. B. Macelwane. Pp. 12+chart 38 in. × 36 in. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1935.) 10*s*. net.

(1) THE "International Seismological Summary" is a comprehensive work in which practically every reading of every seismogram at every seismological station in the world is placed on record and co-ordinated. The "Summary" is prepared at the University Observatory, Oxford. Since the death of Prof. H. H. Turner, who inaugurated the work, the tabulations have been prepared and edited by Mr. J. S. Hughes and Miss E. F. Bellamy. To the cost of production contributions are made by the International Seismological Association (one of the constituent bodies of the International Union for Geodesy and Geophysics), the British Association and the University of Oxford. The provision of funds for this enterprise has always presented difficulties, which are really due to the inadequate share of its income allotted by the International Union to the Seismological Association. There was much discussion of this matter during the Lisbon meeting of the Union, until M. Rothé, the secretary of the Association, generously moved a resolution by which the reserve funds then in hand were allotted to the "Summary". Special grants have also been given by the British Association to tide over the period up to the Edinburgh meeting of the Union.

From the first issue, that for 1918, the "Summary" has appeared in quarterly parts. This plan, though acceptable to active investigators who have had the results of the co-ordinating work at Oxford in their hands as early as possible, has obvious disadvantages, and the "Summary" for 1930 was offered to regular recipients alternatively in parts or as a bound volume. Nearly half preferred the latter form. Their patience is rewarded by the possession of a neat volume, appropriately bound in Oxford blue.

Mr. Hughes has written for the introduction a useful explanation of the practice adopted at Oxford in analysing the records. An important innovation was made in the discussion of the earthquakes which occurred in the year under review. Previously, the standard of reference for the times of passage of earthquake waves to assigned distances had been the tables, based on pioneer work by Zöppritz, which Turner adopted tentatively when the I.S.S. was commenced. For the 1930 earthquakes the tables prepared by Jeffreys and Bullen were used. A scale of merit has been introduced to indicate the trustworthiness of the stated epicentres. For earthquakes in the highest classes, which are designated $N1$ and $R1$ (signifying new and repeated epicentres), the probable error of the position is stated. This is generally given as $\pm$ 0·3°. It seems to be implied that it is an even chance whether the true epicentre lies within 20 miles of the nominal epicentre, but there is reason to believe that the precision is really much higher than this.

The number of earthquakes for which epicentres are given in the "Summary" for 1930 is 653. Of these, 20 had deep foci. It is interesting to notice that there were no earthquakes to which it was found necessary to allot high foci. It appears that with more reliable observations and more reliable standard tables, the anomalies which led Turner to assume high foci for certain earthquakes do not occur.

(2) For investigators who are not concerned with seismological observations as evidence for the transmission of waves through the globe so

much as the locating and times of earthquakes, the I.S.S. is unnecessarily bulky. Such persons will welcome the issue by the British Association of the catalogue of the earthquakes of 1925–30 prepared by Miss E. F. Bellamy. This is in exactly the same form as that published by Prof. Turner covering the years 1918–24. Miss Bellamy discusses briefly the annual variation in the frequency of earthquakes. In the seven years 1918–24 there were no less than five in which there were more earthquakes in September than in any other month. The maximum did not occur in September in any of the following six years. On the other hand, the rule that the maximum frequency of determinable epicentres occurs in one of the months from October to March has persisted. Without a critical examination of the material, it would be unwise to deduce that earthquakes have been less frequent in this half of the year. It may mean simply that the records of the stations in the northern hemisphere are more disturbed by microseisms, so that it is more difficult to identify epicentres.

(3) The use of hodograms—diagrams in which the times of transmission of seismic waves are graphed as functions of epicentral distance—is as old as instrumental seismology, but hitherto no such diagram on a large scale has been available for the observatory library.

A chart has now been prepared by the Rev. C. J. Brunner, S.J., which can be used for identifying the phases of ordinary earthquakes, but which is specially designed to show the times of transmission of the waves proceeding from foci at great depths. Hitherto an observer faced with the record of a deep focus earthquake has known that the tables constructed for ordinary earthquakes could not be used with safety for finding the distance of the epicentre. With the aid of the new diagram and the explanatory pamphlet prepared by Brunner and Macelwane, he will proceed with confidence. There are, of course, uncertainties as to the best average values of times of transmission even in the case of epicentres at normal depths, so that the times plotted in the diagram may differ from those found by other authors. These uncertainties are likely to be greatest for ranges at which the phases in question have seldom if ever been read on seismograms. For example, *SKS* at a range of 170° is said by Wadati and Masuda (*Geophys. Mag. Tokyo*, 8, No. 2 (Nov. 1934), p. 189) to have when the focal depth is zero a time transmission 27m. 17s. According to the Brunner diagram, the time should be 26m. 55s. There is, however, practically no energy available for *SKS* at 170°, for the rays reaching that distance would be nearly vertical; the *S* reaching the core must in that case be mostly reflected as *ScS*, and such energy as was transmitted in the *K* wave would be passed on as a *P* wave.

It is perhaps a pity that Brunner has not included the *PcP* and *ScS* phases in his diagram, as these phases are of special interest for deep-focus earthquakes. Tables from which the phases can readily be plotted are given in the paper by Wadati and Masuda.

It may be added that the chart is very clearly reproduced and mounted on linen. It has been found convenient at Kew Observatory to attach the chart to a roller. F. J. W. W.

Animal Life in Palestine

Animal Life in Palestine:
an Introduction to the Problems of Animal Ecology and Zoogeography. By Prof. F. S. Bodenheimer. Pp. vii+507 (70 plates). (Jerusalem: L. Mayer, 1935.) n.p.

EVERY naturalist who has visited Palestine—and there have been many in the years of the Great War and since—has felt a particular interest in its animals and plants. The English ornithologist sees hoopoes and bee-eaters and storks, and if he descends to Jericho may meet such exotic birds as babblers and sun-birds. Others notice the jerboas, the harvesting ants or the spring flowers, or observe that some at least of the Biblical animals still range the land. The whole flora and fauna is indeed unusual, partly because the surface and climate are so varied, partly because Palestine is like a peninsula, pushed southwards with the sea on one side and the desert on the other and at the end. It is for this reason that in Palestine many European forms, the newt and salamander, the voles and the sparrow hawk find their southerly limit.

Prof. Bodenheimer has endeavoured to produce a general account of the whole fauna of this interesting country. The book is an unusual piece of work and there are few men alive who would venture to write on so wide a subject. The author is himself professor of zoology in the Hebrew University, Jerusalem. He has lived and worked in Palestine for some thirteen years, and from the

mass of detailed work which is summarised in his book, we must assume that he is at the head of a group of industrious assistants, many of them good field naturalists.

The book opens with four general chapters, which give a synthetic view of the fauna and its setting. The author deals first with the history of the zoological exploration of Palestine, taking the main groups of the animal kingdom successively. It appears that about 8,000 species have been recorded. He then passes to zoogeography, which is treated in a formal manner, with an elaborate system of kingdoms, sub-kingdoms, etc., some of which are delimited on the map. The evidence for these units is not given in detail; indeed the reader is not clear whether the criteria by which they are distinguished are climatic, botanical or faunistic. The reviewer believes that if the facts were set out and considered at length, it would not prove possible to demarcate these zoogeographical areas. It might perhaps be better to say that the zoogeography of Palestine depends on several major causes; the orographical divisions of the country run from north to south, but the climatic divisions (at least the isohyets) tend to run from east to west, so that as one passes southwards, either along the coast or in the hills, the face of Nature becomes more and more arid. Added to this, and rendering the fauna still more complex, there are considerable elements from Asia and Africa, though the greater part of the animals are widely spread round the Mediterranean.

The general account is brought to an end by chapters on the palæontology and the general ecology. This last is perhaps the most important part of the book, for it summarises much of Bodenheimer's own work. In it he writes vigorously of the effect of climate, soil and vegetation upon the animal world. There are many ingenious diagrams; for example, those which show the degree of activity of groups of insects, at different times of day and through the twelve months.

The rest of the book is given to a consideration of the fauna, group by group, from mammals to Protozoa, with additional chapters on helminths, marine biology and other sides of applied zoology. It is only possible to give a passing reference to the many delightful things which the reader finds described in this book. One might give as an example the account of the migrant flights of Painted Lady butterflies, of the Large White butterfly, which comes in from the north in the autumn, and is killed by the heat every July, and of *Teracolus fausta*, a butterfly which thrives on the heat of summer, and is killed by the winter. One passes on to notes on the æstivation of snails, the seasonal events in the life of the grasshoppers, the elaborate gall-fauna of Pistachio, and the wood-louse (*Hemilepistus*), which wanders on the soil all through the day in spring, but hides itself in summer except when the sun is low.

As a conception the book is very fine, for the author has swept over the whole range of zoology, and read very nearly all that has been published on the zoology of Palestine: it is less successful in execution, for he is not invariably critical in his statements, and slightly careless in proof-reading. The book would have gained had the manuscript been read by a person with a knowledge of English technical terms, in climatology, geology, entomology and other sciences. The errors are occasionally misleading; the insects in Fig. 37 are certainly not "blackbeetles or roaches"; a misuse of technical English attributes the insects (which are beetles and black ones) to the wrong order. Similarly the use of "Blind worm" for the blind snake *Typhlops* conveys a completely wrong sense. The familiar bluebottle appears as the "large humming Blue fly"; "goldwasp" and "mussel" (for Lamellibranch) prepare the reader for other animal names which are frankly German, the ren, the iltis and the featherling. Many of the names given to reptiles are certainly not English, and would be meaningless except for the Latin equivalents; among such names are efa, waran, scheltopusik and mastiguer: of these the first is Arabic, the second German, the third incomprehensible and the fourth a misprint! As to the batha (botanical), we know neither its meaning nor its origin.

P. A. BUXTON.

Chimneys and Flues: Domestic and Industrial
By Percy L. Marks. Pp. 131. (London: The Technical Press, Ltd., 1935.) 4*s*. net.

THIS small book deals in a hundred pages with chimney flue construction and the troubles which often arise through down draughts. It is written in a manner which makes it quite intelligible to the layman, and does not attempt any mathematical analysis.

A few pages on the development and construction of the chimney are followed by an account of principles involved, including the views of various authorities, some of ancient date. Short chapters on fuels, the fireplace and the chimney stack follow. Smoky chimneys are only given a chapter of six pages, but information follows on ventilators and cowls, though for the latter the author has not much to say in recommendation. Finally, tall chimneys of the factory type are dealt with, in which connexion it may be remarked that it is quite possible to erect such chimneys without a detached flue lining by the use of modern porous bricks, with some economy of material and space. The book concludes with appendixes upon various enactments and a glossary and index.

Heredity and Evolution

By Arthur Ernest Watkins. Pp. viii+243+2 plates. (London: John Murray, 1935.) 7*s*. 6*d*. net.

THE recent co-ordination of experimental breeding and chromosome study has led to a complete reconstruction of our knowledge of heredity and variation. This in turn has given us the means of re-examining the mechanism of evolution and seeing the whole problem in a new light. Haldane, Fisher, Müller, Timofeeff-Ressovsky and others have taken advantage of this splendid opportunity. We therefore turn to a new book on the subject with eager anticipation.

The subject is a difficult one requiring clarity of thought and exposition as well as accuracy of information. The present work is disappointing in both these respects. After the first simple problems are dealt with, a vagueness overcasts the argument; the author does not appear to have grasped either the essential conclusions of modern genetics or the primary assumptions of Darwinism. The result is complete confusion in the treatment of selection (for example, on pp. 22, 196, 207, 215, *et seq.*). He mixes up self-sterility with cross-sterility as a condition of species-formation. He is surprised that selection will not account for the sterility of hybrids. Darwin, he says, considered that selection alone was the agent of evolution, and he concludes that Darwin was wrong. Students of evolution outside the field of genetics should know that this view would not be accepted generally by geneticists. The student will be misled by such statements as that reciprocal crosses are nearly always identical, that roses are peculiar in being permanent hybrids, and that Mendel bred sweet peas.

The book contains bibliographies, a glossary and an index. It will serve as an introduction to the general reader who wants to know what geneticists are talking about. C. D. D.

Hydrostatics and Mechanics

By A. E. E. McKenzie. Pp. x+272. (Cambridge: At the University Press, 1934.) 3*s*. 6*d*.

THIS book, which covers the whole of the ground associated with a course up to School Certificate standard, is likely to prove unusually attractive. The author realises from his teaching experience the very true fact that "mechanics is often considered by boys as one of the dullest parts of physics", and in order to meet this difficulty he has endeavoured to sustain interest throughout by showing the bearing of the principles of mechanics on modern industrial practice in engineering, aeronautics and hydraulics. The book is notable for the number of first-class photographs of examples of these applications shown in construction and use; such instances as famous bridges, cranes, diving apparatus, turbines, Piccard's balloon, and the *R*. 101 may be mentioned. The style throughout is readable and the presentation interesting, and special attention is directed to familiar applications, frequently little understood, in this mechanical age. A careful selection of problems and examination questions is appended to each chapter. N. M. B.

Songs of the Birds

By Prof. Walter Garstang. (The Week-end Library.) Revised third edition, with a New Chapter on the Classification of Birds. Pp. 139. (London: John Lane, The Bodley Head, Ltd., 1935.) 3*s*. 6*d*. net.

IN this new edition, Prof. Garstang endeavours to strengthen the scientific aspect of his subject by the inclusion of a classification of birds. Another new feature is a systematic index which is undoubtedly a boon to the reader.

The author's syllabic notation, clever though it is, would be of small use without some means of marking the rhythmic nature of the songs. This he has given by incorporating the sounds in verses, some of them representing imaginary conversations between two songsters, a pleasant device for the non-scientific reader. The reviewer finds the songs, as thus transcribed, generally recognisable by one familiar with them—no mean achievement.

It is on the scientific side of the little book that we encounter difficulties. Prof. Garstang implies that the syllabic notation of birds' song may be used as a serious contribution to taxonomic zoology. The example he cites—the willow warblers, true warblers and whitethroats—fails to convince the reviewer. The difficulty of getting observers of uniform 'reception' for these sounds would of itself render the method unfitted for strictly scientific purposes. Prof. Garstang does not take much notice of the imitation factor in the songs of birds, or of the individual differences, which are considerable. An immense number of mechanical records, showing the variations in the songs of each species, possible seasonal variations and so forth, would seem to afford the only means of putting the study of bird music on a scientific basis. Meanwhile, let us be grateful for the author's help in the æsthetic appreciation of songs of birds.

Lehrbuch der angewandten Geophysik (Geophysikalische Aufschlussmethoden)

Von Prof. Dr. Hans Haalck. Pp. vii+376+6 plates. (Berlin: Gebrüder Borntraeger, 1934.) 24 gold marks.

THIS book is intended to serve as an introductory textbook, of not too difficult character, covering the whole field of applied geophysics in a systematic manner, for the use of students—physicists, geologists, mining engineers, surveyors—who desire to be acquainted with this important branch of science. It is written from a definitely practical point of view and with practical aims, and theoretical development and proofs of formulæ are kept within narrow limits. It is about equally divided between the gravimetric, magnetic, electric and seismic methods; in each case an account is given of the physical principles underlying the method, the instruments used and the way in which they are employed, the method of reducing the observations and making deductions from them, with practical examples and a description of typical surveys and results obtained, with references. The book well serves its purpose as a comprehensive introductory textbook.

Galileo and Scientific History

The Leaning Tower and Other Stories

By Prof. A. S. Eve, F.R.S.

GOOD stories are apt to survive by their very fitness. In old age they may lose their savour because they are deemed legendary, but it is not well to part too lightly with old friends. The three best stories about Galileo are all under suspicion—the swinging lamp, the leaning tower, and "eppur si muove". I am sufficiently naïve to believe that all these three stories may have an underlying basis of fact.

The Swinging Lamp

There is a familiar story of Galileo (in 1581) timing with his pulse the swings of a hanging lamp in the Cathedral at Pisa and finding that the period was independent of the amplitude. The beautiful bronze lamp of Maestro Possenti which hung (and still hangs) from the roof of the nave is pointed out as the lamp which Galileo observed. J. J. Fahie, in his "Galileo, his Life and Work", adds to the story this critical footnote :

"Whether this be only a pretty fable, like that of Newton and the apple, cannot now be decided, but it is at least certain that Possenti's lamp was not the one that Galileo observed, since it was not made until 1587, and was only hung in its present place on the 20th December in that year."

Nevertheless, Galileo early invented a small pendulum, adjustable in length, wherewith to measure the rate of the beats of the human pulse. This was used by physicians, and drawings and descriptions of four different forms of such *pulsilogia* were published in 1607 by Santorio, professor of medicine at Padua.

The Leaning Tower

The last assault on the tower has been made by Prof. Lane Cooper in his interesting book "Aristotle, Galileo and the Tower of Pisa", which recently received a full and able review by Dr. R. T. Gunther in NATURE[1]. It is not necessary to recapitulate the whole case, but it is sufficient to state that Galileo's last pupil and first biographer, Viviani, told the story in his life of the master (1654) only thirteen years after his death. In 1832 J. E. Drinkwater told the same story in his "Life of Galileo". Referring to the Aristotelians, he wrote :

"Galileo repeated his experiments in their presence from the famous leaning tower of Pisa ; and with the sound of the simultaneously falling weights still ringing in their ears, they could persist in gravely maintaining that a weight of ten pounds would reach the ground in a tenth part of the time taken by one of a single pound, because they were able to quote chapter and verse in which Aristotle assures them that such is the fact."

Prof. Lane Cooper claims that there is no contemporary evidence of this story and that Galileo never mentions such an experiment in any of his works. The remarkable thing is that Prof. Lane Cooper does not quote, or even refer to, the most important passage bearing on this subject. He quotes correctly (on page 51) page 64 of Crew and de Salvio's translation of Galileo's "Dialogues of Two New Sciences", but he does not notice at all the relevant passages two pages earlier.

These are the words that he does quote (p. 64) :

"*Salviati*

"Aristotle says that 'an iron ball of one hundred pounds falling from a height of one hundred cubits reaches the ground before a one pound ball has fallen a single cubit !' I say that they arrive at the same time. You find, on making the experiment, that the larger outstrips the smaller by two finger breadths, that is, when the larger has reached the ground, the other is short of it by two finger breadths ; now you would not hide behind those two fingers the ninety-nine cubits of Aristotle."

Prof. Lane Cooper points out in his book (p. 51) that "the speaker is not Galileo, but 'Salviati' who to some extent represents Galileo, *as 'Sagredi' does also* [my italics]—'Simplicio' is an Aristotelian man of straw who fares ill in the argument, and whose name recalls the faithful sixth-century commentator on the treatise, De Caelo."

The following is the interesting and important passage in Crew and de Salvio's translation (p. 62) of the Dialogue which is ignored by Prof. Lane Cooper. Note well that Sagredi "who to some extent represents Galileo" distinctly used the words "I, who have made the test".

"*Simplicio*

"So far as I can remember Aristotle inveighs against the ancient view that a vacuum is a necessary prerequisite for motion and that the latter could not occur without the former. . . . Aristotle shows that it is precisely the phenomenon of motion, as we shall see, which renders untenable the idea of a vacuum. His method is to divide the argument into two parts. He first supposes bodies of different weights to move

in the same medium, then supposes one and the same body to move in different media. In the first case, he supposes bodies of different weights to move in one and the same medium with different speeds which stand to one another in the same ratio as the weights; so that for example a body which is ten times as heavy as another will move ten times as rapidly as the other. In the second case, he assumes that the speeds of one and the same body moving in different media are in inverse ratio to the densities of these media; thus, for instance, if the density of water were ten times that of air, the speed in air would be ten times greater than in water. From this second supposition he shows that, since the tenuity of a vacuum differs infinitely from that of any medium filled with matter however rare, any body which moves in a plenum through a certain space in a certain time ought to move through a vacuum instantaneously; but instantaneous motion is an impossibility, it is therefore impossible that a vacuum should be produced by motion."

This seems to be an honest attempt by Galileo to express the views of Aristotle (see Lane Cooper, p. 40), but it is not certain that the *void* of Aristotle and the *vacuum* of to-day mean the same kind of emptiness! However that may be, the dialogue continues:

"*Salviati*

"The argument is, as you see, *ad hominem*, that is, it is directed against those who thought the vacuum prerequisite for motion. Now if I admit the argument to be conclusive and concede also that motion cannot take place in a vacuum, the assumption of a vacuum considered absolutely and without reference to motion, is not thereby invalidated. But to tell you what the ancients might possibly have replied and in order better to understand just how conclusive Aristotle's demonstration is, we may, in my opinion, deny both of his assumptions. And as to the first, I greatly doubt that Aristotle ever tested by experiment whether it be true that two stones, one weighing ten times as much as the other, if allowed to fall at the same instant, from the height, say, of one hundred cubits, would so differ in speed that when the heavier had reached the ground, the other would not have fallen more than ten cubits."

"*Simplicio*

"His language would seem to indicate that he had tried the experiment, because he says: *We see the heavier*; now the word *see* shows that he had made the experiment.

"*Sagredo*

"But I, Simplicio, *who have made the test*" [my italics] "can assure you that a cannon ball weighing one or two hundred pounds or even more, will not reach the ground by as much as a span ahead of a musket ball weighing only half-a-pound, provided both are dropped from a height of 200 cubits."

It is certainly disconcerting to find Sagredo altering the height from 100 to 200 cubits. One hundred cubits, or bracchia, would mean about $58\frac{1}{2}$ metres, while the height of the leaning tower is said to be 54 metres. Nevertheless, this definite claim, written by Galileo himself, published in the Dialogue in 1638, before Renieri made his experiments from the tower in 1641, seems to give some basis for the story told by Viviani. Weight may also be given to the words, duly quoted by Lane Cooper, written in Galileo's manuscript "De Motu" about 1590, in turn consulted by Viviani in 1654, but not published until the nineteenth century. The passage is this:

"If two stones were flung at the same moment from a high tower one stone twice the size of the other who would believe that when the smaller was half-way down the largest had already reached the ground?"

No doubt Lane Cooper is correct in saying that Galileo was flogging a dead horse, and that many had already attacked the rash statement of Aristotle, stated thus by Lane Cooper (p. 40):

"Bodies in the same medium with unequal weights, alike in other respects, move faster over an equal space and in the ratio which their magnitudes bear to each other."

There is another passage (p. 64) from Aristotle's "De Caelo", very suggestive of his erroneous view of falling bodies:

"The downward movement of a mass of gold or lead or of any other body endowed with weight is quicker in proportion to its size."

It may well be that Galileo had to confute not Aristotle, but his followers in Italy.

To sum up: it is not unlikely that Viviani founded his story about the Leaning Tower of Pisa on traditional information linked up with the specific claim that Galileo placed in the mouth of Sagredo in the "Dialogue of Two New Sciences". At the same time, our gratitude is due to Prof. Lane Cooper for showing that definite historical evidence is lacking.

EPPUR SI MUOVE

The traditional story is that no sooner had Galileo recanted before the Inquisition than he exclaimed: "It moves nevertheless."

Such a remark made audibly before the Holy Office, after his abjuration, would doubtless have led him quickly to a dungeon or even the stake. It would have been rash to whisper such a remark even to a faithful friend. For many years this story, started by Giuseppi Baretti about 1757, was therefore regarded as legendary.

However, J. J. Fahie in his exquisite "Memorials of Galileo Galilei 1564–1642" shows that these words were connected with Galileo from a much earlier date. A strange discovery, made in 1911, strongly indicates that the famous remark was recorded in a curious manner only a few years after Galileo's death.

It is well known that the Archbishop of Siena was a good friend to Galileo, who lived with him for some time after his condemnation as "vehemently suspected of heresy". Now the archbishop had a soldier brother, General Piccolomini, who served in Italy, Austria, Spain and Flanders. It is supposed that he asked Murillo in Spain to paint a portrait of his famous fellow-countryman Galileo, and the general may have shown some earlier picture to the artist for the purpose of the portrait.

In due course the Spanish portrait came into the hands of Mr. Jules Van Belle of Roulers, who found that the portrait had been framed in such fashion as to hide a heretical portion depicting the earth going round the sun, together with other astronomical symbols connected with the discoveries of Galileo, who is shown in a dungeon as the main figure with a nail in his hand, scratching the heretical figures on the wall. The date on the picture is deciphered as 1646, the signature is perhaps that of Murillo, and under the largest astronomical figure appear the words :

E PUR SI MUOVE.

[1] NATURE, 136, 6, July 6 (1935).

Coal Production and Utilisation*

THE report of the Fuel Research Board for the year ending March 31, 1935, is timely, coming just when the difficulties of the coal industries are again forced upon public notice by the restiveness of labour in the mining community. Here is an industry equipped and staffed for a production of coal greatly in excess of current requirements. The industry itself seems to have lacked prevision of the results of the natural trend of events. It has sunk large new pits as though consumption would continue the expansion of pre-War days. Then an abundant export market existed and wasteful consumption at home offered tempting opportunities to secure economy by attention to more efficient consumption. Indeed, this economy was enjoined by the Ministry of Reconstruction at the end of the Great War, as an aim to be sought by national action. Consumers have grasped at the economies to be secured by better technique in fuel consumption, and the report gives clear illustrations by quoting figures covering the reign of King George.

"Despite increasing industrial prosperity and rising population the consumption of coal in Great Britain has fallen from 180 million tons a year in 1910 to 165 million tons in 1934. It is sometimes said that this fall is due to the replacement of coal by oil but the report shows that this is largely erroneous and the decrease is due mainly to the increased efficiency of practically every process for which coal is used.

"In 1910 about $4\frac{1}{2}$ million tons of coal were required to produce 2,500 million units of electricity, while for the 16,100 million units generated by authorised undertakings in 1934 only 11·4 million tons were necessary. If the efficiency of production of electrical power had remained the same, 29 million tons of coal would have been used in 1934."

Collieries themselves have greatly improved the efficiency of coal-getting by mechanisation and its preparation for the market by methods of cleaning.

"The coke-oven industry is closely associated with the iron and steel industries, whose coal requirements have fallen by some 15 million tons a year. A considerable proportion of this is due to reduction in the amount of pig iron produced, but it is claimed by the British Iron and Steel Federation that since 1923, largely from the application of the results of research, £4,500,000 per annum has been saved in the cost of fuel. This figure indicates broadly that about 6 million tons less coal were necessary in 1934 than would otherwise have been the case."

It is generally recognised that the organisation of distribution has lagged behind. Production capacity in excess of needs and free competition both by individuals and districts produced marketing conditions favouring the buyer, and the working miners have suffered from loss of employment and reduced earnings. Few would wish to deny them an improved livelihood ; but this can only be gained by an increased return for coal sold, because wages constitute the major item in the cost of raising coal. The coal industry itself seeks to increase consumption by any and every method, regardless of its desirability on other grounds. In fact, to judge by its spokesmen, it has a "raw coal mentality". One may cite a north of England mining borough which insists on equipping its municipal houses with wash boilers fired with coal rather than with gas. Moreover, the industry itself apparently envisages that the increased price shall not be got from raw coal burnt in the domestic fire. This does not accord with the view advanced in the report that "there is an ever increasing movement to regard coal as raised from the mine as a raw material which must be processed before it is offered for sale". It is to be hoped that this

* Department of Scientific and Industrial Research. Report of the Fuel Research Board for the Year ended 31st March, 1935 ; with Report of the Director of Fuel Research. Pp. xi+188+11 plates. London H.M. Stationery Office, 1935.) 3*s*. 6*d*. net.

will not be overlooked in any State action to relieve the miner, that such action shall not, in effect, take the form of subsidising the wasteful and air-polluting consumption of raw coal. In the long run, such action will be futile, for the natural trend is for fuel to be consumed in smokeless forms and preferably fluid, such as gas and electricity, which permit cleanliness and better control in use. This is true both in industry and the home. Already whole estates of houses are being built with provision for the use of smokeless fuel only, and there is little doubt that these examples will be followed.

One reform which a rational sales system would enforce would be to relate prices more to calorific value and less to size of coal. Present practice dates from the time when big coal usually was clean coal. Modern cleaning processes have altered this, and the high premium on size cannot be justified. There are few uses for coal in large lumps, and even the householder is demanding sized nuts and cobbles. Mechanical stokers and pulverised fuel plants can only use small fuel. To an increasing extent, collieries are having to break lump coal, and the best methods of doing this provide technical problems with which the report deals. Selling prices based on calorific value would tend to penalise only those industries which use the heat in an unthrifty manner. There is in dearer coal a dilemma for the coal trade, for higher prices will encourage more economy and therefore reduced consumption.

The Coal Survey, one of the most beneficent activities of the Board, has now been in operation so long and has collected such extensive data as to show its value increasing with time.

The Fuel Research Station has a plant, described in the report, for experimental hydrogenation of coal and tar. With the plant "it has been found that the technique of hydrogenation does not necessarily require high pressure, and thanks to increasing knowledge of catalysts, a process has been worked out on a semi-commercial scale for treating at atmospheric pressure the acids present in tar from gas works and coke ovens to obtain motor spirits".

The report refers to many other aspects of fuel problems and the reader will miss few topics of current interest. H. J. H.

Scientific Centenaries in 1936

By Eng.-Capt. Edgar C. Smith, O.B.E., R.N.

"THE great inheritance of mathematical knowledge which the ancients bequeathed to posterity could not, on the revival of learning, be immediately taken possession of nor could even its existence be discovered, but by degrees . . . The repositories of the ancient treasures were to be opened, and made accessible; the knowledge of the languages was to be acquired; the manuscripts were to be deciphered; and the skill of the grammarian and the critic were to precede, in a certain degree, that of the geometrician or the astronomer . . . The study of the remains of antiquity gradually produced men of taste and intelligence, who were able to correct the faults of the manuscripts they copied, and to explain the difficulties of the authors they translated. Such were Purbach, Regiomontanus, Commandine, Maurolycus, and many others."

So wrote John Playfair more than a century ago in his historical sketch of the principal discoveries made in natural philosophy from the revival of learning down to the end of the eighteenth century, and he said that of the mathematicians of the fifteenth century it was Regiomontanus who held the highest rank. A review of the scientific centenaries for 1936 may therefore well begin with a note on this famous man, who was born on June 6, 1436, five hundred years ago, and, in his short life of forty years, in various ways made the world his debtor.

The son of well-to-do parents and born in Franconia, Regiomontanus (or Johann Müller, to give him his German name) was still a youth when Gutenberg made his first metal type and the learned Greeks fled from Constantinople to Italy and elsewhere, carrying their precious manuscripts; but he was destined to be remembered for the use he made of both those manuscripts and the printing press. His schooldays were passed at Leipzig, and later he was a pupil of Purbach's at Vienna. His abilities soon attracted attention, and through the patronage of Cardinal Bessarion he was able to visit Italy. One of the first fruits of his labours was his "De Triangulis" written in 1464, which has been called the earliest modern systematic exposition of trigonometry, plane and spherical. To him we owe the term 'sine'. From his visit to Italy he returned northward to become astronomer to Matthias Corvinus, the able king of Hungary, but a few years later he settled at Nuremberg, where with the aid of one of its wealthy citizens he set up a printing press and fitted up an observatory.

It was at Nuremberg that Regiomontanus published his "Ephemerides", a copy of which was used by Columbus. This book was the forerunner of our

nautical almanacs. In 1475 Pope Sixtus IV made Regiomontanus bishop of Ratisbon, and called him to Rome to assist in the reformation of the calendar. He died at Rome on July 6, 1476. His fame was such that he was buried in the Pantheon, the honours paid to him at his death proving, said Playfair, "that science had now become a distinction which the great were disposed to recognise".

Just three centuries after the birth of Regiomontanus at Königsberg, Joseph Louis Lagrange, the greatest mathematician of the eighteenth century, was born at Turin. The interval which separates the lives of these two eminent men had seen the labours of Copernicus, Kepler, Napier, Descartes, Pascal, Galileo, Huygens, Leibniz and Newton. Both mathematics and astronomy had flourished increasingly and experimental science had become established, and whereas the work of Regiomontanus had been largely concerned with the writings of the Ancients, that of Lagrange related entirely to the extension and application of the discoveries of his immediate predecessors. His great contemporaries included Euler, the Bernoullis and Laplace.

Born in Italy, but of French descent, Lagrange at the age of nineteen was made a professor of geometry in the Artillery School at Turin and at twenty-five years of age had gained an international reputation. In 1766, through D'Alembert, he was invited by Frederick the Great to fill the place in the Berlin Academy of Sciences left vacant by Euler's removal to St. Petersburg. One of D'Alembert's letters to Frederick ran : "M. de la Grange ne tardera pas à venir remplacer M. Euler ; et j'ose assurer Votre Majesté qu'il le remplacera très bien pour les talents et le travail, et que d'ailleurs, par son caractère et sa conduite, il n'excitera jamais dans l'Académie la moindre division ni le moindre trouble. Je prends la liberté de demander à Votre Majesté ses bontés particulières pour cet homme d'un mérite vraiment rare, et aussi estimable par ses sentiments que par son génie supérieur."

For twenty years Lagrange lived in Berlin, writing some sixty memoirs and compiling his "Mécanique Analytique", published in 1788. On the death of Frederick in 1786, he removed to Paris, was given apartments in the Louvre, and was welcomed into that brilliant circle of men of science which during the Consulate and Empire made Paris the centre of the scientific world. He died on April 10, 1813, at the age of seventy-seven years, and just as Regiomontanus was buried in the Pantheon at Rome, so Lagrange was interred in the Panthéon in Paris.

Six days before Lagrange was born at Turin, the great engineer James Watt was born at Greenock. Though he has for long been placed "at the head of all inventors in all ages and nations", Watt wrote when still a young man : "To-day I enter the 35th year of my life and I think I have hardly yet done 35 pence work of good in the world—but I cannot help it." More fitted for the laboratory than the factory, Watt was never a master of men, and his fate might well have been that of many another inventor had he not linked his fortunes with those of Matthew Boulton, whose self-confidence nothing could shake. In 1919, the centenary of Watt's death was worthily commemorated, and arrangements are now being made to celebrate the bicentenary of his birth. At Greenock the proceedings will extend from January 13 until 19. There will be an exhibition, a pageant, a commemoration service, and on January 17 Lord Rutherford will deliver the Watt Lecture. There will be other lectures at Birmingham and in London, and on Sunday, January 19, representatives of the engineering institutions will attend Evensong in Westminster Abbey, and at the close of the service wreaths will be placed on Chantrey's monument to Watt in St. Paul's Chapel. A memorial exhibition was opened at the Science Museum, South Kensington, on December 20 and will remain open until April 19. Other commemorations are being held in the United States, Germany and Japan.

Of no less interest than the lives of Lagrange and Watt is that of André-Marie Ampère, who died on June 10, 1836, a hundred years ago, and whose centenary will be celebrated by an exhibition at Lyons. The fact that his name, like those of Watt, Ohm and Volta, is familiar throughout the civilised world through being given to one of the electrical units by a later generation of men of science, is but a tribute to the high esteem in which his memory is held. He has indeed been referred to as the "Newton of Electricity". The son of a magistrate of Lyons who fell on the scaffold on November 25, 1793, Ampère was born at the village of Polémieux. He was precocious and studious far beyond his years, and at twelve years of age he was asking for the works of Bernoulli and Euler, and at eighteen read the "Mécanique Analytique". Poetry, history and chemistry were all read with the same eagerness. At twenty-one he met the charming Julie Carron, to whom he was married three years later, and at twenty-five he was made professor of physics and chemistry at the Central School at Bourg, the birthplace of Lalande, who with Delambre was afterwards to recognise Ampère's genius and further his promotion. Transferred in 1804 to Lyons, he was a year or so later assistant professor of analysis at the Ecole Polytechnique, and in 1814 was made a member of the Paris Academy of Sciences. He also

held the chair of experimental physics in the Collège de France. It was the repetition of Œrsted's experiment at the Academy that led to Ampère's work on electro-dynamics which made him famous. He died at Marseilles, and was buried there, but to-day he rests in the Cimetière de Montmartre in Paris.

The years 1736 and 1836 recall many besides Lagrange, Watt and Ampère who left their mark on the progress of science. In February 1736 Stephen Gray died in the seclusion of the Charterhouse, where for years he had assiduously devoted himself to electricity, his experiments on which led the Royal Society to grant him the first awards made under the will of Sir Godfrey Copley. A few months later the German instrument-maker of Amsterdam, Gabriel Fahrenheit, died at the age of fifty years. Fahrenheit made experiments on the boiling points of liquids, brought into general use the mercurial thermometer and in 1724 devised his thermometer scale, one of the three, out of the many used in the eighteenth century, which has survived.

The day before Fahrenheit died, the ill-fated French astronomer Jean Sylvain Bailly was born in Paris (Sept. 15, 1736). Gifted in many ways, Bailly was both president of the National Assembly and Mayor of Paris in 1789, but he lost his popularity over the affair on the Champ des Mars on July 17, 1791, and two years later perished miserably beneath the guillotine. Two other French men of science born in 1736 were Charles Augustin de Coulomb (1736–1806), known for his experiments on friction, his invention of the torsion balance and his investigation on electrical and magnetical attraction, and Jean Baptiste Louis Romé de l'Isle (1736–1790), an artillery officer who became distinguished for his researches in mineralogy and crystallography.

The year 1736 also saw the birth in Great Britain of Francis Egerton, third Duke of Bridgewater (1736–1803), the monument to whom at Ashridge, now the property of the National Trust, bears an inscription stating that by "devoting the energies of his mind to the accomplishment of the most splendid works of inland navigation" he "opened a new field of national industry and rendered the most important services to the commercial interests of this country".

It is but natural that centenaries should be more numerous than bicentenaries, and to give a complete list of men of science of note who either died or were born in 1836 would take much space. A few brief notes must therefore suffice. A contemporary of Ampère's at the Ecole Polytechnique who passed away in 1836 was Louis Marie Henri Navier (1785–1836), a distinguished officer of the Corps des Ponts et Chaussées, known for his work on suspension bridges and his investigations on elasticity. In Great Britain, 1836 saw the death of William Henry (1774–1836), the Manchester chemist who was Copley medallist in 1808; of John Loudon McAdam (1756–1836), who was voted £10,000 by the Government for his improvements in road-making, and of John Pond (1767–1836), the amateur astronomer who became the successor of Maskelyne and the predecessor of Airy at the Royal Observatory, Greenwich. During Pond's period of office, wrote Airy, "astronomy considered as an accurate representation of the state of the heavens in the most material points has acquired a certainty and an extent which it never had before".

Turning finally to the list of those born in 1836, physics is represented by Emilio Villari (1836–1904), a foreign member of the Royal Society and the president of the Academy of the Lincei, and by William Grylls Adams (1836–1915), at one time president of the Physical Society and of the Institution of Electrical Engineers; meteorology by Niels Heinrik Hoffmeyer (1836–1884), the first director of the Danish Government Meteorological Institute; chemistry by Charles Graham (1836–1909), professor of chemical technology at University College, London; geodesy by Major-General Sir Charles Wilson (1836–1905), the director-general of the Ordnance Survey; and engineering by Sir John Wolfe-Barry (1836–1918), the builder of the Tower Bridge and the virtual founder of the British Standards Institution. Mineralogy and geology are represented by Harry Rosenbusch (1836–1914), of Heidelberg; Gustav Tschermak (1836–1927), of Vienna; and Frederick Wollaston Hutton (1836–1905), one of the pioneers of geology in New Zealand; while among the astronomers born in 1836 were George Washington Hough (1836–1909) and Truman Henry Safford (1836–1901), both graduates of Harvard, both connected with the Chicago Observatory and both associates of the Royal Astronomical Society, and also Henry Chamberlain Russell (1836–1907), who organised the meteorological service of Australia and was director of Sydney Observatory.

Lastly, we recall the birth on May 17, 1836, of Sir Norman Lockyer, of whom it is said on the memorial tablet to him at the Norman Lockyer Observatory, Salcombe Hill, Sidmouth, that he was a pioneer in astronomical physics, the discoverer of helium in the sun, founder of the British Science Guild and the founder and editor of NATURE, 1869–1919. His death took place at Sidmouth on August 16, 1920, less than a year after the publication of the Jubilee number of this journal, in which M. Deslandres had referred to him as "one of the greatest astronomers of all time."

Obituary

Prof. J. E. A. Steggall

PROF. JOHN EDWARD ALOYSIUS STEGGALL died in Dundee on November 26. He was born in London on November 19, 1855, the son of Dr. J. W. B. Steggall, a physician whose family came from East Anglia, and from whom he inherited a love of architecture. He was educated under the well-known headmaster, Dr. Abbott, at the City of London School, and afterwards at Trinity College, Cambridge, where in 1877 he gained the Sheepshanks Medal for astronomy and in the next year graduated second wrangler, Hobson being senior. After taking the first Smith's prize, Steggall taught for a few terms at Clifton College (1878–79), next at Owens College, Manchester (1880–83), and in 1883 was appointed to the chair of mathematics and natural philosophy at the newly founded University College of Dundee. The responsibility of shouldering the work of two separate departments was considerable: and when in 1895 a redistribution was made, he continued as professor of pure and applied mathematics until he retired in 1933, after attaining the jubilee year of his work in the Dundee post.

Steggall was a brilliant mathematician who carried far into the twentieth century that adaptability and gift for problem solving which used to be such a feature in the training for the Cambridge Mathematical Tripos. The present less spectacular, but more solid, methods which lay the foundations for prolonged research were scarcely encouraged in those days, and later the full time-table of the early years at Dundee left little opportunity for embarking on such a course. Yet the papers which Steggall wrote for the Edinburgh Mathematical Society show an incisive neatness revealing no mean artistic power. His chief interests were in the theory of numbers and kinematical geometry. He was an exceptionally good examiner who maintained an alertness and freshness of outlook to the end.

Steggall was an admirable colleague, and with his students he was popular. One who is now a professor of engineering writes: "He sparkled in the many branches of learning which his facile genius enabled him to pursue. He was at home in physics and mathematics, a connoisseur in music and in art—more than a dilettante in architecture—whatever he touched he adorned. . . . It must have been difficult for an intellect such as his to break down the stores of knowledge into fragments suited to our powers of assimilation. He exercised on us his wit, but, though sometimes caustic, it was never used to humiliate. His encouragement was vitalizing".

Steggall's collection of books and engravings, his delicate pen sketches of architectural detail and spreading mountain form, his mathematical models and his craftsmanship in woodwork and photography reveal many interests. He was a keen cyclist, and when close on seventy years of age rode the five hundred miles from Dundee to Cardiff to attend the meeting of the British Association. He was a buoyant and entertaining holiday companion.

At Dundee Steggall took an active interest in college, city and church: and as a scientific worker he insisted on the importance of fostering the classical and artistic side of education at a college set in a large industrial city. In 1878, he married Isabella Katherine, the sister of Sir James Frazer (his college friend at Trinity, Cambridge, who was second classic in the same year of graduation). He is survived by his wife and two daughters. His only son, who was an officer in the Royal Navy, was killed at the Battle of Jutland in 1916.

On vacating his chair in 1933, Steggall received the honorary degree of LL.D. of the University of St. Andrews. He was also an honorary associate of the Royal Institute of British Architects. An outstanding figure in the life of the youngest college of the University of St. Andrews has passed on.

H. W. T.

Prof. Erich von Hornbostel

THE death of Prof. Erich von Hornbostel at Cambridge on November 28 is a great loss to the small body of students of comparative music. He was born in Vienna fifty-eight years ago. After specialising in chemistry at the Universities of Vienna, Heidelberg and Berlin, he settled in Berlin where in 1901 he began his studies in physiology, psychology, anthropology and ethnology, which laid the foundation of his life's work in 'musicology', as the Germans term it. With Stumpf and Abraham, he began in 1903 to collect and to analyse phonographic and gramophone records of primitive music, accurately determining the pitch of the notes sung and of the musical instruments employed. He was able to show that the pan-pipes and the harmonica, despite their wide wanderings, retain the same pitch, the former in Melanesia and Brazil, the latter in Burma and Africa. He ascribed this remarkable constancy in part to the influence of the memory of absolute pitch in primitive man.

Von Hornbostel worked also on the affinities of Sumerian, Chinese and similar early cultures in other directions, and at the time of his death was engaged in discovering the basis of certain forms of African symbolism. He devised a theory of consonance in music and he carried out valuable investigations into the binaural localisation of sounds, formulating the now favourite hypothesis which is based on the time-relations of the sound reaching each ear. He also conducted, with the assistance of pupils, researches upon smell, dealing particularly with certain psychological characters which he believed to be analogous to those found in other senses.

Under Hornbostel's care, direction and generosity, the now famous Berlin 'Archives' of primitive music grew so that ultimately it comprised about 10,000 records. This he presented to the University, which conferred on him the rank of professor. Being a non-Aryan (his mother was a Jewess, related to the well-known banking family of Warburg in Hamburg), he was compelled to leave Berlin in 1933. He was at once offered a post at the new School of Social Research in New York. But never a man of strong physique, he succumbed, after spending a few months there, to a severe cardiac lesion, and was advised to exchange the climate of New York for that of England. He arrived here in a critical condition from which he made only a partial recovery. His financial means had at one time been considerable, but he arrived with his wife in England almost penniless. He received much help from the Academic Assistance Council, and spent the last few months of his life happily in Cambridge, where he was able to resume his musical and ethnological studies.

Prof. von Hornbostel was a man of unusually wide interests and culture, who endeared himself to all with whom he came into contact. He was an ardent and original worker and a great enthusiast in the application of scientific methods to psychological and ethnological problems. His only son is working in physics at New York. C. S. M.

We regret to announce the death on September 28 at the age of seventy-two years of Prof. Ernest Gérard, honorary professor of the Lille faculty of medicine and pharmacy, corresponding national member of the French Academy of Medicine and Society of Pharmacy and knight of the Legion of Honour. He qualified in 1887, and after acting as lecturer in pharmacy at Paris and Toulouse, he was appointed professor at Lille in 1902. He is best known for his work on fatty acids, fermentation and the role of cholesterol in health and disease. He was the author of a manual of galenic pharmacy, manipulations in pharmacy, the technique of sterilisation, a treatise on the urine, and a practical work on the analysis of food stuffs.

We regret to announce the following deaths :

Miss Marian Frost, librarian and curator of the Public Library, Museum and Art Gallery, Worthing, on December 27.

Prof. Victor Grignard, professor of general chemistry in the University of Lyons and an honorary fellow of the Chemical Society, on December 13, aged sixty-four years.

Prof. Vassil Zlatarski, professor of Bulgarian history in the University of Sofia, an authority on Byzantine culture, on December 16, aged seventy years.

News and Views

New Year Honours

The New Year honours list contains the following names of men of science and others associated with scientific work and interests : *Knights :* B. C. Burt, agricultural expert to the Imperial Council of Agricultural Research ; H. B. Devine, for services to surgery in the State of Victoria ; Prof. A. Harden, emeritus professor of biochemistry, University of London ; Dr. H. J. W. Hetherington, vice-chancellor of the University of Liverpool ; Dr. Humphrey Milford, publisher to the University of Oxford ; Prof. D. P. D. Wilkie, professor of surgery at the University of Edinburgh, member of the Medical Research Council ; *C.B. :* A. Humphries, late chief mechanical engineer and superintendent, Building Works, Engineering Department, Royal Arsenal, Woolwich ; *C.M.G. :* Willi Fels, for services to ethnology in the Dominion of New Zealand ; A. C. Barnes, director of agriculture, Jamaica ; G. T. McCaw, civil assistant, War Office, for services in connexion with surveys in the Colonies ; H. R. Montgomery, chief native commissioner, Kenya ; W. Nowell, director of the East African Agricultural Research Station ; *C.I.E. :* R. G. Allan, director of agriculture, United Provinces, India ; E. A. Wraight, metallurgical inspector, Jamshedpur ; *C.B.E. :* J. N. Cameron, director of the Department of Agriculture, Sudan Government ; Lieut.-Colonel A. MacD. Dick, professor of ophthalmology, King Edward Medical College, Lahore, Punjab ; Dr. P. Hartley, director of the Department of Biological Standards, Medical Research Council ; J. F. Marshall, honorary director of the British Mosquito Control Institute, Hayling Island ; A. J. Martin, assistant comptroller, Patent Office, Board of Trade ; *O.B.E. :* Dr. S. S. Bhatnagar, professor of physical chemistry and director, University Laboratories, Punjab University ; T. Crook, principal of the Mineral Resources Department, Imperial Institute ; Dr. R. W. Dodgson, director of shellfish services, Ministry of Agriculture and Fisheries ; F. A. A. Hart, forest adviser, Eastern States Agency ; G. E. Holden, technical adviser to the Dyestuffs Advisory Licensing Committee ; Dr. N. R. Junner, director of the Geological Survey, Gold Coast ; E. MacDonald, conservator of forests, Sierra Leone ; F. Rayns, director of the Norfolk Agricultural Station ; Capt. A. T. A. Ritchie, game warden, Kenya ; H. L. Stevens, principal scientific officer, Air Ministry ; T. Waites, Government statistician, State of New South Wales ; *M.B.E. :* T. Close, agricultural machinery officer, Ministry of Agriculture and Fisheries ; R. R. Glanville, agricultural officer, Sierre Leone ; A. F. B. Hull, for services to natural history in the Commonwealth of Australia.

National Socialism and 'Non-Aryans' in Germany

IT may be impossible, as has been maintained on occasion, to indict a nation ; but the letter in which Mr. James G. McDonald resigns office under the League of Nations as High Commissioner for Refugees from Germany does more. By the terms of that letter, which cannot be questioned seriously, Germany stands condemned as guilty of a persecution no less barbarous and an intolerance as rigid and as crass as any that figure in the annals of the Middle Ages. Though economic forces have taken the place of open massacre, the end in due time will be no less certain. For even half a million Jews, and with them the 'non-Aryans' who are to share their fate, cannot in modern conditions so organise themselves as to avoid being ground to extinction between the alternatives of destitution and an exile which leaves them practically penniless. As Mr. McDonald points out, the conditions created by the Nuremberg legislation of September last have destroyed the utility of the office he now lays down, and have passed beyond the capacity of the activities of philanthropic and other bodies by whom provision has been made for all but some seventeen thousand of the eighty thousand refugees who have left Germany in the last three years. This legislation, by confining Reich citizenship to 'Aryans' and those who accept the National Socialist conception of the State, has deprived Jews and 'non-Aryans' of all rights as citizens—not only of the right to hold office, but also of the right to make a living by the exercise of profession, trade or business as between 'Aryan' and 'non-Aryan' and, debarring them from all social relationship except *inter se*, has sought to create a social and intellectual ghetto, in which it will become increasingly difficult for them to survive.

THE changed conditions, Mr. McDonald holds, justify collective action on the part of the League of Nations. Half a million people are being crushed for their inability to comply with a condition beyond their control, namely, an Aryan racial origin, and with them are penalised all who are unable to accept the Nazi doctrine of complete subordination of the individual to the State, but still cling to the ideal of freedom of thought and individual liberty, which was until recently, in theory at least, a fundamental doctrine of citizenship. Hence Germany, by creating a situation for which the obvious relief is expatriation on an extended scale, endangers the economic stability of her neighbours and the peace of Europe. Further, she has laid herself open to the charge of differential treatment of a minority, which she herself recognises implicitly as such, thus violating a principle of the public law of Europe, which has been accepted as a safeguard of minorities for the past hundred years. It is scarcely necessary to point out once more the vital interest to science of this struggle for freedom of the individual, irrespective of race, creed or conviction. Not only would the work of many men of science, not a few indeed of international eminence, have been lost to the world, had it not been for the assistance afforded by other countries, but it may also be taken as axiomatic that a political faction which seeks to control and mould the religious belief of its countrymen to support its own political views, will not lightly allow scientific research and the advancement of knowledge to proceed in search of truth without regard to extraneous circumstance.

Retirement of Sir Robert Robertson, K.B.E., F.R.S.

DURING the fifteen years that Sir Robert Robertson has filled the post of Government Chemist, the work of the Government Laboratory in Clement's Inn Passage has increased very greatly, both in amount and complexity. The number of samples dealt with has grown in the proportion of 5 : 3 and now amounts to more than half a million a year. Much of the increase is due to the additional import duties that have been introduced, but a considerable proportion of it is caused by the constant call for more governmental control in various directions. The Government Chemist is a member of a number of committees appointed by Crown departments, and on many others he is represented by members of his staff ; partly for this reason, the personnel of qualified chemists has had to be raised gradually from thirty-eight to seventy. In spite of all these official activities, Sir Robert has found time to advance the cause of science in other ways. He has carried out important researches on the infra-red spectra of ammonia, phosphine and arsine, and his investigations of diamonds led to the discovery that there are two varieties of this precious stone with distinctive atomic structures. In 1926–29 he was secretary of the Royal Institution, and since then as treasurer he has been responsible for raising large sums of money for rebuilding and for the endowment of research.

PRACTICALLY the whole of Sir Robert's career has been in Government service : for some fifteen years he was a chemist at the Royal Gunpowder Factory, Waltham Abbey. When he first went there, the manufacture of cordite was quite a new thing, but before he left he had carried out important investigations on its stability. From there he went to Woolwich as Director of Explosives Research in 1907, so that when the Great War broke out he was in a position to do much to assist the enormous developments in the manufacture and control of explosives. For this he was made K.B.E., and he was also elected to the Royal Society. When Sir Robert retires on April 17, he will be succeeded by his deputy, Dr. J. J. Fox, who has served in the Government Laboratory for some thirty-six years, during which time he has also worked under Sir T. E. Thorpe and Sir J. J. Dobbie. Dr. Fox studied physics and chemistry at the East London Technical Schools, and afterwards continued his chemical studies at the Royal College of Science. He has always been specially interested in physics and the application of physical methods to chemical analysis, upon which he has published much work. He collaborated with Sir Robert Robertson in the researches already mentioned on infra-red spectra and the diamond.

(*Continued on p.* 25.)

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The Size and Age of the Universe*

By Sir James Jeans, F.R.S.

IT has often been said that the history of the race is that of the individual writ large, and this remark is specially applicable to the question of the size of the universe. The new-born child is unable to form an adequate conception of the size of the world, probably because it takes its cradle or its nursery as its unit of measurement. It was the same with the human race in its infancy. Taking for granted that the earth was the central and most important part of the universe, it somewhat naturally supposed that the earth was comparable in size with the whole universe.

Early Discussions of the Problem

Peering into the dimly-lit recesses of early science, we see the gradual crumbling away of this belief. In the sixth century B.C., Pythagoras taught that the earth was globular in shape; and in the fourth century B.C., Heraclides of Pontus explained that the apparent rotation of the heavens arose from the rotation of this globular earth under the stars. Such teachings as these inevitably led men to revise their estimates both of the relative size and relative importance of the earth. In the third century B.C., we find Aristarchus of Samos making the first attempts to estimate the size of the universe by the really scientific method of exact measurement. He saw that when the moon was exactly half illuminated, the line from the sun to the moon must be perpendicular to the line from the moon to the earth. Thus in the triangle formed by the sun, the earth and the moon, one angle is a right angle, while another, that at the earth, can readily be measured by observation taken on earth. In this way Aristarchus hoped to obtain the relative lengths of the sides of the triangle in question, and so also the relative distances of the sun and moon.

His theory was perfect, but his observations very faulty. Actually the angle at the earth differs from a right angle by only about nine minutes of arc. Aristarchus estimated it to be three degrees, and so concluded that the sun was only about twenty times as distant as the moon—actually it is four hundred times as distant.

He also made estimates of the actual distances. Thanks to the genius of Anaxagoras, the nature of eclipses was already well understood. It was known that the darkness which spreads over the moon at an eclipse is the shadow of the earth. Aristarchus, knowing that the sun was many times more distant than the moon, saw that this shadow must be approximately of the same dimensions as the earth itself—it was a circle of the size of the earth seen at the distance of the moon. Knowing the size of the earth, it was an easy matter to compute the distance of the moon.

Once again Aristarchus relied on a series of erroneous measures. He estimated that the earth's shadow had only twice the diameter of the moon—actually it has four times this diameter. Also, the moon subtends an angle of half a degree in the sky, but Aristarchus took the angle to be two degrees, and so got erroneous values for the moon's distance as well as for its size. Clearly, exact measurement was not his strong point, yet he was the first to demonstrate the order of magnitude of astronomical distances.

Aristarchus made an even more important contribution to the large-scale problems of astronomy. He showed, by reasoning very similar to that used by Copernicus 1,800 years later, that the earth revolved in a circular orbit about the sun. He

* Discourse delivered at the Royal Institution on November 29, 1935.

then argued that, as the fixed stars appeared in spite of this motion to retain fixed places in the heavens, they must be at immeasurably great distances from the earth, saying that the distances of these stars "bore the same relation to the earth's orbit as the radius of a sphere bears to its centre" —in other words, the whole solar system was a mere point in the immensity of space.

I need scarcely remind you how, in the second century after Christ, these enlightened views were challenged and temporarily vanquished by Ptolemy of Alexandria. Ptolemy argued that if the earth were rotating, objects at the equator would be in the most violent rotation, and so would fly off into space, since "matter which is in violent rotation does not seem fit to be massed together, but rather dispersed". He went on to say that "long before now the disintegrated parts of the earth would have been dissipated over the heavens themselves, which is very ridiculous". He also said that, if the earth were rotating, a stone dropped to earth would not reach its destined place, because the earth would be moving eastward under it all the time it was falling. He said further that if the earth were rotating, the clouds would move over our heads from east to west as a consequence of this rotation. Clearly he had never stood in the track of the trade-winds and seen the clouds moving in endless procession from east to west as a consequence of the very rotation he was trying to discredit.

It was not until 1543 that these arguments were refuted by Copernicus. Ptolemy's argument had been that the earth cannot be rotating, because if it were it would fly to pieces ; thus the nightly motion of the stars must result from the rotation of the heavens themselves. Yet if the whole heavens rotated once every twenty-four hours, they must have an even higher tangential velocity than he, Copernicus, wished to attribute to the earth. Why then, asks Copernicus, do not the heavens themselves fly to pieces ? It was a shrewd thrust, but Copernicus was betrayed into pursuing his stricken enemy too far. For he went on to inquire whether the heavens really could be expanding under the centrifugal force of their rotation ; and his argument has a strange ring of 1935 about it. He scornfully asks what the heavens could possibly be expanding into, for as they are the whole universe, there can be no space beyond them into which they could expand.

The theories of Copernicus fared better than those of Aristarchus, the two principal reasons for their greater success being that printing and the telescope had been invented in the meantime. Two-thirds of a century after Copernicus published his book, the telescope of Galileo had virtually established the truth of his doctrines, and the sun replaced the earth as the fundamental unit of the universe. Ten years before Galileo had looked through his first telescope, Giordano Bruno was maintaining that the stars were similar objects to the earth, moon and planets—as Pythagoras had conjectured 2,000 years before. Ten years after, Kepler was saying that they must be similar objects to the sun ; and this led to the first real comprehension of the immensity of space. For, if the stars were intrinsically as bright as the sun, they must be at stupendous distances to look so much fainter than the sun. We receive approximately 100,000 million times as much light from the sun as we do from a first-magnitude star such as Altair, Betelgeux or Aldebaran. Thus, if these stars are comparable with the sun in luminosity, they must needs be about 320,000 times as distant—no smaller distance would be compatible with their faintness. In modern terminology, these first magnitude stars would be at distances of approximately $1\frac{1}{2}$ parsecs or 5 light years.

This method of calculation was first used by Newton in his "System of the World". We know now that it cannot lead to very accurate results, at any rate in the crude form in which Newton used it, because the supposition that the stars are all of the same candle-power as the sun is very far from the truth—some have more than 10,000 times the candle-power of the sun, while others have less than a 10,000th part. But the method admits of almost endless refinement, and in its modern form provides the most useful, and indeed almost the only, method for estimating the distances of very remote objects.

The Modern Method of Attack

The stars fall into clearly defined categories. As an unassorted whole, they exhibit an enormous range in candle-power, but all the stars in any one category are of approximately the same candle-power, so that we can obtain a reasonably good estimate of a star's distance by considering its apparent brightness in conjunction with the category into which it falls. For the majority of stars, the category is determined mainly by the star's spectrum, but in the case of variable stars the period of variability is even more important

than the spectrum, and leads to results of far greater precision.

To take an instance of the simplest kind, the star Sirius, which looks the brightest in the whole sky, is one of those nearer stars whose distance can be determined by ordinary trigonometrical methods —methods which are the same in principle as those which the surveyor uses to determine the distance of an inaccessible mountain-peak. The whole process is, of course, conducted on an enormously larger scale ; the surveyor takes a base-line a few miles long on the earth's surface and finds his mountain is a few miles distant, while the astronomer takes as his base-line the diameter of the earth's orbit round the sun—a base-line 186,000,000 miles long—and finds that his star is many millions of millions of miles distant. In this way he finds that the distance of Sirius is 51 million million miles, or 8·65 light years. Knowing this, we can estimate the distance of all stars which belong to the same category as Sirius ; for example, a similar star which looks 100 times less bright must be 10 times as distant, because light falls off as the square of the distance.

Variable stars provide a more reliable method of estimating astronomical distances. For example, the star δ Cephei is found by the ordinary surveyor's method to be about sixty times as distant as Sirius. All stars which have the same period of variability as δ Cephei are found to have about the same candle-power, so that again their distance can be estimated from their faintness. As these variable stars are enormously bright, they can be seen to immense distances—hence their special value as indicators of astronomical distance.

We can test these methods in various ways. The obvious one is to find a group of stars which are already known to be all at the same distance, and see whether each of the stars tells the same story as to the distance of the group. Such groups of stars are to be found in the globular clusters, the Magellanic clouds, and in the nearer of the extra-galactic nebulæ.

In these last objects, even the vivid Cepheid variables look very faint. Nevertheless they are visible, and their feeble brightness can be measured with considerable accuracy in a large telescope. In this way, we find that the distance of the nearest of these nebulæ is about 770,000 light-years.

This is the nebula M 33 in the constellation Triangulum. The second nearest nebula is the well-known "Great" nebula in Andromeda ; this is at a distance about 3 per cent greater. In this last nebula, no fewer than forty Cepheid variables can be detected, but as we pass to more distant nebulæ, the number of identifiable Cepheids naturally decreases, and this particular method becomes less reliable. Finally it fails altogether through the impossibility of discovering Cepheid variables at all.

Yet many stars are even brighter than Cepheid variables, and these enable us to carry on with the same method to even greater distances.

In Table I, the second column shows the distances of eight near objects as determined from the Cepheid variables observed in them. The last column shows the candle-power of the brightest stars observed in these objects, that of the sun being taken as unity.

TABLE I.

Object	Distance in Light years	Candle-power of Brightest Star (Sun = 1)
Large Magellanic Cloud	85,000	100,000
Small Magellanic Cloud	95,000	18,000
Globular Cluster N.G.C. 6822	620,000	15,000
Nebula M 33	770,000	29,000
Nebula M 31 (Andromeda)	800,000	18,000
Nebula M 101	1,300,000	22,000
Nebula N.G.C. 2403	2,000,000	22,000
Nebula N 81	2,400,000	18,000

With one exception, the brightest star in each of these objects has about 20,000 times the candle-power of the sun. Now stars can be identified in forty nebulæ in all, and if we assume that in each of these the brightest star has about 20,000 times the candle-power of the sun, we can immediately estimate the distance of these nebulæ also.

We have been gradually moving farther out into space, and if we still continue our journey, we come in time to nebulæ in which even the brightest of stars are invisible. How then can we discover the distances of these nebulæ ?

The answer is that the nebulæ—like the stars—appear to be built to pattern. When two stars show the same spectrum and the same period of variability they belong to the same category, and are of approximately the same candle-power. In the same way, when two nebulæ show the same build—the same shape and distribution of relative brightness—they are of approximately the same candle-power. We reach this conclusion from a study of the nearer nebulæ, whose distance can be ascertained, and then assume that it is true of the further nebulæ also. Thus the faintness of the nebulæ gives a measure of their distance, and in this way we can estimate the distances of even the faintest of visible nebulæ.

FIG. 1. A group of nebulæ in the constellation Pegasus. The three nebulæ near the centre of the plate are of approximately the same build, and as they all appear to be of the same size and brightness, we conclude that they are all at the same distance, and so form a close group in space.

All this, let us notice, is an extension of the method introduced by Newton 250 years ago.

THE VISIBLE UNIVERSE

Using this method, we find that the faintest nebulæ which are visible in our telescopes are at a distance of 150 million light years. Before we proceed further, let us try to see all this in proportion—let us make a small-scale model on the scale of two million light years to the inch. Then our visible universe will be a sphere 12 ft. 6 in. in diameter. Our galaxy is a small disc, of the size of an average pinhead—perhaps 1/10 inch in diameter. The naked-eye stars are all contained in a sphere of about 1/600 inch radius—a mere speck of dust. Our sun is a single electron, and the earth is a millionth part of an electron.

There is no reason to suppose that this sphere of 150 million light years radius contains the whole of the universe; we may be sure that a larger telescope would show still fainter, and therefore still remoter, nebulæ, so that there is no means of fixing the total size of the universe—if it has a finite size—in this way. We must turn to other, and less direct, methods.

RELATIVITY THEORY AND THE UNIVERSE

According to the theory of relativity, space curves back into itself, so that the total volume of space is finite—just as the total area of the earth's surface is finite. If the earth's surface were plane, the area within a distance x of any given point, say Charing Cross, would be exactly proportional to x^2. But, because of the curvature of the earth's surface, the actual area increases less rapidly than x^2. A circle one mile in radius has an area of 3·1416 square miles, but a circle 100 miles in radius has an area of less than 31,416 square miles. If space is curved in a similar way, the volume of space which lies within a distance x of the earth would increase less rapidly than x^3, so that if the nebulæ are

FIG. 2. A group of nebulæ in another part of the constellation of Pegasus. One of the nebulæ looks far larger and brighter than the others, whence we conclude that it is much nearer to us, so that these nebulæ do not form a close group in space.

uniformly distributed in space, the number of nebulæ would also increase less rapidly than x^3.

Efforts are being made at Mount Wilson to examine whether the number of nebulæ falls off in this way at great distances, but so far the number appears to vary approximately as the cube of the distance—there are no signs of falling off as yet. Indeed, preliminary statistics which have only reached Great Britain within the last few days seem to indicate the exact reverse. This may perhaps mean that we live in a part of the universe which is only sparsely filled with nebulæ, so that we come to a greater density of nebulæ when we go far from home. But a more likely interpretation is that the present observational material is inadequate for statistical treatment. We may hope that the new 200-inch telescope will solve the problem for us in due course. In the meantime, the only inference that we may legitimately draw from our present telescopic observations is that, in all probability, the nebulæ extend very much further than the 150 million light years to which our telescopes can penetrate.

If the effect just mentioned had been observed, it might have been possible to form an estimate of the total volume of space. As this method is not available, we must fall back on other, and less reliable, methods.

According to an earlier form of the theory of relativity, there was a quite simple relation between the total volume of space and the average density of matter in space. Unhappily, it is not easy to estimate the density of matter in space with any accuracy, but it is at least possible to assign upper and lower limits between which it must lie. This, of course, leads to upper and lower limits for the total volume of space; and calculation showed that if this theory were sound, space was immense in comparison with that part to which our telescopes can reach. The 150 million light years to the farthest visible nebula is only a minute fraction —perhaps a 500th part—of the radius of space. Or, to say the same thing in another way, light takes 150 million years to travel from the farthest visible nebulæ to us, but would take 500,000 million years to complete the journey round space and get back to its starting point.

This particular development of the theory of relativity has fallen into disfavour of recent years; it is still possible that it may give a rough approximation to the truth, but it seems quite certain that it is not the whole truth. Other theories have suggested radii of space of about 2,000 and 10,000 million light years respectively, but it is hard to feel much confidence in these estimates. All that we can say with any confidence is that the dimensions of space are probably far greater than the 150 million light years to which our telescopic eyes can see. Einstein's latest conjecture is that space may after all, his earlier theories notwithstanding, be of literally infinite dimensions.

The Age of the Universe

The question of the age of the universe is of a somewhat different nature. There are a great number of different ways of estimating this age; none of them are completely trustworthy, and unhappily they appear to lead to inconsistent results. Stated in its crudest and most obvious form, the problem is of course that of examining how far we can trace back the universe into the past, and it is perhaps not surprising that the further we go the less certainty we find.

The big telescope at Mount Wilson shows us objects in space whose light has taken 150 million years to reach us. When we turn the telescope on to these objects we see them, not as they are now, but as they were 150 million years ago. These parts of the universe, then, must have been in existence 150 million years ago, and we seem justified in concluding that the universe as a whole is more than 150 million years old. Not only so, but these distant parts of space are occupied by objects which do not differ in essentials from those nearer home, from which it seems safe to conclude that the universe has not altered greatly in the past 150 million years; in other words, this period is only a small part of the evolutionary life of the universe, so that the age of the universe is probably many times 150 million years.

A study of our own earth confirms this conclusion. Geology can reconstruct for us the physical conditions of 150 million years ago, and we see that, broadly speaking, they were very similar to those prevailing to-day. This not only shows that the earth is more than 150 million years old, but also that the sun has changed but little in the past 150 million years. Thus the sun, and so also the universe of which the sun forms part, must probably have an age of many times 150 million years.

By analysing the radioactive properties of rocks of various kinds in the crust of the earth, we can discover the length of time which has elapsed

since these various rocks solidified. The oldest rocks of all show ages ranging up to 1,750 million years since solidification. Thus we may safely conclude that the universe is at least 1,750 millions of years old.

The Expanding Universe

For the next piece of evidence, we must return to the extreme depths of space. We believe the great extra-galactic nebulæ to be galaxies of stars generally similar to our own, and these are found to be receding from our galaxy with immense speeds—the largest speeds we encounter in astronomy, apart from the velocity of light. The greatest so far observed is 25,000 km. a second, which is one-twelfth of the velocity of light. It is found to be a general rule that the most distant nebulæ are receding the most rapidly, and the speeds of the various nebulæ are proportional to their distances from us. This is shown in Fig. 3,

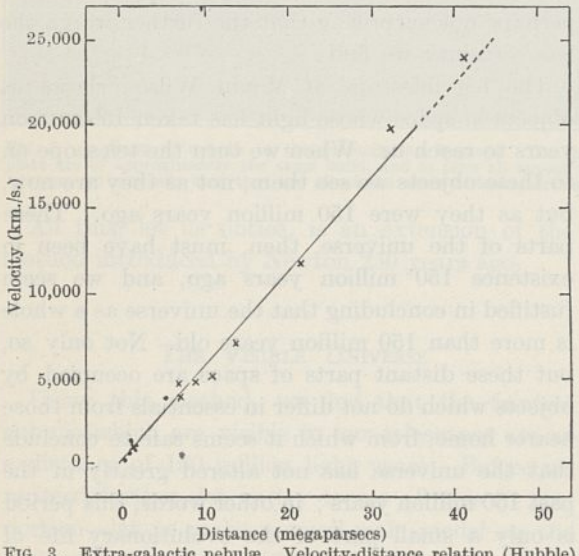

FIG. 3. Extra-galactic nebulæ. Velocity-distance relation (Hubble). •, Isolated nebulæ (grouped). ×, Clusters of nebulæ.

which embodies results recently obtained by Hubble and Humason at Mount Wilson. The abscissæ represent the distances of various nebulæ and groups of nebulæ at distances ranging up to about 40 million parsecs (130 million light years); the ordinates represent the observed velocities of recession of these nebulæ expressed in kilometres per second. It is at once seen that the velocities are very approximately proportional to the distances of the nebulæ.

The theory of relativity provides a very simple explanation of these observed motions of the extra-galactic nebulæ, and of the law obeyed by the speeds of the nebulæ at different distances. It is, in brief, that space itself is uniformly expanding, and that the nebulæ embedded in it indicate the motions of space, much as floating straws indicate the currents in a stream. If this is the true explanation, then the nebular motions show that space is at present expanding at such a rate that its linear dimensions double every 2,000 million years—which, let us notice in passing, is just about the probable age of the earth. But the theory of relativity goes further than this, and tells us that space is very unlikely to expand continually at a uniform rate. Certain assumptions suggest that the expansion increases, approximately at least, in geometrical progression with the time. If this is the true law, then the present nebular motions show that space doubles its linear dimensions every 1,400 million years. In other words, 1,400 million years ago space had only half its present linear dimensions, 2,800 million years ago only a quarter of its present linear dimensions, and so on.

We must not, however, go on in this way for ever. It would take an infinity of time to reduce space to a point, but this is unimportant, for obviously we must not reduce space to a point; we must stop somewhere before we reach that stage. Detailed mathematical investigations, too complicated even to summarise here, seem to suggest that space cannot have been expanding for more than about 100,000 million years. This figure is, however, very uncertain, and in any case provides no conclusive evidence as to the age of the universe. For mathematical investigation also shows that the present period of expansion may well have been preceded by a period of contraction. Indeed the mathematical equations admit of solutions of two different types. In one, the present epoch of expansion is preceded by an earlier epoch of contraction, and no limits can be set to the possible duration of this. In the other, the present epoch of expansion is only one of a great number of epochs of regularly alternating contractions and expansions, and no limit can be set to the possible number of these epochs. This line of discussion, then, can tell us nothing definite as to the age of the universe.

It may, of course, be argued that, even though definite evidence is lacking, considerations of probability fix a probable limit to the age of the universe. The general line of argument would be that in the last 1,000 million years, the dimensions of space have changed very appreciably—probably by about 60 per cent—so that the time-scale of change is one of thousands of millions of years, and it is likely that the total age must also be

measured in terms of thousands of millions of years. To take a parallel instance, if a zoologist captured a new kind of animal, of entirely unknown species, and found that its weight increased by 60 per cent in a month, he would probably conclude, rightly or wrongly, that the creature was not many months old. If a tree increases its height by 60 per cent in a year, the botanist may be fairly sure that it is not many years old. The argument undeniably carries some weight, but we must be careful not to overrate it. In brief, we must remember that the universe is neither an animal nor a tree. The population of England has increased by 60 per cent in the last half-century, but we should not be justified in concluding that England is only a few half-centuries old. The brightness of the star Mira Ceti has changed by about 60 per cent in the last month, but we must not conclude that Mira Ceti cannot be more than a few months old. Thus general considerations of probability can at best give a presumption, and not a very strong one at that.

The Motions of the Stars

Another line of argument, which seems to me far more convincing than the foregoing, leads to very different conclusions. If I set a pendulum swinging, it comes to rest after a short time. It has been reduced to rest by its continued impact with molecules of air ; in brief, it has shared its energy with these molecules.

Actual experiment may show that this pendulum comes to rest in a few minutes, but I could calculate this out without experiment. All I need to know is the size and weight of the pendulum, and the density of the air in which it swings. Thus if I come into the room and find the pendulum swinging vigorously, I can conclude, from purely abstract calculations, that it has not been swinging for many minutes ; it must have been set into motion only a few minutes ago. But if I find that it is at rest, and that hundreds of other similar pendulums are also at rest, I can conclude that they have stood undisturbed for many minutes—they may previously have been in motion, but if so, they have already shared their energy with the surrounding molecules of air.

This tendency to sharing energy pervades the whole of physics and prevails also in astronomy. The laws which govern the motions of the stars show that these also must share their energies with one another, and if they have been left undisturbed for a sufficiently long time, this sharing of energy will be complete. We can calculate how long a time is needed for the process to be effected, and it proves to be a matter of millions of millions of years. Thus if we find that the stars have already shared their energy, we know that they must be millions of millions of years old.

The method admits of greater refinements. Suppose I have a row of pendulums of different sizes and weights, one of which comes approximately to rest in two minutes, while the next requires 4 minutes, others require 6, 8, 10 and 12 minutes respectively. Suppose a cataclysm of some kind occurs—say, an earthquake—and after a time I come into the room and find that the 2, 4 and 6 minute pendulums have already come to rest, while the 8, 10 and 12 minute pendulums are still swinging with varying degrees of force. It is reasonable to conclude that the cataclysm occurred between 6 and 8 minutes ago. With a sufficient number of pendulums, it might be possible to fix the time with considerable precision.

Now the different kinds of stars form just such a range of pendulums. Fortunately, they share their energies at very different rates. When we proceed to observation, we find that in actual fact some types of stars have already shared their energies almost completely, both with other stars and with one another ; for other types the process has barely begun. This is shown in the three following tables.

Table II. Orbits of Visual Binaries classified by Eccentricity

Limit of e	Observed	Equipartition of Energy
$e < 0{\cdot}1$	0	2
$e < 0{\cdot}2$	11	9
$e < 0{\cdot}3$	20	21
$e < 0{\cdot}4$	34	37
$e < 0{\cdot}5$	58	58
$e < 0{\cdot}6$	83	83
$e < 0{\cdot}7$	89	113
$e < 0{\cdot}8$	102	148
$e < 0{\cdot}9$	109	187
$e < 1{\cdot}0$	116	231

Table II is concerned with observations of 116 stars ; for 83 the eccentricity of orbit is less than 0·6, and for 33 stars it is greater than 0·6. The last column shows the statistical distribution of eccentricities we should find in a group of stars in which the process of energy-sharing was complete, the group being chosen to be of such a size that there are again 83 stars of eccentricity less than 0·6. A comparison of this and the preceding column shows that the energy-sharing process is fairly complete up to eccentricity 0·6, but that for

eccentricities higher than 0·6, there is very little evidence of energy-sharing. These stars of high eccentricity correspond to very slow 'pendulums', but we must not overlook that our table may be incomplete on the observational side, since binary stars of eccentricity greater than about 0·6 are difficult to detect and still more difficult to measure.

The visual binaries of eccentricity less than about 0·6 form a range of pendulums in which the process of energy-sharing requires a time of millions of millions of years. In another class of binary stars, the spectroscopic binaries, the components lie much closer together—so close in fact that the gravitational forces from other stars have very little effect in modifying their orbits. In these stars, the process of energy-sharing is a matter of hundreds of millions of millions of years at least. Table III contains statistics as to the orbits of these stars. We see at once that there is no appreciable sharing of energy.

Table III. Orbits of Spectroscopic Binaries classified by Eccentricity

Limit of e	Observed	Equipartition of Energy
$e < 0·2$	78	12
$e < 0·4$	96	50
$e < 0·6$	112	112
$e < 0·8$	118	199
$e < 1·0$	119	311

Finally, the linear motions of ordinary single stars provide yet another range of 'pendulums'. We know that the molecules in a gas tend to share their energy until finally all types of molecules, big and small, light and heavy, have, on the average, the same amount of energy. In the same way the stars tend to share their energy, and groups of stars of different masses form a range of pendulums, the most massive stars sharing their energy most slowly and the lightest the most rapidly.

Table IV gives the average linear velocities of stars of different masses as determined by Seares at Mount Wilson. We see that all except the most massive stars are well on towards equipartition of energy, all having an average energy which is not very far from 3,750 in the units we are using.

Table IV. The Linear Velocities of Stars of Different Masses

Mass of Star	Average Velocity	Energy
7·6	15·3	1785
5·5	26	3675
4·0	30	3550
2·5	36	3240
1·5	48	3550
1·0	65	4070
0·7	78	4420
0·6	76	3470

These and various other 'pendulums' agree in suggesting that we must assign to the universe an age of 5–10 millions of millions of years.

The Source of Stellar Energy

Let us now consider the state of things 5 millions of millions of years ago. Observation shows that the sun is at present radiating energy away at the rate of about 250 million tons a minute. This time yesterday, then, it weighed 360,000 million tons more than now. A million million years ago, it weighed a very great, but still calculable, number of tons more than now; it was about 6 per cent more massive than now; and, because of this, it was also a brighter star than now, radiating not 250 million tons a minute, but about 300 million tons a minute. After adjusting our calculations for such considerations as this, we find that 5 million million years ago, the sun was probably many times as massive as now and many times as bright. In the intervening period, it has been gradually getting rid of its mass in the form of radiation, until it is reduced to a mere relic of its former magnificence.

A few years ago, it was difficult to believe that the sun could produce its radiation by the actual annihilation of its substance, but in these few years the short-lived positive electron, or 'positron', has been detected in the laboratory. This has given us every reason for thinking that the transformation of matter into radiation is continually going on in ordinary terrestrial matter, as well as the converse process of the creation of matter out of the energy of radiation. With this source of energy to call on, there is no longer any objection to our assigning ages of millions of millions of years to the stars.

It was not easy to visualise the vastness of astronomical space, and it is even less easy to conceive of the immensity of astronomical time. A fairly lengthy book contains about 200,000 words averaging five letters each. Let us take the whole of such a book to represent the age of the earth. Then the whole of civilisation is represented by the last word or two, and the whole of the Christian era by something less than the last letter. A single lifetime is a good deal less than the final full stop with which the book ends. Such is the age of our own planet; according to the view I have put forward, the whole age of the universe must be represented, on the same scale, by a library of some thousands of volumes.

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"Round the Empire" Christmas Broadcast

FOR the fourth successive year, a radio broadcast tour of the Empire was conducted on Christmas Day by the British Broadcasting Corporation, with the assistance of the radio telephone services of the Post Office. The result was a great tribute to the technical skill and the organising ability of both administrations. On this occasion, the listener played the part of an eavesdropper on a series of almost private telephone conversations between individuals or families in various parts of the British Isles and other groups in Canada, India, South Africa, Australia and New Zealand. The longest communication link covered on this occasion was employed for an exchange of greetings between two children in the London studio and their grandfather at Wellington, New Zealand. The technically minded listener must tremble to think of the number of electrical circuits used in such a programme and of the possibilities of faults and breakdowns which do not seem to occur. The more mathematically minded may pause to consider whether the number of listeners on such an occasion may be truly termed an astronomical figure. The ordinary person may still have cause to wonder at the fact that when parts of England are covered with snow, Australians can thoroughly enjoy surf-bathing on Christmas Day. Will this wonder be dispelled or increased when television, which is already poking its nose round the corner, transforms this Empire broadcast programme into a pictorial tour with a suitable running commentary ?

Winter Floods

THE remarkable persistence of heavy rainfall during the closing months of 1935 has been the cause of much material damage and inconvenience to the inhabitants of low-lying districts and notably in the case of the Thames Valley, where extensive flooding has occurred, and the river has attained heights occasioning serious concern to the authorities Up to the end of November, the aggregate rainfall of 13·96 inches for the three autumn months exceeded all previous records of the Thames Conservancy Board for more than fifty years. On the last day of December, the aggregate for four months was touching 17 inches and the flow over Teddington Weir was at the rate of 6,500 million gallons per twenty-four hours, a thousand million gallons more than in mid-November, as reported in NATURE of November 23 (p. 826), and two thousand million gallons in excess of the 'root figure' of 4,500 million gallons, when the river is flowing bank high. At Lechlade and Radcot, where thousands of acres are under a foot of water, the river reached its highest level since the great floods of 1929. At Reading the stream was in many places a quarter of a mile wide. Flooded areas of equally considerable extent have been reported from various parts of the south and east of England—from Kent, Hampshire, Cambridgeshire, Nottinghamshire, Lincolnshire, Worcestershire and the East Midlands. The infliction of widespread havoc of this kind once more emphasises the importance of the survey undertaken by the Inland Water Survey Committee of the Ministry of Health, the issue of the first annual report of which in the near future is awaited with much interest. Heavy rains and inundations are unfortunately not confined to Great Britain. From France, Switzerland and elsewhere come reports of gales and floods, and a recrudescence of the conditions described in NATURE of November 23. The Rivers Saône, Ardèche, Loire and Garonne are stated to be rising continuously, and in the Rhone Valley, Avignon is again threatened with submergence.

Newspaper Production as an Industry

A BROADSHEET recently issued by P.E.P. (Political and Economic Planning) gives a summary of elementary facts about the Press of Great Britain collected as a preliminary to a constructive investigation of the possibilities of improvements in the Press to meet modern needs. Including for this purpose the entire preparation and publication of newspapers and periodicals, although attention is concentrated mainly on the London daily newspapers, the survey emphasises the extent to which the Press has become an important industry, ranking in size with electricity supply and the manufacture of bricks and tiles and considerably above the brewing or the silk and rayon industry. In the decade 1921–32, its personnel in England and Wales rose from 56,488 to 79,558, and it is characterised by a high proportion of males to females, a low proportion of juvenile workers (less than 9 per cent) and an extremely high proportion of administrative staff (30 per cent), about one sixth of the total being professional workers, a figure four times the average for all industries. Unemployment is low, the net output in terms of money value very high and employment is largely concentrated in large units in a few of the great towns. The two most important points in a newspaper's finances are its advertisement revenue and the price of newsprint, cost of ink being negligible. Production costs (largely wages) come third and editorial services fourth, being equalled for the larger newspapers by the cost of physical distribution. Industrially, the Press is thus healthier and more flourishing than other British industries, but on industrial grounds as well as on the ground of social responsibilities, there is a case for considering whether the financial structure cannot be simplified and made sounder.

Noise

WE have received from the Anti-Noise League at 66 Victoria Street, S.W.1, a reprint of an article on "Noise" by Dr. L. E. C. Hughes, which originally appeared in the columns of the *Electrician*. The League is doing admirable work in sponsoring a considerable number of publications on the various aspects of noise. These will be found both interesting and of service to the largely increasing public which is concerned with the problem of noise, whether from mechanical transport, modern housing or other contributory cause. That the country has become noise conscious is reflected in the noise abatement activities of the Ministry of Transport, the Ministry of Health, the National Physical Laboratory, the

British Standards Institution and other bodies; and further restrictive legislation in various directions would appear to be not unlikely. The problem of the measurement of noise, or rather of its 'equivalent loudness', is finding generally accepted solution both in Great Britain and abroad. The standard of comparison is a reference tone of 1,000 cycles per second with a specified arbitrary 'zero' of intensity. If the reference tone is increased in successive decibel steps of energy above the zero, the resulting changes of loudness are expressed in numerically identical steps on a scale of phons. The equivalent loudnesses of other sounds and noises are evaluated by aural matching against the reference tone when suitably adjusted. Other features to which Dr. Hughes refers in his informative article are the abatement of both air-borne sounds and impact noises and vibrations in buildings, impulse noises, and commercially available noise-measuring instruments.

Wonders of Tinplate

AN interesting film dealing with tinplate and canning, produced in France under the title "Magie du Fer-Blanc", was shown for the first time in England on December 2 at the Polytechnic Extension, Little Tichfield Street, London, W.1. The display took place under the auspices of the International Tin Research and Development Council, and Sir John Campbell, chairman of the Internation Tin Committee, introduced to the audience M. Peissi, director of l'Office Technique pour l'Utilisation de l'Acier, by whom the film had been produced. Various phases in the production of tinplate, the fabrication of containers and the canning of food were depicted. At present the film has French subtitles, but we understand that it is probable that an English accompaniment will be arranged and the film exhibited publicly in Great Britain.

Meat Inspection in South America

THE fourteenth Benjamin Ward Richardson lecture, founded in 1922 by the Model Abattoir Society (dissolved in 1935), was delivered in the rooms of the Royal Sanitary Institute, which has taken over the management of the Richardson Trust, on November 12, by Dr. M. T. Morgan of the Ministry of Health, on the system of health inspection of meat and meat products destined for export in the great abattoirs of South America. In accordance with instructions from his Department, Dr. Morgan recently visited the large factory abattoirs in the Argentine, Uruguay and Brazil which serve for the preparation of meat and meat products destined for export overseas and for local consumption. The products range from the finest quality chilled beef destined for the English market down to every variety of by-product from agricultural fertilisers to buttons for clothes. The finest quality meat is produced in the Argentine, and a slightly inferior quality in Uruguay. The system of inspection of meat and meat products is the same in all three countries, but is most highly developed in the Argentine, where it is a special branch of the State service of inspection of livestock and is not attached to the public health service as in Great Britain. A most efficient inspection of the animals is made both before and after death. Whole carcasses or sides or portions or viscera are rejected on the slightest grounds of a suspicion that they are unhealthy or unsuitable for human consumption. In conclusion, Dr. Morgan states that in all three countries he was struck by the extraordinarily high standard of the service of inspection and the extreme cleanliness and efficiency in every department of the enormous factories.

Britain in the Dark Ages

A MAP of Britain in the Dark Ages (A.D. 410 to 871) is the third of the period maps to be published by the Ordnance Survey. The south sheet covering England, Wales and part of southern Scotland has now appeared (Southampton: Ordnance Survey. Cloth mounted. 5*s*. Paper, flat and unmounted. 2*s*. 6*d*.). The scale is 1 : 1,000,000 and the map is contoured and layer coloured. No attempt has been made at the almost impossible task of restoring the ancient coast line, but the forest covering is shown, and is the same as that on the map of Roman Britain. The entries on the map have been derived from both archæological and historical sources, and an attempt has been made to represent both the Celtic and Saxon aspects of the period. Different characters are used for place names of the two origins. Latin names, constantly used in documents of the period, are also differentiated. Roman roads, with one exception are omitted, since their use was uncertain. Churches, crosses, battle-sites, villages and other dwellings, and burial places are shown, and in the introductory pamphlet that goes with the map there are small maps showing respectively place names ending in -ing and the distribution of cemeteries. There is a complete index of ancient names with modern equivalents. The map is a beautiful example of cartography and shows a wide range of historical research without any suggestion of crowding of names or symbols.

The *Present Age*

WE have received the first two numbers of the *Present Age*, a new monthly journal edited and published by Dr. W. J. Stein, 144 Harborough Road, London, S.W.16 (2*s*. a month). The editor, in a covering circular, points out that modern life has created such a high degree of specialisation that it has become almost impossible to have cognisance of more than one sphere of knowledge or activity. The *Present Age* is designed to relate different fields of knowledge by the publication of articles apparently independent, but showing their true interrelationships. The January issue (1, No. 2) contains, among others, historical articles on "King Arthur", "Christmas through the Ages", and "Eurythmy in Ancient Greece", the last-named with four excellent plates of Nereids from figures in the Nereid Room of the British Museum. Science is represented by articles on "Alterations in the Earth's Surface", and "The

Classification of the Animal Kingdom", and medical science by one on "The Nature and Treatment of Sclerosis", a process terminating in hardening and calcification in tissues and organs. The latter presents the subject largely from a metaphysical and homœopathic point of view, and cannot be accepted as representing modern medical conceptions. The metaphysical also looms large in "Alterations in the Earth's Surface", and so far as science is concerned, the articles can scarcely be accepted as representative of its modern aspects.

New Garden Plants

THE present generation of horticulturists is fortunate in the ever-increasing number of new contributions to garden beauty. Scientific hybridisation and selection have produced more pleasing shades of bloom, or enhanced symmetry of form from old favourites, whilst ardent botanists roam amongst the wilder parts of the world to find new grandeur for the rockery or herbaceous border. Plants from these sources which have stood the test of English cultivation are described (*J. Roy. Hort. Soc.*, November) by Dr. Fred Stoker, who writes on "Ericaceous Plants" and Mr. Ben Wells, who discusses herbaceous subjects. Both accounts are well illustrated with excellent half-tone plates, and give many practical details.

Memorandum on Pneumonia

PNEUMONIA, as a cause of national mortality, has long been a matter of concern to public health authorities. In 1934, for example, this disease was responsible for 28,623 deaths in England and Wales, and in times of influenza prevalence the mortality may reach a much higher figure. The Ministry of Health has, therefore, issued a Memorandum (Memo. 189 Med.) with covering circular (No. 1499) on the subject for the use of public health authorities, in which the classification and bacteriology, its prophylaxis and the general administrative measures applicable, are dealt with (H.M. Stationery Office. 1*d*. net).

Physical Society's Exhibition

THE twenty-sixth annual exhibition of scientific instruments and apparatus arranged by the Physical Society opens at the Imperial College of Science and Technology on January 7. The times of admission are 3–6 and 7–10 p.m. (January 7), 2–4, 4–6 and 7–10 p.m. (January 8) and 3–6 and 7–10 p.m. (January 9). A descriptive catalogue of the exhibits can be obtained from the Exhibition Secretary, Physical Society, 1 Lowther Gardens, Exhibition Road, London, S.W.7 (1*s*. post paid), to whom applications for tickets of admission should also be addressed.

Indian Science Congress Association

THE twenty-third annual meeting of the Indian Science Congress Association is being held on January 2–8 at Indore, under the presidency of Rai Sir Upendranath Brahmachari Bahadur. The presidents of sections are as follow: (1) *Mathematics and Physics:* Dr. T. Royds, director of the Kodaikanal Observatory; (2) *Chemistry:* Dr. P. C. Guha, professor of organic chemistry, Indian Institute of Science, Bangalore; (3) *Geology and Geography:* B. Rama Rao, officiating director of geology, Mysore Geological Department, Bangalore; (4) *Botany:* Dr. S. R. Bose, professor of botany, Carmichael Medical College, Calcutta; (5) *Zoology:* Dr. H. K. Mookerjee, University professor and head of the Department of Zoology, University of Calcutta; (6) *Anthropology:* H. C. Chakladar, lecturer in anthropology, University of Calcutta; (7) *Agriculture:* A. K. Yagna Narayan Aiyer, formerly director of agriculture, Sankarapuram, Bangalore; (8) *Medical and Veterinary Research:* Lieut.-Col. H. E. Shortt, director of the King Institute, Guindy, Madras; (9) *Physiology:* Dr. W. Burridge, professor of physiology, University of Lucknow; (10) *Psychology:* J. M. Sen, inspector of schools, Presidency Division, Bengal.

Recent Meteors and Fireballs

THE METEORIC DISPLAY OF NOVEMBER 21. A letter has been received from Mohd. A. R. Khan, whose wireless message was published in NATURE of November 30, p. 867, as follows: "I observed over one hundred meteors between 6h. 50m. and 7h. 10m. G.M.T. on November 21, of which several were of first magnitude with long trails. Eleven more were observed in the next 20 minutes. The sky was rather hazy. Perhaps the richest part of the shower occurred somewhat earlier, before I began observation". The possible return of this shower should be looked for by meteor observers in future years.

A GREAT DETONATING FIREBALL. On November 25, at 0h. 20m. U.T., a meteor which announced its arrival with a 'blinding glare of light' was observed in south-west England by many people. At Bridgwater there was a loud explosion after the disappearance of the fireball, "followed by a rumbling noise resembling thunder, lasting for about a minute". Heavy detonations were also heard at Weston-super-Mare and Bristol. Mr. A. King, of 53 Victoria Road, Ashby, Scunthorpe, Lincs, has received some ten accounts, but they are mostly so vague (and in some cases contradictory) that a definitive real path cannot be computed. All that can be said in this respect is that the object passed over the district between Bridgwater and Bristol at a low height.

DAYLIGHT FIREBALL. On December 3, at 11h. 30m. U.T., an observer in Bradford saw a meteor with a long tail shoot across the eastern sky. This must have been a very fine fireball. Observations of the fireball should be sent to Mr. King.

Announcements

THE Catherine Wolfe Bruce Gold Medal for 1936 of the Astronomical Society of the Pacific has been awarded to Prof. A. O. Leuschner, professor of astronomy and director of the Students' Observatory in the University of California, for distinguished services in astronomy. Prof. Leuschner is an authority on the determination of the orbits of planets.

THE Prix Binoux of 1935 for the history and philosophy of science has been awarded by the Paris Academy of Sciences to Dr. George Sarton, editor of *Isis* and associate of the Carnegie Institution, for the published volumes of his "Introduction to the History of Science". This is the second time that the French Academy has awarded the Prix Binoux to Dr. Sarton; it was first awarded to him in 1915.

DR. E. C. BULLARD has been appointed Smithson research fellow of the Royal Society as from January 1. Dr. Bullard proposes to continue his present work on the development of methods of measurement and their application to geological problems, in the Department of Geodesy and Geophysics of the University of Cambridge. This work includes the explosion method of studying geological structure. The first problem in this connexion will be the determination of the depth of the Palæozoic rocks under eastern England. It is also hoped to develop methods for the measurement of heat leaving the earth per unit area and its variation from place to place.

THE Right Hon. Lord Rutherford will deliver the sixteenth Faraday Lecture of the Chemical Society in the lecture theatre of the Royal Institution on February 12, at 5.30. The subject of Lord Rutherford's lecture will be "Radioactivity and Atomic Theory".

MR. A. HAMPTON BROWN has retired from the position of assistant secretary of the Royal Meteorological Society after serving on the office staff for forty years. Miss E. N. Kidner has been appointed to succeed him as assistant secretary.

THE arrangements made for the transfer of apparatus from the Royal Society Mond Laboratory at Cambridge to a new laboratory which is being built for Prof. P. Kapitza in Moscow were described in a paragraph in NATURE of November 23, 1935, p. 825. The new laboratory is not yet in a working condition, but friends of Prof. Kapitza in many parts of the world will be interested to know that his address is now, Institute for Physical Problems, Kaloujskoe Shosse 24, Moscow, U.S.S.R.

A LARGE earthquake was recorded at Kew Observatory on December 28. The first impulses reached Kew at 2 hr. 48 min. 56 sec., and the record indicates that the shock originated 6,300 miles away, apparently near the northern end of Sumatra.

A CORRESPONDENT writes to us: "Now that our Teutonic colleagues have abandoned the clumsy and unpatriotic word *Mikroscop*, it is to be presumed that we shall no longer be harassed by the barbaric term *Binokular*? Heil, *Doppelaugigenbenützbar Kleinsehwerkzeug!* How much more neat and appropriate"!

A MARBLE plaque has recently been affixed to the birthplace at Villeneuve-le-Guyard of Prof. Chauveau, who was born there in 1827 and died in Paris in 1917. At the time of his death, he was a member of the Academy of Medicine, honorary professor of the Veterinary School at Lyons, professor at the Paris Museum, inspector of the French Veterinary Schools and Grand Officer of the Legion of Honour.

PART 3 of the classified catalogue of books in the Library (including Departmental Libraries) of the London School of Hygiene and Tropical Medicine has been issued. It is compiled by the librarian, Mr. Cyril Barnard, and includes the literature in Classes E, F and G, dealing with epidemiology, vital statistics and medical geography; ætiology, diseases of doubtful causation and those due to physical agents; toxicology and diseases of chemical causation.

THE Cambridge University Press will shortly publish in the Craftsman Series, "James Watt, the Craftsman", by Mr. H. W. Dickinson. Other writers have dealt with his career as an inventor, but, as Mr. Dickinson's book shows, Watt's craftsmanship is an equally interesting aspect of his character. It was a faculty that stood him in good stead as an inventor, and it turned out to be the solace of his old age. This book comes opportunely; the bicentenary of Watt's birth falls in 1936.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:

A teacher of mathematics and physics in the Northampton Polytechnic, St. John Street, London, E.C.1 (Jan. 10).

Assistants (Grade III) in the Directorate of Technical Development of the Air Ministry—The Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants (Jan. 11).

Technical assistants (physics or engineering) in a War Department Establishment at Woolwich—The Superintendent, Signals Experimental Establishment, Woolwich Common, S.E.18 (Jan. 13).

An assistant (III) at the Forest Products Research Laboratory, Princes Risborough—The Establishment Officer, Department of Scientific and Industrial Research, 16 Old Queen Street, Westminster, S.W.1 (Jan. 15).

An agricultural instructor for the administrative County of the Isle of Ely—The Director of Education, Education Department, County Hall, March (Jan. 17).

A senior scientific officer at the Royal Aircraft Establishment, South Farnborough, Hants—The Chief Superintendent (Jan. 17).

A guide lecturer in the Geological Survey and Museum, Exhibition Road, S.W.7—The Director (Jan. 28).

A cartographer in the Hydrographic Department of the Admiralty—The Secretary, Civil Service Commission, Burlington Gardens, W.1 (Feb. 20).

A male vocational guidance officer in the National Institute of Industrial Psychology, Aldwych House, W.C.2—The Secretary.

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot 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.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 34.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Metallurgy of Gold and Platinum among the Pre-Columbian Indians

WILLIAMS CURTIS FARABEE[1] refers to some finds of gold and platinum objects which come from La Tolita, Esmeraldas, Ecuador. During the washing process, in addition to the natural gold and platinum, a quantity of quite small gold objects were obtained, which bear witness to the surprising skill of the Indians, who used gold not only for ornaments, but also for many useful objects, which in the form of fishing-hooks, sewing needles, safety-pins, hooks and eyes demonstrate the existence of a true gold age. The use of gold extended even to nails, which, it is known[2], are found but seldom in South America. In Antioquia, in Columbia, which lies to the north, objects are found made particularly of the gold alloy (copper 50, gold 33, silver 12 per cent) which is known as 'tumbago'[2]; but the La Tolita gold is of an essentially different composition, and the metal is often alloyed with platinum, obviously with the intention of producing white alloys.

There is a certain mystery about this find; what has especially aroused surprise is that the prehistoric Indians were able to prepare platinum in a compact state, so that they were able to use it not only for jewellery (nose rings) but also as a coating for gold; for small plates have been found with an upper side of platinum and a lower side of gold. Yet it is quite impossible to melt platinum by primitive means.

Some new finds which I have had the opportunity of studying very thoroughly seem meanwhile to throw light on these problems. It is to be observed first and foremost that, among the thousands of small objects, not a single one which has been cast is to be found; all are either wrought or made from plate or wire. Furthermore, it is remarkable that the use of solder cannot be demonstrated with any certainty; all joins were made by welding. Cold-hammering was used obviously for the sake of greater hardness, as Erland Nordenskiöld[2] has demonstrated for other pre-Columbian copper, bronze and gold tools. Investigation of the hardness is now in progress.

Silver does not seem to have been known at this place; the silver content of the alloys investigated does not exceed what can be assumed to occur naturally along with the gold. On the other hand, the gold is very often alloyed with copper; in one piece of gold which has been found, the melting was not altogether successful and a piece of copper which was added and has not quite been melted can be seen. What makes the new find so interesting is the presence of a quantity of work which has just been begun or is half-finished, which makes it possible to follow all the processes right from the mixing of the metals to the melting, forging and finishing. A number of round flat pieces of gold, of 1–20 gm. weight, are sharply distinguished from natural gold partly by their composition and partly by their appearance, for their surface shows a number of crystals laid bare by liquation.

These articles have obviously been melted on wood charcoal with the help of a blowpipe; the use of this instrument is known from other places in South America[3]. On the lower side, they often have an impression of the grain in the charcoal. An equally large number of these pieces have been wrought, some into flat plates and some into small cubical pieces or into long bars. Three pieces have been used for wire-drawing; for they have been wrought in such a way that the ends could be clamped with the help of wedges, and then a wire could be made by drawing. The wire could be softened by heat and then drawn out further. Drawing through a hole could certainly not have been employed. The thickest wire found is 2 mm., the thinnest 0·1 mm.

Most interesting of all is the method by which the Indians were able to get the small platinum grains into a coherent form. Analysis showed that the platinum objects found do not consist of pure platinum, but that they contain about 30 per cent of gold in addition to the silver contained in the gold. Some of the small pieces of platinum ore more or less sintered together show the procedure to have been as follows: the grains of platinum were mixed with a little gold, which sealed them together during the melting. It is a well-known fact that during continued heating the molten metal diffuses into the unmelted, which partly dissolves again in the melted one. The result is a mass sintered together, which during subsequent alternate hammering and heating eventually becomes so homogeneous that it can be wrought into plates or other objects. Such plates can afterwards be welded on to a piece of gold, and the pieces welded together can finally be beaten out into quite thin plates.

These investigations are being continued, and further reports will be published shortly.

PAUL BERGSØE.

Copenhagen.
Nov. 27.

[1] *Museum J.*, Philadelphia, March 1921.
[2] Erland Nordenskiöld, "Comparative Ethnographical Studies", Gothenburg, vols. 4 and 9.
[3] P. Rivet, *J. Soc. des Americanistes*, 15, 185 (1923).

Inhibition of Homogeneous Reactions by Small Quantities of Nitric Oxide

THERE is convincing evidence that some chemical changes take place by a mechanism involving reaction chains of considerable length, and equally convincing evidence that in other reactions no such long chains occur. Nearly every chemical reaction, however, starts by the activation of certain molecules, that is, by considerable highly localised thermodynamic fluctuations, and in principle it is possible

that some of these fluctuations are intense enough for their influence to persist through several cycles of chemical change, giving rise to the effect of very short chains, although the normal characteristics of a chain reaction would not be exhibited. This point of view has been emphasised by Semenov at the end of his recent book. Either the fluctuation is simply an accumulation of energy, or, in accordance with a widely held modern view, it leads to the escape of free radicles. These are thermodynamically unstable, and must at once, or after a greater or smaller interval of time, disappear from the system.

The detection of quite short chains is, however, experimentally difficult, and the following observations may therefore be of interest. In the course of a systematic study of the catalytic influence of nitric oxide on various organic decomposition reactions, we observed that small amounts of this gas, of the order 0·1–1 mm., could reduce the rate of reaction to a well-defined limit, smaller than the original by a factor of up to two or three times. The effect is as though quite short reaction chains were broken by the nitric oxide. (Direct experiment shows that the inhibition is not connected with a surface reaction.) If the ratio of the original rate to that corresponding to the maximum inhibition be taken as a chain length, then these lengths in a few typical cases are as follows: diethyl ether 2·6–3·5 over a range of temperature; propionic aldehyde, about 2; ethyl propyl ether, about 3; di-isopropyl ether, about 1·5. By this test, we may say that not only methyl alcohol and acetone, but also acetaldehyde give negative results.

In connexion with the free radicle theory it may be observed that in electronic structure nitric oxide is itself virtually a free radicle.

Although the apparent existence of these very short chains in certain cases is an interesting fact, their length is too small to render necessary any appreciable modification of our present views on the mechanism of activation in unimolecular reactions, as detailed analysis in the case of diethyl ether has shown.

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Recombination of Neutron with Proton

IN further experiments on γ-rays excited by neutrons, we have recently measured a change of the number of kicks of a counter as a function of the thickness of the water sheets, 10 cm. × 15 cm., in cross-section, inserted between the neutron source and the counter. The experimental method was similar to that used in previous work[1], with certain improvements.

The number of counts decreases initially and reaches its minimum at a thickness of about 3 cm., and then begins to increase. We have confirmed by several auxiliary experiments that this increase in number was due to radiations emitted from the water sheets themselves, and was not due to the effect of slow neutrons emitted from the water sheets upon the surrounding substances. A similar effect was recently reported by Fleischmann[2]. On comparing the effect produced when we use paraffin and glycerin instead of water, we further conclude that this radiation (probably γ-rays) may be due mainly to H atoms in water and not to O atoms in water. Thus we are very probably dealing with γ-rays emitted by the recombination of a proton with a neutron. The initial decrease of the curve is due to the absorption of background radiation, which is probably fast neutrons emitted from the target. The fact that the curve decreases initially suggests that before neutrons are captured they must be slowed down to a certain energy.

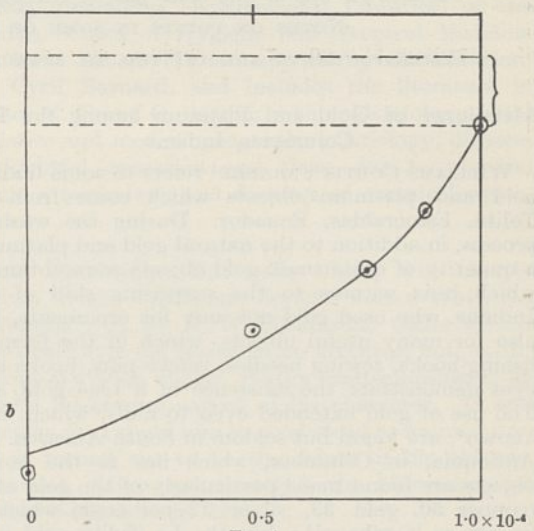

FIG. 1.

Now, we have observed that the intensity of γ-rays was much increased by dissolving a very small amount of cadmium salt in water. As was expected in this case, if the number of cadmium atoms is very small and the density distribution of the slow neutrons in water is not appreciably affected by the presence of the cadmium atoms, we can determine the mean cross-section for recombination of neutron with proton relative to that for the capture process of a slow neutron by cadmium atoms, from the amount of increase in γ-ray emission and the known amount of cadmium atoms relative to hydrogen atoms in water. We must, of course, assume that the efficiencies of the counter for γ-rays from proton and cadmium atoms are equal. If the above condition is fulfilled, the emission of γ-rays must increase linearly with the concentration. Fig. 1 shows the results of an experiment carried out with water-sheets of 14·0 cm. thickness and of different concentrations. The abscissa indicates the ratio of the number of cadmium atoms to that of hydrogen atoms. For low concentration, as will be seen from Fig. 1, the intensity of γ-rays increases almost linearly. From the gradient of the curve at concentration 0, we can determine the cross-section in question.

The difficulty arises, however, of estimating γ-rays from pure water. For there was background radiation of uncertain origin, and it was difficult to separate it from the effect of γ-rays. By assuming that the effect observed for pure water is entirely due to γ-rays, we can deduce the upper limit of the cross-section. Thus we have reached the conclusion that the cross-section in question could not be larger than $0{\cdot}25 \times 10^{-4}$ times that for the capture process of a slow neutron by a cadmium atom.

We determined the lower limit of the cross-section by determining the lower limit of γ-ray emission as follows. We dissolved H_3BO_3 in water to decrease the intensity of γ-ray emission, without decreasing

the intensity of background radiation. The decrease in number of kicks (*b* in Fig. 1) corresponds to the lower limit of γ-ray emission, from which we conclude that the lower limit of the cross-section in question is $0{\cdot}09 \times 10^{-4}$ times that for the cadmium atom.

Dunning and Pegram[3] have obtained the value $3{,}300 \times 10^{-24}$ cm.^{2} for the absolute scattering cross-section of cadmium atoms. Assuming that this is equal to the cross-section for the process of capture[4] accompanied by the γ-ray emission, we can locate the cross-section for the recombination of neutron with proton as lying between $8{\cdot}3 \times 10^{-26}$ cm.^{2} and $3{\cdot}0 \times 10^{-26}$ cm.^{2}.

Our method is free from any ambiguous assumptions, and the correctness of the values depends mainly upon the value of the cross-section of cadmium atoms, the determination of which can be carried out fairly accurately. We believe, therefore, that our values are correct within an error of twenty per cent, though they are much lower than those obtained by other investigators with different methods. Details will be published soon in the *Proc. Phys.-Math. Soc. Jap.*

S. KIKUCHI.
K. HUSIMI.
H. AOKI.

Osaka Imperial University,
Japan.
Nov. 10.

[1] S. Kikuchi, H. Aoki and K. Husimi, *Proc. Phys.-Math. Soc. Jap.*, **17**, 369 (1935). *Proc. Imp. Acad. Jap.*, **11**, 253 (1935).
[2] R. Fleischmann, *Z. Phys.*, **97**, 242 (1935).
[3] J. R. Dunning, G. B. Pegram, G. A. Fink and D. P. Mitchell, *Phys. Rev.*, **47**, 970.
[4] J. R. Dunning and G. B. Pegram, *Phys. Rev.*, **48**, 265 (1935).

Angular Momentum of Circularly Polarised Light

BY suspending a 6 mm. diameter circular half-wave plate horizontally from a quartz fibre with a torsional constant of 2×10^{-8} dyne cm. per radian, and allowing circularly polarised light to traverse it, thus reversing the direction of rotation of the electromagnetic light-vectors, we were able to observe torques of amounts plus and minus 2×10^{-11} dyne cm., according to the direction of rotation of the incident light. The circular polarisation of the incident light was produced by passing plane polarised light through a quarter-wave plate. By rotating this quarter-wave plate through 360°, the light could be polarised twice in a clockwise direction and twice anti-clockwise.

Different observations of the torque were consistent to 3 per cent. If the angular momentum of elliptically polarised light is $k\frac{E}{2\pi\nu}\sin\gamma$, where E is its energy, ν its frequency and γ the phase difference of the equal and perpendicular vibrations composing it, then from our experiments $k = 1{\cdot}05 \pm 0{\cdot}15$, or the angular momentum of one quantum of circularly polarised light is $h/2\pi$ within the experimental error. The chief experimental uncertainty at present is in the determination of E.

This confirms the qualitative results obtained by R. A. Beth[1] in September.

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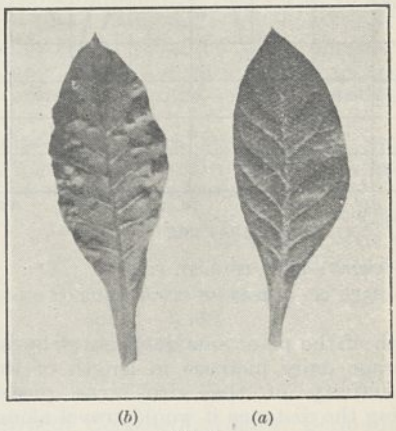
Dec. 13.

Phys. Rev., **48**, No. 5, 471 (1935).

Low-Temperature Masking of Tobacco Mosaic Symptoms

SEVERAL plants, when infected with an appropriate virus, fail to show symptoms upon new growth made during a period of relatively high temperature. Thus leaves of tobacco infected with mosaic (tobacco virus 1 of Johnson), when grown above 98° F., show no appearance of the disease. This is known as 'masking', and was first described by Prof. James Johnson[1] in 1921. Most workers on plant viruses realise that the appearance of symptoms is delayed at cool temperatures; but an actual masking below a temperature of about 51° F. can be demonstrated.



(*b*) (*a*)

FIG. 1.

Six young tobacco plants showing mosaic symptoms were placed in a cool greenhouse on October 5, 1934. Growth was very slow, but six weeks later, on November 16, each had formed about three newly-expanded leaves, which were all unmottled, and to all appearances healthy (Fig. 1*a*). These plants were then placed in a glass chamber maintained at a temperature of 75° F., with full light. Within seven days, symptoms appeared on all the young leaves (Fig. 1*b*) made above the masked leaves. The latter remained seemingly healthy. All the plants were afterwards removed to the cool house, and by Christmas 1934 had made further symptom-free growth. The cool greenhouse maintained a temperature of 51° F. ± 2°, except during bright sunlight. This was of short duration in Huddersfield, during the period of the experiment, and the maximum temperature was 57° F. Masking could not be due to the effects of low light intensity, since ten diseased tobacco plants in a neighbouring house at 65° F., and with similar light conditions, maintained their symptoms on all leaves throughout the time of the experiment.

The trial has been repeated this year with ten diseased plants, five at an average temperature of 55° F. and five at 45° F. The higher temperature did not completely mask the appearance of symptoms, for one or two slightly-mottled areas often appeared on a leaf. Plants grown at the temperature of 45° F. ± 3° showed completely masked symptoms.

It appears, therefore, that the symptoms of tobacco mosaic are masked when the host plant is grown at a temperature below about 51° F.

A preliminary attempt to compare the optimum temperature of growth of the plant with that for the greatest activity of the virus seems to indicate that the plant grows quickest at 75° F. under Huddersfield

conditions, whereas the virus travels as quickly along the leaf at 85° F. as at 75° F. (Fig. 2). It is slower above 85° F. and below 75° F. The greatest facility of movement for the virus is apparently provided by a temperature between these two values, and is therefore, in all probability, different from that of the host.

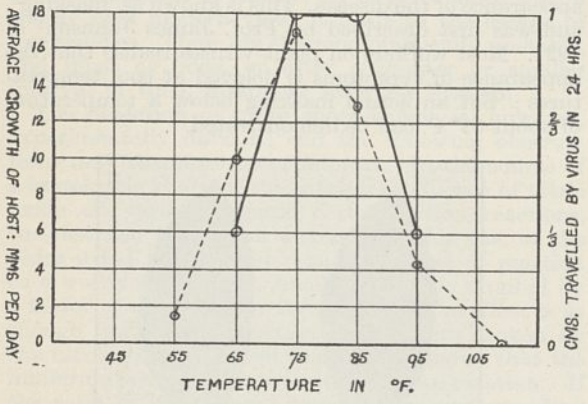


FIG. 2.

Growth of the plant was determined by measuring the average daily increase in length of the leaves, whilst activity of the virus was measured by estimating the distance it would travel along the leaf in 24 hr., 48 hr. and 72 hr. For convenience of expression, the distance travelled in 24 hr. has been adopted in the diagram (Fig. 2); the later records are similar in form. All the determinations round the peaks of the curves were duplicated in constant-temperature chambers controlled within 1° C., but experiments are in progress to test this question further.

JOHN GRAINGER.

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Ravensknowle,
Huddersfield.
Dec. 4.

[1] "The Relation of Air Temperature to Certain Plant Diseases" *Phytopath.*, **11**, No. 11, 446-458 (1921).

Habitat of *Procerodes* (*Gunda*) *ulvae*

IN his description of the adaptation of *Procerodes ulvae* to salinity, Pantin[1] has given an account of the environment of this estuarine form. During a survey of the freshwater of Bardsey Island (Caernarvonshire) in the past summer, *P. ulvae* was found in two places under similar conditions. In one of these the habitat was almost exactly the same, topographically, as the beach at Wembury described by Pantin.

It is thus of interest to compare the faunistic results in the two cases. In July, the distribution of *P. ulvae* corresponded roughly to that at Wembury, but in September the freshwater stream flowing over the shore and feeding the rocky pools in which *Procerodes* was found had been dammed higher up its course to provide a drinking place for sheep and cattle. The rocky pools were thus dry except at high tide. Under these conditions, *P. ulvae* was found several inches below the surface under much smaller stones (1–2 inches diameter) where a thin layer of salt water remained. As the tide rose, a migration up to the surface took place, followed by a gradual retreat downwards as the tide fell and the surface stones dried. At the same time a migration up the shore was taking place, and *P. ulvae* was found occupying the lower three feet of the 'desert' area of loose shingle between high water springs and high water neaps. Again, *Procerodes* was only to be found deeper down.

Thus *P. ulvae* must be able to withstand at least two sets of conditions, at one time of the year, alternations between sea- and freshwater (measurements of this show that the change is rapid, from 0·3396 gm. Cl_2/litre to 18·38 gm. Cl_2/litre within half an hour), and at another time, constant immersion in sea-water. In confirmation of Pantin's[2] conclusions, it is interesting to note that the calcium content of the stream water was high (50·75 mgm. Ca/litre in July).

Pantin also points out that *Procerodes* is most abundant where the alternation of sea- and fresh-water is most rapid, and that it dies out farther down the beach. Observations on the Bardsey system seem to indicate that the dominant factor in the zoning of this species on the shore is the nature of the substratum. *Procerodes* only occurred under moderate sized stones resting on shingle; under smaller stones, stones of similar size resting on coarse sand, or under large boulders, it was absent. This suggestion is supported by the occurrence of *Procerodes* in a large brackish water-pool (chloride content 12·23 gm. Cl_2/litre—approximately 62 per cent sea-water) farther up the coast, where no alternation between sea- and freshwater took place, but where the substratum was more suitable.

In all the cases described, the planarians appeared to be healthy and active.

A full account of this survey will be published elsewhere.

K. A. PYEFINCH.

Department of Zoology,
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[1] Pantin, C. F. A., *J. Exp. Biol.*, **8**, 63 (1931)
[2] Pantin, C. F. A., *ibid.*, 73.

Discriminative Ability of a Parasitoid

IN a previous communication[1], Dr. Salt and Miss Laing asserted that individual females of *Trichogramma evanescens* avoid host eggs which have already received the attention of other individuals of the same species. In the experiment described, a parasite was allowed to walk on, but not to parasitise, some host eggs. The parasite was then removed, and clean eggs placed alternately with the others. A second parasite was introduced which "avoided the hosts that had been visited by the first, as though they had already been parasitised". From this is deduced that the sense of smell warns the parasites of those eggs which have received attention, so that they leave them alone.

I was interested in this conclusion, which is contrary to my experience, as I have noticed super-parasitism even in such small eggs as those of *Ephestia kühniella*, in which there is room only for one full-sized parasite to develop. The following experiments may, therefore, be of interest, carried out on the same general lines as the one referred to above, *Trichogramma evanescens* and the eggs of *Ephestia kühniella* being used:

1. A parasite was allowed to examine, but not to oviposit in, four host eggs, numbered 1–4. The parasite was removed, three clean eggs placed alternately with the others, numbered 5–7, and a new parasite introduced. She readily oviposited in Nos. 2, 3, 5 and 6, and also in Nos. 1 and 7 after some examination. No. 4 was examined but not stung.

2. A repetition of the above, using ten eggs, numbered 1–10. The parasite examined but was prevented from ovipositing in eggs numbered 1, 2, 3, 4, 7, 8 and 10, and was then removed, a further ten eggs, numbered 11–20, being placed alternately with the others. Three new female parasites were added and they oviposited in Nos. 2, 3, 4, 5, 13, 14 and 19. One of them oviposited twice in No. 3.

3. In another batch of ten eggs, three parasites oviposited in eggs numbered 1, 2, 3, 4, 8, 9, 10, one of them doing so twice in No. 4. The three insects were removed and ten fresh eggs, numbered 11–20, arranged alternately with the others. Three new parasites which were then introduced oviposited in Nos. 1, 3, 4, 6, 7, 8, 12 and 19.

These experiments indicate that the behaviour observed by Dr. Salt and Miss Laing is by no means fixed. Superparasitism is common in eggs which permit more than one full-sized individual to develop in them, at least under experimental conditions. For example, in one case, out of 100 eggs of *Agrotis ypsilon*, 93 were parasitised by *T. evanescens*, and 187 parasites emerged; with regard to the Eri silk worm moth, *Attacus ricini*, more than twenty commonly issue from one egg.

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Nov. 19.

[1] NATURE, **135**, 792, May 11 (1935).

Preliminary Report on Respiratory Studies of *Littorina irrorata*

THE necessity for taking into consideration an organism's previous physiological condition in interpreting its respiratory rate was revealed incidentally in a series of experiments originally designed to show the effects of temperature and salinity on the respiratory rate of the intertidal gastropod *Littorina irrorata*.

Snails were collected after known periods of submergence and exposure, placed in two-litre bottles containing filtered sea-water at the desired temperature, and their respiratory rates measured by a semi-micro Winkler method. The rates of respiration at 32° C., following periods of submergence of 0, 12, 24, 48, and 225 hours, were, respectively, 0·31, 0·27, 0·179, 0·189 and 0·168 c.c. oxygen per gram per hour. It seems, therefore, that after 24 hours of submergence the respiratory rate is relatively constant. The effect of exposure, following prolonged submergence, is to increase the respiratory rate. However, after a period of 50 hours of exposure, the rate appears to be fairly constant.

The average rate of respiration of *Littorina irrorata*, collected at random with respect to submergence time, was found to be 0·31 c.c. oxygen per gram per hour. This result is based on seven experiments performed at 32° C.

To determine the effect of temperature on respiration, experiments were conducted at temperatures ranging from 10° to 40° C. The maximum rate measured, namely 0·507 c.c. oxygen per gram per hour, occurred at 35° C. The rate decreases rapidly at lower temperatures, having a value of 0·136 c.c. oxygen per gram per hour at 20° C., and of 0·058 c.c. oxygen per gram per hour at 10° C. The rate of respiration also decreases rapidly at temperatures above 35° C. until approximately 43° C. is reached, at which point a lethal effect is approached. It is difficult to obtain reliable results at temperatures below 10° C. and above 40° C. because all the snails do not remain open.

In all of these experiments, two parallel determinations were run simultaneously, each with 15 specimens possessing a mean fresh body weight of 0·5129 gm. (width range, 16·0–17·9 mm.). Two determinations were adequate, since the variation in oxygen consumption from the average seldom exceeded 4 per cent.

The results emphasise the necessity for considering the submergence and exposure factors in respiratory studies of intertidal gastropods.

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Record of *Gorgonorhynchus* at Bermuda

THE new marine Nemertean reported by Dakin and Fordham[1] from the coastal waters of New South Wales has been found under stones at low tide at Bermuda. The peculiarity of *Gorgonorhynchus*, distinguishing it from all other members of the group, is the branching proboscis.

While collecting at St. George's Island in April, 1932, I found a Lineid worm which when irritated shot out a number of thin white threads in place of the single normal proboscis. Another worm similar in external appearance was taken in 1933, but the proboscis had been lost. This year a number of specimens have been collected, and the presence of the dichotomously branched proboscis confirmed. The worms have been observed to swim with an undulatory movement suggestive of the genus *Cerebratulus*, and this relationship is further shown by the presence of a caudal appendage.

The occurrence of this animal in localities so remote from one another as New South Wales and Bermuda is an interesting problem in distribution.

J. F. G. WHEELER.

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St. George's West, Bermuda.

[1] Dakin, W. J., and Fordham, M. G. C., NATURE, **128**, 796 (1931).

Physiological Races of *Lucilia sericata*, Mg.

RATCLIFFE[1] has recently suggested that there may possibly be two physiological races of *L. sericata*, as the length of the pupal period of this insect at 32° C. in Scotland is 5·4 days while in France at the same temperature it is 8 days. This latter figure is quoted from a paper by Davies[2] who, in turn, is only quoting the work of Cousin[3] in France. Unfortunately, the figure given by Davies is inaccurate and should be 4·9 days, not 8 days. I have found[4] that humidity

plays some part in determining the length of the pupal period, and as Cousin and Ratcliffe have not controlled this factor in their work, it is probable that the discrepancy observed is due to variable humidity. The postulation of physiological races on this type of data is to be deprecated.

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Harpenden, Herts.
Nov. 18.

[1] *Ann. Appl. Biol.*, **22**, 742 (1935).
[2] *Ann. Appl. Biol.*, **21**, 267 (1934).
[3] *Bull. Biol. France Belg.* Suppl. 15 (1932).
[4] *Parasitology*, **27**, 291 (1935).

Absorption of Residual Neutrons

DR. SZILARD has observed that although cadmium has a very high absorption cross-section for slow neutrons, the residual slow neutrons not absorbed by a cadmium filter are strongly absorbed by a thin sheet of indium[1]. This, he points out, is in contradiction to the conclusions drawn from current theory as advanced by Fermi and others.

Since the absorption cross-section for neutrons is, for many elements, larger than the nucleus cross-section, it is possible that the neutrons may be captured in energy levels outside the nucleus. This would at once explain why for many elements the cross-section is larger for slow neutrons than for fast neutrons, and further would account for the selective absorption effects observed by Dr. Szilard.

JOHN TUTIN.

[1] NATURE, **136**, 95 (1935).

The Thermometer Scale of de l'Isle

IN NATURE of September 7, p. 365, Dr. N. V. Nordenmark is credited with the remark "that the thermometer of Anders Celsius used the scale of de l'Isle, the freezing point being at 100°, the boiling point at 0° ". As a matter of fact the scale of de l'Isle (who was a member of the Academy of Sciences of St. Petersburg from 1725 until 1747, when he returned to Paris) had the freezing point at 150°, the boiling point at 0°. De l'Isle's thermometer was used at the time in Russia. About 1750, M. V. Lomonosov constructed a thermometer with the inverted scale of de l'Isle, that is, with the boiling point at 150° and the freezing point at 0°, and used it in all his physico-chemical experiments.

B. N. MENSCHUTKIN.

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Nov. 15.

Points from Foregoing Letters

New finds of half-finished objects of gold and platinum, from Ecuador, are described by P. Bergsøe. The objects are either wrought or made from plate or wire, and throw light on the metallurgical processes used by South American Indians before the time of Columbus. Some of the objects show traces of having been melted on wood charcoal with the help of a blowpipe; platinum grains were apparently joined together by the addition of a little gold, and then alternately heated and hammered into homogeneous thin plates.

Small amounts of nitric oxide gas (0·1–1 millimol) are found by L. A. K. Staveley and C. N. Hinshelwood to reduce the rate of decomposition of certain organic compounds (diethyl ether, propionic aldehyde, etc.). The authors point out that if, as seems likely, the original reactions take place by means of short 'chain' reactions (that is, certain molecules possessing excess energy which persists through several cycles of chemical change), then one may explain the effect of nitric oxide as due to the breaking of such chain reactions.

From the relative intensity of the ionising radiation (probably gamma-rays) emitted under neutron bombardment by water and by aqueous solutions of boric acid and of a cadmium salt, S. Kikuchi, K. Husimi and H. Aoki have found that the mean cross-section for the recombination of a 'slow neutron' with a proton, relative to that for the capture process of a slow neutron by a cadmium atom, lies between $8{\cdot}3\times10^{-26}$ cm.^{2} and $3{\cdot}0\times10^{-26}$ cm.^{2}.

According to theory, a beam of light, circularly polarised by passage through a thin quarter-wave plate of a doubly-refracting crystal such as quartz, should exert a torque on a similar half-wave plate, which changes the state of polarisation of the light beam. Such an effect was recently detected by R. A. Beth, and now A. H. S. Holbourn has measured the torque and finds that, as expected, it corresponds to an angular momentum of $h/2\pi$ per quantum of circularly polarised light.

A masking of symptoms of the virus disease tobacco mosaic has been found by Dr. John Grainger when the host plant is grown below 51° F. Preliminary experiments to compare the optimum temperatures of host plant and virus suggest that the plant grows quickest at 75° F., whilst the virus has a different optimum—between 75° F. and 85° F.

The habitat of *Procerodes ulvæ*, at Bardsey Island, Caernarvonshire, is described by K. A. Pyefinch. Pantin had pointed out that this planarian is most abundant in river estuaries where alternations of sea- and freshwater are most rapid. Pyefinch suggests that the nature of the substratum is of prime importance, the animal preferring moderate-sized stones resting on shingle.

Unlike previous experimenters, C. B. Redman King finds that the parasite insect *Trichogramma evanescens* lays its eggs within those of other insects (such as the Mediterranean flour moth, *Ephestia kühniella*, the Noctuid moth, *Agrotis ypsilon* and the Eri silk worm moth, *Attacus ricini*) without distinguishing between fresh eggs and those that have been already parasitised.

J. F. G. Wheeler records that specimens of *Gorgonorhynchus*, an unsegmented worm with branching proboscis, recently described from the coastal waters of New South Wales, has also been found at Bermuda, a fact which raises interesting problems in geographical distribution.

A. C. Evans states that the pupal period of the 'greenbottle', *Lucilia sericata*, is the same in Scotland as in France, and it is therefore unnecessary to postulate distinct 'physiological' races. The differences observed by other investigators may be due, he states, to the influence of moisture.

Research Items

Pukapuka

PUKAPUKA, an atoll about 390 miles north-east of Samoa, was visited by Mr. Gordon Macgregor in 1933 as a member of the Templeton Crocker Expedition (Bernice P. Bishop Museum, Honolulu: Occasional Papers, 11, No. 6). Although the island was discovered in 1765, it has been remarkably free from intercourse with Europeans. It was formally annexed by Great Britain in 1892. The first people of Pukapuka, or Nukaloa as it was named by the ancients, were descended from the chief god of the island. This god sprang from a rock, which he afterwards made into the land. Their creation tale has several incidents that relate to the creation stories of the western Polynesians. There is also a story of the settlement of a people called "Eaki" under Tongan chiefs. The village on Pukapuka is divided into four sections belonging to three groups of people. The westward, or leeward, section is divided from the remainder of the village by a shallow cove. To the central and the windward section has now been added a fourth section, belonging to people who formerly lived in the central section and were flooded out by a tidal wave. The early people cultivated taro by digging pits, creating the necessary rich soil by depositing dead coconut fronds and other leaf material in the pits and allowing it to rot. During the centuries these pits have enlarged into huge excavations, which are capable of growing sufficient taro to feed the whole population. Each section of the village owns part of the atoll on which it grows its taro and coconuts. The division of small food supply must be carefully supervised and restricted. Formerly the food collected was divided among all, children receiving a smaller share. Now there are both communal patches and individually owned plots, each individual cultivating a plot for his own subsistence; but the coconuts from the communal plots are still divided for the making of copra, the village council allotting to each the number of nuts he must cut and dry.

Relations between Parasitic Protozoa and their Hosts

D. H. WENRICH (*Proc. Amer. Phil. Soc.*, 75 (1935)) states that, as the result of his observations on parasitic Protozoa, the conviction has grown that the idea of the rigidity of host-specificity has too many exceptions to make it a safe guide to the study and naming of new parasites. Every gradation can be found from early stages of facultative invasion of hosts to highly modified forms with rigid host-specificity. At one extreme are free-living species capable of living endozoically for a time when opportunity affords, for example, *Euglena gracilis* in the millipede *Spirobolus*. At the other extreme are the highly evolved gregarines and astomatous ciliates with specially adapted structures for attachment to their respective hosts and a high degree of host-specificity. Members of the flagellate genus *Giardia* are limited to vertebrates, and they also have a high degree of host-specificity, whereas the species of the nearly related genus *Hexamita* are found in a wide range of environments, including both fresh and salt water, and upon or within animals belonging to many different phyla, and they show much less host-specificity. Evolution of species has been extensive in some groups and slight in others. As examples of the former the author cites the ciliate family Ophryoscolecidæ in ruminants, the polymastigote and hypermastigote flagellates in the termites and the trypanosomes found in many different kinds of hosts. By contrast, little change has apparently taken place since the endozoic habit was established in the endozoic euglenoids and in certain of the ciliates found in sea-urchins.

An Interesting Hydroid

A NEW species of hydroid of rather unusual interest has recently been described by P. L. Kramp ("*Corydendrium dispar*, a New Athecate Hydroid from Scandinavian Seas with Remarks on Classification". *Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälles Handlingar*, Femte Följden, Ser. B, 4, No. 11). This hydroid, which belongs to the genus *Corydendrium*, has male gonophores which do not develop as secondary buds, but are placed and developed in the same way as the hydranth buds. They may thus be regarded as 'polypoid gonophores', in which the sperms are developed in the entire endoderm layer and are evacuated through the top. The female gonophores, while being situated in a similar position to that of the male gonophores, eventually have the ectoderm differentiated into two layers at the top. The endoderm in the distal part becomes folded inwards and a slit in the distal ectoderm layer is widened, so that a bell cavity is formed. Although egg-cells were not visible in the stages examined, the female gonophore thus has a decidedly medusoid character. This hydroid therefore is an example strongly confirming the view that generic value cannot be attached to the degree of development of the gonophore. The author also discusses the bearings that this species has on the problem of metagenesis, and points to the conclusion "that all hydroid gonophores are, in reality, of a polypoid nature, and also that metagenesis of hydroids is not fundamentally different from direct development".

Formosa Earthquake of April 21, 1935

FOR a brief but interesting report of this destructive earthquake (see NATURE, April 27, 1935, p. 646), we are indebted to Mr. T. Suzuki of the Earthquake Research Institute (*Japan. J. Astr. Geophys.*, 13, 55–59; 1935). The earthquake occurred at 7.2 a.m. (April 20, 10.2 p.m., G.M.T.), and the position of its epicentre, estimated from the records at Tokyo and local stations, is lat. 24° 21′ N., long. 120° 49′ E., in a district unvisited by any destructive earthquake for at least forty years. According to the latest official reports, 3,410 persons were killed and 17,907 houses completely destroyed. The towns and villages in which more than half the houses were ruined lie in a zone, 43 miles long and 9 miles wide, in the prefectures of Sintiku and Taityû. The maximum acceleration is estimated at less than $\frac{1}{3}g$, so that the earthquake, though the strongest felt in Formosa for nearly half a century, was less severe than the Tango earthquake of 1927 or the Idu earthquake of 1930. The

meizoseismal area includes that within which the deformation of the ground was most marked. In one fault six miles long, in the north-eastern portion of the area, the ground on the western side was raised 8 ft. above the other.

A New Electron Multiplier

IN the conventional type of thermionic valve, secondary emission is regarded as a handicap, although it has been put to practical use in one or two cases. A special type of amplifier, termed an electron multiplier and making use of secondary emission, was referred to in NATURE of March 16, 1935 (p. 440). A novel arrangement of electron multiplier was described recently in a paper read before the Institute of Radio Engineers in New York, by Dr. V. K. Zworykin, Dr. D. A. Morton and Mr. L. Malter; and illustrated summaries of this paper are given in *Electronics* of November and the *Wireless World* of November 22. In this new device, primary electrons from the cathode are made to impinge on a target constructed of suitable material with a surface-layer having a high secondary emission characteristic; so that the ratio of secondary to primary electrons may be as much as ten. This amplified electron stream is then focused and made to impinge on a second target, when the process is repeated. In this way, the original electron emission may be amplified in as many as ten or twelve stages with an overall gain of several million. The device is particularly adaptable to a photo-electric cell arrangement, since the cathode may form the emitter operated directly by the incident light. It is claimed that in this way much of the noise which originates in the coupling circuit between the photo-electric cell and the thermionic amplifier is eliminated, and that the signal to noise ratio is 60–100 times better than in the conventional arrangements. Some of the details of the construction of the new tubes are shown in *Electronics*; at each stage the electron stream is diverted through a right angle, and the mechanical construction is such as to avoid the diversion of the electrons from one target by the higher potential applied to the succeeding target. The focusing of the electron streams between targets is carried out by a combination of electric and magnetic fields.

A Cathode Ray Oscillograph for Electrical Research

AT a meeting of the Institution of Electrical Engineers held on December 19, a paper was read by Mr. G. A. Whipple entitled "A Cathode Ray Oscillograph with High-Speed Drum Camera Rotating in Vacuo". This paper contained a description of an all-metal cathode ray oscillograph equipment designed for the investigation of the performance of electrical apparatus such as transformers and circuit-breakers under short-circuit conditions, when transients having frequency components up to 50,000 cycles per second may occur in the test circuit. The oscillograph is of the cold cathode type using accelerating voltages between 30 and 50 kv., and between 0·5 and 1·2 milliamperes anode-cathode current. This electron stream tube is mounted vertically above the camera housing, which contains a photographic recording drum, 63 cm. in diameter, rotating *in vacuo* at a speed of 3,000 r.p.m. The photographic film is 125 mm. wide and recording is carried out during five revolutions, by traversing the electron beam across the drum. The vacuum technique employed to obtain the low pressures required in the short times necessary for routine testing is described in some detail. In practice, it has been found possible to unload an exposed film, wind on a fresh film, and pump out ready for test, in 16 minutes; of this, the actual evacuation time was 11 minutes. Photographs accompanying the paper illustrate details of the equipment and some of the results obtained therewith; amongst the latter is a record of a damped oscillation at a frequency of 95 kilocycles per second.

Strength of Concrete Walls

THE tests reported in Bulletin No. 277 of the Engineering Experiment Station of the University of Illinois, entitled "The Strength of Monolithic Concrete Walls", by Frank E. Richart and Nathan M. Newmark, were made to obtain information on the strength and stability of monolithic concrete walls of types used in concrete house construction. Eighteen large and six small wall panels, and two ribbed walls, were tested with a uniformly-applied axial load. Two ribbed walls were tested with an eccentric load, and seven walls were tested in flexure. Three different mixes of dry-tamped concrete, and two mixes of poured concrete were used in the construction of the walls. Wall panels six feet long and nine feet high were used, and several small panels 32 inches long and 48 inches high were tested to determine whether or not they could be established as representative test specimens. Among the results noted were the following: (*a*) The wall strength was affected to a slight extent by the type of wall, and to a very great extent by the strength of the concrete composing the wall. (*b*) The compressive strength of all axially-loaded walls was more than 55 per cent of the strength of the concrete control cylinders, and averaged about 78 per cent of the cylinder strength. (*c*) The eccentrically-loaded ribbed walls were able to carry only 20–30 per cent as great a load as the axially-loaded ribbed walls. The eccentricity was very high, almost four-tenths of the total depth of the section. Heavier rib sections might very profitably be used in walls of this kind.

Longitude Operations of 1933

A FURTHER result of the work undertaken by many observatories all over the world in 1933 has appeared in print, under the title "Längenbestimmung des Astronomischen Observatoriums an der Polytechnischen Hochschule Warszawa, anlässlich der Internationalen Längenbestimmung 1933" (Publ. 14, Inst. d'Astron., Warsaw) by F. Kepinski. The main article is in Polish, but there is an abstract in German. The observations were all made by M. Kepinski himself with a broken transit telescope of 7 cm. aperture and 65 cm. focal length, with a hand-driven registering micrometer. The observer made a determination of his personal equation relative to two other observers (who took no other part in the observations), the result of the one night's work being $F.K. - L.Z. = -0{\cdot}016^s$, and on another night $F.K. - W.K. = -0{\cdot}001^s$. These tests are not exhaustive, but it is unlikely that the observer has a personality of more than $0{\cdot}02^s$. The result found for the longitude of the central pillar of the Astronomical Observatory of the Polytechnic at Warsaw is $-\ 1^h\ 24^m\ 2{\cdot}374^s \pm 0{\cdot}009^s$. It will be recalled that one other result of the international operations has been noticed in our columns, namely, that of the Observatory at Zi-Ka-Wei (NATURE, Sept. 14, p. 445).

The Carnegie Trusts

ANDREW CARNEGIE was born on November 25, 1835, the son of a hand-loom weaver of Dunfermline. A centenary commemorative volume bears the title "Andrew Carnegie : the Trusts and their Work".* There is a peculiar fitness in the close association of his name with the word 'trust', for the notion of trust was fundamental in the creed which dictated his disposition of the vast wealth he controlled. He believed that great private wealth was a public trust ; that the increment of large fortunes was socially created and should be redispensed to the society that had created it. In conformity with this "gospel of wealth", as he called it, nine-tenths of his public benefactions were designed to promote the welfare of the people of the United States of America, the country of his adoption (he emigrated to America with his parents in 1848), and the earliest of the series of great foundations which have immortalised his name and ideals was for the creation of a cultural centre in Pittsburgh, the city where he had laid the foundations of his career and his fortune.

The series culminated in 1911, when he had already given away 300 million dollars, in the endowment with 125 million dollars of the Carnegie Corporation of New York. The field of activity of this corporation, limited at first to the United States, has been extended by an amendment of its charter to the British Dominions and Colonies. Lastly, in 1914, came the United Kingdom Trust, for assisting pioneer projects of national scope. Thus the whole series dates from the twenty years immediately preceding the Great War, comprising the span of life between Mr. Carnegie's sixtieth and eightieth birthdays. He died on August 11, 1919. A brief summary of the American foundations, including, in addition to those already mentioned, the Carnegie Institution of Washington, the Carnegie Foundation for the Advancement of Teaching, and the Carnegie Endowment for International Peace, is given in the present volume, the greater part of which is devoted to the history of the British Trusts, namely, that for the Universities of Scotland (1901), the Dunfermline (1903), the Hero Fund Trust of Great Britain (1908), and the United Kingdom Trust.

Carnegie's gifts, says Mr. Ramsay MacDonald in a foreword, were never casual, but bore the stamp of the constructive genius which displayed itself in everything he did. Of the unifying purpose underlying his benefactions in the United States it has been said : "not succour nor alleviation, but opportunity for growth . . . his mind was on the underprivileged : not the materially under-privileged, that they might increase their substance, so much as the under-privileged in access to means of cultural elevation ; and the under-privileged not as individuals, but as members of a society. In opportunity for cultural advancement of the whole, he saw the betterment for which all men strove". These same principles are well exemplified in his scheme for the universities of Scotland : one half of the revenue of his Trust to be used to pay the fees of deserving poor students and the other half to improve the universities. Nor was he unmindful of the vital importance for the improvement of universities of encouraging scientific research. He was deeply impressed by the friendly advice on this point of Mr. A. J. Balfour (afterwards the Earl of Balfour), and took a particular interest in the Trust's provision for discovering and, so far as possible, supplying the demands for higher study and research throughout Scotland.

Carnegie's religion was manifestly a living force ; but the flame of his philanthropy burned with a light neither dimmed nor refracted by any cloud of dogma, and he displayed in relation to his Trusts something of the humility and the detachment of the scientific investigator. The scope of the Dunfermline is, of course, purely local, while that of the United Kingdom Trust is national, but they are alike in leaving to the Trustees a freedom from restrictive definition that is rare in the history of charitable trusts. In an explanatory letter to the Dunfermline Trustees, Mr. Carnegie emphasised the experimental character of the work he was entrusting to them : "The problem you have to solve is 'What can be done in towns for the benefit of the masses by money in the hands of the most public-spirited citizens'. If you prove that good can be done you open new fields to the rich which I am certain they are to be more and more anxious to find for their surplus wealth. Remember you are pioneers, and do not be afraid of making mistakes. . . . I can imagine it may be your duty in the future to abandon beneficent fields from time to time when municipalities enlarge their spheres of action and embrace these. . . . As conditions of life change rapidly you will not be restricted as to your plans or the scope of your activities". At the same time he left no room for doubt as to what he meant by "benefit". He confided to them his aspiration that the Trust would be the means of bringing "into the monotonous lives of the toiling masses of Dunfermline more of sweetness and light", of giving to them—"especially the young—some charm, some happiness, some elevating conditions of life which residence elsewhere would have denied".

The United Kingdom Trust is, in respect of the wide effects of its many-sided activities, the most interesting of Mr. Carnegie's ventures. Here the 'pioneer' function of the Trust supplies its keynote, and the Trustees are enjoined to bear in mind that the needs of the community are continually changing "as the masses advance". A very large proportion of their income is expended on large-scale experiments planned over a limited period of years, and applications for grants are invited under specified conditions and upon a more or less rigidly fixed scale. Public opinion is thus created and consolidated in favour of the particular services in view, as, for example, county and regional libraries, maternity and child welfare, playing fields and play centres for young children and village halls.

A striking success was achieved by the Trustees' playing field policy, begun in 1927 with an allocation of £200,000 in response to an appeal by H.M. the King, and carried out in collaboration with the National Playing Fields Association to such purpose that the country is richer by playing fields to the value of

* Centenary of the Birth of Andrew Carnegie. The British Trusts and their Work, with a Chapter on the American Foundations. Pp. x+155+29 plates. (Dunfermline : The Carnegie United Kingdom Trust, Comely Park House, 1935.)

nearly £2,000,000, and more than 6,000 acres of land has been preserved for all time for recreation. In this as in other enterprises the Trustees have hastened that enlargement of the spheres of action of local authorities foreseen by Mr. Carnegie. As they point out in the review contributed by them to "The Trusts and their Work", there has been since the Great War a growing recognition by local authorities that certain activities of a pioneer kind are more effectively administered by volunteer workers than by the official machine. This has led to enlightened experiments in which the Trustees have participated and have assisted voluntary bodies to earn Government grants.

Of post-War developments in the social life of the people of the United Kingdom there is one that would, beyond all others, had he lived to see it, have excited Mr. Carnegie's interest and aroused in him, as an apostle of sweetness and light, the gravest concern—the gigantic growth of the cinematograph industry. The inquiry by the Commission on Educational and Cultural Films and the resulting report entitled "The Film in Education", which led to the establishment in 1933 of the British Film Institute, were financed by the Trustees to the extent of £6,100. In the face of their splendid record of work accomplished, it would be hypercritical to suggest that the Trustees might have hastened the advent of that Institute, but one cannot help wishing that it had come into existence ten years earlier.

At the dawn of the twentieth century, Mr. Carnegie was already sixty-five years of age, and many of his views on social problems were, of course, coloured by a social background as far removed from ours of to-day as was that from the Middle Ages. But these few notes on "The Trusts and their Work" are sufficient to show that he is very far indeed from being a spent or retro-active force.

Resolutions of the Sixth International Botanical Congress

THE Executive Committee of the Sixth International Botanical Congress recently held at Amsterdam (see NATURE of November 12) has issued the draft of the general and sectional resolutions passed at the final plenary meeting.

It was agreed that the Botanical Section of the International Union of Biological Sciences should act as an administrative link between successive International Botanical Congresses, and should be authorised to carry through the resolutions passed. The Union was asked to approach the various Governments in order to obtain inexpensive facilities for the exchange by post or otherwise of collections of dried plants.

The attention of public and scientific bodies was directed to the danger of destruction of natural vegetation in tropical and subtropical countries by brushwood and prairie fires and by human agency. The necessity of permanent natural reserves, and of the maintenance of an adequate proportion of natural forest areas was emphasised, and a committee was set up to study associated problems and to inform the Governments concerned. The importance of international discussions and action in the campaign against plant diseases and insect pests was stressed—this resolution is to be brought to the attention of the League of Nations.

A committee was appointed to elaborate proposals for a classification of climates from a phytogeographic point of view; the committee on the description and nomenclature of plant viruses was empowered to continue its work; and application is to be made to the International Committee for Genetical Congresses for the appointment of a committee to clarify and improve the terminology of genetics and cytology. Propositions in favour of the preparation of a new "Phytography"—a compilation of lists of the collections represented in the larger herbaria—and of an "International Dictionary of Botanical Terminology", were approved; also the desirability of photographing the Linnæan type specimens at the Linnean Society and the British Museum.

Appreciation of the admirable work of the Centraalbureau voor Schimmelcultures at Baarn was expressed, and also grave concern at the present financial difficulties of what is essentially an international institution. The editorial committee of the International Rules of Botanical Nomenclature, third ed. (1935) was thanked for its work; the decisions of the Section of Taxonomy and Nomenclature concerning modifications of the rules were accepted, and the appointment of the standing committees of the Section was sanctioned.

Progressive Traffic Signals in London

IN the engineering supplement to the *Siemens Magazine* for November, Mr. F. G. Tyack gives a full account of the 'Autoflex progressive system' of traffic control which the experience of the last two years has shown to be very satisfactory in certain London streets. The problem is a difficult one, but its analogy to the corresponding problem of controlling 'the traffic' in telephony has been a great help in finding a solution. For the first time the theory of probability has been applied to street traffic problems. Mathematicians will be interested to learn that the method of 'least squares' is applied to the plotting of time and distance diagrams.

Motorists are well aware that one of the principal difficulties experienced by traffic police at complex intersections, or along busy thoroughfares, is efficient co-operation. They are often not in sight of one another and are generally fully occupied with the control of traffic in their immediate vicinity. Electrical signalling has been found to be the most convenient means of controlling the traffic.

In the flexible progressive system, there is a large number of 'local' traffic controlling devices at each intersection throughout the controlled area. These are linked electrically to a master controller which co-ordinates the indications given to the traffic and

so ensures a smooth flow along the main roads without the numerous halts and resulting congestion which sometimes occur at present.

It is difficult to describe all the complicated arrangements, but from the simplest and most elementary point of view, the signals in such a system may be regarded as changing from red to green and back again to red in such a manner that the green lamps appear to be travelling along the road at the speed of the traffic. Actually, the problem is not so simple as this, for there are two streams of traffic in opposite directions. Equal facilities for a smooth flow must be given to both, and in addition all cross traffic must be given frequent and adequate opportunities to proceed. A time and distance diagram has first to be constructed, and from this the various controllers have to be adjusted.

One of the essentials of the system is that the 'cycle time', that is, the time of one complete cycle of events as indicated by the sum of the red and green indications on any signal, must be the same at all intersections, and the master controller automatically ensures this. Long cycle times are desirable when the traffic is dense, and short cycle times when the traffic is light.

Until recently, the only progressive systems were operated on the 'fixed time' principle with predetermined 'go' and 'stop' periods, with the master controller transmitting its unifying signals at a predetermined frequency. In the case of the Oxford Street system, London, the master controller cycle time is varied twice each day—early each morning and late each evening. The arbitrary speeds between these times are only suitable for one particular traffic density.

In the new autoflex progressive system which is used at 74 intersections in the west end of London, mostly in the borough of St. Marylebone, a traffic 'integrator' is introduced to adjust the speed of the signal indications to suit the particular traffic density at the time. To do this, a 'key' intersection at which the traffic is representative of the whole system is selected, and the ordinary local detector mats fulfil the dual purpose of local signalling and traffic counting.

One curious and unforeseen industrial development is that telephone relays are being used at the rate of about 17,500 a year to meet the requirements of the autoflex controllers. In the Marylebone master controllers alone, 6,500 press keys have been fitted. Motoring readers resident near London should drive along a thoroughfare under the control of a traffic integrator and notice the facility with which they can proceed. One of the largest and most impressive systems is in operation in Marylebone Road.

Analysis of Intelligence

MANY years of mental testing have shown that most kinds of intelligence are positively correlated, so that a person talented in one direction is more likely than not to be talented in others. This suggests that each ability may be analysed into the sum of parts or 'factors', one of which (Spearman's 'general factor' g) is common to every kind of ability. At first, attention was directed mainly to certain dissimilar mental tests which satisfied the tetrad equations. The score of each such test can be expressed as the sum of two parts, which are positive multiples of g and of a 'specific factor', uncorrelated with g or with the specific factors occurring in the other tests. This simple form of 'two-factor theory' applies to the Spearman-Stephenson form perception tests. But W. Stephenson has shown that the ordinary verbal mental tests have a verbal group factor, and so are analysed into three parts, positive multiples of g, v, and specific factors. However, those who use tetrads are still called 'the two-factor school', as opposed to those who prefer other methods ('the multiple factor school'), such as H. Hotelling and L. L. Thurstone; but there is now no difference in principle or in the final results, merely in technique. It should be remarked that the verbal *factor* does not itself measure verbal *ability*, but (roughly) what is left of that ability when the parts due to g and the specific factor are deducted.

Unfortunately, the same set of test scores can be factorised in an infinite number of ways. Are factors merely mathematical symbols without psychological meaning? This criticism is especially difficult to repel in some earlier forms of multiple factor analysis, where some parts were subtracted from the others. To overcome this difficulty, and ensure that all parts occur with the same sign, has been the starting point of recent investigations independently carried out by Thurstone[1] and W. P. Alexander[2]. Alexander, after obtaining a first set of factors by any of the usual methods, then transforms them to a new set chosen on psychological grounds. Stephenson's results for perceptual and verbal tests are confirmed, and a new 'practical factor' F (in addition to g and specifics) is found in 'practical tests', such as those using cubes or mazes. On the other hand, Thurstone, analysing a mixed set of perceptual, verbal and practical tests, transforms his original factors so as to obtain three factors, G, V, S, such that no test should contain more than two of them (in addition to a specific factor). G occurred in all, G and V in the verbal tests, and G and S in the practical. Thus G, V, S seem to be the same as g, v, F, but Thurstone chose them mathematically and interpreted them psychologically, while Alexander reversed the process.

The psychological definitions of v and F fit in with Alexander's extension of his method to achievement tests such as school examinations; g and v, but not F, occur in written examinations, while g and F, but not v, occur in practical examinations. But two more factors are now required, apparently measuring character rather than intelligence: X, interpreted as 'persistence' or 'the will to succeed', and Z, whose meaning has not yet been fixed. In mathematics and science X is more important than g or v, but in English v is predominant. It is hoped that results of this kind may be useful in educational and vocational guidance, but the investigations should be confirmed (with an indication of the limits of accuracy), extended to include tests of temperament, and linked up with biological considerations such as growth.

H. T. H. PIAGGIO.

[1] *J. Gen. Psych.*, **11**, 126; 1934.
[2] "Intelligence, Concrete and Abstract" (*Brit. J. Psychol. Monograph Supplement* 19), Camb. Univ. Press, 1935. 12*s*. 6*d*.

Educational Topics and Events

BIRMINGHAM.—The degree of D.Sc. has been awarded to A. A. Hirst for papers published in the *Transactions of the Institution of Mining Engineers* on the cleaning of coal, principles involved in separation of particles, and allied subjects; and to F. M. Lea for work published in the *Philosophical Transactions*, the *Journal of the Society of Chemical Industry* and in building research technical papers, mainly dealing with properties of cement.

BRISTOL.—Dr. E. L. Hirst has been appointed to the Alfred Capper Pass chair of chemistry, in succession to Prof. F. Francis, who is to retire in July next. Dr. Hirst is at present reader in the chemistry of natural products in the University of Birmingham, and in addition has had experience as a lecturer in the University of St. Andrews, at Newcastle and in the University of Manchester. He is an organic chemist with an international reputation for his work on sugars, starches and celluloses. His studies have led him to chemical and biological investigations into the nature of vitamin C which involved collaboration on the biological side with the Lister Institute of Preventive Medicine. Dr. Hirst was successful in elucidating the constitution of vitamin C and, in collaboration with Prof. W. N. Haworth, has devised methods for the manufacture of the vitamin from the simpler sugars. He is also interested in the part played by sugars in the growth of plants. For these researches he was awarded the fellowship of the Royal Society in 1934.

Prof. W. E. Garner, Leverhulme professor of physical chemistry in the University, has been appointed director of the Chemical Laboratories, on the retirement of Prof. Francis.

IN the eleventh annual report, for 1934–35, to the Court of Governors of the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1, attention is directed to the finances of the School. The accounts show a deficit of nearly £3,000 for the year, annual subscriptions and donations amounting to about £10,000. It is the aim of the School that funds raised in this way should supplement the University grant and income from endowments to the extent of £12,000–£15,000. Sir Austen Chamberlain, the chairman of the Court of Governors, became a member of the Board of Management, by virtue of his office under the provisions of the revised charter, and Sir Cooper Perry succeeds Sir Harry Goschen as chairman of the Board. Prof. W. Jameson's report on the work of the School for the year ended July 31, 1935, surveys the activities of the School. The Ross Institute of Tropical Hygiene, incorporated in the School, has assisted in various ways industrial undertakings in many parts of the world. These include gold, copper and other mines, development companies in Australia, Africa and Europe, and plantations in India, Ceylon and Malaya. In the Department of Industrial Physiology, consultations and collaboration with industrial bodies have featured largely in the work of the session, and include problems of lighting and dust, protective masks for furnace workers, heat insulation in ships, tropical tentage and insulation of tropical helmets with linings of reinforced aluminium foil, and electric aids to hearing. A list of the papers, reports, etc., published from the School during the year is appended.

Science News a Century Ago

The Royal Observatory, Greenwich, in 1836

THE year 1835 had been for Airy, as he wrote in his autobiography, "a busy and anxious year". Appointed to succeed Pond as Astronomer Royal, during the last quarter of the year he had resided at Cambridge but had visited Greenwich once a week. "Through the last quarter of 1835," he said, "I had kept everything going on at the Greenwich Observatory in the same manner in which Mr. Pond had carried it on. With the beginning of 1836 my new system began. I had already prepared 30 printed skeleton forms (a system totally unknown to Mr. Pond) which were now brought into use. And, having seen the utility of the Copying Press in merchants' offices, I procured one. From this time my correspondence, public and private, is exceeding perfect.

"At this time the dwelling house was still unconnected with the Observatory. It had no staircase to the Octagon Room. . . . The North-east Dome ground floor was still a passage room. The North Terrace was the official passage to the North-west Dome where there was a miserable Equatoreal, and to the 25-foot Zenith Tube (in a square tower like a steeple, which connected the N.W. Dome with Flamsteed's house). . . . The Computing Room was a most pitiful little room. There was so little room for me that I transported the principal table to a room in my house, where I conducted much of my own official business. A large useless reflecting telescope (Ramage's), on the plan and nearly of the size of Sir W. Herschel's principal telescope, encumbered the centre of the Front Court."

Of the matters which occupied Airy in January 1836, one was connected with the projected London and Gravesend Railway and another the chronometer work of the Observatory. It was proposed to carry the railway at a high level across the bottom of Greenwich Park. "On Jan. 9th," said Airy, "I received orders from the Admiralty to examine into its possible effect in producing vibrations in the Observatory. After much correspondence, examination of ground, etc., I fixed upon a part of the Greenwich Railway (not yet opened for traffic) near the place where the Croydon trunk line now joins it, as the place for trains to run upon, while I made observations with a telescope viewing a collimator by reflection in mercury at the distance of 500 feet. The experiments were made on Jan. 25th, and I reported on Feb. 4th. It was shown that there would be some danger to the Observatory."

As regards the custody of chronometers, Airy wrote: "In the inferior departments of the Admiralty . . . the Observatory was considered rather as a place for managing Government chronometers than as a place of science. . . . On Jan. 17th I mentally sketched my regulations for my own share in chronometer business. I had some correspondence with Captain Beaufort, but we could not agree, and the matter was referred to the Admiralty. Finally arrangements were made which put the chronometer business in proper subordination to the scientific charge of the Observatory."

The Hot Springs of the Pyrenees

WRITING from Edinburgh to Whewell, on January 7, 1836, J. D. Forbes said: ". . . My special thanks for Hopkins' paper, which arrived at an admirable

moment. I was reading a paper to our Royal Society about Auvergne, and particularly upon elevation craters, which was quite in point. I am writing a paper just now which I intend for the R. S., London, on the Pyrenean springs, their temperature, geological relations, etc. ; and on the former point, temp., I am vain enough to hope that it may prove a sort of model to future observers : at least no one has hitherto so observed, I believe. . . . But these are only secondary occupations, which, with my lecturing labours, only revolve round my primary, the polarized heat. I have managed to magnify the effects so as to be, I hope, beyond cavil. . . . I think that experiment is a quietus for Biot".

Societies and Academies

PARIS

Academy of Sciences, December 2 (*C.R.*, 201, 1073–1156). HENRI DOUVILLÉ : Notice on the work of the late H. F. Osborn, *Correspondant* of the Academy. ALEXANDRE GUILLIERMOND, MAURICE FONTAINE and MLLE. ANNE RAFFY : The existence in *Eremothecium Ashbyii* of a yellow pigment belonging to the flavin group. The pigment from the *Eremothecium* has been directly compared with Karrer's lactoflavin and shown to possess similar properties. It is suggested that the pigment may play an important part in the metabolism of these fungi. JULIEN COSTANTIN : The *enroulement* of the *Belle de Juillet* variety of the potato. Remarks on the favourable effects of high altitudes on this disease. CHARLES PÉREZ was elected a member of the Section of Anatomy and Zoology in succession to the late Louis Joubin. KAROL BORSUK : Contribution to the theory of dimensions. P. RACHEVSKY : A dual bimetric system. SERGE FINIKOFF : Stratifiable couples attached to surfaces the asymptotics of which belong to linear complexes. SZOLEM MANDELBROJT : The $\bar{J}$ right lines and singular points of functions represented by Dirichlet's series. R. O. KUZMIN : The method of Tschebicheff for the approximate evaluation of integrals. JEAN LAGRULA : The intensity of gravity in Algeria, in the Midi of France and in the island of Majorca. Tables of results obtained during 1935 with the Holweck-Lejay pendulum. SANTIAGO ANTUNEZ DE MAYOLO : The interpretation of the α coefficient of fine structure. JACQUES YVON : The fluctuations of the density at the critical point. Discussion of a theorem of Smoluchowski from the point of view of the effect of gravity. PIERRE VERNOTTE : Concerning a problem of convection : insufficiency of the equation of heat. JEAN MERCIER : The determination of the region of synchronisation of two oscillators. JEAN BERNAMONT : The fluctuations of potential at the boundaries of a metallic conductor of small volume traversed by a current. MARCEL LAPORTE : The duration of the very short flashes of light obtained by discharging a condenser through a gas tube. Study of the discharge through a tube containing argon and mercury vapour. The duration of the very intense part of the flash was of the order of 10^{-5} second. JACQUES SOLOMON : The absorption in matter of particles of great energy. JEAN BECQUEREL : The determination of the paramagnetic susceptibilities of crystals of the rare earths, by the measurement of the paramagnetic rotatory powers. RAYMOND RICARD and ANTOINE SAUNIER : The spark spectra of cadmium. Results of a study of the Cd III and Cd IV spectra. PIERRE AUGER and ALBERT ROSENBERG : The analysis of the cosmic corpuscular radiation under a screen of 28 metres of soil. The results differ considerably from those obtained above the soil at various altitudes. The soft group, if it exists at this depth, cannot be more than 3 per cent, while at 3,500 metres it amounts to 40 per cent. GEORGES CHAMPETIER : The hydration of chromic chloride in heavy water (deutohydrogen oxide). The hydration of chromium chloride in ordinary and heavy water has been followed by measurements of the electrical conductivity. The reaction proceeds more slowly in the heavy water, the ratio of the velocities being approximately one to three. MLLE. M. T. SALAZAR : The constitution of the capillary layer in solutions of malachite green. RENÉ DALMON : The nitration of cellulose by the vapour of nitrogen pentoxide. The yield of trinitrocellulose in this reaction was found to be 99·3 per cent. MARCEL BALLAY : The constitution and properties of some alloys of iron, carbon and beryllium. Study of seven alloys containing amounts of beryllium increasing up to 3·88 per cent. PIERRE VAN RYSSELBERGHE : Thermodynamic potentials and affinity. PAUL RENAUD and ERNEST BAUMGARDT : The law of displacement of equilibrium. ANDRÉ CHRÉTIEN and OSCAR HOFFER : The existence of two hydrates of potassium thiocyanate. HENRI GUÉRIN : The action of heat on calcium and strontium ortho-, pyro- and metarsenates. The orthoarsenates can be heated to 1,200° C. in a vacuum without change : pyroarsenates and metarsenates by prolonged heating at temperatures above 800° C. are slowly converted into orthoarsenates. XAVIER THIESSE : The action of oxidising agents on sodium hypoferrite. A description of various products obtained by treating alkaline solutions of sodium hypoferrite with chlorine and bromine : the concentration of the sodium hydroxide is the determining factor. JEAN BARLOT : The hydrogenation of bituminous schists at the ordinary pressure. Results of the distillation of four schists of different types in hydrogen at the ordinary pressure. The yields of oil were increased, the tar and sulphur percentages reduced. MLLE. RENÉE LE BLANC : Some *Chætoceros* of the Etang de Thau. ANTONIN TRONCHET : Observation *in vivo* of the tactile dots of the tendrils of *Bryonia dioica*. A. QUINTANILHA : The cytology of the *copulations illégitimes* in *Coprinus fimetarius*. ANTOINE MAGNAN and HENRY GIRERD : Study of the pressures about a pigeon beating its wings. BORIS EPHRUSSI and GEORGE W. BEADLE : The conditions of autodifferentiation of Mendelian characters. JEAN LAVOLLAY : The fixation and exchange of cations in living beings. The character of generality of the laws of exchange of bases. EMIL CIONGA : An acid ester contained in the root of officinal valerian. RAOUL LECOQ and RENÉ CAREL : Comparison of the acetone-producing action of some food lipids and castor oil.

AMSTERDAM

Royal Academy (*Proc.*, 38, No. 8, October 1935). J. H. C. LISMAN and W. H. KEESOM : The melting curve of oxygen to 170 kgm./cm.^{2}. The melting point of oxygen as a function of the pressure and a calculation of the triple point and density at the latter temperature. W. H. KEESOM and J. HAANTJES. (1) Further results of the separation by rectification of neon into its isotopic components. Densities and mean atomic weights of various

fractions. (2) Vapour pressures of neon of different isotopic compositions. Deduction of the ratio p_{20}/p_{22} of the two isotopes and comparison with theory. J. DE GIER and P. ZEEMAN: The isotopes of nickel. Results with the parabola method for the abundance of the isotopes 58, 60, 62 and 64. J. G. VAN DER CORPUT: Distribution functions. T. J. POPPEMA and F. M. JAEGER: The exact measurement of the specific heats of solid substances at higher temperatures. (20) On the molecular heats of the alloys of palladium and antimony in comparison with the sum of the atomic heats of the free elements. (21) On the molecular heat of the compound $PtSb_2$ in comparison with the sum of the atomic heats of the free component elements. (22) The molecular heats of the supposed binary compounds of copper and palladium. E. COHEN and J. J. A. BLEKKINGH, JR.: The influence of the degree of dispersion on physico-chemical constants (4). The density of potassium chloride is the same whether the particles have a mean diameter of 0·1 mm., 0·5 mm. or 5 mm. E. DUBOIS: The sixth (fifth new) femur of *Pithecanthropus erectus*. A further fragment of a shaft of a femur in the author's collection has been identified as a fossil bone of *Pithecanthropus erectus*. A. J. HAAGEN SMIT and F. W. WENT: A physiological analysis of the growth substance. Tests on a large number of substances to determine the influence of chemical properties on ability to stimulate plant growth. H. P. BERLAGE, jun.: The theorem of minimum loss of energy due to viscosity in steady motion and the origin of the planetary system from a rotating gaseous disc. J. POPKEN and K. MAHLER: A new principle for proof of transcendency. G. H. R. VON KOENIGSWALD: A fossil mammalian fauna from South China containing simians. ELSA REUHL: Oxygen intake of oily and starchy seeds. The effect of variation of the partial pressure of oxygen on its intake by various germinating seeds. J. DOUTRELIGNE: Note on the structure of the chloroplasts. K. V. THIMANN: An analysis of the activity of two growth-promoting substances on plant tissues. Physiological tests on substances having a chemical structure similar to that proposed for auxin *A*. B. VAN DER EYKEN: Development of denture and teeth in *Salmo irideus*. (1) Lower jaw. K. H. FINLEY: An anatomical study in familial olivo-ponto-cerebellar hypoplasia in cats. G. BLOMHERT: Contribution to the study of the haptic perception of proportions. Experiments to determine whether it is possible to perceive the proportions of a simple geometrical object (rectangle) by touch alone. P. E. VERKADE, J. VAN DER LEE, A. J. T. VAN ALPHEN and M. ELZAS: Researches on fat metabolism. (7) β-oxidation of normal saturated dicarboxylic acids administered *per os*. Evidence of β-oxidation of dicarboxylic acids by the living organism from experiments with dogs. J. M. WEGENER: Investigation of the two and three dimensional Finsler spaces with the ground form $L = \sqrt[3]{(a_{ikl}x'^i x'^k x'^l)}$.

CRACOW

Polish Academy of Science and Letters, November 4. K. DZIEWONSKI and L. GIZLER: The reactions of thio-urea with the arylalkylketones. K. ROUPPERT: *Peridermium truncicola* on the stone pine in the Tatra massif. Z. GRODZINSKI: The development of the veins of the blastoderm of the fowl. W. CISLIK and Z. KAWECKI: The appearance in Poland of *Aphelinus mali*. MLLE. H. LUCZYNSKA: The sense of distinction of form and visual memory in lizards.

Forthcoming Events

[*Meetings marked with an asterisk are open to the public.*]

Monday, January 6

SOCIETY OF GLASS TECHNOLOGY (MIDLANDS SECTION), at 7.30.—(at the Talbot Hotel, Stourbridge).—W. H. S. Chance: "The History of Optical Glass".

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—W. B. Kennedy Shaw: "An Expedition in the Southern Libyan Desert".

Tuesday, January 7

UNIVERSITY OF LEEDS, at 6.—(in the Philosophical Hall, Park Row, Leeds).—Prof. J. H. Priestley: "Woodalive".

Wednesday, January 8

SOCIETY OF GLASS TECHNOLOGY (Joint Meeting with the PLASTICS GROUP OF THE SOCIETY OF CHEMICAL INDUSTRY), at 8 (in the rooms of the Chemical Society, Burlington House, Piccadilly, W.1).—Prof. G. T. Morgan, N. J. L. Megson and L. E. Holmes: "Organic Glasses".

J. Wilson: "Plastics for Laminated Safety Glass".

Friday, January 10

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—J. Johnson: "The Future of Steam Propulsion" (Thomas Lowe Gray Lecture).

PHYSICAL SOCIETY'S EXHIBITION, January 7–9.—Annual Exhibition to be held at the Imperial College of Science and Technology.

January 7, at 7.45: R. A. Bull: "Some Instruments used in recording Sound on Film".

January 8, at 7.45: R. W. Paul: "Electrical Measurements before 1886".

CONFERENCE ON "MECHANIZATION IN MIXED FARMING", January 7–10. To be held at Rhodes House, Oxford.

Official Publications Received

Great Britain and Ireland

Agricultural Research Council. Observations by the Tuberculosis Committee on the Experiment with Spahlinger Vaccine in Northern Ireland. Pp. 6. (London: H.M. Stationery Offices.) 2*d*. net. [412

Department of Scientific and Industrial Research. Index to the Literature of Food Investigation. Vol. 6, No. 2. Compiled by Agnes Elisabeth Glennie, assisted by Gwen Davies. Pp. v+311–621. (London: H.M. Stationery Office.) 5*s*. net. [912

Other Countries

New Zealand: Department of Lands and Survey. Annual Report on Scenery-Preservation for the Year ended 31st March 1935. Pp. 7. (Wellington: Government Printer.) 6*d*. [1612

The Institute for Science of Labour, Kurasiki. Annual Report of the Director for 1934. Pp. ii+40. 70 sen. Report No. 31: An Essay on the Basal Metabolism of the Japanese. By Dr. Gito Teruoka. Pp. 34. 70 sen. Report No. 32: On the Measurement of Sitting Height (First Report). By Dr. T. Yagi. Pp. 15. 30 sen. (Kurasiki: Institute for Science of Labour.) [1612

Journal of the Indian Institute of Science. Vol. 18A, Part 14: Study of the Bismuth Electrode. By D. N. Mehta and S. K. Kulkarni Jatkar. Pp. 100–113. 10 annas. Vol. 18A, Part 15: The Estimation of Acetone in Methyl and Ethyl Alcohol. By S. D. Sunawala and M. C. T. Katti. Pp. 115–122. 12 annas. Vol. 18A, Part 16: The Steric Factor in Organic Chemical Reactions. Part 1: Influence of Esterification on the Mode of Addition of Bromine to β-Phenyl-Propiolic Acid. By P. Ramaswami Ayyar. Pp. 123–128. 10 annas. (Bangalore: Indian Institute of Science.) [1612

Observatoire de Zi-ka-wei. Annales de l'Observatoire astronomique de Zô-sè (Chine). Tome 19: Tables de petites planètes. Fasc. 2: Sept planètes du type flora ($1000'' < n < 1100''$). Par le P. E. de la Villamarqué. Pp. ix+80. (Sung-kiang: Observatoire de Zô-sè.) [1612

Catalogues, etc.

Catalogue of the Twenty-sixth Annual Exhibition of Scientific Instruments and Apparatus, held at the Imperial College of Science and Technology, South Kensington, London, S.W.7, January 7th, 8th and 9th, 1936. Pp. 192+lxxiv. (London: The Physical Society.)

Diary for 1936. Pp. 64+16+16+Diary. (Bonnybridge: John G. Stein and Co., Ltd.)