NATURE

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CONTENTS.

Co-operation in Forestry and Forest Products Research.

CONSIDERING the importance of wood and its by-products in the necessities of life, it is strange how comparatively little systematic action has been taken in England to study the constitution of wood-substance and the structure and properties of the different timbers in relation to their uses. Much of our knowledge, whether it be of the chemistry of wood or its mechanical and physical behaviour, is empirical.

Most of the difficulties encountered in connexion with timber are due to its extraordinary lack of uniformity. When anything goes wrong, as, for example, when an aeroplane strut breaks without warning, the first question always asked is: 'Is this a normal piece of wood?' A piece of wood may be regarded as normal or abnormal from several different points of view; for example, in its behaviour under mechanical stress, in either its minute or gross structure, with respect to its treatment during seasoning, or as representing normal growing conditions. The interrelation of these aspects is of very great importance. A timber is usually judged in practice by its mechanical properties, but until our knowledge of the connexion between structure, growth, seasoning, and strength is increased, it will remain impossible to assess the mechanical properties of a piece of timber with any degree of certainty otherwise than by actually breaking a test stick. Further, will the growing conditions which the forester aims at as ideal, produce timber which gives the best results under mechanical tests?

One can only hope to solve such problems by the close collaboration of a number of specialists in different branches of research. The establishment, under the Department of Scientific and Industrial Research, of the Forest Products Research Laboratory at Princes Risborough, within sixteen miles of the Imperial Forestry Institute at Oxford, has opened up a prospect of such collaboration which both institutions have been quick to grasp. These two institutions together provide the much-needed link between the sylviculturist on one hand and the wood-user on the other, harnessing science to the task of informing the sylviculturist of the species to plant, the quality of timber desired, and the means of obtaining it, and the wood-user of the right timber for the several uses, based on mechanical and physical properties, with the best method of preparing it for use.

In this work the Imperial Forestry Institute is primarily concerned with the living tree, from

the germination of the seed to the felling of the tree for timber: from this point the problems are proper to the Forest Products Research Laboratory, which is concerned with mechanical strength, seasoning, preservation, and manufacture of the timber, and with the investigation of by-products. There exists, however, a common ground, more especially in wood technology, mycology, and entomology. In these three subjects, in order to secure the closest co-operation, the staffs of the two institutions have been practically combined to form a joint section, working on a joint programme, the Forest Products staff being housed at the Imperial Forestry Institute at Oxford.

In dealing with complex problems, it has thus been possible to co-ordinate very different aspects, and the personal contact between the two staffs greatly facilitates the dissemination of information and ideas. For example, a number of independent lines of research, which are being undertaken, have been so arranged that their results may form the basis of an investigation into the problem of 'brashness,' which means an unexpected brittleness in a wood which is not normally brittle; this is a problem of particular importance in aeroplane construction. Other problems coming within this system of co-operative research are the relation between anatomical variation, mechanical strength, and growing conditions; the range of variation consistent with normal mechanical strength; the physical and chemical factors involved in the process of seasoning; the effect of different degrees of fungal attack and the possible relation between insect and fungal attack. In the chemistry of wood-substance, a beginning has been made by arranging for work to be carried out under Sir James Irvine at the University of St. Andrews. This will be closely co-ordinated with the physico-chemical research included in the joint programme of the Laboratory and the Imperial Forestry Institute, especially in its relation to shrinking and swelling.

The problems connected with colonial timbers also can only be effectively solved by a combined investigation in which both the growing of the timber and its utilisation are fully considered. Here the co-operation of the systematist and the wood technologist forms an indispensable link, and is very strong under the existing arrangements. Such a combined scheme has already been put forward, in a joint pamphlet which has been circulated to the Forest Services of those parts of the British Empire which do not yet possess facilities to undertake the work themselves.

An Orthodox View of Witchcraft.

The History of Witchcraft and Demonology. By Montague Summers. (The History of Civilisation Series.) Pp. xv + 353 + 8 plates. (London: Kegan Paul and Co., Ltd.; New York: Alfred A. Knopf, 1926.) 12*s.* 6*d.* net.

ANY anthropologist into whose hands this book may come will rub his eyes to find himself translated to an atmosphere of theological controversy which might well be that of the seventeenth century. Indeed, he may even go further and ask why a series entitled "L'Évolution de l'Humanité," or, in translation, "A History of Civilisation," in which an impersonally objective treatment of its subject matter might reasonably be expected, should include a book so subjective in outlook as Dr. Summers' "History of Witchcraft and Demonology." It is surely not the function of the student of the development of thought and belief to inquire into the truth or validity of the tenets he examines, or to obtrude his own beliefs; his interest lies in the process of development and its product; he may legitimately be expected to regard them as objective matters of fact, the truth or falsity of their content being irrelevant to his purpose.

Dr. Summers, however, believes in witches, and accepts the witchcraft belief as set forth in contemporary or nearly contemporary accounts and in the reports of witch trials as in the main a true record of a real cult and an actual manifestation of the principle of evil. He believes in the possible efficacy of a malediction. It is true that he acknowledges that the leader of the witches' coven was often proved to be a man—Francis Bothwell, for example, for political and other reasons was suspected of inspiring the Berwick witches who were accused of plotting against James I., and the suspicion is made almost a certainty by his notorious reputation as a 'witch master' when afterwards living at Naples—but he says:

"When God's Ape the Demon can work so successfully and obtain not merely devoted adherents but fervent worshippers by human agency, there is plainly no need for him to manifest himself in person either to particular individuals or at the Sabbats, but none the less that he can do so, and has done so, is certain, since such is the sense of the Church, and there are many striking cases in the records and trials which are to be explained in no other way."

It is therefore with scarcely a feeling of surprise that we read: "anthropology alone offers no explanation of witchcraft. Only the trained theologian can adequately treat the subject." In the

true spirit of the orthodox when a belief in witchcraft was a test of orthodoxy, Dr. Summers gives a long list of fathers of the early Church, theologians, lawyers, and writers on witchcraft who held firmly to the belief in the reality of the existence and powers of the witch; but he might just as well have cited an almost equally long list of those who denied it. It is significant that while references to Sprenger and the "Malleus Maleficarum"—the bible of the witchfinder—Boguet, Bodin, and de Spina are frequent, such writers as Scott, Cotta, Bernard, Wierus, Webster, Becker, and Hutchinson, critics of the belief, are barely mentioned, if at all. As most of these writers are English, it may be that Dr. Summers will deal faithfully with them in the later volume in which he promises to discuss the witchcraft belief in its local manifestation in England, France, Germany, and elsewhere.

Bodin, the famous French lawyer and writer of the sixteenth century, defined a witch as "Sorcier est celuy qui par moyens diaboliques sciemment s'efforce de parvenir à quelque chose" (a sorcerer is one who by commerce with the devil has a full intention of attaining some end). British jurists laid rather more stress on the existence of a pact with the devil. Virtually there was a general agreement in the witchcraft prosecutions in the fifteenth, sixteenth, and seventeenth centuries throughout Europe and in the American colonies, that whatever may have been the specific act upon which the accusation was brought, witchcraft involved a league with the devil and a renunciation of Christianity. The frenzied fear of the populace was responsible for the cruelty of the duckings and other forms of outrage and the witch-findings of Hopkins and his peers in the small towns and villages of Puritan England and Presbyterian Scotland of the seventeenth century, but it was the animus of the Church against the heretic which brought literally thousands to their death after the issue of the Bull of Innocent VIII. in 1484. It is quite correct, as Dr. Summers points out, that the witchcraft prosecutions did not begin with this Bull; but they increased enormously in number after its promulgation, and it was responsible for the activities of Sprenger and his colleagues in Germany, inspiring them to the authorship of the "Malleus Maleficarum," which became the text-book and code of those who emulated their achievements in prosecution elsewhere.

The charges of heresy and witchcraft, it is true, were almost interchangeable, and accusations of witchcraft were brought freely against heretical sects; but it is difficult to accept Dr. Summers' view that the Bull of 1484 was directed against heresy alone. The various activities of witches are specifically enumerated: the renunciation of the faith is mentioned as an added crime, not as the head and front of the offending, however much importance may attach to it. In order to support his view that the witch as heretic was the object of the Church's attack and that the outburst of witch prosecutions of the fifteenth century was no new thing, Dr. Summers cites earlier Bulls of the popes and refers to earlier heresy trials. Among these he quotes an account of an assembly of Manichees at which the devil appeared. These Manichees were condemned by a synod at Orleans in 1022. But a similar account, almost identical in wording, appears in Walter Mapes about the Paturini, and much the same sort of accusation was brought against the assemblies of most of the many schismatic sects which sprang up about this time. It has all the flavour of a commonplace of ecclesiastical scandal and gossip which was fastened on to any sect that was forced by circumstances to meet in secret. Dr. Summers, however, is convinced of the connexion of heresy and witchcraft. He says:

"The full fury of the prosecution burst over England . . . shortly after the era of a great religious upheaval, when the work of rehabilitation and recovery so nobly initiated by Queen Mary I. had been wrecked owing to the pride, lust, and baseness of her sister. In Scotland, envenomed to the core with the poison of Calvin and Knox, fire and cord were seldom at rest. It is clear that heresy had brought witchcraft swiftly in its train."

In Ireland, on the other hand, for obvious reasons, "the devil's claws were finely clipped."

It is not possible here to follow Dr. Summers in all the consequences which are entailed by this acceptance of the purely heretical character of witchcraft and the orthodox attitude of the Roman Church towards such matters, which almost necessarily involves the view that at the present day witchcraft persists in the celebration of the black mass, satanism, and spiritualism—a conclusion which an anthropologist at least would find it difficult to accept, for psychologically and culturally they are poles apart. It explains why he traces witchcraft back to the Gnostics and the Manichæans, and also why he rejects the anthropological view. His rejection of the contribution of anthropology to the study of witchcraft might carry more weight had it been clear that he is fully aware of what that contribution is. The anthropologist no longer accepts, if he ever did, "devil-worship," the term used by Dr. Summers, as an adequate description of a primitive cult, secret or

other; nor incidentally is 'Bantu' a territorial term. The belief in the witch is widespread in time and space. Possibly its origin may go back to palæolithic times. The animal-headed human figure depicted in the cavern at Les Eyziès, or the leader of the dance in the paintings of Cogul, may be the ancestors of the leader of the coven. Witchcraft exists to-day among both primitive peoples and the peasant populations of Europe. At a time of universal credulity it was elevated by the Church, as a self-protective measure, into a heresy; but that does not place it outside the scope of the science which studies the beliefs of man as objective facts of experience, or remove it from the category of primitive religions, even if it survived only in a mutilated or attenuated form.

In conclusion, although there are still many controversial points upon which it has not been possible to touch, it must be said in fairness to Dr. Summers, and to those who are interested in one of the most extraordinary chapters in history, that notwithstanding the point of view from which the book is written, and the bias which has determined the line of discussion of the origin of the belief, this is the best and most complete account of the witch cult in mediæval and early modern Europe which has been written in recent years.

Tungsten.

Tungsten: a Treatise on its Metallurgy, Properties, and Applications. By Dr. Colin J. Smithells. Pp. viii + 167 + 33 plates. (London: Chapman and Hall, Ltd., 1926.) 21*s*. net.

TUNGSTEN is a metal which presents so many points of special interest both from the practical and the scientific aspect, that a treatise dealing with it in detail is welcome. From the time when tungstic acid was first prepared by Scheele in 1781 and Bergman soon afterwards isolated the metal, tungsten remained a rare metal, and it only began to assume industrial importance as the result of the work of Oxland in 1847–57. The important position which the metal now occupies, both in connexion with the electric lamp industry and for the production of high-speed tool steel, is an often-quoted but none the less instructive example of the way in which a curiosity of the laboratory may become a valuable product of industry. Apart from this historical interest, however, the properties of tungsten itself are remarkable. The metal, at room temperatures and slightly above these, is chemically inert, and uses based on its resistance to oxidation and to chemical attack are numerous and important. Its application to electric contacts may be recalled. On the other hand, at higher temperatures, tungsten becomes chemically much more active, combining readily with oxygen and even exerting a strong reducing action on the oxides of other elements. For this reason, both in the manufacturing processes applied to it and in its practical applications at elevated temperatures, it must be kept out of contact with oxygen or other oxidising agencies. As a result we find that it is hot-worked usually in an atmosphere of hydrogen, or maintained in a vacuum or in an inert atmosphere such as nitrogen or argon.

Tungsten is remarkable from yet another point of view. If we take account of what may be termed the 'relative temperatures' of metals, tungsten at room temperature must be regarded as one of the 'coldest' substances which it is possible to obtain; *i.e.* it is further removed from its melting point than any other metal. Since the properties of metals are closely associated with their 'distance' from their melting points, it is not surprising to find that the mechanical properties of tungsten are correspondingly extreme. At room temperature it is probably the strongest known material, and it can be produced in a ductile condition only in special circumstances. When thus produced, however, it can be cold-worked and work-hardened like other metals, but with this difference, that plastic deformation applied to it at any temperature much below 1500° C. still produces work-hardness. The re-crystallisation normally associated with annealing only occurs above that temperature, which thus corresponds roughly with, say, 550° C. for iron. Finally, tungsten cannot, like other metals, be melted and cast, since its melting temperature is so high that it is not yet possible to obtain a refractory capable of holding molten tungsten. It remains to be seen whether this will yet be accomplished, or whether it will be worth while. Dr. Smithells states that tungsten which has been fused is rendered permanently brittle, but recent work on other metals at least suggests that such brittleness may be due to the presence of traces of inter-crystalline impurities which readily escape detection.

Meanwhile, the process of manufacture of ductile tungsten is again of special interest. Like wrought iron, the metal is brought into a coherent solid form by the high-temperature welding of small particles without previous fusion. The metal is obtained in the form of powder, of the desired degree of purity, and this is welded into the form

of rods by heating the compressed material in an atmosphere of hydrogen and then 'swaging' it while hot. The rods thus produced are 'sintered' by heating them electrically by the direct passage of a heavy electric current, and the material thus consolidated can then be worked down, while hot, by further hammering. Ultimately it can be drawn down to exceedingly fine wire in the cold. Perhaps the most curious fact of all is that such wire shows a considerable degree of ductility, but is rendered completely brittle by heating it up to or beyond 1500° C. The proximate explanation is that in the cold-drawn wire the crystals are elongated into long fibre-like bodies, so that bending or twisting of the wire implies deformation of the crystals themselves, but little or no relative motion between adjacent crystals. After annealing, the crystals resume an equi-axed arrangement, and any plastic deformation implies considerable relative movement of the crystals with the result that, at room temperature, rupture immediately occurs. This phenomenon has been interpreted, both by Z. Jeffries and the present writer, in terms of the 'amorphous cement' theory, according to which there is a thin layer of non-crystalline metal between adjacent crystals. At temperatures very far below the normal melting point of the metal, this amorphous layer is brittle and incapable of even a minute amount of flow. A similar phenomenon occurs in iron at very low temperatures.

The question just briefly discussed is an example of the way in which the behaviour of tungsten is apt to become the testing-ground of theories of the structure and behaviour of metals in general. In fact, a considerable portion of Dr. Smithells' book, and perhaps the most interesting portion of it, is devoted to an account of a series of researches of a general fundamental nature in which tungsten has served as the material for experiment. In view of the difficult technique, often involving the use of very fine wires and of exceedingly high temperatures in high vacua or in carefully controlled atmospheres, it is surprising to find the degree of success which these investigations have attained. The researches of Goucher and of Smithells himself are excellent examples. The only misgiving is whether tungsten, which differs in so many remarkable ways from other metals, is the best choice for work of this kind. No doubt the most fundamental phenomena are common to all metals, but each of them has its own peculiarities, and tungsten perhaps more so than the majority.

Dr. Smithells' book deals with the various matters already mentioned, and many others bearing on the manufacture, properties, and applications of tungsten in a lucid and interesting manner. The matter of the book is selected in a way which speaks at once of the fact that it is the work of a man writing on his own subject, largely on the basis of direct personal knowledge, and the book is to be valued accordingly. The only section to which this does not apply so fully is that relating to the use of tungsten in alloy steels. No doubt this section has been included for the sake of completeness, but it is not on the same level as the rest of the book. One can scarcely blame Dr. Smithells because he is not also an alloy-steel metallurgist, but it might have been wiser to omit this section.

Finally, the photo-micrographs of tungsten which are given in the book deserve a word of praise. They frequently represent sections of very thin wire wound in spirals and have been obtained by an ingenious technique used with great skill. Fortunately, the structures encountered in a pure or nearly pure metal like tungsten are sufficiently simple to be readily understood by the technical reader even if he is not a trained metallographer. On the whole, Dr. Smithells' book is to be commended as a clear and well-written monograph on a subject of great interest. W. ROSENHAIN.

Parasites and Man.

(1) *Contributions from the Harvard Institute for Tropical Biology and Medicine, No.* 4. *Medical Report of the Hamilton Rice Seventh Expedition to the Amazon, in conjunction with the Department of Tropical Medicine of Harvard University, 1924–1925.* Members of the Medical Expedition: Prof. Richard P. Strong, Prof. Joseph C. Bequaert, Prof. George C. Shattuck, Ralph E. Wheeler. Pp. xvi + 313 + 70 plates. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1926.) 20*s.* net.

(2) *Animal Parasites and Human Disease.* By Dr. Asa C. Chandler. Third edition, revised. Pp. xiii + 573. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1926.) 22*s.* 6*d.* net.

(1) THIS attractive volume, printed and illustrated with the expensive excellence that is found so frequently in American publications, is a prelude to adventure in a scientific sense rather than a record of completed researches. While this is true up to a point of the actual work

accomplished, the summing up of the knowledge concerning all the matters touched upon is vividly and skilfully done, so that the reader is presented with the state of knowledge in connexion with the matter in hand in relation to the particular experience and contribution made by the members of the expedition. This is well shown by the very interesting account of yellow fever. Scarcely any cases occurred during the period spent by the expedition in Brazil; the preventive measures, and probably also a spontaneous remission, have resulted in the almost total disappearance of the disease. The writer, however, summarises the studies carried out on the last epidemic at Bahia in 1923, and concludes that the evidence incriminating *Leptospira icteroides* was strengthened and the identity of the yellow fever occurring in Palmeira and Bahia with that which is found in Mexico, Peru, and Colombia was established.

Among the medical matters investigated, the chapter on malaria and splenomegaly is of particular interest. Malaria, in spite of quinine and of all the knowledge that has been accumulated in the last thirty years, remains the most prevalent and serious disease of Amazonia, as indeed of practically all tropical and many subtropical countries. It is true even now that the disease is accepted fatalistically in countries much more civilised and better administered than that traversed by the expedition. The workers show the wide experience that they bring to the problem, which is well handled, and the ravages of the disease as an agent of human degradation and of actual depopulation of considerable areas are forcibly and eloquently described.

The chapters dealing with insect life are, as might be expected, of great interest, tropical South America being a naturalists' paradise in this respect. Simulium and Tabanus were found in large numbers, and are reported upon in some detail. The summing up of the rôle of Tabanus species in the transmission of disease, especially protozoan diseases such as trypanosomiasis, is judicial and well informed. The problem of the transmission of the trypanosome of Mal de Caderas remains, however, unsolved.

The expedition, as has already been shown, had a happy and catholic taste in knowledge, and there is an excellent account of a new dipterous fly *Malacophagula neotropica* (Bequaert), parasitic in a snail. This chapter also gives an account of the arthropod enemies of snails.

(2) If the report of the Hamilton Rice expedition cast its net in a wide and leisurely way into a sea of tropical life, and brought back a mixed catch which is set out with a truly scientific interest in knowledge for itself, the second book to be considered deals with the wide range of its subject in a totally different spirit.

In "Animal Parasites and Human Disease," Dr. Chandler takes his title to heart from the first page, and we are considering animal parasites and animal life strictly from the view-point of the doctor and the sanitarian. The author knows what he is about, and the preface states the position with admirable clarity. It purports to give the results of scientific research in this particular field in such a way that it shall be useful to those who seek to apply them to practical problems. Dr. Chandler is inclined to reprove the scientific worker for his failure in propaganda, but this vivid, condensed, and readable treatment of the subject is itself a proof that the task of exposition is probably better executed by those who are applying the fruits of inquiry rather than by those whose energies are absorbed in the pursuit of new knowledge.

There is here quite frankly a different attitude towards knowledge, and the energetic insistence of this type of statement requires gifts which differ from those usually possessed by the research worker.

The book succeeds in its aim. It contains an enormous amount of information; it deals with all the protozoan parasites of man, their life-histories, means of transmission, and with the history of the insect vectors—this last section is particularly well done considering the scope of the book. All the spirochætes of man are described; all the 'worms' parasitic in man, with a brief chapter on leeches, and all the arthropods which are either parasites of man or suck his blood, are included; and all this is achieved within the compass of 528 pages. It is in the main a very accurate and fair presentation of the case, and if there are some rather sweeping generalisations and a slightly optimistic sense of progress and achievement, as, for example, in the account of malaria, it is nevertheless a sound and valuable book and excellently suited to the reader for whom it is designed.

One wonders if such doubtful forms as the Chlamydozoa and *Cyclasterion scarlatinæ* are worth including in this book, but the fact that they are mentioned gives a measure of the completeness with which the author has dealt with the subject.

These two books are an interesting comment upon each other, for the Hamilton Rice report reveals how lamentably the use of knowledge lags behind its possession.

Cainozoic Plants.

British Museum (Natural History): Catalogue of Cainozoic Plants in the Department of Geology. Vol. 1: *The Bembridge Flora.* By Eleanor Mary Reid and Marjorie Elizabeth Jane Chandler. With a section on the Charophyta, by James Groves. Pp. viii + 206 + 12 plates. (London: British Museum (Natural History), 1926.) 15*s.*

THE appearance of the first volume of the catalogue of Cainozoic plants in the British Museum is a noteworthy event. Catalogues of the older plant remains have already appeared, but the great and valuable stores of Tertiary plants in the national collections have received scant attention.

The plant remains of this period are of great interest but present exceptional difficulties; they are derived chiefly from Angiosperms, often closely resembling modern genera or even species, but usually are represented by leaf impressions only. These are so difficult to identify that many eminent botanists have regarded the task as practically impossible, and have thrown doubt upon the validity of much of the work already done. If, however, we could be sure of the identity of the remains which have come down to us, we should have material of great value for the solution of some of the difficult problems of plant evolution and distribution.

In the present catalogue a number of species are described, identified, and established on grounds which are far more secure than those which Hooker and others have criticised. In the Bembridge beds there are not merely leaf impressions but also the remains, often very well preserved, of seeds and fruits; many of these can be compared so closely with the seeds and fruits of living plants that it is impossible to doubt the correctness of their determination. The cuticle-structure of some of the leaves is preserved also, and in several cases their identification may be taken as firmly established.

Among the more interesting forms described may be mentioned a new species of Azolla, founded on astonishingly well-preserved material, and most interesting in view of the re-establishment of this genus in England in recent years. Dr. Florin has aided the authors in establishing the presence of a new species of Araucarites, while Sequoia, Cupressus, and Pinus were also present. The majority of the Angiosperms have been compared with plants now existing and have been given suitable generic and specific names, but others which could not be matched with any known living forms are described and placed in the non-committal genera Carpolithus and Dicotylophyllum. The remains of Charophyta are abundant in the flora and have been treated in a separate section by Mr. James Groves, the well-known authority on this group.

One of the most interesting parts of the volume is the introduction, in which, among other matters, the authors give an analysis of the flora and compare it with other fossil and modern floras. It is shown that the Bembridge flora has a greater affinity with the plants living to-day in eastern Asia and North America than with the present European flora, and the authors point out how greatly the recent work on the floras of China and the neighbouring lands affects the determinations and conclusions of the earlier writers on Cainozoic plants. H. H. T.

Our Bookshelf.

(1) *Wireless Pictures and Television: a Practical Description of the Telegraphy of Pictures, Photographs, and Visual Images.* By T. Thorne Baker. Pp. x + 188. (London: Constable and Co., Ltd., 1926.) 6*s.* 6*d.* net.

(2) *Television (Seeing by Wire or Wireless).* By Alfred Dinsdale. Pp. 62. (London: Sir Isaac Pitman and Sons, Ltd., 1926.) 2*s.* net.

(1) APPLIED photo-electricity has perhaps developed more rapidly than any other branch of applied physics. The discoveries of outstanding importance which have resulted from photo-electric observations have stimulated the production of improved apparatus, and this has had a healthy reaction upon practical applications. Of these, telephotography and television are among the most interesting. Of the former, Mr. Thorne Baker was one of the most distinguished pioneers, and it is well to have a book on the subject from his pen. The various methods of picture transmission, such as those of Bakewell, Caselli, Charbonelle, Korn, Belin, and others, are described, but considerably more might well have been said about the code method by which Sanger Shepherd transmitted the race for the America Cup. A great deal is naturally said about selenium, and most of it correctly, though the date of discovery of its light-sensitiveness is given as 1861 instead of 1872, and the very prevalent mistake is made of describing it as particularly sensitive to red light, the great response to which is solely due to the abundance of energy in the red end of the spectra of most terrestrial sources.

The successes achieved by Korn with his selenium transmitter in 1907 have almost been forgotten; the speed was five seconds per line, in spite of the 'lag' of selenium. Portraits were transmitted between Paris, London, and Berlin, of a quality suitable for newspaper reproduction. More recent methods, employing photo-electric cells with a million-fold amplification, may be somewhat speedier but scarcely give a better quality, though giving more detail. The method worked out by Mr.

Herbert Ives, of the American Telegraph and Telephone Co., is particularly interesting in view of the fact that it has recently been successfully applied to television. The difficulty of synchronisation is in this case got over by phonic wheels at the sending and receiving stations, both controlled by the same tuning fork.

(2) Mr. Dinsdale's booklet purports to give a general statement of the problem of television and the various attempts to solve it. Much is said about the results achieved by Mr. J. L. Baird, and said in a rather rhetorical manner, without, however, giving sufficient data to judge of the originality of the method adopted. But at a time when the solution of the problem is being achieved simultaneously along different lines, it is useful even to have a partial description of one of the successful systems. E. E. F. D'A.

The Yearbook of the Universities of the Empire, 1927. Edited by Walter H. Dawson. Published for the Universities Bureau of the British Empire. Pp. xii + 858. (London: G. Bell and Sons, Ltd., 1927.) 7*s.* 6*d.* net.

A BOOK such as this falls, usually, into one of two classes. It can be an indispensable (if tiresome) list of names to which are attached groups of more or less intelligible statistics, a somewhat dull reiteration of policy, an urbane or challenging record of things accomplished, some indigestible lumps of 'useful information,' and a dissertation which veils but thinly the propagandist hand. In this case it goes so swiftly to the reference shelf that, almost in the same breath, we bid it welcome and farewell. Alternatively, it may present all the names, statistics, records, and useful information, and still retain the subtle quality of the dictionary. We take it up to seek some special point of interest and find ourselves absorbed delightfully by old things which appear in new light, and by new things which stimulate and surprise.

It is in the second class we would place the present volume. It is an admirable condensation of authentic information which could otherwise be obtained only by research in individual university calendars—volumes comprising in their total some 50,000 pages. From each of these, extracts concerning personnel, organisation, regulations, and recent activities have been taken and arranged in an interesting and easily accessible form.

With regard to the details of the libraries, laboratories, degrees, scholarships, publications, etc., of each university, we need say no more than that no essential point appears to have been neglected. We must not fail to note, however, that, especially in the appendices, information appears which helps vastly to see how the conception of university work is growing and to note the widening of its function in modern life. One appendix gives lists of the titles of theses accepted for research degrees. Another sets out a remarkably full list of centres of research outside the universities. Details of professional schools show how the advanced work in technical and other colleges is becoming identified with the university. Descriptions of varied careers give some indication of the delimitation of university aims. Finally, an account of federations and foreign universities cannot fail to leave some impression of the vast possibilities of international understanding yet to be explored.

Beyond the Milky Way. By George Ellery Hale. Pp. xv + 105. (New York and London: Charles Scribner's Sons, 1926.) 7*s.* 6*d.* net.

THIS little book is a continuation of the series of books by Dr. Hale, of which "The New Heavens" and "The Depths of the Universe" were the first representatives. Like those volumes, it forms an *édition de luxe* of three articles which originally appeared in *Scribner's Magazine*: their titles are—"The Oriental Ancestry of the Telescope"; "Heat from the Stars"; "Beyond the Milky Way." They are plentifully illustrated by excellent photographs and diagrams, and the volume in every respect reaches the high standard set by its predecessors.

The contents of the chapters have already been separately noticed in NATURE on their first appearances, so that little of a descriptive character need be said. It is unnecessary also to comment on the accuracy and lucidity of style of a book by Dr. Hale. His main purpose in this excellent little series is "to tell of some of the principal advances of my associates, with such historical background as to render their significance clear," but that he is not rigidly restricted by the terms of this statement is shown by the fact that the first chapter of the present volume has been constructed, as he says, from material gathered chiefly in Egypt and England. The book will be found useful, not only by the general reader, for whom it is evident that it has chiefly been prepared, but also by workers in astronomy who often feel the need of authoritative statements on matters of current research, disentangled from the mass of detail in which they are necessarily involved in the original publications. A new attitude to the problem of variable stars is inevitably induced in the reader by the direct statement that "while to the eye X-Cygni is 10,000 times as bright at maximum as at minimum, the total radiation as measured with a thermocouple undergoes a variation of only 1·7 times." We hope that Dr. Hale will continue to enrich the literature of astronomy by further additions to this admirable series.

An Introduction to the Study of Map Projections. By J. A. Steers. With a Foreword by F. Debenham. Pp. xxiii + 189. (London: University of London Press, Ltd., 1927.) 7*s.* 6*d.* net.

THE author of this book, realising that geographers are not necessarily mathematicians, has attempted to explain the subject of map projections. The construction of the map has frequently been beyond the geographical student. The mathematician could arrive at an understanding of this section, but to others it was a morass where few found the path, and the majority had to be content with an imperfect notion. This book, without any pretence to finality, provides a guide for such geographers. It is introductory in the true sense.

It may be urged that the book would be improved by dealing with difficulties as they arise, instead of deferring them—for example, in the zenithal equidistant, the equatorial and oblique cases are postponed to p. 154, whilst the simple polar case is treated on p. 54. The answer to this is that the difficulty is left until the reader is able to deal with such problems. The lucidity of the constructions, geographical and trigonometrical, and the liberal use of figures (even simple cases are illustrated) will be appreciated.

The author might realise that having used a light inside the sphere to project, it is a difficult task to "bring back the shadows." Again, the definition of latitude (p. 19) lacks precision. It is unfortunate that the determination of latitude and longitude was not incorporated into chap. iii., and some of the figures would be improved by the use of perspective. Figs. 12 and 13 illustrate this; the latter gives a much better impression of the sphere. Visualisation is a great help to any reader. The book will be welcomed as a sound basis for the study of map productions.

J. ELING COLECLOUGH.

The Statesman's Year Book: Statistical and Historical Annual of the States of the World for 1927. Edited by Dr. M. Epstein. Sixty-fourth Annual Publication. Revised after Official Returns. Pp. xxxviii+1519. (London: Macmillan and Co., Ltd., 1927.) 20*s.* net.

FOR the first time for forty-three years this volume makes its appearance without the name of Sir J. Scott Keltie on the title-page. The joint editor for the last seventeen years now has sole control. The volume is arranged on the plan of past years, which it would be difficult to improve, and, as usual, has been revised in every detail according to the latest returns available. With its fifteen hundred pages it is a marvel of condensation and convenient size. The recent census figures of the Irish Free State, Northern Ireland, South Africa, New Zealand, France, and Egypt are included. Improvements have been made in the section on Morocco in order to bring out the distinction between the French, Spanish, and Tangier zones. Additions are also made to the Russian section, particularly in the portion relating to central Asia and the Caucasus. The introductory tables include various statistics of world production, and there is also a section on the League of Nations. The three coloured maps illustrate African railways and political jurisdiction, the Egypt-Cyrenaica boundary, and the boundaries between Nejd, Trans-Jordan, and Iraq. The valuable bibliographies contain the most authoritative works of reference on every State.

Our Early Ancestors: an Introductory Study of Mesolithic, Neolithic, and Copper Age Cultures in Europe and Adjacent Regions. By M. C. Burkitt. Pp. xii+243. (Cambridge: At the University Press, 1926.) 7*s.* 6*d.* net.

IN attempting to give an account of the development of civilisation from the end of the palæolithic age to the bronze age in Europe and adjacent regions, within the compass of this small volume, Mr. Burkitt has essayed a very difficult task—difficult in more ways than one, for the material does not lend itself easily to systematic treatment. It has not been worked over and classified to the same extent as the material of the old stone age, and in the later stages the problem of dealing with a multiplicity of detail of which the bearing is often still obscure is complicated by ethnological questions to which the answers are still very much at the hypothetical stage. All credit is therefore due to Mr. Burkitt for the success with which he has carried out his task, even though in its later pages his book suffers from over-condensation and lack of space for adequate discussion of many doubtful points. Probably to most of his readers much of the material relating to the copper and bronze age will be seen in a new perspective, while the chapter on art brings together material which is usually scattered. It gains greatly in significance by the author's method of treatment.

Delphos: the Future of International Language. (To-day and To-morrow Series.) By E. Sylvia Pankhurst. Pp. 95. (London: Kegan Paul and Co., Ltd.; New York: E. P. Dutton and Co., n.d.) 2*s.* 6*d.* net.

THE student of this recurrent and ever-present problem will welcome this extremely handy analysis of all hitherto attempted universal languages, contributed by Miss Pankhurst to the "To-day and To-morrow" series of opuscula. Both the purely 'invented' languages and those based upon existing languages are dispassionately discussed and explained, and the natural conclusion arrived at is a return to that form of the original universal language—Latin—which has been standardised by Sig. G. Peano under the name 'Interlingua' and already possesses a well-established academy. The examples given speak eloquently for themselves, for 'Interlingua' does not require to be 'learnt' by any ordinarily educated person. Any one with a superficial knowledge of elementary Latin can produce his own 'Interlingua,' and use it in case of need. E. H.-A.

The Annual Register: a Review of Public Events at Home and Abroad for the Year 1926. Edited by Dr. M. Epstein. Pp. xiv+341+192. (London: Longmans, Green and Co., Ltd., 1927.) 30*s.* net.

THIS admirable volume is arranged on the usual lines. Part I. contains summaries of British foreign and imperial history, the arrangement under States greatly facilitating reference. Part II. includes a chronicle of events, an obituary of the year with short biographies, and a retrospect of literature, science, art, finance, and law. No aspect of the year's history is omitted, and the balance between different interests is well kept. The twelve pages in which the science of the year is recorded mention the most important researches and publications. Among the public documents printed in full is the text of the Report of the Inter-Imperial Relation Committee that was adopted by the Imperial Conference in November 1926.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Diffraction of Cathode Rays by a Thin Film.

IF a fine beam of homogeneous cathode rays is sent nearly normally through a thin celluloid film (of the order 3×10^{-6} cm. thick) and then received on a photographic plate 10 cm. away and parallel to the film, we find that the central spot formed by the undeflected rays is surrounded by rings, recalling in appearance the haloes formed by mist round the sun. A photograph so obtained is reproduced (Fig. 1). If the density of the plate is measured by a photometer at a number of points along a radius, and the intensity of the rays at these points found by using the characteristic blackening curve of the plate (see *Phil. Mag.*, vol. 1, p. 963, 1926), the rings appear as humps on the intensity-distance curves. In this way rings can be

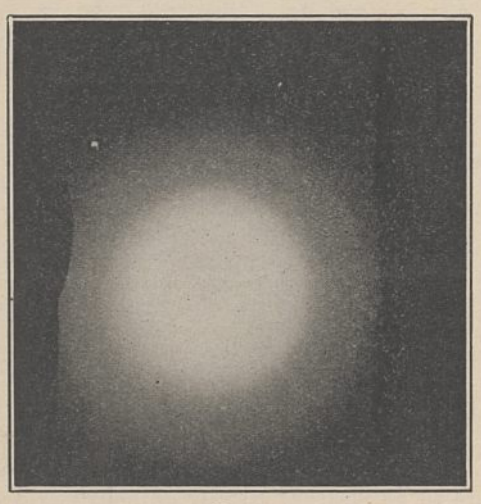

FIG. 1.

detected which may not be obvious to direct inspection. With rays of about 13,000 volts two rings have been found inside the obvious one. Traces have been found of a fourth ring in other photographs, but not more than three have been found on any one exposure. This is probably due to the limited range of intensity within which photometric measurements are feasible.

The size of the rings decreases with increasing energy of the rays, the radius of any given ring being roughly inversely proportional to the velocity, but as the rings are rather wide the measurements so far made are not very accurate. The energy of the rays, as measured by their electrostatic deflexion, varied from 3900 volts to 16,500 volts. The rings are sharpest at the higher energies and were indistinguishable at about 2500 volts. In one photograph the radii of the rings were approximately 3, 5, and 6·7 mm. for an energy of 13,800 volts.

It is natural to regard this phenomenon as allied to the effect found by Dymond (NATURE, Sept. 4, 1926, p. 336) for the scattering of electrons in helium, though the angles are of course much smaller than he found. This would be due partly to the greater speed of the rays giving them a smaller wave-length. Using the formula $\lambda = h/mv$ the wave-length in the above-quoted case would be $\lambda = 1{\cdot}0 \times 10^{-9}$ cm. It is quite possible that there are other rings inside or outside those observed at present, and no opinion is advanced as to whether the diffracting systems are atoms or molecules. The disappearance of the rays at low speeds is probably due to the increased total amount of scattering which occurs. In all, about fifteen plates have been taken showing the effect, including some using a slit, instead of a pin hole, to limit the beam of rays. It is hoped to make further experiments with rays of greater energy and to obtain more accurate measurements of the size of the rings.

G. P. THOMSON.
A. REID.

University of Aberdeen,
May 24.

British Settlement in the Dominions Overseas.

HAVING read the interesting criticism in NATURE of May 14 of the annual report of the Oversea Settlement Committee, may I, as a member of that Committee, be permitted to make certain comments?

It is claimed that the report fails adequately to cover the field of activity of the Oversea Settlement Department, and that no mention is made of many of the various factors that bear more or less directly on the question of the settlement of our people in the Dominions.

The answer to this stricture is twofold. In the first place some of our earlier reports cover a wide range; but in a time of transition like the present there would be great difficulty—in fact danger—in attempting to forecast, for example, the economic results from different types of farming. Secondly, our reports are intended primarily for Parliamentary use, and are not intended for purposes of propaganda or to furnish information to would-be settlers. The latter functions properly belong to the handbooks on the various Dominions and Colonies which are prepared and issued free to inquirers by the Department. These handbooks which, it may be said, are compiled with the utmost care and are revised twice yearly, contain much of that information we are charged with omitting from our report, where its inclusion would be quite impracticable, if only on the grounds of bulk and expense.

The O.S.C. has no widespread policy of propaganda, for the simple reason that, without it, there are more migrants willing to leave our shores than the Dominions can at present absorb.

This point should be clearly understood—the volume of migration from Great Britain is governed by the absorbing power of the Dominions.

In regard to this power of absorption, I would point out that the article in NATURE overlooks the fact that New Zealand, per head of her population and *pro rata* for her area, places far more settlers than any other Dominion.

One reason for the small numbers who migrate to South Africa is that more capital is required there than is the case in the other Dominions. There are other reasons as well that it is inexpedient to discuss.

One very important point raised in the criticism is that of the suitability of previously inexperienced men for settlement upon the land. We can say quite definitely that, given the right conditions of settlement, inexperienced men can and do succeed well. The Group Settlements of Rochester and Shepperton in Victoria, Australia, are convincing proof. Started in 1910, with the settlers drawn almost entirely from our great cities, these are to-day well-developed and flourishing communities. But this form of settlement,

though in the long run economic, entails heavy initial expenditure. On the other hand, to place townsmen on the land as isolated units and without adequate training and supervision is to court failure.

The comments upon the part education should play go to the very root of the matter. There is nothing to be gained by shutting our eyes to the fact that since the foreign migrant has a far more highly developed 'land sense' than the British migrant, less has to be spent upon looking after him during his early years. So far as I am aware, foreign Governments do not, and have no need to, give grants in aid of migration. But we have to deal with the fact that the drift to the town is more accentuated in the case of the Anglo-Saxon than with other nationals. Considerations of national safety demand that that tendency should be combated.

If we are to develop the empty spaces of the Empire by men of our own race, we must take the necessary steps to guide cultivators of the soil to those areas. A high degree of organisation and the full co-operation of all the Governments of the Empire is called for; and such organisation will cost money. We must maintain balance. Such effort does not preclude the migration of thousands of men who will not go upon the land, but it will be fatal if the agricultural side be overlooked.

CHRISTOPHER TURNOR.

Stoke Rochford,
Grantham, May 31.

THE main criticism contained in the article in NATURE of May 14 was that the report of the Overseas Settlement Committee did not deal with those very points on which members of Parliament should be informed. The report should have contained the information given in Mr. Turnor's interesting letter, that the Dominions cannot at present absorb all those of our people willing to migrate, and that New Zealand absorbs, per head of population and *pro rata* for her area, more migrants than any other Dominion. Possibly there would be some difficulty in attempting to deal with certain of the factors enumerated in these columns which influence overseas settlement, but most of them could be dealt with—in particular, the inter-relations between overseas settlement and trade with the Dominions, and the programme of development and other development projects put forward by the Dominions which must at some time have been discussed by the Committee. We cannot altogether agree with Mr. Turnor that it is inexpedient to deal with the causes operating against the migration of our peoples to South Africa. They are not sufficiently well known to members of Parliament. Mr. Turnor suggests that migrants of other nations do not receive financial assistance. Possibly foreign Governments do not give direct assistance, but it is a fact that one of the principal objects of the 'Deutsche-Kolonialgesellschaft' is to afford financial support to German emigrants. With Mr. Turnor's concluding sentences we are in entire agreement. That is why regret was expressed that the report did not deal adequately with problems which face the Committee.

THE WRITER OF THE ARTICLE.

Measurement of Evaporation of Sea Water.

MANY methods have been devised for the investigation of the evaporation of sea water, but of them all only those can be applied aboard a ship in which errors caused by the rolling of the ship are prevented. Therefore the method invented by Dieulafait and modified by Penck and Merz has largely come into use. The authors mentioned measured the quantity of evaporated water by observing an increase of the concentration, or density, of the salt solution.

Evidently, however, such an increase must always be very small, because the concentration itself of the salt in the sea water is usually equal to 30-37 per thousand. For example, Merz and Wüst were obliged to wait 12-24 hours before it was possible to make a good observation of the increase of concentration. During such a long time all the meteorological conditions may be altered and the temperature of the evaporating water will change.

The simple method which I describe here is free from all these defects. It is based on the observation of the *cooling* of water caused by evaporation.

The sea water must be poured into a so-called Dewar vessel of a special form, represented in Fig. 1.

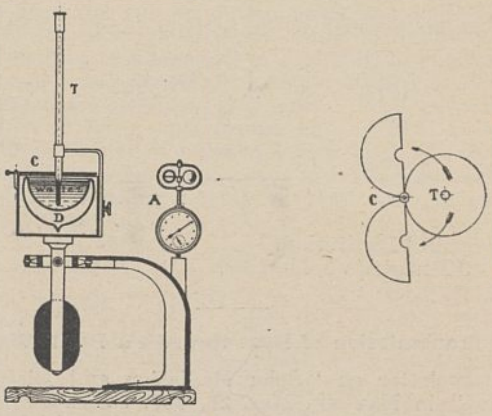

FIG. 1.

The thermometer T gives the initial temperature, when the instrument is closed with a cover C. When the latter is opened the water will begin to evaporate through the action of the wind blowing over its surface. The latent heat of evaporation, specific heat of water, the volume of the vessel, and the area of the water level are known. It is easy, therefore, to calculate the quantity of water which evaporates in 1 sec., per unit area, but only if the mean temperature of the water—before and after evaporation—is equal to that of the air. The interval of time sufficient for the perceptible cooling of the water usually *does not exceed a few minutes*, the thermometer scale showing not smaller parts than fifths of a degree.

The temperature of water is usually higher than that of the air. In such cases one must draw the curve of cooling (Fig. 2). The ordinates of this diagram represent the temperature of the water, and abscissæ either the time or the "distance which the air-particles travelled in the wind." This latter case occurs when the velocity of the wind varies strongly during a short period of time. (For further details on this question see my article mentioned below.)

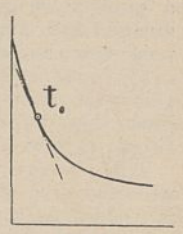

FIG. 2.

We will now consider only the case of constant velocity of the wind. Let us denote the temperature of the water by t (t_0 being the temperature of the air) and the time by T. Then it is evident that the velocity of evaporation is proportional to dt/dT, calculated for a point of the curve, where $t = t_0$. To the same quantity $(dt/dT)_0$ is proportional the quantity of heat which is lost by the water. If we calculate analogous quantities

for other points of the curve (in Fig. 2), we shall obtain data for the study of the *thermal interchange* between the sea and the air : if the temperature of the former is greater than that of the air, there will be a more rapid cooling of the water ; conversely, the cooling down will be retarded. From such observations can be deduced the law of thermal interchange, a law of very great importance for geophysical problems.

A great number of observations have been made by me from the Black Sea, over the Mediterranean, Red Sea, Indian Ocean, to the China and Japan Seas, from July 1925 to March 1927. The results of the measurements of the evaporation and thermal interchange will appear in *Gerlands Beiträge zur Geophysik*. The instrument used for these measurements was suspended on Cardan-rings, as is shown in Fig. 1 ; *A* is the anemometer, placed on the same level with the water in the vessel.

With an analogous instrument one can measure the evaporation of water immediately from the level of the sea or of the lake ; in this case it must float in the water so that the edges of the Dewar vessel just touch the water-level. Thus it is possible to find the connexion between the evaporation from a vessel on board a ship and the evaporation in natural conditions.

It is understood, of course, that such experiments can be made only when the water is sufficiently calm.

WAS. SHOULEJKIN.

Physical Institution,
3 Miusskaja 3, Moscow.

Transmission of Heat through a Brick Wall.

THE letter on "Solar Radiation and Diathermancy" in NATURE, Mar. 26, 460, seems worthy of comment. Radiation, which Mr. Dufton thinks must be called into account to explain the rapid transmission of heat through a brick wall as shown by his curves, is, of course, a possible factor in heat conduction. It appears to us, however, an unlikely one in this case, so we have tried some calculations on the transmission to see if it cannot be explained on the basis of ordinary conduction, assuming reasonable values for the thermal constants.

Fortunately for the purposes of calculation a ladder has, by its shadow, impressed upon the curves at one point a very fair sine periodicity (period T about 1650 seconds), and the velocity V with which the maximum or minimum phase penetrates into the material can be computed. The thermal diffusivity (conductivity divided by product of specific heat and density) is connected with V and T in this case by the relation $V^2T/4\pi$. V may be determined by plotting maxima and minima against time. The points up to a quarter of the whole thickness give a very fair straight line, and even the total thickness curve gives points on the same line if a reasonable assumption is made in identifying corresponding maxima. The half thickness curve does not fit at all, but little weight is given these two latter curves as, strictly speaking, the simple theory does not apply so well to them.

The average velocity comes out 0·0072 cm./sec., which gives a diffusivity of 0·0068 c.g.s. units. This is within the range 0·005 to 0·007 usually found for brick. Accordingly we feel that, while there are certain things about some of the curves which require further explanation, there is no good reason for bringing in other than ordinary conductivity considerations in accounting for the penetration.

L. R. INGERSOLL.
JOHN BARDEEN.

University of Wisconsin,
Madison, Wis., May 7.

A New Type of Primary Cell.

WITH reference to the new type of primary cell described by Jindal (NATURE, April 30, p. 639), a description of a two-fluid 'oxidation' cell recently constructed by me may prove interesting.

Zinc, in a saturated solution of ammonium sulphate, and carbon, in an acidified solution of potassium permanganate, form the constituents. In order to maintain the permanganate solution saturated, a layer of the crushed salt is placed at the bottom of the containing vessel.

This cell has an E.M.F. of 2·16 volts, with an internal resistance of 0·5 ohm approximately, for currents varying from 0·6 to 0·2 ampere.

On a simple test, with continuous discharge for twenty hours, the output remained constant for eight hours at 0·3 ampere, afterwards decreasing to 0·2 ampere.

At the conclusion of the test the initial E.M.F. was quickly reached.

Practically no polarisation occurs, and the amount of zinc dissolved is inappreciable.

The cell possesses many advantages over the Daniell elements used in laboratories, and should prove useful, in a modified form, as a source of high tension supply in wireless work.

D. R. BARBER.

Department of Physics,
University College, Exeter,
May 13.

The Industrial Revolution.

MISS BUER'S letter in NATURE of May 7 removes the difficulties which I felt in accepting the reviewer's statement that the rise and population in England after 1750 was due to the introduction of inoculation and a consequent decline in infant mortality.

I am, however, mainly interested in the industrial history of Great Britain in the first half of the eighteenth century, and here I still think that Miss Buer has underestimated the influence of the Colonial trade upon developments in the west of England. In her chapter on commerce Miss Buer says that "Bristol and Norwich were stationary and Liverpool had hardly begun to be." The chroniclers of Bristol (Nicholls and Taylor, for example) do not support this statement. Bristol, it would appear, had been growing in importance long before 1750, and this prosperity had extended beyond the City walls. In 1756, Dean Tucker estimated that the proportion of iron manufacturers—that is, smiths to iron-makers—was two thousand to one. The former were using largely American bar iron, but the iron industry had already moved from the Weald to the west to be in a position to supply this growing market. Hence it is probable that there was in the first half of the eighteenth century a considerable redistribution of population in Great Britain—some depopulation by the southern counties being more than offset by an increase in the western area.

E. WYNDHAM HULME.

Old House,
East St., Littlehampton.

A Convenient and Rapid Method of Sampling.

IN a recent investigation carried out by the writers, with Mr. E. B. Wedmore (see paper read before the Institution of Electrical Engineers on April 7, entitled "A Contribution to the Study of the Number of Tests required to establish the Rupturing Capacity of an Oil Circuit Breaker"), it was desirable to

perform some sampling of a population of Pearson's Type I. As the method used is a simple one and apparently new, and appears to give satisfactory results, a description of it may be of interest.

A stout cardboard disc was accurately subdivided into a number of sectors, such that the angle of each sector was proportional to the number of individuals of the smoothed population corresponding to each of the equal steps of the independent variable. The disc was then pinned down by its centre on top of a cardboard washer and spun rapidly. While still spinning so fast that the markings were indistinguishable, it was stabbed with a sharp instrument and brought to rest. The value attached to the stabbed sector was then noted.

As to the rate of sampling, once the disc is made up, at least 500 samples can be taken in this way per hour per person, using the left hand for spinning and stabbing.

CHAS. E. R. BRUCE.
W. BEVAN WHITNEY.
The British Electrical and Allied Industries Research Association,
36 and 38 Kingsway, London, W.C.2,
May 12.

The Occurrence of Indium in Tin.

MR. M. W. GARRETT has recently reported the general occurrence of traces of indium in tin (NATURE, Feb. 12, 1927, p. 260). I wish to confirm this observation, which was also made here last January in the course of some other work.

Indium was then detected spectrographically in three samples of tin, and of a number from varying sources since examined only four were found free from it. These included two specimens containing 98·94 per cent. and 97·60 per cent. tin, probably of Chinese origin, the leady 'RBW' brand from electrolytic detinning of tinplate scrap, and the extremely pure 'Chempur' brand (99·998 + per cent. tin). All 'English' brands tested showed strong traces of indium.

Several varieties of soft solder gave a positive result also, and in both tin and solder the most persistent line was found to be $\lambda = 4102$, the next in persistency being $\lambda = 4511$, in agreement with Garrett's result in the case of tin, and contrary, as he has remarked, to de Gramont's.

Indium does not appear to be recognised at all as an impurity in tin. The almost complete neglect of spectral methods of analysis by metallurgists and others may explain this, as the line at 4511 is close to the strong tin line at 4525, and can scarcely fail to be noticed if present.

J. R. GREEN.
The Laboratory,
Batchelor, Robinson and Co., Ltd.,
Nevill's Dock, Llanelly,
May 13.

Sand-flies and Kala-azar.

IN the issue of NATURE dated Mar. 26, p. 460, there is a letter from the Kala-azar Commission of the Royal Society working in north China in which the claim is made that for the first time an infection with kala-azar has been produced by means of the intra-peritoneal inoculation of the midgut contents of the genus Phlebotomus into an experimental animal.

As the letter is dated Jan. 28 the mistake is a natural one, since the writers cannot then have seen the report of a similar and earlier experimental success on the same lines obtained by the Indian Kala-azar Commission in Assam. The report of this experiment, in which a white mouse was infected with kala-azar by the intra-peritoneal inoculation of the alimentary canal contents of *P. argentipes* infected by feeding on kala-azar cases, was published in the Jan. 1927 number of the *Indian Journal of Medical Research*, but was actually received for publication on Sept. 6, 1926. The fact that the workers in China were working with *P. sergenti var.* and the hamster *Cricetulus griseus*, while the Indian Commission was working with *P. argentipes* and the white mouse, does not affect the question of priority at issue.

H. E. SHORT.
(Director.)
Kala-azar Commission,
Shillong, Assam, India,
May 14.

Early Suggestion as to the Vacuum Flask.

THE following extract from "Mechanical Inventions and Suggestions," by Lewis Gompertz, may interest some readers of NATURE:

"SUGGESTION TO PRODUCE A FIRE-PROOF BOX.

"That this suggestion would succeed, I am far from trusting to, but as possibly it might to some extent do so, it may not be amiss to describe it untried. The box is made of steel, etc., highly polished, as polished metals reflect back the heat as well as the light that are cast upon them. This box is then put into a much larger air-tight case of iron, and has legs of thin wire to prevent it touching the outside case, and all the air is pumped out so as to leave a vacuum between the two boxes, and so that no heat can be conveyed to it by the contact of air; and as the radiant heat is rendered harmless by the polish, and the heat of contact is prevented by the vacuum, it seems that the heat is kept out entirely, excepting through the small wire legs."

The book, which is a second edition, unfortunately bears no printed date, but was given to me in 1856. Lewis Gompertz was secretary to the Animals' Friend Society about 1840.

RICHARD INWARDS.
6 Croftdown Road, London, N.W.5,
May 15.

The Hythe Skulls.

IN a recent number of *Biometrika* (vol. 18, p. 22) Miss Hooke writes that the measurements which I made upon the well-known skulls at Hythe were "made on 590 crania selected from at least double that number." The impression which this gives, and actually has given, is that, out of a large number, half had been selected or chosen for some special reason, and that, therefore, probably they did not fairly represent the whole collection. The skulls were in no way 'selected,' but I had measured all which were available at the time, though more have since been recovered.

Miss Hooke says that she believes that these were skulls of Kentish people, while the whole of my work shows that they were those of brachycephalic immigrants of the Alpine race who had settled in Hythe, probably quite peacefully, in or before the fourteenth century.

The work on the Hythe skulls has been so often quoted by anthropologists that I feel that I must correct what I regard as a serious mis-statement.

F. G. PARSONS.
St. Thomas's Hospital,
London, May 5.

The Beginnings and the Early Spread of Agriculture.[1]

By HAROLD J. E. PEAKE.

FOR hundreds of thousands of years, man depended for food and clothing upon the products of the chase. As the last northern ice-cap retreated, Upper Palæolithic man hunted big game on the tundra and cold steppe that lay outside it. Then, as the ice-cap diminished, the zone of open country contracted, and first a coniferous forest, followed by a deciduous forest, occupied the temperate latitudes. Oak forests covered the greater part of these regions in late Magdalenian times, causing big game to become scarce and to retreat to such open lands as were left.

Thus ended the Palæolithic Age. During the Epipalæolithic Age that followed, small isolated communities lived by the shores of the sea, or of lakes and rivers, feeding on birds, fish, and molluscs, supplemented by nuts, berries, and roots. These were hungry times, and it seems likely that some had recourse to collecting wild grass-seeds, as do the natives of Queensland to-day.

Some Epipalæolithic man, or probably one of his woman kind, having collected the seeds of some grass, ancestral to modern grain, must have cast some of these on an open patch of soil and noted that fresh and sturdier plants arose on the spot; a repetition of this process constituted the first advance in agriculture. To ascertain where and when this happened, we must discuss the grains now in use and the places where they occur wild.

The countries in which rice is now grown are known to have received their civilisation from areas long acquainted with the cultivation of wheat and barley. A species of millet, *Panicum colonum*, was used at an early date in Egypt, but it may have been collected from wild plants. *P. miliaceum*, the millet now cultivated, was first grown in south Russia at a much later date. Rye was a common weed in fields of wheat, and in high altitudes supplanted the crop. Oats are a northern crop, and the first evidence of the cultivation of this grain comes from an early Iron Age village in Wiltshire. Barley and wheat have been cultivated from a very early time, though it is not clear which grain was grown first. It is obvious that both must first have been cultivated where they occur wild.

Wild barley is found in south-west Asia; it has been found also in two places in Tripoli. It may once have grown wild along a strip of north Africa from Palestine to the Gulf of Gabes. Wheats are of many species, but may be divided into three groups: einkorns (*T. monococcum*) with 7 chromosomes, emmers (*T. dicoccum*, etc.) with 14, and bread wheats (*T. vulgare*, etc.) with 21. Wild einkorn (*T. ægilopoides*) is found throughout Asia Minor and in Syria; it occurs also in parts of Greece, Bulgaria, and southern Yugoslavia. Wild emmer (*T. dicoccoides*) occurs from Mount Hermon and the Anti-Lebanon to the mountains of Moab, east of the Dead Sea; a claim has been made for its occurrence farther east, on the borders of Persia. The origin of the bread wheats is uncertain; they are thought to be hybrids, but whether of *T. dicoccoides* and an Ægilops, an unknown Triticum and an Ægilops or *T. dicoccoides* and *T. ægilopoides* is uncertain. At one place only are both emmer and einkorn found growing wild together; this is on the slopes of Mount Hermon, near Damascus, where Aaronsohn found both growing with wild barley.

There is, however, a school of thought which claims that there was corn in Egypt before it was known elsewhere. This school is championed by Prof. Elliot Smith. Since no form of wheat is known to have grown wild in Africa, the claim is made that barley, which, as we have seen, occurs wild near the north coast of that continent, was first cultivated by the banks of the Nile.

Between 1901 and 1903, Mr. Lythgoe, under Dr. Reisner's directions, explored a predynastic cemetery at Naga-ed-Dêr; this is known as cemetery 7000. No account of the contents of these graves has yet been published, but short references to the cemetery occur in "The Early Dynastic Cemeteries of Naga-ed-Dêr" and in "The Archæological Survey of Nubia." From the latter it would appear that Dr. Reisner has divided the predynastic graves which he has found into three categories—early, middle, and late—and that the graves of cemetery 7000 were early and middle predynastic.

Elliot Smith examined the bodies from these graves, and submitted the contents of the stomachs of a number of them to Dr. Netolitzky, who reported in a letter that several of them contained husks of barley. In two papers that he published shortly afterwards he stated that the glumes were either those of wheat or barley, but later he passed on the material to a pupil, Dr. Hedwig Gherazim, who finally proved that the glumes were those of barley. This proves that these predynastic Egyptians ate barley, and presumably cultivated it, but, as Percival has pointed out in NATURE, since the glumes of wheat do not adhere to the grain, they may have eaten that too.

The predynastic period is a long one, and it is important to know to what part of it these graves belong. Though no dates for this period are available, Sir Flinders Petrie has invented an ingenious device for zoning it. This is the system of sequence dates, which is accepted by nearly all Egyptologists except Dr. Reisner. These sequence dates run from 30 to 78, and the period is usually divided into early S.D. 30–39, middle S.D. 40–59, and late S.D. 60–78. It is not clear that these agree exactly with the corresponding divisions of Dr. Reisner.

Now about S.D. 40 there appears a number of objects not met with in earlier graves; notably

[1] Substance of two lectures delivered at the Royal Institution on Mar. 31 and April 7.

pear-shaped mace-heads and wavy-handled pottery. Both of these occur in Palestine, and the former are found in very early deposits in Mesopotamia. The inference is that invaders from Palestine had brought in these new objects; they might also have brought with them the knowledge of wheat and barley.

Dr. Hrozny, quoting Schäfer, states that Legrain and Lampre found barley and emmer in a tomb with a contracted burial at Silsileh, without a trace of copper. I cannot find an account of this grave, for de Morgan, who mentions the cemetery, says nothing of grain. Schulz, however, says that the grain was barley, and not emmer, as had been thought.

At Abydos, Prof. Peet found kilns for drying grain, and in them some carbonised matter from which Prof. Harvey Gibson extracted grains of wheat. In similar kilns near by, Peet found pottery fragments belonging to the middle predynastic period. At Badari, Miss Caton-Thompson found grain, identified by Percival as emmer, in a ruined hut; above this hut was a layer of late middle predynastic pottery. In a grave at Hemamieh, between Qua and Badari, Brunton found grain, also identified by Percival as emmer; the pottery, he tells me, is rough and not very typical, but he places this between S.D. 37 and 44. He adds: "A slate, a disk-shaped mace-head, and a stone vase would all be round about S.D. 40."

The evidence of these three discoveries tends to show that wheat arrived in Egypt in S.D. 40, and was freely used early in the middle predynastic period. Whether barley was grown earlier depends on whether the graves in cemetery 7000 at Naga-ed-Dêr and that at Silsileh date from before this time. In the absence of details as to the grave contents this must remain for the present an open question.

Thus it would appear that wheat certainly, and perhaps barley too, were first cultivated in Syria, probably on the slopes of Mount Hermon. In this connexion it is well to remember the statement of Diodorus Siculus, written 2000 years ago, that the Egyptian goddess Isis discovered "wheat (πυρός) and barley growing promiscuously about the country along with other plants, and unknown to mankind," and that this occurred at "Nysa, a high mountain in Phœnicia, far away."

As we have seen, emmer was taken to Egypt at the beginning of the middle predynastic period; thence this grain appears to have been carried to the lands surrounding the Mediterranean. Grain was also cultivated early in Mesopotamia, though which grain was known there first is uncertain.

Before 2000 B.C. the Sumerians compiled lists of kings and dynasties, beginning with eight or ten antediluvian monarchs, who ruled at various cities in Mesopotamia. One of these kings reigned at Eridu, while another, who ruled at Suruppak, escaped in a boat from the flood. After the flood there ruled in succession dynasties at Kish, Erech, and Ur. A tablet found near Ur mentions A-anni-padda, son of Mesannipadda, the founder of the first dynasty of that city, and quite lately a lapis lazuli cylinder seal of Nin-Kur-Nin, Mesannipadda's queen, was found in a grave at Ur. No search has yet been made for relics of the first dynasty of Erech, but at Kish, Prof. Langdon has found a layer which he believes dates from the first dynasty of that city, the first after the flood. Here have been found tablets covered with pictographic inscriptions and also some pots of a polychrome ware.

Similar polychrome pottery was found last year at Jemdet Nasr, about 16 miles from Kish, and in one of these pots some grain, which is clearly a kind of wheat. Unfortunately, experts differ as to the species. An American botanist has identified it as *T. vulgare*, Dr. Stapf believes it to be *T. compactum*, a more developed type of *T. vulgare*, while Percival states that it is *T. turgidum*, a more developed type of *T. dicoccum* or emmer. Whatever may be the ultimate verdict, it is clear that wheat of some kind had long been cultivated in Mesopotamia at the time of the first dynasty of Kish.

At Tell el Obeid, however, graves have been found which are believed to antedate the first dynasty of that city by a long time; they contained fine painted pottery. Similar pottery, sickles, hoes, and querns, and pear-shaped mace-heads, have been found at Abu-Shahrein, the site of Eridu, the seat of one of the antediluvian monarchs. It is clear that grain was grown in Mesopotamia before there took place the disaster which gave rise to the story of the Great Flood.

At a very early date people making highly burnished pottery had been living at Knossos in Crete; their figurines suggest that they came from Asia Minor. No evidence of agriculture has been found among their remains, but if they cultivated grain it is likely to have been einkorn, which is native to Asia Minor. About 3400 B.C. fresh people arrived on the Mesara Plain; these Sir Arthur Evans believes came from the north-western corner of the Delta. Though there is again no evidence of agriculture among the remains found of these people, they can scarcely have been ignorant of the practice, and probably cultivated emmer. It seems likely that it was the Cretans who disseminated this grain throughout the Mediterranean area.

Other people from south-west Asia Minor were working the mineral resources in the Cyclades about the same time, and a few centuries later settled in Argolis and near Corinth. It is thought that these people grew grain, and if so it is likely to have been einkorn. Other people, also from Asia Minor, settled still earlier in Thessaly. These are known to have grown grain, though of what type is uncertain; again it seems likely that it was einkorn. A third set of people, probably from Asia Minor, came apparently by boat to the Middle Danube basin, and settled near the gold and copper deposits of Hungary and Transylvania. It seems likely that they had arrived there some centuries before 3000 B.C. Einkorn has been found in some of their settlements.

Lastly, we have the Black Earth lands of south Russia, in which we have evidence of a civilisation, the first stage of which is thought by most people to be coeval with those mentioned in Thessaly and the Danube basin. This civilisation is distinguished by a profusion of painted pottery, and evidence that the people who made it were grain growers. According to Prof. Childe, this civilisation was destroyed about 2600 B.C., when some of the people fled to Thessaly, inaugurating there the second Thessalian civilisation. The destroyers seem to have been nomads from the steppes east of the Dnieper; these seem to have invaded the Danube basin, founding there the second Danubian civilisation. Now at Sesklo, a second Thessalian site, and at Lengyel, a second Danubian site, grain has been found; in both cases the sample contains both einkorn and *T. vulgare*. The inference is that both regions grew einkorn during the first phase, and that *T. vulgare* was introduced into both from the Black Earth lands. Quite recently a paper has been published in Kiev, citing the existence of *T. vulgare* from a site near that city, belonging to this culture, though whether this belongs to the first or second phase is uncertain.

At Anau, a village site in Turkestan, painted pottery has been found, bearing some resemblance to that of the Black Earth lands. In the earliest layer on this site were found potsherds containing impressions of grain; this grain has been identified as *T. vulgare*. From this it is suspected that the art of painting pottery and the cultivation of bread wheats both arose somewhere in Transcaucasia.

From Crete and the Danube basin the practice of agriculture spread, by sea and by land, to all parts of Europe, while from Turkestan it was carried, with painted pottery, certainly to north China and most probably also to north-west India.

Television.

By Prof. E. TAYLOR JONES, University of Glasgow.

ON May 24 and 26 I proceeded, at the invitation of Mr. John L. Baird, to the Central Station Hotel, Glasgow, to witness demonstrations of television between London and this city. I was received by Mr. Baird's colleague, Capt. Hutchinson, who explained that the transmission was to take place over the telephone line, Mr. Baird, in his laboratory in London, being in charge of the transmitting apparatus.

The earlier apparatus devised and used by Mr. Baird has been described by him in the *Journal of Scientific Instruments* for Feb. 1927. A model of the original transmitting apparatus is in the possession of the University of Glasgow, of which Mr. Baird is a former student. The following additional information as to the method has been supplied by him:

"The method used in the London-to-Glasgow demonstration consisted in passing an image of the object being transmitted over a light-sensitive cell in a series of strips. The modulated current from the cell was transmitted over the ordinary trunk telephone line, and at the receiving station in Glasgow was used, after amplification, to control the light of a glow discharge lamp, a modified form of neon tube, giving a light of intense brilliance, being employed. By means of a revolving slotted shutter a point of light from this lamp was caused to travel over the field of vision in exact synchronism with the traversal of the image over the cell at the transmitting station, complete traversal taking place in about one-eighth of a second."

The receiving apparatus was set up in a semi-darkened room, the lamp and shutter being enclosed in a case provided with an aperture. The observer looking into the aperture saw at first a vertical band of light in which the luminosity appeared to travel rapidly sideways, disappearing at one side and then reappearing at the other. When any object having 'contrast' was placed in the light at the sending end, the band broke up into light and dark portions forming a number of 'images' of the object. The impression of side-way movement of the light was then almost entirely lost, and the whole of the image appeared to be formed simultaneously. The image was perfectly steady in position, was remarkably free from distortion, and showed no sign of the 'streakiness' which was, I believe, in evidence in the earlier experiments.

The size of the image was small, not more than about two inches across when the 'object' was a person's face, and it could be seen by only a few people at a time. The image was sufficiently bright to be seen vividly even when the electric light in the room was switched on, and I understand that there is no difficulty in enlarging the image to full size. I was told also that arrangements will soon be made for transmitting larger 'objects,' and for increasing the number of appearances of the image per second.

The amount of light and shade shown in the image was amply sufficient to secure recognisability of the person being 'televised,' and movements of the face or features were clearly seen. At the second demonstration some of those present had the experience of seeing the image of Mr. Baird transmitted from London while conversing with him (over a separate line) by telephone.

My impression after witnessing these demonstrations is that the chief difficulties connected with television have been overcome by Mr. Baird, and that the improvements still to be effected are mainly matters of detail. We shall doubtless all join in wishing Mr. Baird every success in his future experiments.

The Forthcoming Eclipse.

EXCURSIONS AND OTHER RAILWAY ARRANGEMENTS.

London and North Eastern.

THE London and North Eastern Railway (King's Cross Station, London, N.1) is running the following excursions in connexion with the eclipse :

(*a*) June 28. King's Cross, dep. 9.50 P.M.
Peterborough, dep. 11.28 P.M.
Grantham, dep. 12.7 A.M. (June 29).
Newark, dep. 12.28 A.M.
Retford, dep. 12.54 A.M.

arriving at Richmond, Yorkshire, at 3.42 A.M., returning from there at 10.55 A.M., due York, 12.25 P.M., a stop being made to give passengers an opportunity to look round York. The train will leave York at 3.45 P.M., due Retford 4.57 P.M., Newark 5.22 P.M., Grantham 5.43 P.M., Peterborough North 6.20 P.M., and King's Cross 7.55 P.M. Restaurant cars will be provided, and arrangements are being made to serve refreshments to passengers in the train after the eclipse and before the train leaves Richmond, in addition to meals *en route*.

(*b*) From Marylebone, leaving about 9 P.M., calling at Amersham, Finmere, Rugby, Leicester, Loughborough, Nottingham, and Sheffield to Richmond, returning on the morning of June 29, with a stop of a few hours at York, arriving at Marylebone in the evening. Buffet cars will be provided to serve light refreshments.

(*c*) From Colchester about 7.30 P.M., with bookings from Cambridge (via Ely or Bury St. Edmunds), Ipswich, Bury St. Edmunds, Thetford, Ely, March, Spalding, Sleaford, Lincoln, Gainsboro' Lea Road, and Doncaster, returning from Richmond on the morning of June 29, time being allowed for a few hours at York.

London, Midland and Scottish.

Special restaurant excursion trains are announced by the London, Midland and Scottish Railway (Euston Station, London) to Southport, which is on the centre line of totality.

A cheap excursion to Southport will leave Euston at 11.10 P.M. on Tuesday night, June 28, and supper will be served on this train. Passengers will return by the 8.20 A.M. train from Southport (Chapel Street) on Wednesday, June 29, on which train breakfast will be served.

Another cheap excursion to Southport, with bookings for 2, 5, and 8 days, will leave Euston at 11.12 A.M. on Tuesday, June 28. Luncheon will be served on the outward journey on June 28 and on the return journey on June 29.

Excursion bookings from certain provincial towns are also being given to Southport, Settle, Llandudno, Colwyn Bay, Rhyl, St. Annes, and Blackpool.

In addition, period bookings will be given on Tuesday, June 28, returning on three specified dates, to stations on the North Wales coast from Manchester, Liverpool, and Lancaster and Yorkshire districts generally, also to Carnarvon and Llanberis from Manchester and Liverpool districts and Chester. Similar bookings will also be given to Southport—Blackpool from stations in Lancashire and Yorkshire.

A special train for the Institution of Civil Engineers is leaving St. Pancras for Settle on June 28, and one for a Stowe Public School party is leaving Buckingham for Rhyl on the same evening.

Great Western.

The Great Western Railway (Paddington, London) announces that a liberal programme of day and period excursion bookings has been arranged to Criccieth and other North Wales resorts for the eclipse from principal stations on its system.

A special train will leave Paddington Station on Tuesday evening, June 28, by which cheap bookings will be given from London, Reading, Oxford, and other principal stations on the G.W.R. route to the north. Day trips will also be run from Cardiff, Bristol, Gloucester, Cheltenham, Worcester, etc., and from the Wrexham District.

Period excursions will also be run from the west of England on Monday night, June 27, and from other principal G.W.R. stations on June 28, enabling passengers to return on June 29, July 2, or July 4.

Obituary.

WE record with regret the death of Prof. John Bagnell Bury, Regius professor of modern history at Cambridge, which took place at Rome on June 1. Born in County Monaghan on Oct. 16, 1861, he entered Trinity College, Dublin, as a sizar, and was elected to a fellowship in 1885. After his election he began to specialise as a historian, publishing his "History of the Later Roman Empire from Arcadius to Irene" in 1889. In 1893 he was appointed professor of modern history in the University of Dublin, and in 1902 he succeeded Lord Acton as Regius professor at Cambridge. He had already published his most important and lasting work, in his "History of the Roman Empire from its Foundation to the Death of Marcus Aurelius" (Murray's "Student's Histories," 1893), the "History of Greece to the Death of Alexander" (1900), and his edition of Gibbon (1896–1900). In these, his remarkably wide range of knowledge, his extensive acquaintance with languages, his ability to marshal a vast array of facts, and his scientific conception of history, were utilised to the full in a treatment of historical matters which combined a broad grasp of the trend of events with a scrupulous care for detail. In addition to his other published work, he was responsible for the plan of the Cambridge "Medieval History," and collaborated in the editorship of the Cambridge "Ancient History."

News and Views.

How experimental research carried out on dogs has benefited both that animal and man is described in the Memorandum of the Medical Research Council on the Dogs Protection Bill now before Parliament. Recent advances in knowledge have been made by this means in the study of rickets, disorders of the teeth, diseases of the heart and circulation, and in diabetes, as well as in distemper and various types of jaundice prevalent among dogs. The proof that rickets is a dietary disease and can be cured by changing the diet, so as to supply an adequate amount of the anti-rachitic vitamin, was first obtained by feeding experiments carried out on puppies. An unexpected outcome of these experiments was the discovery that absence or deficiency of this vitamin in the diet prevents the proper development of the hard enamel of the teeth: this work is still in progress, and may lead to the prevention of dental decay in human beings. The control of diabetes by the use of insulin, which has been such a boon to sufferers from this disease, was made possible by experiments on dogs: in fact the whole of our knowledge of this disease from the time of the discovery of the relation of the pancreas to diabetes to the discovery of insulin has been gained by experiments on this animal. Nor must the benefits to the dog itself from experimental research be forgotten: protection against distemper is already becoming practicable, as also against the spirochætal jaundice which is not uncommon in Great Britain and often fatal, whilst a cure has been found for the malignant jaundice or piroplasmosis of dogs in the injection of the dye trypan blue.

IT is the considered and unanimous judgment of the Medical Research Council that the proposals of the Dogs Protection Bill would place an insuperable and permanent barrier across some of the chief paths of progress in medical research. The memorandum describes the reasons which make the use of dogs for experimental purposes necessary, and gives in some detail results which have been, or are being, obtained from such experiments. Considerations of size are frequently important: practicable alternatives to the dog are the sheep, pig, goat, or ape, but none can be kept completely healthy and comfortable in the laboratory except the dog. Moreover, its long domestication has assimilated its natural diet to that of man, and many of its bodily structures provide the nearest approximation among animals to those of man, so that results of experiments, both dietary and pharmacological, can often be applied directly to the case of human beings. The special habituation of the dog to man's presence is also in favour of its use, since it is less terrified by the near approach of human beings than other less domesticated animals. On the other hand, the memorandum points out that the dog is only used when no other smaller animal is available, and only a very small minority of experiments are performed with it. The knowledge which has been gained from such experiments forms part of the every-day armamentarium of the physician or surgeon, and includes the foundations of the physiology of the digestive and circulatory systems. To avoid the danger of the use of stolen dogs for purposes of experiment, the Council recommends that the Dogs Act, 1906, be amended to allow of the use of some of the 50,000 animals annually destroyed in London alone. These dogs are those which either have no owner or whose owners do not care enough about them to make inquiries when they are lost. It would allow part at least of the now useless annual massacre of dogs to be turned to the permanent advantage of mankind and of other animals.

THE forthcoming total eclipse of the sun affords radio amateurs an excellent opportunity of experimenting on the effects produced by the eclipse in preventing the sun's rays passing through part of the conducting layer in the upper atmosphere. The shadow cast by the moon will pass through the reflecting surface of this layer at approximately 100 miles south-east of the path of the visible eclipse. During the eclipse, the layers over a broad band of the country between Cardiff and Grimsby will be a band of totality for radio observations. In the *Wireless World* for June 8, Prof. E. V. Appleton gives a popular description of the phenomena that are likely to happen, and offers useful advice to all who desire to attempt to record them. Observations, he says, ought to be confined to the broadcasting range or even to waves of shorter wave-length. These will probably give indications of the phenomena associated with sunrise and sunset after the normal sunrise has taken place. The observations made on the day of the eclipse will, however, be of little value unless they can be compared with the results normally obtained. Hence observations of a similar character should be made at least on the morning before, and on the morning after the day on which the eclipse occurs. Observers should choose a station the signals from which they can receive with great ease, and make a special study of the sunrise and sunset characteristics of these signals. They will, therefore, only have to note if any extra phenomena are observed on the morning of the eclipse. It is important to time each observation correctly with a watch or clock checked before and after the series of observations by means of time signals. It should also be recorded whether the times given are in British summer time or Greenwich mean time.

THE Halley Lecture on "Modern Eclipse Problems," delivered by Mr. F. J. M. Stratton on May 20 and just published by the Clarendon Press, Oxford, at 2*s.* 6*d.* net, provides a comprehensive and clear account of investigations, carried out and contemplated, into the nature of coronal light and related matters. Chief attention is rightly devoted to these subjects, because it is only during the brief period of a total eclipse that the corona can be studied spectroscopically or its form be portrayed. As Mr. Stratton remarks, "The question of the source of the coronal light, particularly in the lower levels, remains a very open one, and

further detailed work must be done, combining spectroscopic, photometric, and polariscopic methods, before a final answer can be obtained." The characteristic bright-line spectrum of the corona has not yet been reproduced in the laboratory, so that although a fair amount is known as to coronal lines and their relation to the chromosphere, some very fundamental questions still remain unanswered, and while it is only possible to study them for less than two minutes a year on an average, they are likely to remain so. All students of physical science will find Mr. Stratton's lecture full of interest, and his notes on the forthcoming eclipse on June 29 afford much valuable guidance to lay readers as well. We are glad that the lecture is available in time to be mentioned in this week's issue of NATURE and are sure that it will find many appreciative readers.

THE announcement that Sir Daniel Hall has ceased to hold the post of Director of the Intelligence Division of the Ministry of Agriculture will cause general regret on the part of agriculturists and many others. It is true that he retains the post of Scientific Adviser to the Ministry, and that, consequently, no immediate change in policy affecting agricultural research need be feared, but the need of scientific direction in the lower walk of education will always remain, and it is not clear how far the spirit of science will be permitted to inform the future administration of the Department. But Sir Daniel Hall's influence in the past has extended far beyond strictly scientific issues. It is no exaggeration to say that he has displayed a remarkable capacity for handling the difficult border-land problems that lie between technical husbandry and public policy. With no intention of commending the arts of the demagogue, we must admit that, in these days, the influence of the finished public speaker is very great, and that influence Sir Daniel Hall has exercised in a very marked degree. In a narrower field also, that of the committee of experts, this spiritual gift—if we may be permitted the epithet—has been equally marked, as many a doughty opponent, to his chagrin, has experienced. But we particularly cherish the recollection of an address delivered to a body of American students some years ago, which well illustrates Sir Daniel's many-sided gifts. His address —with delightful irony if we note the environment—deprecated the relentless pursuit of efficiency, and recalled with regret the conversion of a certain meadow "starred with Grass of Parnassus ('where, too, the sedgewarbler swung her nest') into a pond for the growth of food—to wit, watercress to grace the Cockney's tea-table."

WE are glad that the B.B.C. has decided to adopt the principle of stating the kilocycle figures instead of the wave-length figures in connexion with all its stations. The reason that has frequently been urged against giving the frequency instead of the wave-length is that the large figures involved might easily lead to mistakes. For broadcasting, however, this would not apply. The wave-length of the waves broadcast from Aberdeen, for example, is 500 metres and the number of kilocycles per second is 600. The Union Internationale de Radiophonie, Geneva, has based its system of measurement on kilocycles (1000 cycles) and not on wave-lengths. The minimum spacing between a wave exclusive to a single station and a common wave used by several stations has been fixed at 10 kilocycles. When this is done the heterodyne note has a frequency of 10,000 vibrations per second, and so, even to one whose hearing is acute, it is barely audible. With the new arrangement all the kilocycle measurements are in round numbers. It is easier to remember that Daventry is 187 kilocycles per second than that it has a wave-length of 1604·3 metres. The London station has a frequency of 830 kilocycles and a wave-length of 361·4 m. In the future it will be designated by the former number.

AMONG the six ingenious inventors, Kay, Paul, Hargreaves, Arkwright, Crompton, and Cartwright, whose work laid the foundation of the great textile industry of Lancashire and ushered in the Industrial Revolution, Crompton is famous for his invention of the spinning-mule, a machine embodying some of the principles of the drawing rollers of Paul and Arkwright with the stretching contrivance of Hargreaves' jenny, which solved the problem of spinning fine yarns. Crompton was born on Dec. 3, 1753, and died at 15 King Street, Bolton, on June 26, 1827, and Bolton during Whitsun week has just been worthily commemorating the centenary of his death. The celebrations included an official visit of the Mayor and Corporation to the Swedenborgian Church of which Crompton was long organist and choirmaster, an exhibition at the Chadwick Museum, a pageant, a civic procession to Crompton's tomb and monument, and meetings of the Textile Institute at which papers were read referring to Crompton's work. Among these was a historical review by Mr. H. W. Dickinson, who represented the Newcomen Society; an account of the state of the cotton trade during its early development, by Mr. Frank Nasmith; and a paper by Mr. W. Scott Taggart dealing with the significance of Crompton's invention and subsequent developments. Like many of his fellows, Crompton, partly due to his shy and reserved character, failed to reap the full benefit of his invention. He was, it is true, given a Parliamentary grant of £5000, but he died in comparative poverty and obscurity, leaving furniture which was valued at £17.

DURING this summer the new diocese of Derby will be inaugurated, and All Saints' Church, Derby, will become the Cathedral Church. It is in the Cavendish vault in this church that Henry Cavendish is buried, and as there is no memorial to him it has been proposed that steps should now be taken to erect one. Cavendish was born in 1731 and died in 1810, and practically all his life was devoted to experimental science. His investigation of the properties of hydrogen and discovery of the composition of water, his famous experiment on the mean density of the earth, and his electrical investigations, have rendered his name immortal.

For nearly fifty years he was a fellow of the Royal Society. Some of his experiments were probably made in his father's stables in Great Marlborough Street, but the greater part of his life was passed in his bachelor home which faced Clapham Common. Though gifted with great acuteness of mind and sound judgment, and with a passion for accuracy equal to that of an Airy or a Rayleigh, he was morbidly shy and reserved and his life was almost that of a recluse. So shy was he, that no portrait of him was ever taken, and the only sketch we have was made surreptitiously. Brougham declared that Cavendish probably uttered fewer words than any one, outside a Trappist monastery, who lived to nearly four-score years. A contemporary of Watt, Black, and Priestley, Cavendish was the most distinguished natural philosopher Great Britain could claim, and he was recognised as such by other nations. Biot wrote of him as "le plus riche de tous les savants, et probablement aussi le plus savant de tous les riches." There are reasons for believing that a memorial tablet to Cavendish once existed in the church in which he lies, and it may have been removed when the church was restored about fifty years ago. In any event, the proposal now put forward is one which should meet with the support of all the various scientific societies whose work is included in the great domain of physical science and its application.

THE History of Science Society, which has its headquarters in the United States but is well known in Great Britain through its journal *Isis*, is following up the Newton celebration of last March at Grantham by a similar gathering at the Columbia University in New York on Nov. 25 and 26. The programme is full and varied. Mathematical, astronomical, and physical papers are to be followed by others which deal with matters only alluded to incidentally, if at all, at the English meetings. Thus there will be a full account of Newton's "Theological Thoughts" and his "Mint Problems," and an equally long paper on Newton's "First Disciple in America." We shall look forward with interest to this, for his name is not familiar to the ordinary Newtonian in England. There is also to be an exhibition of Newtonia, including the first edition of the "Principia," with portraits, medals, and autograph letters, of which very likely the United States may possess a larger store than we have in England. Any one who has such material and would be willing to lend it, should communicate with the secretary of the History of Science Society, Frederick E. Brasch, at the Library of Congress, Washington, D.C. The Programme Committee includes some of the best-known names in American mathematics, astronomy, and physics, and we wish the celebration every success.

DR. JOSEPH S. AMES, of Baltimore, has been elected chairman of the U.S. National Advisory Committee for Aeronautics in succession to the late Dr. Charles D. Walcott, who died on Feb. 9 last. Dr. Ames is one of the original twelve members of the Committee appointed in 1915. He was born in Manchester, Vermont, in 1864, and worked at the Johns Hopkins University, from which he received his doctorate in 1890. After studying abroad, he went as assistant professor of physics to Johns Hopkins University and has been professor of physics there since 1890. In 1909 he was elected a member of the National Academy of Sciences for "outstanding work in physics," and was one of the first members of the National Research Council organised by the Academy in 1917. He is the author of many articles and books on physics, electricity, and mathematics. For the past eight years, Dr. Ames has been chairman of the Committee on Aerodynamics of the U.S. National Advisory Committee for Aeronautics, and as such has directed the preparation of research programmes for the air services of the U.S. Army and Navy, the Langley Memorial Aeronautical Laboratory, and the Bureau of Standards, and has effected a practical co-ordination of effort among the government and private agencies concerned with the scientific study of various aspects of the fundamental problems of flight.

THE report of the chairman of the National Illumination Committee for the year 1926 mentions that the proposed plenary session of the International Illumination Commission in New York has been provisionally postponed to 1928. In the meantime, meetings of the executive and technical committees are to take place in Rome in September this year. It is also stated that Belgium, Germany, and Japan have been added to the list of countries represented on the International Illumination Commission. In a supplementary report an account is given of the work of the committees operating under the British Engineering Standards Association. Five British standard specifications have been issued, or are on the point of completion, namely, those dealing with portable photometers, the British standard glossary of terms used in illumination and photometry, industrial reflectors for direct general lighting, illuminating fittings of translucent glassware for interior lighting, and street lighting. The question of neck dimensions of illumination glassware is now being considered, and the work on industrial reflectors is based mainly on the specification of a suitable 'cut-off angle' so as to diminish glare. The work of both these committees has been rendered difficult by the wide tolerances allowed on the light-centre-length of electric lamps, and it is hoped to set up standards for all types of lamps, or at least for pear-shaped and spherical lamps. Reference is also made to a method of defining glare which has been embodied in the specification on street lighting.

THE publications of the Science Museum, South Kensington, are most useful to inventors and to students of the development of various branches of manufacturing industry. We can commend the catalogue of the electrical engineering section recently published (London: H.M. Stationery Office, 1927. 1*s*. 6*d*. net). The descriptive and historical notes are well done, and the numerous illustrations almost dispense with the necessity of making a visit to the

museum. It proves the leading part taken by the pioneers of Great Britain in the development of the industry. In many cases the apparatus appears crude, but it generally shows the principle which the inventor more or less successfully endeavoured to apply in practice. From this point of view we think that replicas of the original apparatus, when the latter is not available, are most useful, and we think that the number of them might advantageously be increased. Faraday was the first and the greatest of the pioneers, but he was closely followed by Kelvin, Parsons, and Ferranti. Many of the exhibits have figured in famous law cases. Some of the apparatus was invented for special purposes and is no longer required. Some of the machines are still being manufactured with practically no change in their appearance or design, but others have been developed almost beyond recognition. We doubt whether high-tension direct current will ever develop in England. The transverter has still to prove its usefulness. The 230 kilovolt lines in California, mentioned by the writer of the 'notes,' will be eclipsed by the 380 kilovolt line being constructed in Germany. 'Copper-clad steel' for transmission lines is not now so popular as aluminium wires with a steel core. With this conductor spans of so much as 1000 feet are used in South Wales.

THE National Broadcasting Company of America has made good progress since it started six months ago. Its objects are to provide a high-class programme which will be within easy reach of every inhabitant of the United States. Its position to other broadcasting companies is analogous to that of the Associated Press to the local newspapers in Great Britain. It is noteworthy that it is paid for by indirect advertising. The American advertiser broadcasts what is called a 'sponsored' programme. His name is only heard in an unobtrusive way in connexion with the announcement of an item of the programme. An interesting account of the company's activities by A. Dinsdale appears in the *Wireless World* for May 11. More than a hundred broadcasting stations have applied for the N.B.C. service. Their lines radiate from New York to the Canadian border, to the Pacific coast, and to Florida and Texas. Special telephone circuits with special valve repeaters are used to carry the programmes to the various stations. On Feb. 22, 42 stations broadcast President Coolidge's address. It is estimated that 25 million people heard him. It was also transmitted by a beam wave and broadcast by the B.B.C. in England. In broadcasting *Faust* from the Chicago Civic Opera House, no less than 15 microphones in parallel were used. Two microphones were hung up high over the audience so as to produce an 'echo' effect, the sounds reaching them a fraction of a second later than they did the seven footlights microphones. The N.B.C. is not seeking a monopoly of broadcasting, and welcomes new local broadcasting stations. It is also hoped that considerable use will be made of its facilities, for educational purposes. A 'univerity in the air' well endowed by philanthropists is one of its ideals.

THE divergent views held by the Cambridge and Vienna schools on the question of disintegration of atomic nuclei by α-particles have again been brought into prominence with the publication by the latter of a group of papers in the *Zeitschrift für Physik* of May 5. It is still maintained that the conditions employed in the Cavendish Laboratory are such that a large number of scintillations due to H-particles of short range are missed, and, in particular, that with the special Hilger microscope used by Dr. Chadwick, the intensity of the flashes is limited because the pencil that emerges from the eye-piece more than fills the pupil of the observer. The validity of the Geiger test for efficiency of observation is also disputed, on the ground that when two persons count a group of particles of variable speed simultaneously, both will tend to miss the weaker scintillations. If the conclusions of Dr. Pettersson and his collaborators are to be accepted, the nuclei of almost all elements so far examined can be broken up, and the disruption can be accomplished by α-particles of small speed, with the production of protons the velocity of which has no marked lower limit. All of these results are in sharp disagreement with the experiments of Sir E. Rutherford and Dr. Chadwick. Carbon, for which the latter workers found no evidence of disintegration, and aluminium have been carefully re-examined, and the earlier Austrian results have apparently been confirmed by use of a photographic method, and with the Wilson expansion apparatus. Dr. Stetter has also succeeded in applying a modified form of the Aston mass-spectrograph to the problem, and has shown that protons are present in about the numbers found in the scintillation experiments, and with about the same velocities. The opinion of the Austrian workers is that whilst counting of scintillations does not always lead to accurate quantitative determinations, they can nevertheless usually distinguish between the flashes produced by α-particles and by H-particles, and that the results which they have obtained in this way are adequately confirmed by other methods.

REGIONALISM in some form or other has made rapid strides during recent years. Towns and districts with a local consciousness are taking stock of themselves in an endeavour to see what manner of region they are at present and what they will or may become. The latest aspirant to self-examination is south-west England. Its sponsor is the University College of South-West England, situate at Exeter. This region, it is claimed, is "a distinct natural unit with a long tradition of human settlement rooted in native soil and with a continuous cultural history little disturbed by the violent innovation of industrial activity." The survey aims at a detailed investigation of social life "viewed as the interaction of Place, People, and Work or Function." Under this comprehensive scheme everything within south-west England from boglands to betting, and from social stratification to the stratification of the rocks, comes under review. Now the collection of exact data, whether geological, anthropological, or social, for any locality is eminently desirable. Too often the recording of the present has

been forgotten in the admiration of the past or the aspiration for the future. It is desirable, also, that regional data shall be housed in some recognised centre for reference and possible collation for various purposes. To this extent the new survey is to be commended for the work it is about to undertake. The accumulated data will furnish raw material for innumerable workers and will provide a datum line to which subsequent investigations may be referred. There is a danger, however, that the survey may go beyond the scientific collection of data to a pseudo-scientific philosophy. To state that "racial or temperamental traits may be the result of climatic conditions and may in turn have some part in determining the religious outlook" is doubtful wisdom. The survey may well rest content if it can adequately observe and record all the data enumerated in its programme without speculating on doubtful relationships among various groups of data.

PENDING the publication of the report of the Board of Education's Committee on the public library service in Great Britain, which is expected shortly, the Carnegie United Kingdom Trust, according to the annual report for 1926, has for the most part been content to develop upon traditional lines. The most notable new departure is the policy of offering assistance in book purchase to the smaller-sized libraries on condition of their imposing a higher library rate. This, no doubt, is a step in the right direction in the case of growing towns, in which expenditure on book purchase is often pitifully low. We think, however, that the Trust should have differentiated between towns with stationary and growing populations. Town Councils are proverbially short-sighted in their willingness to accept cash gifts without adequate consideration of the liabilities attached thereto. When the period over which the Trust's gifts carry has passed away, the town may find itself saddled with higher official salaries, a larger stock of books to maintain, and little surplus income to meet the increased liabilities. We think also that the Trust would have been well advised if in making these grants it had stressed the importance of building up strong reference libraries. The tendency of the town's library is always in the direction of increasing its fiction department. Satisfactory progress is recorded in respect of the growth of the Central Library for Students and the 'outlier' library policy of the Trust, and we note with pleasure the rapid development of the work of the National Institute of Industrial Psychology. The fees received by the Institute increased from £6700 in 1925 to £8600 in 1926. The value of its system of vocational tests is now beginning to be recognised both in Great Britain and in the United States.

THE Malthusian League will celebrate its fiftieth anniversary by a dinner, on July 26, at the Holborn Restaurant, London. Among the speakers will be Mr. J. M. Keynes, Mr. H. G. Wells, and Mrs. Annie Besant, who was the first secretary of the League.

PROF. F. G. DONNAN, professor of general chemistry in the University of London, has been elected a member of the Royal Academy of Sciences of Amsterdam, thus filling the vacancy caused by the death of Prof. C. Golgi, of Pavia.

THE Makdougall-Brisbane Prize for the period 1924–1926 has been awarded by the council of the Royal Society of Edinburgh to Dr. C. M. Wenyon, for his distinguished work in protozoology. He will deliver an address to the Society at the annual statutory meeting to be held on Oct. 24, when the prize will be presented. The James Scott Prize for the period 1922–1926 "for a lecture or essay on the fundamental concepts of Natural Philosophy," has been awarded by the council to Sir Joseph Larmor, who will deliver a lecture to the Society on July 4. The prize will be presented on that date.

IN an address delivered at a meeting of the Psychological Society at Oxford, Sir Oliver Lodge stated that he considered it as not improbable that the synthesis of organic substances may eventually reach a point at which the production of protoplasm will become possible. The exhibition of vitality may follow. It is certain, he said, that living organisms appeared at some period on the earth, which was once a mass of molten material or even of incandescent gas; and what has happened before may happen again. The production and control of living substance may possibly come within the power of human agency.

"HEALTH WEEK" will be celebrated in Great Britain this year on Oct. 2-8. The object of Health Week is to focus public attention for one week in the year on matters of health, and to arouse that personal responsibility for health without which all public work, whether by the Government or local authorities, must fall far short of its aims. It is suggested that the dominant idea should be "Self help in Health." The movement known as Health Week was instituted in 1912, their Majesties the King and Queen are patrons, and the Royal Sanitary Institute undertakes the central organisation, but local celebrations in each centre are organised and controlled by local committees. A circular may be obtained from the Secretary, Mr. E. White Wallis, 90 Buckingham Palace Road, London, S.W., giving information of the aims and procedure and formation of local committees, with suggestions regarding items for the programme and subjects for lectures.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A full-time lecturer in electrical engineering in the Newport, Mon., Technical College and Institute—The Secretary and Executive Officer, Education Offices, Charles Street, Newport, Mon. (June 24). A metallurgical assistant, Grade II., in the Ordnance Factories—The Chief Superintendent of Ordnance Factories, Royal Arsenal, Woolwich, S.E.18 (June 24). An assistant lecturer in pharmaceutical chemistry at the Cardiff Technical College—The Principal, Technical College, Cardiff (June 25). An assistant for cancer research in the Bland-Sutton Institute of Pathology of the Middlesex Hospital Medical School—The Secretary, Cancer and General Research Committee, Middlesex

Hospital, W.1 (June 30). An assistant librarian (male) for the University of Aberdeen—The Secretary, The University, Aberdeen (June 30). An assistant lecturer in philosophy in the University of Birmingham—The Secretary, The University, Birmingham (July 1). A laboratory steward and lecture assistant in, respectively, physics and chemistry in the Durham Division of the University of Durham—The Head of the Department of Science, University of Durham, South Road, Durham (July 2). A medically qualified demonstrator in the physiology department of the Middlesex Hospital Medical School—The School Secretary, Middlesex Hospital Medical School, W.1 (July 7). A teacher of engineering subjects at the Gloucester Technical College—The Principal, Technical College, Gloucester. An assistant bacteriologist at the Wellcome Tropical Research Laboratories, Khartoum—The Controller, Sudan Government, London Office, Wellington House, Buckingham Gate, S.W.1. A laboratory assistant under the Sudan Government—The Controller, Sudan Government, London Office, Wellington House, Buckingham Gate, S.W.1. A temporary junior assistant under the directorate of Metallurgical Research of the Research Department, Woolwich—The Chief Superintendent, Research Department, Woolwich, S.E.18.

Our Astronomical Column.

TIME SIGNALS FOR THE ECLIPSE.—Very ample arrangements have been made by the Astronomer Royal, in conjunction with Mr. Hope Jones and Mr. P. H. Hepburn, and with the kind co-operation of the B.B.C., for transmitting time signals on the morning of the eclipse. The 6-dot signals will be sent at $5^h\ 0^m$, $5^h\ 15^m$, $5^h\ 20^m$, and $5^h\ 30^m$ U.T. The sixth is the exact minute. Also every second, except 29^s and 59^s of each minute, from $5^h\ 22^m$ to $5^h\ 26^m$ U.T., which covers the whole period of totality in Great Britain (Summer Time 1 hour greater than above). The minutes and every fifth second will be named verbally. The signals will be transmitted from Daventry (wave-length, 1600 metres), and we understand from London also. A full rehearsal of the programme was given on Saturday, June 11. Probably no previous eclipse has had such facilities for accurate time determination.

NEW COMET.—The sixth cometary discovery of the year has been made by Mr. Gale at Sydney. There are two previous comets in the catalogue, 1894 II. and 1912 II., discovered by Mr. W. F. Gale. As no initials are given in the present case, there is a doubt whether this discovery is due to him or to his son, Mr. A. W. W. Gale. The following two positions have come to hand.

	U.T.	R.A.	S. Decl.	Mag.	Observer.
June	7·604	$21^h\ 38^m\ 0^s$	31° 38′	8·0	Gale, Sydney.
	10·137	21 53 4	31 38	10·0	Gonnessiat, Algiers.

The deduced daily motion is $+5^m\ 57^s$, 0′. Not much stress can be laid on the decline in magnitude, as there is considerable personality in estimating this for comets. The comet is on the meridian at $3^h\ 30^m$ U.T., but is too far south for convenient observation in England. Its designation is 1927*f*. Of the six discoveries this year, four are new comets and two are the returns of periodic ones.

A LARGE SUNSPOT.—The large group of sunspots described in NATURE for May 21, p. 759, has made its appearance for the second time, being seen in transit across the sun's disc on June 1-15. When near the sun's east limb, there was a large spot followed closely by a smaller composite one. The latter spot was the nucleus of a growing train, which together with the original leader spot finally stretched across 10° of solar longitude, or about 70,000 miles, and had a total area of nearly 2000 millions of square miles. Latterly the group was decreasing perceptibly. It may be remarked that no magnetic disturbance was registered by the magnetographs about the time of the central meridian passage of the group on June 8. It is also of interest that at the time of the forthcoming total solar eclipse on June 29, the tail-end of this group of spots, if still existent, will be at the sun's east limb at position angle 70°, measured from the north point of the disc. A solar prominence or any peculiarity in the sun's corona should be looked for in this region. Other details of this naked-eye spot—the largest seen as yet this year—are as follows:

No.	Date on Disc.	Central Meridian Passage.	Latitude.	Maximum Area.
5	June 1-15	June 8·0	16° N.	1/650 of hemisphere

THE NUMBER OF THE STARS.—The Scientific News Service of the Smithsonian Institution, Washington, for May 22, contains an interesting article by Dr. C. G. Abbot on the total number of stars in our system, which he takes as thirty thousand millions, or, as he calls it, 'thirty billions.' (This diversity of use between England and America as to the meaning of 'billion,' 'trillion,' etc., is a perpetual source of confusion, and a decision on the subject by the International Astronomical Union is much to be desired.)

The estimate is derived from star counts down to different limiting magnitudes on photographs of the Kapteyn selected areas. The ratio of increase in numbers for an increase of a unit in the limiting magnitude is found to tend to zero as the stars grow fainter. Assuming that the law continues for still fainter stars, the total number of stars can be arrived at, and is found to be 30,000,000,000.

Earlier investigations of the same kind were made by Chapman and Melotte from the Franklin Adams plates, and by P. J. van Rhijn. The former found the number of stars down to mag. 16·0 to be 33 millions, and by extrapolation similar to that of Dr. Abbot, found the total number in our system to be 3 or 4 thousand millions, which is only $\frac{1}{10}$ or $\frac{1}{8}$ of Dr. Abbot's result. But his is based on photographs showing much fainter stars than the other, so is more trustworthy.

Incidentally, Dr. Abbot gives a fallacious proof that the total number of stars is not infinite; for he says the whole heavens would then blaze like the sun. This is correct only for uniform distribution of stars throughout all space. There is an infinite number of ways in which we could arrange an infinite number of stars, without making the heavens more luminous than they are at present, even granting the perfect transparency of space. We would not contend that the number of stars is infinite, but it is desirable to avoid misleading statements in these articles. Dr. Abbot's estimate of the size of our stellar system is 100,000 light years in its maximum diameter, and 20,000 light years in its minimum one. The article goes on to give some details of stellar physics, including Eddington's recent researches.

Research Items.

ARROW-RELEASE.—Mr. A. L. Kroeber has worked over the material relating to methods of arrow-release, with special reference to the distribution of the various types and its bearing upon the problems of diffusion. His results are published as No. 4 of vol. 23 of the *University of California Publications in American Archæology and Ethnology*. Five methods of release are recognised: two, the primary and secondary, depend upon a direct hold on the arrow; the tertiary draws on the string holding the arrow between thumb and index; the Mediterranean draws on the string with the end of the fingers at right angles, holding the arrow between index and middle fingers; and the Mongolian employs a thumb, usually with a ring, to pull the string, this release being closely associated with the composite bow of horn, sinew, and wood. The distribution of the Mongolian release is compact and Asiatic, with an extra-Asiatic occurrence among the Yahi in nothern California, here attributed to independent invention. The Mediterranean occurs in three areas—Europe to south-east Asia, with the earliest record in Twelfth Dynasty Egypt, Eskimo (Siberia, Alaska, and Baffinland), and in south California, Arizona, and Sonora. These are construed as separate origins. The distribution of the tertiary release is irregular, occurring in central North America, Central America, and the Congo, with eight cases between India and Melanesia. The secondary is the least wide-spread, being reported, apart from doubtful cases, only from North America. The primary is the most irregular, and appears to be due to the persistence of originally 'primitive' or simple methods, and occurs in a distribution marginal to the tertiary release. The general conclusion is that there is a seemingly limited number of normal growth or spread distributions and several probabilities of independent origins.

ORIGIN OF THE CRIMEAN FLORA.—The Russian botanist Wulf has published recently (in the *Mem. Crimean Society of Natural History*, vol. 9, 1926) an interesting paper in which the problem of the origin of the flora of the Crimea is discussed on the basis of some new botanical evidence as well as of the geological data. The main conclusion is that the Crimea represents a fragment of a mountainous 'Pontic continent,' which was a continuation of the northern Asia Minor and existed to the end of the Pliocene, if not in the Quartenary period. The original flora of the Crimea was, accordingly, that of the eastern Mediterranean type, and relics of that flora are still numerous in the Crimea. During its history the Pontic continent had been connected temporarily with other neighbouring lands—with southern Russia, with Dobrudsha, with the region of the Azov sea. At the end of the Tertiary and early in the Quarternary Age the eastern regions of the Mediterranean countries sunk, the Black Sea depression was formed, and the Crimea became a peninsula. During the Ice Age the flora of the Crimea became considerably poorer. Endemic element in the Crimean flora is of two kinds: ancient relics, only 13 in number (*Cerastium biebersteini*, *Eremurus tauricus*, *Centaurea comperiana*, and others), and a large number of young endemic forms (subspecies), which testify to the insular character of the flora. Population of the Crimea by plants, as an analysis of the flora shows, occurred from various sources: from Asia Minor, from western Transcausia, from the Balkanian peninsula, and from southern Russia. Prof. L. Berg, who is a well-known Russia ichthyologist, in giving a review of Wulf's paper in *Priroda* (1927, No. 3), says that the evidence offered by the study of the fresh-water fishes of Crimea does not contradict the suggestion of the former existence of the Pontic continent; this fauna is somewhat poor, including about fifteen species altogether, and the only endemic form is *Barbus tauricus*, which is merely a geographical subspecies of *B. escherichi* distributed in the rivers of Asia Minor flowing into Black Sea.

GRAPHIC COMPARISON OF RELATIVE VARIABILITY.—Prof. Raymond Pearl has devised a simple graphic method for comparing the relative variability of unlike characters belonging to the same or different populations (*Science*, Mar. 11, 1927). The coefficient of variation does not give a clear picture of the scatter in a distribution; but the variation of a population in such diverse features as age, stature, body weight and relative cell volume of the blood can be compared by making two simple transformations of the data: (*a*) expressing the frequency of each class unit as a percentage of the mean value for each character, and (*b*) expressing the frequencies as so much per one per cent. of the mean of each character. The values so obtained can be directly plotted on co-ordinate paper and will give superimposed graphs which are directly comparable with each other in all their details. In this way the variability in milk yield of cows may be compared with, for example, the egg production of fowls, and the populations compared may differ widely in number of individuals.

GENETICS AT THE CARNEGIE INSTITUTION OF WASHINGTON.—In the Department of Genetics of the Carnegie Institution of Washington, which has now been in existence twenty-three years, Dr. Banta has now bred parthenogenetic Cladocera for 650 generations, obtaining mutations in reactiveness to light, 'excavated head' and intersexes, which show Mendelian behaviour in crossing (Year-Book, 1925–26). It is believed that evidence of the compound nature of the gene is obtained from the multiple allelomorphism in Drosophila and also from Delphinium. In the fly Sciara, Metz finds that in spermatogenesis the chromosomes do not pair, but all the maternal chromosomes pass into the sperm while their paternal homologues are cast off. Consequently the sperm fails to transmit paternal traits. Some genetic confirmation of this has been obtained. In the continuation of genetical and cytological studies of Datura, evidence is obtained that non-homologous chromosomes may show mutual attraction, and that pieces of such chromosomes may unite to form whole chromosomes which give aberrant genetic results. In pigeon breeding, strains with high and low thyroid content have been produced, and the action of endocrine glands as a complication in inheritance is emphasised.

LAMSIEKTE IN CATTLE IN SOUTH AFRICA.—This disease is characterised by weakness and paralysis, chiefly of the locomotor system, and causes considerable mortality and loss. Sir Arnold Theiler and his collaborators have now proved that the disease is caused by the ingestion of a bacterial poison or toxin elaborated by an organism closely allied to the *Bacillus botulinus* which causes the form of food poisoning in man known as botulism; lamsiekte may therefore be termed "parabotulism" (Union of S. Africa: Dep. of Agriculture, 11th and 12th Reports of the Director of Vet. Education and Research. Pt. 2. By A. Theiler, with P. R. Viljoen, H. H. Green, P. J. du Toit, H. Meier, and E. M. Robinson. Pretoria: Gov. Printing and Stationery Office, 1927). The manner in which the cattle become

poisoned is of considerable interest. The veld soil and herbage are very poor in phosphates and it does not pay to apply phosphatic manures. Consequently, the cattle suffer from phosphorus deficiency, particularly in certain districts. To supplement this deficiency the animals develop perverted appetites, which impel them to gnaw or eat substances foreign to their normal diet, such as bones, carcases, or the offal thereof, derived from animals or game which have died on the veld. Now the toxin-producing micro-organism (*B. parabotulinus*) inhabits the soil, may infect the carcase, and may there produce its toxin. A beast ingesting some of the toxin-impregnated offal is poisoned and thus develops the disease lamsiekte. It had long been recognised that phosphorus deficiency was in some way connected with the development of lamsiekte, and that a ration of bone-meal added to the diet would to a large extent prevent it, but the connexion between the two was unknown until explained by the present researches. Bone-meal supplies the phosphorus lacking, so that the animals do not turn to the toxin-impregnated offal to supply their needs, and are therefore not poisoned, *i.e.* do not contract lamsiekte.

FAUNA OF KARACHI.—In December 1920 a party of advanced students of the University of the Panjab, under the direction of Prof. G. Matthai, made a collecting excursion to Karachi, when a number of specimens of the polychaet genus Eurythoe were obtained. In October 1922, S. S. Bindra made a further collection in the same area, and his report, based on the examination of nearly five hundred specimens of the genus, is published in vol. 1, pp. 1-18, of the Memoirs of the Department of Zoology, Panjab University, 1927. A key to the twenty-three known species of Eurythoe is given, and careful descriptions are provided of the five species represented in the collection from Karachi; two of these species are described as new. The memoir is illustrated by two excellent collotype plates and by text figures. Prof. Matthai states that this is the first of a series of papers on the fauna of Karachi which is to be published.

FOSSIL DECAPOD CRUSTACEA.—In a memoir on "The Fossil Stalk-eyed Crustacea of the Pacific slope of North America" (*Bull. U.S. Nat. Mus.*, 138, 1926), Miss M. J. Rathbun gives an account of all the species of decapod Crustacea which have been found fossil in that region and describes a large number of new forms. The age of the deposits ranges from Upper Cretaceous to Pleistocene. By far the larger number of species belong to the Brachyura. The Astacura and Palinura have only a small number of representatives; one Pliocene species of the former group is referred to the genus Astacus. Only two species of Stomatopoda are recorded. Of the 11 genera of decapods from the Cretaceous of the Pacific slope, 10 have representatives in Europe; of the 15 from the Eocene, 11 are known in Europe; but in the Oligocene the proportion of European forms is smaller.

ATOMIC PHYSICS.—The issue of the *Proceedings of the Physical Society* for April 15 contains the presidential address of Prof. O. W. Richardson on the present state of atomic physics. He points out that although the quantum theory and the nuclear atom have admitted of great advances into the physics of atoms, they have led to difficulties which it has not been possible to overcome. Of these, the necessity for using half quanta to explain band spectra, the lengthening of the mean free path of an electron in an inert gas when the speed is reduced, and the excess of the calculated over the observed ionising potentials for the simpler gases may be mentioned. They have led to a revolt against the views which three or four years ago held the field, and Heisenberg two years ago discarded the atomic model and dealt with the radiations only. These may be treated as the terms of a matrix and are subject to the laws of matrix algebra. Another line has been taken by de Broglie in his wave mechanics, and Schrödinger has followed it with marked success. The electron is taken as a train of waves with a group and a phase velocity, and this leads to explanations of a number of the difficulties of previous theories, although it is not free from difficulties of its own.

DIRECTION CHANGES AND FADING IN RADIO SIGNALS.—Many observations have recently been made on the phenomena of the change of direction of radio waves and on fading, that is, the fluctuation of their intensity. The results seem to depend on several factors and there is no general agreement as to which are the most important. H. J. Reich, in the *Journal of the Franklin Institute* for April, describes careful tests made to determine to what extent change of direction of the waves is connected with fading. He mentions incidentally that on one evening it was impossible to find at his observing station directional minima from any sending station. The experimenters concluded that something had gone wrong with their apparatus and gave up testing. Later on they discovered that on that evening there had been a brilliant display of the aurora borealis. It would be interesting to know why this should result in a complete absence of directional minima. The author concludes from his observations that rapid and pronounced fading is usually accompanied by rapid direction changes of large amplitude. There seems, however, to be no relation as to the exact time at which the changes occur in the two phenomena. The two phenomena often begin and end almost simultaneously. No relation could be detected in the direction changes of the signals between two different stations. There is generally a pronounced deflexion of fairly long duration shortly after sunset and shortly before sunrise. The direction of the deflexion in this case does not always verify the theory that refraction takes place at the border surface between day and night. Further experimental work seems to be desirable in order to clear up the seeming discrepancies between the results of various experimenters.

MATHEMATICAL MODELS.—Messrs. G. Cussons, Ltd., of the Technical Works, Manchester, and Thanet House, 231 Strand, W.C.2, have issued an interesting list of mathematical models, according to the collection of Messrs. Weiner and Treutlein. H. Weiner's models are mostly formed of threads, wires, and adjustable rods. This representation visualises the regular polyhedra to great advantage, one typical model showing the five cubes whose vertices are corners of a regular dodecahedron. Surfaces of the second order are illustrated by wire models showing their principal sections, generating lines, and circular sections. More elaborate systems of wires illustrate surfaces of revolution, screw surfaces, and twisted curves, including their singularities. Weiner's list also includes a variety of link polyhedra to illustrate the bending of surfaces and developables, together with a few ruled surfaces of higher order. P. Treutlein's models explain systems of measures, weight, and coinage. The simpler ones, illustrating theorems about congruent figures and areas, are followed by various prisms, cylinders, sections of cylinders and cones, and quadric surfaces. A student or teacher of solid geometry will find that such models as these help him greatly in visualising the figures with which he deals.

Foot-and-Mouth Disease.

THE ravages of foot-and-mouth disease in Great Britain during the past few years, though now, happily, declining, yet lend great importance to the discovery of methods of prevention and cure less drastic than the slaughter of all affected animals. Although in its second progress report,[1] the Foot-and-Mouth Disease Research Committee is unable to prescribe certain means of prevention and cure, the results already achieved suggest that in the future such may be discovered; thus the experiments described on methods of destroying the virus and on immunity to it in animals point the way to possible means by which these ends may be successfully accomplished.

Work on the disease is hampered by the fact that the causative agent has not yet been seen, nor has it been cultivated on artificial media. Further, it appears that there are at least two types of the virus, and infection with one, though producing immunity to this type, usually does not result in immunity to the other. The virus can only be recognised by the effects it produces in a susceptible animal such as the guinea-pig, which is chiefly used for this purpose. The same animal also serves as a useful source of the virus, since after several passages through guinea-pigs, the fluid obtained from the vesicular lesions of the disease contains virus of a very high potency, as shown by the fact that the fluid may still be infective when diluted even to 1 in 10 million.

The spread of infection of foot-and-mouth disease must depend on the natural resistance of the virus and the presence of susceptible animals. Various species which might carry the infection to cattle have been examined: rats and rabbits are relatively resistant; lesions can be produced by inoculation, but the disease does not spread from one animal to another. Cats, dogs, and hedgehogs can also be infected: no contact infections were seen, although the mortality among kittens and puppies was very high. Birds, however, were found to be insusceptible to inoculation. It is therefore probable that infection of cattle does not, at any rate easily, take place by contact with other animals: in fact, cross-infection experiments with guinea-pigs were negative unless the vesicles on the guinea-pig's feet were opened and allowed to discharge over the fodder, etc., of the cattle.

A large number of experiments were performed on the survival of the virus under a variety of conditions. It was found that in buffered phosphate solutions of neutral reaction, potency was only slowly lost in the cold: in 50 per cent. glycerine, containing a little of the phosphate solution, the virus may also remain active for more than six months. When dried on glass slides the virus soon lost activity, especially if kept in a moist atmosphere, but on other materials the potency might be retained for a longer period, especially on hay or an infusion thereof. Carcases of guinea-pigs, cattle, and pigs may remain infective for several weeks, especially the bone marrow. Burial with lime or salting of the carcase does not alter the period of infectivity in this tissue. The virus is destroyed by exposure to a temperature of 55° C. for about twenty minutes, by light, but not easily by chemical reagents: the most useful antiseptic is probably 0·1 per cent. commercial formalin, which always destroys it in two days at 26°-27° C.

Immunity is produced by an attack of the disease, which in the guinea-pig lasts about four months and in cattle about a year. After this period, 'partial' immunity is still present, since intracutaneous inoculation of the sole of a foot in the guinea-pig will produce local lesions, whilst intramuscular inoculation is quite ineffective. In the susceptible guinea-pig, as in cattle, there is always a difference between different sites of inoculation in the ease with which infection can be produced: thus intracutaneous inoculation or scarification of the mucous membrane of the mouth is a much more certain means of infecting than intramuscular injection. Complete passive immunity in the guinea-pig has not been produced, the injection of serum from a recovered animal giving only 'partial' immunity. Complete (active) immunity by inoculation of living virus can be produced, but the results are not very certain and an actual attack of the disease may result. On the other hand, inoculation with a formalised vaccine regularly produces 'partial' immunity in the guinea-pig, and 'complete' immunity may follow a further inoculation of living virus: this formalised vaccine is being tested for its protective powers in cattle against natural infection with foot-and-mouth disease. Another method which may be of use in the protection of cattle is to inoculate first with serum and then with the living virus. These observations suggest possibilities of the ultimate protection of farm animals, which are encouraging and may form the basis of future work along these lines.

[1] Ministry of Agriculture and Fisheries. Second Progress Report of the Foot-and-Mouth Disease Research Committee. Pp. 117. (London: H.M. Stationery Office, 1927.) 3s. net.

Recent Studies of Skilled Performances, with Reference to the Transfer of Training.[1]

By Prof. T. H. PEAR.

THE popular descriptions of a person as 'clever with his hands,' or 'clever with his head,' raise some intricate problems for physiology and psychology, and in the sphere of applied science, for education, industry, and sport. For the latter vague phrase the concept of 'intelligence' has been substituted, with substantial empirical support. Tests of intelligence give results which correlate highly with each other. For the former phrase, attempts to substitute the concept of 'motor ability' (strictly speaking, of motor capacity) have met with unforeseen and interesting difficulties. For while there seems ample evidence for the existence of a 'general intelligence,' the results of simple tests for isolated motor performances as far as possible excluding intelligence, show extremely low or even negative correlations with each other. Results along these lines corroborating earlier work by Wissler have been obtained by F. A. C. Perrin and Bernard Muscio. Moreover, in these investigations there seems to be no support for a belief in the correlation between simple motor abilities and 'intelligence.'

From such results, far-reaching inferences have been drawn, as that there is no 'general motor

[1] Substance of a paper read before the Manchester Literary and Philosophical Society on April 26.

capacity,' no ' motor type ' of person, and the practical conclusion that tests for ability in any performance give valid results only when the test performance is identical with that for which the test is being administered.

It is possible to offer an alternative explanation of these results, based upon the suggestions of Sir Henry Head. The test involves the simplest muscular co-ordinations, many of them confined to limited parts of the body. Intelligence was deliberately excluded so far as possible from the tests used by Muscio. Consequently the bodily mechanisms involved in the test performances may have required comparatively low levels of the nervous system. The test results would not exclude the possibility that a higher, more complex power may use and co-ordinate these simple mechanisms in ordinary ' skilled ' performances.

In this connexion it is important to consider the rôle of the motives in acquiring muscular skill. It cannot be assumed that those motives urging university graduates and undergraduates (the performers in these tests) to do their very best in a simple, apparently trivial, and often boring motor test are identical with those producing keenness in a test of intelligence.

There appear to be reasons for restricting the word skill to more complex motor performances, a skilled human action being described as a highly integrated learned adjustment. The above tests would then be described as of simple motor *abilities*.

Another method of investigating the problem of 'motor ability or motor abilities' is to reset it in the form of the ' transfer of training.'

Subjects may be intensely trained in some definitely skilled activity, so that their curve of practice shows a considerable rise over a long period. It may then be discovered whether the undoubted ability gained in the test activity has been transferred to apparently closely related performances. Such an investigation obviously requires controls of a kind which cannot be described here.

Though much work upon the relation of general to specific training has been done with regard to such powers as memory, sensory discrimination, etc., little is known of this problem as it relates to skill. Recently, C. E. Beeby has investigated the transfer of ability between performances requiring the use of one or both hands. He found an *initial positive transfer* which gradually diminished with further practice until it became a *final negative transfer* or interference. The actual amounts of transfer (initial and final) in his tests were the same whether it took place from (*a*) one hand to the other, (*b*) a double-handed action to one of the single-handed movements comprising it, (*c*) a single-handed to a double-handed action. He concludes that the only transfer was of general mental attitude. There was no evidence of positive transfer of specific habits of manipulation. Nothing but interference was shown between these specific habits. This it is which explains the final negative transfer as distinct from the initial positive transfer, due to ' carry over ' of mental attitude.

An extensive investigation into the transfer of motor training is being carried out, under the auspices of the Industrial Fatigue Research Board, by J. N. Langdon and Edna M. Yates. Certain experimental conditions (such as adequate motivation of the learners, a skilled performance as the test-activity, the training of controlled subjects under comparable conditions, the simultaneous provision of analytic tests) being strictly observed, it is possible that the results will be of interest to psychology, industry, and sport.

University and Educational Intelligence.

CAMBRIDGE.—Mr. H. E. Woodward, Trinity College, has been appointed University lecturer in engineering. Dr. C. M. Yonge, Edinburgh, has been elected Balfour student. The Faculty Board of Mathematics proposes the restoral of the title ' Stokes Lecturer ' to be attached to one of the University lectureships in mathematics.

The report of the Committee for Geodesy and Geodynamics gives the result of the pendulum observations made in July 1921 by Mr. G. Manley on Sabine Island. Helmert's value for g at sea-level at latitude 74° 32′ 19″ N. is 982·849. Sabine's determination gave 982·785, while Manley's value is 982·888. The larger value of g is what would be expected at an island station, judging from other observations elsewhere. The pendulums used by Mr. Manley in Mr. Wordie's expedition to East Greenland are the same as those taken with the Scott expedition to the Antarctic. It is welcome news that the Ordnance Survey and the Geographical Section of the General Staff propose to co-operate in a gravity survey of Great Britain.

Research studentships are advertised at Pembroke College, the Stokes studentship in mathematical or experimental physics, physical chemistry or the study of physical laws in relation to living matter ; at Clare College, the Denman Baynes studentship in mathematics, physics, or chemistry ; and at Peterhouse, the Charles Abercrombie Smith studentship for research in any approved subject.

EDINBURGH.—As Munro Lecturer for the present year, Prof. G. Baldwin Brown is delivering a course of ten lectures during this term on " The Activities of Prehistoric Man in their Relation to the Origins of the Arts."

On June 6 and 7, Dr. H. H. Dale delivered the two Cameron prize lectures for this year, taking as his subjects " The Nature and Action of Insulin " and " Capillary Circulation and its Chemical Control."

Mr. Thomas Cowan, of Leith, has offered the University a sum of £40,000, the interest of which is to be used to meet administration and maintenance costs of the University hostel with which his name is to be associated through previous gifts to the University.

OXFORD.—Prof. A. M. Carr-Saunders of Magdalen College, professor of social science at the University of Liverpool, has been appointed Herbert Spencer Lecturer for 1928.

A RESEARCH fellowship of the value of £500 is being offered by the Australian Federation of University Women to women graduates of British universities, excluding those of Australia, Tasmania, and New Zealand. The fellowship is for research in biology, anthropology, geology, economics, or colonial history. Applications must be received by June 30, by the Secretary, British Federation of University Women, Crosby Hall, Cheyne Walk, S.W.3.

A LIMITED number of research scholarships in technology, each of the value of not more than £100, will be awarded by the Manchester College of Technology in July next. Research may be undertaken in any of the following departments :—mechanical engineering, electrical engineering, municipal and sanitary engineering, applied chemistry, textile industries, photographic technology, printing, and industrial administration. Forms of application, returnable by, at latest, July 6, may be obtained from the Registrar of the College.

AT the annual meeting of shareholders of the Burmah Oil Company, held in Glasgow on June 10, Sir John Cargill announced that the directors had offered £100,000 to establish a college of mining and engineering in the new University of Burma, to be associated in some way with the name of the company.

THE Medical Research Council announces that on behalf of the Rockefeller Foundation the following awards of medical fellowships provided by the Foundation and tenable in the United States of America during the academic year 1927–28 have been made. These fellowships are awarded to graduates who have had some training in research work either in the primary sciences of medicine or in clinical medicine or surgery, and are likely to profit by a period of work at a university or other chosen centre in America before taking up positions for higher teaching or research in the British Isles: Mr. R. W. F. Collis, King's College Hospital, London; Dr. D. Krestin, London Hospital; Mr. G. L. Peskett, University of Oxford; Dr. Isabella M. Robertson, Maudsley Hospital, London; Mr. T. Tennant, Maudsley Hospital, London; and Dr. E. W. Todd, St. Mary's Hospital, London.

FROM the League of Nations Union we have received two pamphlets dealing with topics which might well come before the Imperial Education Conference to be held on June 20. They deal with the League of Nations as a subject of instruction in the schools of Great Britain. One is a report on work done by the Union to promote such instruction. It shows that the measures recommended by the League's sub-committee of experts on the subject, in so far as they depend on the initiative of voluntary associations, have already been adopted energetically and successfully in Great Britain, where they are perhaps less needed than elsewhere. The other pamphlet, "The Schools of Britain and the Peace of the World," is a memorandum signed by representatives of all classes of secondary and elementary schools as well as training colleges. The signatories express agreement with the League's experts on the main issue and, so far as they do not trench on the freedom of teachers, their detailed recommendations. They point out that "the study of international co-operation in the modern world should develop from those studies of modern history and geography which form part of the general school education of every boy and girl," but do not recommend for it a separate place in the curriculum. They uphold the Wilsonian doctrine of loyalty to humanity, which should not be difficult for a citizen of the British Commonwealth—itself a model League of Nations: "Disloyalty to the whole involves disloyalty to every part, including one's own state." Appended are some useful notes by Mr. F. S. Marvin on the international aspects of history.

A NOTE on the International Labour Organisation of the League of Nations has been prepared by the League of Nations Union and associations of teachers as an addendum to the "Schools of Britain" pamphlet, referred to in the preceding paragraph, which was submitted to the Board of Education for consideration in connexion with the National Conference of Education Authorities in Great Britain and Northern Ireland. The note directs attention to the modern tendencies to emphasise, in the teaching of history and geography in schools, social developments and industrial conditions rather than names of celebrities and dates of events and names of towns and rivers. It points out that the proposal that the social activities of the League, and, in particular, of the International Labour Organisations, should be noticed in the course of history and geography lessons accords well with these tendencies.

Calendar of Discovery and Invention.

June 19, 1799.—Goethe under this date wrote: "Late in the evening, when the twilight was passing into a clear night, as I was walking up and down with a friend in the garden, we remarked very plainly about the flowers of the Oriental poppy, which were distinguishable above everything else by their brilliant red, something like a flame. We placed ourselves before the plant, and looked steadfastly at it, but could not see the flash again, till we chanced in passing to look at it obliquely; and we could repeat the phenomenon at pleasure."

June 20, 1773.—The famous Collège de France, founded by Francis I. in 1530, has been the home of many eminent scientific men. In the seventeenth and eighteenth centuries, however, its chairs were often given as rewards for social service. Its reorganisation was due to an Order in Council of June 20, 1773, and after this it became the rendezvous of fashionable crowds who thronged to hear the lectures of Lalande, Rouelle, Daubenton, and others. Biot, Ampère, Regnault, and Berthelot have been among its most famous professors.

June 21, 1835.—In 1830 the Emperor of Russia declared "that the honour of the country appeared to him to demand the establishment, near the capital, of a new astronomical observatory, conformable to the actual state of science, and capable of contributing to its ultimate advancement." The outcome of this was the erection of the magnificent observatory of Pulkowa, the foundation-stone of which was laid on June 21, 1835. Gould once described Pulkowa as the astronomical capital of the world.

June 21, 1849.—Joule's work on the connexion of heat and work was done between 1840 and 1850. He employed various methods in his experiments, but his final results were obtained with the water-friction apparatus now preserved in the Science Museum, South Kensington. His epoch-making paper which gave us the unit, 772 foot-pounds, was entitled, "On the Mechanical Equivalent of Heat," and was communicated to the Royal Society on June 21, 1849, by Faraday.

June 21, 1860.—In 1839 Hooker sailed for the Antarctic with Sir James Ross. The expedition was away four years. One of the results of Hooker's work was his valuable memoir, "Outlines of the Distribution of Arctic Plants," read before the Linnean Society on June 21, and published in the Society's *Transactions* with a map.

June 22, 1857.—When the Great Exhibition of 1851 closed, the Commissioners had a balance of about £180,000. With this they bought the tract of land at South Kensington on which now stand the National Museums and Colleges. The first of these to be erected was the South Kensington Museum, which formed the nucleus of the Victoria and Albert Museum and the Science Museum. The original building, an ugly iron structure long known as the 'Brompton Boilers,' was opened by Queen Victoria on June 22, 1857. The present Victoria and Albert Museum was opened by King Edward in 1909, while the first part of the new Science Museum is nearing completion.

June 24, 1784.—The Council of the Royal Society having petitioned George III. for funds to carry out a geodetical survey for connecting the observatories of Paris and Greenwich, on June 24, 1784, the president informed the Council that the King had agreed to the undertaking, "and had permitted Major-General Roy to proceed in the execution of the plan under the direction of the President and Council of the Royal Society." E. C. S.

Societies and Academies.

LONDON.

Association of Economic Biologists, May 13.—Lieut.-Col. A. T. **Gage**: Alkaloids are yielded chiefly by the following plants, *Aconitum Napellus* L. (aconite); *Berberis aristata* DC. (berberin); *Papaver somniferum* L. (morphine and other alkaloids); *Camellia Thea* Link. (caffeine); *Theobroma Cacao* L. (theobromine); *Erythroxylum Coca* Lamk. (cocaine); *Pilocarpus pennatifolius* Lem. (pilocarpine); *Physostigma venenosum* Balf. (physostigmine or eserine); *Conium maculatum* L. (conine); Cinchona, various species (quinine and allied alkaloids); *Coffea arabica* L. (caffeine); *Psychotria Ipecacuanha* Stokes (emetine); *Strychnos Nux vomica* L. (strychnine); *Nicotiana Tabacum* L. (nicotine); *Datura Stramonium* L. (daturine); *Atropa Belladonna* L. (atropine); *Hyoscyamus niger* L. (hyoscamine); *Claviceps purpurea* Tul. (ergotine).—T. A. **Henry**: During the century that has elapsed since the discovery of the first alkaloid, morphine, great progress has been made in our knowledge of these indispensable drugs. Such well-known alkaloids as cocaine and atropine have been made in the laboratory, the synthesis of quinine and the related cinchona alkaloids may be expected at any time and, except in minute details, experts are now agreed as to the structure of even such a difficult alkaloid as morphine. Though supplies of alkaloids are still drawn wholly from natural sources, there has been no intensive study of the bio-chemistry of alkaloids, and virtually nothing is yet known regarding either the methods by which alkaloids originate in plants or the part they play in plant physiology.

Royal Microscopical Society, May 18.—R. R. **Gates** and J. **Latter**: Observations on the pollen development of two species of Lathræa. The two species of Lathraea, *L. clandestina* and *L. squamaria*, are similar in all stages of pollen development, the haploid chromosome number in each being twenty-one. Crystal-like bodies are present in the nucleoli of the resting pollen mother-cells. The threadwork remains a reticulum after synizesis, and chromosome formation apparently takes place by the chromatin flowing into definite aggregations irregularly distributed along the branched threads. In diakinesis the filaments connecting the chromatic aggregations are absorbed and the bivalents become independent of one another. During the entire process of chromosome formation the reticulum is connected to the nucleolus, dark-staining nucleolar bodies marking the points of attachment. The portions of thread nearest the nucleolus are sometimes much thickened as though by an exudation of nucleolar material. The method of chromosome pairing is intermediate between parasynapsis and telosynapsis. The heterotypic and homotypic divisions occur normally, except for an extremely late appearance of the homotypic split. Cytomyxis is observed in prophase and interkinesis. The tapetum on the outer wall of the loculus is differentiated from that on the inner, the former being constantly uninucleate, the latter binucleate throughout all the stages of pollen development.—James **Lomax**: The preparation and examination of coal sections. Sections sufficiently large to enable the whole thickness of a coal seam to be examined in detail have been prepared. All coals are composed of the remains of vegetable matter which can be divided into four components, clarain, vitrain, durain, and fusain. Clarain, which forms the bulk of most British coal seams, has a bright lustrous appearance and is composed of a mixture of leaves, wood, resinous bodies, etc., in a matrix of structureless material. Vitrain also has a bright lustrous appearance, but usually breaks with a conchoidal fracture. It is derived from wood in which all trace of structure has been destroyed, and usually occurs in thin bands and lenticles in the other components. Durain is a dull variety of coal composed mainly of the exines of megaspores and microspores; it often contains a high percentage of ash, but if pure it forms some of the best British coals. Fusain, commonly known as 'mother of coal' or 'mineral charcoal,' is very soft and has a dull black appearance. It occurs as thin bands and lenticles and is present in all coal seams. It is derived from wood from which all the volatile matter is driven off, but the cellular structure is often well preserved.

Physical Society, May 27.—Edgar A. **Griffiths** and Ezer **Griffiths**: A duplex reversal key with mercury contacts. The key employs mercury contacts and is enclosed in a glass casing. The two upper fixed contacts consist of downwardly projecting copper rods, the two lower fixed contacts of cups containing mercury, and the two movable contacts of downwardly projecting copper rods (which enter the fixed cups in one position of the switch) surmounted by cups of mercury (which receive the fixed rods in the other position of the switch). The connexions are those of a reversing switch, and the middle contacts can be raised or lowered by turning a vertical shaft which is retained in either position by a jockey spring.—L. **Hartshorn**: The measurement of the inductances of four terminal resistance standards. The method of measurement is an application of the Kelvin double bridge, used with alternating current, the phase angle adjustment being obtained by condensers shunting the ratio arms. The bridge is free from stray fields, practically independent of frequency, capable of use with almost any desired current strength, and is very easy to work.—C. **Chree**: Magnetic disturbance and aurora as observed by the Australasian Antarctic Expedition at Cape Denison in 1912 and 1913.

SHEFFIELD.

Society of Glass Technology. April 27.—W. E. S. **Turner**: A brief review of furnace development. (*a*) A saving in fuel has been obtained by the newer types of recuperative or regenerative furnaces; (*b*) heavy expense was incurred by the practice of founding only once a week; (*c*) the fuel consumption was greatly increased when the eye of the furnace had worn big. The efficiency of modern British pot furnaces compares favourably with those of Germany. Among the improvements effected during the last few years in furnace design have been (1) greater compactness, (2) better utilisation of waste heat, (3) the introduction of tangential burners, and (4) sillimanite sieges. Tank furnace practice generally on the Continent has not reached the British attainment, which is now equal to anything yet achieved in America. Among the problems which still require more thorough examination are: (*a*) Design of ports; end ports in some cases appear to give longer life to tank blocks; (*b*) bridges, the form of the basin and whether there should be one or two dog-houses; (*c*) depth of the refining end of the tank, whether it should be less than than at the melting end; (*d*) increased insulation in various parts of the furnace crown, side-walls, etc., and (*e*) utilisation of waste heat.

PARIS.

Academy of Sciences, May 9.—Jean **Perrin**: Fluorescence and molecular induction by resonance.

Charles Richet: The conditions of death in electric tetanus in fishes. In fishes, death by electric shock occurs more quickly in small than in large fish of the same species. Fish of different species differ greatly in their resistance to electric shock, and death by electrification is more rapid the higher the temperature of the fish.—A. Bigot: The conditions of deposit of the lower Bathonian in the Bessin and in the region of Caen.—Gaston Julia: The conformal representation of simply connected areas.—Maurice Gevrey: Green's functions: the image point, frontiers with singular points.—Mlle. N. Bary: The finite representation of continued functions.—Haroutune Anjour: New types of the case of movement of the solid body.—G. Reboul: The mechanism of the emission of a radiation by cells of great electrical resistance.—V. Dolejšek: Remarks on the principle of combination.—Privault: The action of the antioxygens on fluorescence. The introduction of a considerable quantity of hydroquinone into a fluorescent solution causes a diminution in the fluorescent power, which almost completely disappears in a concentrated solution of hydroquinone. It is probable that all antioxygens will prove to act similarly.—Francis Perrin: Induced de-activation of the molecules and the theory of antioxygens.—Mlle. Suzanne Veil: The evolution of the hydrate of cobalt sesquioxide in the presence of water. The changes undergone by the hydroxide are followed by the changes produced in the magnetisation coefficient.—Jean Bayol, Paul Marcelin, and Lucien Mayet: A cave with drawings on the walls of the reindeer age in the valley of Gardon: the 'Baoumo-d'en-aut' at Collias (Gard). This cave contains, besides human bones, remains of reindeer, horse, and other animals. It is remarkable for the drawings on the walls—painted, and not engraved.—A. Maige: Remarks concerning the origin of the amylase in plant cells.—Maurice Lenoir: The formation of antipodal nuclei in the embryonic sac of *Fritillaria imperialis*.—George F. Jaubert: The origin of the coloration of beeswax and the composition of propolis. The colouring matter has been identified as 1·3-dioxyflavone. This is derived from the propolis and is not present in the beeswax before melting out.—Auguste Lumière and Mme. Montoloy: The mode of action of autohæmotherapy.—S. Schmidt: The velocity of flocculation and velocity of neutralisation of the antitetanus serum towards the tetanus toxin. The value of a tetanus antitoxin does not depend solely on the amount of antitoxin in the serum; the velocity of flocculation is also an important factor.

BRUSSELS.

Royal Academy of Belgium, Oct. 9.—M. Dehalu: A law of gravitation analogous with that of Einstein.—J. E. Verschaffelt: The trend of the curves of fusion and of sublimation of a pure body.—Paul Stroobant: Discovery and observations of minor planets at the Royal Observatory of Uccle.—Th. de Donder: (1) Contribution to the relativistic quantification. (2) Electrostriction deduced from the Einsteinian gravific.—Fréd. Swarts: (1) Trifluoracetylacetic acid and ester. The great stability of trifluoracetic acid suggested that the condensation of ethyl trifluoracetate with ethyl acetate to form trifluoracetylacetic acid might be possible, and this reaction has been found to take place. The acid is very stable; it can be crystallised and even distilled. (2) Trifluoracetylacetic ester. (ii.) Details of the preparation study of the enol $\rightleftharpoons$ ketone equilibrium. (3) Trifluoracetylacetic acid.—Lucien Godeaux: Researches on algebraic surfaces of genus zero and bigenus unity.—P. Swings: The Riemannian potentials and the Einstein quadratic forms in the problem of two bodies.—A. Macq: Contribution to the study of the unsaturated nitriles of the fatty series.—F. Petit: Contribution to the study of the reaction between the organo-magnesium compounds and the nitriles. The γ-aminonitriles. γ-piperidobutyronitrile behaves as a pseudo acid towards magnesium compounds of the fatty series and there is no synthetic reaction. With the phenyl and benzyl magnesium compounds, on the contrary, the reaction is normal.—M. Theunis: Contribution to the study of the reaction of the organo-magnesium compounds on the nitriles. The α-chloronitriles.—Marc de Hemptinne: The thermal expansion of metallic combinations. The coefficient of expansion of a series of silver-antimony alloys has been measured by means of a simple instrument, a description and diagram of which is given. The abrupt change in the coefficient of expansion for the alloy containing 73 per cent. silver, gives clear indication of the existence of the compound Ag_3Sb.—Théodore Van Hove: (1) Contribution to the study of the nitration of the mixed dihalogen derivatives of benzene. Experiments on the nitration of *p*-bromfluorbenzene. (2) Second communication. Study of the nitration of *p*-iodofluorbenzene and *p*-iodochlorobenzene.—G. Balasse and O. Goche: Study of the luminescence of cæsium vapour in the electrodeless discharge.—Maurice Nuyens: The electron with internal pressure.

Nov. 6.—Th. de Donder: The electronic gas.—Constant Lurquin: The law of probability of Cauchy.—Georges Homès: The electrodeless discharge and active nitrogen. Details of the phenomena produced in nitrogen by the electrodeless discharge and discussion of the interpretation of the results obtained.

Dec. 4.—J. Capart: The excavations at Spiennes. The committee appointed to investigate the discoveries of M. Rutot had not been able to confirm them.—Lucien Godeaux: Researches on the algebraic surfaces of genus zero and bigenus unity.—H. Buttenbach: Description of a mineral from Katanga. This mineral was found in the Prince Leopold mine at Kipushi and has been tentatively named kipushite. It is a basic phosphate of copper and zinc $(Cu,Zn)_3(PO_4)_2 + 3(Cu,Zn)(OH)_2 + 3H_2O$. A complete crystallographic study is given. The same mineral has been discovered in the Rhodesian Broken Hill mine.—A. Juliard: The formation of ozone by the silent electric discharge in the presence of foreign gases. In the presence of hydrogen, silicon tetrafluoride, nitrogen and nitric oxide, the yield of ozone is lowered, other conditions remaining constant. This result is in contradiction with some of the earlier work on the same subject.—G. Gilta: The crystalline form of sodium β-glycerophosphate.—Théodore Van Hove: Some researches on the direct introduction of substituting groups in the aromatic mercaptans. Studies in the bromination, nitration, and sulphonation of thiophenol.

Dec. 15.—A. Rutot: Remarks on the discoveries at Spiennes.—Victor Van Straelen: The first remains of medusæ found in the carboniferous limestone of Belgium.—Jeanne Terby: Study of the chromocentres of the cells of the root nodosities of the Leguminoseæ.

ROME.

Royal National Academy of the Lincei, April 3.—V. Volterra: The periodicity of biological fluctuations. The author has already extended to the hereditary case the three laws of biological fluctuations, the modifications which they undergo being indicated. It is now shown that in the same case small periodic fluctuations round the stationary state are incapable of existence.—F. Severi: (1) Reflections on the area of a curved surface; (2) Further with regard to the

area of a curved surface.—G. Albanese: The fundamental theorem of the base for the whole of the curves of an algebraic surface.—G. Dubourdieu: Groups of holonomy of Riemann spaces of four dimensions. Case of a definite and positive ds^2.—G. Andreoli: Curvature and parallelism on a surface.—L. Fantappiè: The analytic functionals of functions of two complex variables.—U. Crudeli: The motions of a viscous (homogeneous) liquid symmetrical with respect to an axis.—M. L. Pagliarulo: Natural refractive and rotatory dispersion of aqueous solutions of monoethyl aspartate. This ester exhibits anomalous natural rotatory dispersion, the curve showing at the wave-length region 5300-6300 Å.U., a bend similar to that of the curve of refractive dispersion when absorption bands occur. The refractive dispersion curve runs perfectly parallel to that of water, but the curve representing the increments for 100 Å.U. shows a flattened portion, the middle of which coincides with the bend of the rotatory dispersion curve. Thus, monoethyl aspartate exhibits a vibration with characteristic frequency corresponding with wave-length 5780 Å.U.—G. Malquori: The system, $AlCl_3$—KCl—H_2O at 25°. No double salts are observed in this system, the two solid salts existing in contact with the solutions being $AlCl_3$, $6H_2O$, and KCl. Thus, although anhydrous aluminium chloride readily forms double compounds, no tendency in this direction is shown by the hydrated salt.—P. Aloisi: Approximate determination of 2V in thin mineral sections.—R. Savelli: The genetic value of the products of *Nicotiana rustica* × *Nicotiana tabacum*.

VIENNA.

Academy of Sciences, Mar. 24.—E. Röggla: The theory of errors on a geometrical foundation.—A. Tauber: On the integration of linear differential equations.—H. Benndorf: Contributions to our knowledge of atmospheric electricity (No. 68). Outlines of a theory of the electrical field of the earth. It is assumed that the conductivity of the atmosphere increases with height, so that at some 20 kilometres height the conductivity may be a hundredfold that at the ground level, and hence the field only one hundredth of that at the ground level, 99 per cent. of the charge being compressed within the lower 20 kilometres of the atmosphere.—L. Schmid and A. Waschkau: The phyto-sterins of beet oil.—K. Brunner, R. Grüner, and Z. Benes: Preparation of di-proprion-amide and di-iso-butyr-amide.—K. Brunner, M. Matzler, and V. Mössmer: Formation of amides.—K. Brunner and F. Haslwanter: Formation of nitro-phenyl-ethane-amides.—M. Holly: Mormyridæ, Characinidæ and Cyprinidæ from Kamerun.—P. Weiss: Tests of potency on the regeneration blastema of the lizard. In continuation of former experiments on Triton, portions of lizard's tails were transplanted to the foreleg of the same animal.—M. Kohn and J. Sussmann: Some halogen phenols derived from *o*-chloro-phenol.—M. Kohn and J. Sussmann: The di-phenyl-ether of 2, 5- di-oxy-quinone and allied compounds.—M. Kohn and J. Pfeiffer: Removal of halogen from bromo-phenols.—M. Kohn and J. Pfeiffer: Halogenation of chloro-phenols.

Official Publications Received.

BRITISH.

Stonyhurst College Observatory. Results of Geophysical and Solar Observations, 1926; with Reports and Notes of the Director, Rev. E. D. O'Connor. Pp. xiii+48. (Blackburn.)

Methods of Growing Large Metal Crystals. Being the Fourth Sorby Lecture delivered by Prof. H. C. H. Carpenter on Friday, October 22nd, 1926. Pp. 32+7 plates. (Sheffield: Department of Applied Science, The University.) 1*s*.

Manchester Municipal College of Technology. Prospectus of Short Courses of Lectures and Laboratory Work to be given during the Summer, 1927. Pp. 27. (Manchester.)

Transactions of the Royal Society of Edinburgh. Vol. 55, Part 1, No. 11: The Fish-Fauna of the Cementstones of Foulden, Berwickshire. By Errol Ivor White. Pp. 255-287. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.) 4*s*.

Sudan Government: Wellcome Tropical Research Laboratories, Khartoum. Report of the Government Chemist for the Year 1926. (Chemical Section, Publication No. 43.) Pp. iii+34. (Khartoum.)

The Journal of the Royal Agricultural Society of England. Vol. 87. Pp. 356+clxvi+x+20. (London: John Murray.) 15*s*.

Memoirs of the Department of Zoology, Panjab University. Vol. 1: Fauna of Karachi. i: A Study of the Genus *Eurythoe* (Family Amphinomidae). By S. S. Bindra. Pp. 18+2 plates. (Lahore: Panjab University.) 3 rupees.

Imperial Department of Agriculture for the West Indies. Report on the Agricultural Department, Dominica, 1925-26. Pp. iv+36. 6*d*. Report on the Agricultural Department, St. Kitts-Nevis, 1925-26. Pp. iv+30. 6*d*. (Trinidad, B.W.I.)

Journal of the Marine Biological Association of the United Kingdom. New Series, Vol. 14, No. 4, May. Pp. 837-1101. (Plymouth.) 10*s*. net.

Transactions of the Yorkshire Numismatic Society. Edited by T. Sheppard. Vol. 3, Part I. Pp. iv+56+2 plates. (Hull: A. Brown and Sons, Ltd.) 5*s*.

Journal of the Chemical Society: containing Papers communicated to the Society. May. Pp. viii+iv+961-1221. (London: Gurney and Jackson.)

Aeronautical Research Committee: Reports and Memoranda. No. 1070 (Ae. 252): Wind Tunnel Test of Aerofoil M.2. By H. Davies and F. B. Bradfield. (A.3.a. Aerofoils-General, 170.—T. 2363.) Pp. 5. (London: H.M. Stationery Office.) 4*d*. net.

A Report on Work done by the League of Nations Union to help in making known the League of Nations in the Schools and Colleges of Great Britain. Pp. 20. (London: League of Nations Union.)

The Schools of Britain and the Peace of the World. Pp. 35. (London: League of Nations Union.)

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich; read at the Annual Visitation of the Royal Observatory, 1927 June 3. Pp. 22. (Greenwich.)

Pasteur Institute of India, Kasauli. The Twenty-fifth Annual Report of the Central Committee of the Association and the Audited Accounts up to June 30th, 1926; also the Report of the Director of the Institute for the Year ending 31st December 1925. Pp. 80. (Kasauli.)

Kodaikanal Observatory. Bulletin No. 80: Summary of Prominence Observations for the first half of the Year 1926. Pp. 119-133. Kodaikanal.)

Records of the Geological Survey of India. Vol. 59, Part 4, 1926. Pp. viii+371-422+xxvi. (Calcutta: Government of India Central Publication Branch.) 2.12 rupees; 5*s*.

Memoirs of the Geological Survey of India. Palæontologia Indica, New Series. Vol. 10, Memoir No. 2: The Mollusca of the Ranikot Series (together with some Species from the Cardita Beaumonti Beds). By M. Cossman and G. Pissarro; revised by the late E. Vredenburg, with an Introduction and editorial Notes by Dr. G. de P. Cotter. Pp. v+31+4 plates. (Calcutta: Government of India Central Publication Branch.) 2.6 rupees; 4*s*. 3*d*.

Proceedings of the Edinburgh Mathematical Society. Edited by Dr. T. M. MacRobert and Prof. H. W. Turnbull. Series 2, Vol. 1, Part 1, May. Pp. 70. (London: G. Bell and Sons, Ltd.)

University College of Wales, Aberystwyth: Welsh Plant Breeding Station. Seeds Mixture Problems. (Series H, No. 6, Seasons 1923-1926.) Pp. 70+2 plates. (Aberystwyth.) 3*s*. 6*d*.

Proceedings of the South London Entomological and Natural History Society, 1926-27. Pp. xix+155+11 plates. (London.) 15*s*.

Proceedings of the Royal Society of Edinburgh, Session 1926-1927. Vol. 47, Part 2, No. 8: The Rôle of Inbreeding in the Development of the Clydesdale Breed of Horses. By A. Calder. Pp. 118-140. 2*s*. Vol. 47, Part 2, No. 9: Models Illustrative of the Atomic Process in Ferromagnetism. By Sir J. Alfred Ewing. P. 141. 6*d*. Vol. 47, Part 2, No. 10: The Salmon of the R. Grand Cascapedia, Canada. By W. L. Calderwood. Pp. 142-147+2 plates. 1*s*. 6*d*. Vol. 47, Part 2, No. 11: The Effects of Implantation upon Ovarian Grafts in the Male Mouse. By Y. Tamura. Pp. 148-164+2 plates. 2*s*. 3*d*. Vol. 47, Part 2, No. 12: Magnetisation and Temperature in Crystals. By Prof. W. Peddie. Pp. 165-176. 1*s*. Vol. 47, Part 2, No. 13: After Images of Coloured Sources. By Miss W. J. Smith. Pp. 177-189. 1*s*. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.)

FOREIGN.

Statens Meteorologisk-Hydrografiska Anstalt. Årsbok, 8, 1926. i: Månadsöversikt över väderlek och vattentillgång jämte anstaltens årsberättelse. Pp. 99. (Stockholm.) 2.50 kr.

Société des Nations: League of Nations. Bulletins de l'Institut International de Coopération Intellectuelle. Bulletin des relations scientifiques. 2me année, No. 2, Mai. Pp. 229-308. (Paris: Les Presses universitaires de France.) 8 francs.

Smithsonian Institution: United States National Museum. Contributions from the United States National Herbarium. Vol. 26, Part 1: The Lecythidaceae of Central America. By H. Pittier. Pp. v+14+12 plates. Bulletin 100, Vol. 2, Part 5: Contributions to the Biology of the Philippine Archipelago and adjacent Regions. The Shipworms of the Philippine Islands. By Paul Bartsch. Pp. 531-562+plates 53-60. 15 cents. Bulletin 100, Vol. 6, Part 3: Contributions to the Biology of the Philippine Archipelago and adjacent Regions. Report on the Hydroida collected by the United States Fisheries Steamer *Albatross* in the Philippine Region, 1907-1910. By Charles C. Nutting. Pp. 193-242+plates 40-47. 15 cents. (Washington, D.C.: Government Printing Office.)

Proceedings of the Imperial Academy. Vol. 3, No. 3, March. Pp. v-vi+115-193. (Tokyo.)

Report of the Aeronautical Research Institute, Tōkyō Imperial University. No. 22: Studies on Inflammability of Hydrogen. i: Influence of Ethyle Bromide on the Limits of Inflammability of Hydrogen-Air Mixtures. By Yoshio Tanaka and Yūzaburo Nagai. Pp. 249-258. 0.20 yen. No. 23: Studies on Inflammability of Hydrogen. ii: Influence of Organic Bromine and Iodine Compounds on the Upper Limit of Inflammability of Hydrogen-Air Mixtures. By Yoshio Tanaka and Yūzaburo Nagai. Pp. 259-261. 0.12 yen. (Tōkyō: Koseikai Publishing Office.)

Proceedings of the United States National Museum. Vol. 71, Art. 10: Notes on Fishes obtained in Sumatra, Java, and Tahiti. By Henry W. Fowler and Barton A. Bean. (No. 2682.) Pp. 15. (Washington, D.C.: Government Printing Office.)

Smithsonian Institution: United States National Museum. Bulletin 135: Life Histories of North American Marsh Birds; Orders Odontoglossae, Herodiones and Paludicolae. By Arthur Cleveland Bent. Pp. xii+490+98 plates. (Washington, D.C.: Government Printing Office.) 1.25 dollars.

Smithsonian Miscellaneous Collections. Vol. 78, No. 7: Explorations and Field-Work of the Smithsonian Institution in 1926. (Publication 2912.) Pp. iv+259. Vol. 80, No. 2: A Group of Solar Changes. By C. G. Abbot. (Publication 2916.) Pp. ii+16. (Washington, D.C.: Smithsonian Institution.)

Práce Moravské Přírodovědecké Společnosti, Brno, Československo. Svazek 2, Spis 11-20, 1925. Pp. iii+782. 120 Kč. Spisy Lékařské Fakulty Masarykovy University, Brno, Československá Republika. Svazek 4, Spis 33-40, 1926. Pp. iii+26+19+26+30+14+100+44+12. 40 Kč. Spisy vydávané Přírodovědeckou Fakultou Masarykovy University. Rok 1927, Čis. 80: O přechodu diferenční rovnice hypergeometrické v diferenciální rovnici Gaussovu (Sur le passage de l'équation hypergéométrique aux différences finies à l'équation différentielle de Gauss). Napsal Jos. Kaucký. Pp. 43. Rok 1927, Čis. 81: Était l'Ousboï pendant les temps historiques un ancien lit de l'Amou-Daria? Par Pr. Koláček. Pp. 8. Sborník Vysoké Školy Zemědelské v Brně, ČSR. Sign. C9: Váha semen pícních trav a její vztahy ke klíšení a vývoji klíčící rostlinky (Les poids des graines des graminées fourragères et son influence sur la germination et le développement de la plantule en germination). Napsal Josef Nadvorník. Pp. 65. Sign. D4: Nejlepší dusíkatá živina rostlinná (Le meilleur engrais azoté des plantes). Napsal Dr. Gustav Vincent. Pp. 66. Sign. D5: Seznam slovenského ptactva (Avium in Slovenia adhuc cognitarum enumeratio systematica). Napsal Prof. Josef Jirsík. Pp. 67. (Brno: A. Píša.)

CATALOGUES.

The Complete Catalogue of Chatto and Windus, 1927. Pp. 96. (London: Chatto and Windus.)

Supplement to List No. 157: Cambridge Illuminated Dial CO_2 Indicator. Pp. 2. (London: Cambridge Instrument Co., Ltd.)

Annotated and Classified Catalogue of Rare and Standard Works on Astronomy, comprising Chronology, Geodesy, Horology, Dialling and other collateral Subjects. (No. 804.) Pp. 240. (London: Henry Sotheran and Co.) 2s. 6d. net.

Microscopes and their Accessories. Part 4: Instruments for Metallurgy. Thirty-first edition. Pp. 56. (London: W. Watson and Sons, Ltd.)

Standard Catalogue of Scientific Apparatus. 1927 edition. Vol. 3: Biological Sciences. Pp. xxiv+501. Technical Research Series, No. 2: Apparatus required for the Testing of Petroleum Products. Pp. 44. Technical Research Series, No. 5: Analysis of Coal and its By-Products. Pp. xvi+136. (London: Baird and Tatlock (London), Ltd.)

Diary of Societies.

SATURDAY, JUNE 18.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, at 2.30.

PHYSIOLOGICAL SOCIETY (at Middlesex Hospital Medical School), at 4.—Demonstrations:—Prof. Swale Vincent and F. R. Curtis: The Adrenal Bodies of Teleostean Fishes (Microscopical Demonstration).—S. Wright and M. Kremer: Partition Coefficient of Ethyl Iodide.—J. Lee Warner: Interaction between Pituitrin and Insulin.—Communications:—R. D. Lawrence: A Relationship between Body Temperature and Blood Sugar in Rabbits.—A. R. Fee, A. Hemingway, and Prof. E. H. Starling: The Oxygen Usage of the Isolated Kidney.—R. K. Christy: A Chloride Shift between Blood and Tissues.—L. J. J. Muskens: On the Part played by the Supra-vestibular Connexions in Decerebrate Rigidity.—Prof. Swale Vincent and M. Kremer: Further Observations on Vaso-motor Reflexes.—S. Wright: Observations on the Ethyl Iodide Method for Determining the Circulation Rate.—T. Izod Bennett: Observations Concerning the Action of 'Synthalin' in Affecting Glycosuria in Human Subjects.—M. Kremer: On the Effect of Pituitrin on Renal Secretion in a Decerebrate Animal.—W. A. H. Rushton: The Dependence of the Threshold for Nervous Excitation upon the Position of the Electrodes.

ASSOCIATION OF ECONOMIC BIOLOGISTS (at South-Eastern Agricultural College, Wye).

NEWCOMEN SOCIETY FOR THE STUDY OF THE HISTORY OF ENGINEERING AND TECHNOLOGY (Summer Meeting).

MONDAY, JUNE 20.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—Prof. T. J. Jehu and R. M. Craig: Geology of the Outer Hebrides. Part IV. South Harris.—Dr. R. Campbell and Dr. J. W. Lunn: The Tholeiites of the Dalmahoy Syncline (Edinburgh District).—Dr. C. Crossland: Marine Ecology and Coral Formations in the Panama Region, Galapagos, and the Marquesas Islands, and the Atoll of Napuka.—W. G. Thomson: On the Discharge of a Condenser through a Gas at Low Pressure.—Prof. E. L. Ince: Researches into the Characteristic Numbers of the Mathieu Equation (third paper) (*to be read by title*).

ARISTOTELIAN SOCIETY (at University of London Club), at 8.—Prof. W. G. de Burgh: The Significance of the Argument from Design.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (jointly with Institution of Engineers and Shipbuilders in Scotland) (Summer Meeting) (at Glasgow), at 8.—Conversazione.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS (Summer Meeting) (at Bournemouth).

TUESDAY, JUNE 21.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (jointly with Institution of Engineers and Shipbuilders in Scotland) (Summer Meeting) (at Glasgow), at 10.30 A.M.—J. Mollison: Historical References to the Progress in the Use of High-Pressure Steam.—C. Le Maistre: The Trade Value of Simplification and Standardisation in the Details of Ships and their Machinery.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Sir Frederick Gowland Hopkins: The Task of Biochemistry (Croonian Lectures).

ROYAL STATISTICAL SOCIETY (at Royal Society of Arts), at 5.15.—D. Caradog Jones: Pre-War and Post-War Taxation.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS (Summer Meeting) (at Bournemouth).

WEDNESDAY, JUNE 22.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (jointly with Institution of Engineers and Shipbuilders in Scotland) (Summer Meeting) (at Glasgow), at 10 A.M.—J. McGovern: Economy in Shipbuilding: Some Lines of Progress.—F. L. MacLaren: Motor Yachts and Motor Yachting on the Clyde.

INSTITUTION OF WELDING ENGINEERS (at Engineers' Club, Coventry Street, W.), at 8.—A. H. Goodger: The Red-Shortness of Weld Metal.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS (Summer Meeting) (at Bournemouth).

THURSDAY, JUNE 23.

ELECTRICAL ASSOCIATION FOR WOMEN (Visit to Showrooms of Hailwood and Ackroyd, 98 Mansell Street, E.1), at 3.—Mr. Hailwood: The Manufacture of English Glassware.

ROYAL SOCIETY, at 4.30.—A. Caress and Dr. E. K. Rideal: The Combination of Nitrogen and Hydrogen activated by Electrons.—W. T. Astbury: A Simple Radio-active Method for the Photographic Measurements of the Integrated Intensity of X-Ray Spectra.—J. F. Lehmann and J. H. Osgood: The Total Ionisation due to the Absorption in Air of Slow Cathode Rays.—J. F. Lehmann: The Absorption of Slow Cathode Rays in Various Gases.—*To be read in title only*:—Prof. O. W. Richardson and F. S. Robertson: The Emission of Soft X-Rays by Different Elements.—Prof. E. V. Appleton and J. Ratcliffe: On the Nature of Wireless Signal Variations. I.—L. H. Martin: The Efficiency of K Series Emission by K Ionised Atoms.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (jointly with Institution of Engineers and Shipbuilders in Scotland) (Summer Meeting) (at Glasgow).

FRIDAY, JUNE 24.

PHYSICAL SOCIETY OF LONDON (at Imperial College of Science), at 5.—Sybil Marshall: Newton's Law for the Emission of Heat in Carbon Dioxide.—S. R. Humby: Some Experiments with Sound Waves of High Frequency.—J. J. Manley: Some Additional Refinements for Precision Balances.—Demonstration of the Use of a Magnetron to demonstrate the Rise of Current in an Inductive Circuit, by Dr. D Owen.

PUBLIC LECTURE.

SUNDAY, JUNE 19.

GUILDHOUSE (Eccleston Square, S.W.), at 3.30.—C. L. Woolley: Recent Discoveries at Ur.

CONVENTION.

JUNE 20 TO 23.

BRITISH PHARMACEUTICAL CONFERENCE (Annual Conference of the Pharmaceutical Society of Great Britain) (at Brighton).

Monday, June 20.—Reception by the Mayor of Brighton.
Tuesday, June 21.—Welcome by the Mayor of Brighton. Address by the Chairman of the Conference. Science Meetings. Delegates' Meeting.
Wednesday, June 22.—Science Meeting. Delegates' Meeting.
Thursday, June 23.—Visit to Eastbourne.

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Supplement to NATURE

No. 3007 JUNE 18, 1927

The Prediction of Eclipses.

By Dr. L. J. COMRIE.

THE fact that astronomers can predict, many years in advance, the time of a solar eclipse to within a few seconds, and the region on the earth's surface in which it will be visible to within a mile or so, will perhaps surprise the layman. Yet attention was directed to the forthcoming eclipse of June 29 more than half a century ago by the Rev. S. J. Johnson in his "Eclipses Past and Future."

These advance predictions are possible because eclipses pass through a definite cycle, or repeat themselves after an interval of 18 years 11⅓ days. To explain the reason for this, consider the conditions that lead to an eclipse. It is well known that the earth moves round the sun in a nearly fixed plane called the ecliptic. As seen from the earth the apparent motion of the sun in the heavens is along the great circle which represents the intersection of the ecliptic plane and the celestial sphere, or the ecliptic circle. If the motion of the moon round the earth were in the same plane, then once in every lunar month of 29½ days the moon would be in line with the sun, and an eclipse would result. Actually the plane of the moon's orbit is inclined to the plane of the ecliptic at an angle of 5°. This means that the great circle representing the moon's orbit crosses the ecliptic at two opposite points or nodes, while half-way between the nodes the nearest possible approach of the two bodies is 5°.

Should the sun happen to be within a certain limiting distance from either of these nodes at the time the moon crosses the ecliptic, there will be an eclipse, either partial or total. If the nodes remained fixed on the ecliptic, eclipses would take place at the same two seasons each year. Actually the nodes make a complete circuit of the ecliptic in a backward or retrograde direction in a little less than nineteen years, so that the sun, in its annual course through the ecliptic, returns to the same node, not in 365·24 days, but in 346·62 days, a period called the eclipse year. Nineteen of these periods equal 6585·78 days. The interval between successive conjunctions of the sun and moon, or, in other words, the interval between successive new moons, is called the synodical month, and is 29·53 days. 223 of these lunations contain 6585·32 days. That is to say, if the sun and moon at any given moment are in conjunction at or near a node, so that an eclipse is in progress, then after 6585·32 days they will again be in conjunction and in the immediate neighbourhood of a node, so that another eclipse will occur.

The circumstances of an eclipse vary considerably with the distance of the moon from the earth—from an annular eclipse when the moon is at its maximum distance of about 257,000 miles to a long total eclipse of perhaps six or seven minutes' duration when the distance is as small as 223,000 miles. The interval between successive returns to the same distance from the earth, or the anomalistic month, is 27·55 days, and 239 of these intervals are 6585·54 days. Thus not only is there a repetition of the eclipse after 6585 days, but also it will occur under practically the same conditions.

This most useful period of recurrence was known to the Chaldeans as the Saros, and formed the basis of their very successful eclipse predictions. It is still used for the purpose of fixing the dates on which eclipses will occur, although the details of the eclipses are obtained by more refined methods.

One question must be answered. Why was not a total eclipse visible in England eighteen years ago, in 1909? The reason is that 223 lunations exceed 6585 days by about 8 hours, and in that time the earth has rotated, so that successive corresponding eclipses occur, on the average, 120° of longitude farther to the west.

Mention should be made here of Oppolzer's celebrated "Canon der Finsternisse" (Vienna, 1887), which gives particulars of all eclipses between 1207 B.C. and A.D. 2161, together with maps showing the central lines of total eclipses. An inspection of these maps indicates that the eclipse of 1999 will be total in Cornwall only, and that the next total eclipse visible in England in 2135 is the first of a group of four that will be seen in

the course of 25 years, namely, in 2135, 2142, 2151, and 2160.

The accurate prediction of a solar eclipse is dependent ultimately on accurate predictions of the positions of the sun and moon. These bodies have been carefully observed with meridian circles for more than two centuries. The principal object in founding the Royal Observatory at Greenwich was the making of these observations, and to this day unrelaxing efforts are made to observe every meridian passage. In the hands of those masters of celestial mechanics, Delaunay, Hansen, Leverrier, Newcomb, Hill, and Brown, these observations and Newton's gravitational theory have led to tables from which the positions of the sun and moon for any date in historical times, or for centuries to come, may be found. Even the eclipses recorded by the ancients have contributed to these tables, for it is evident that the tables should reproduce the eclipses as observed.

The tables used by the "Nautical Almanac" are Newcomb's "Tables of the Sun" and Brown's "Tables of the Moon." The latter is a ponderous tome, too heavy, when bound, to be accepted by the British Post Office! Its two million figures, printed at Cambridge for the Oxford University Press, are the life-work of an English-born professor living in the United States. It requires the continuous efforts of two highly skilled computers to produce from these tables the hourly ephemeris of the moon given annually in the "Nautical Almanac."

The problem of predicting the circumstances of an eclipse for a given point on a non-spherical rotating earth would at first sight seem hopelessly difficult. But the classical solution offered a century ago by Bessel, and later most ably expounded by Chauvenet, has, by the simplicity, beauty, and rigour of its conceptions, lived to this day.

The movements of the sun and moon are expressed by means of suitable rectangular co-ordinates on a fundamental plane through the centre of the earth, and at right angles to the line joining their centres. The shadow of the moon is a cone, the intersection of which with the fundamental plane is a circle. Upon this same plane the position of the observer is projected orthographically, and the projected distance from the origin, which is the centre of the earth, is resolved into components parallel to the previously chosen axes.

The co-ordinates x and y of the moon's centre, which are also the co-ordinates of the centre of the shadow, and those of the observer ξ and η, will be the same on a plane through the observer and parallel to the fundamental plane, but the radius of the shadow-cone, L, which is readily determined, will be different. The fundamental equation of eclipse prediction simply expresses the condition that when an eclipse is beginning or ending the observer is on the edge of the shadow cone, or his distance from the centre of the shadow cone is equal to its radius. Symbolically,

$$(x-\xi)^2+(y-\eta)^2=L^2.$$

The two times when this quadratic equation is satisfied represent the beginning and ending of an eclipse.

The quantities x and y, the dimensions of the shadow cone, and other functions which are independent of the position of the observer, are tabulated in the "Nautical Almanac" for each eclipse as Besselian elements. With the aid of these elements, complete predictions for any given place can be made in a few hours.

The difficulties which prevent the making of perfect predictions must now be reviewed. First, the diameters of the sun and moon. When a bright body is projected on a dark background it appears to be larger than its true size—a phenomenon known as irradiation. Hence the diameter of the moon as usually measured has to be considerably reduced for eclipse purposes; in fact, the so-called eclipse diameter, which is used in predictions, has been determined from eclipse observations alone. Further, the limb of the moon is irregular, owing to the presence of lunar mountains; on this account alone an exact prediction cannot be made, for a valley 1000 feet deep could affect the time of eclipse by a second or more, especially if the observer were near the northern or southern limit of totality.

Another difficulty lies in the unavoidable errors of the solar and lunar tables. These arise partly from the fact that some of the quantities required in their construction, such as, for example, the masses of perturbing planets, are exceedingly difficult to determine, even from a prolonged series of observations. Another contributory cause is the fact that there appear to be some unknown influences at work. Prof. E. W. Brown, formerly a pupil of the illustrious George Darwin, in the preface to his "Tables of the Moon," says: "While many efforts have been made in the past to represent the motion of the moon by gravitational theory alone, it is now admitted that this cannot be done completely. . . . There are oscil-

lating differences which do not correspond to any theoretical gravitational terms. . . . The causes of these differences . . . are matters of conjecture.[1] . . . Still more puzzling are certain oscillations with smaller amplitudes and shorter periods. . . . All that can be done is to make an estimate . . . from the observations of the past few years whenever it is desirable to predict the position of the moon with high accuracy, as in the case of an eclipse of the sun, and alter the values obtained from the Tables accordingly."

When the coming eclipse was first accurately predicted three years ago, a correction of +7″·0 was applied to the mean longitude of the moon as derived from Brown's "Tables," but, strangely, no correction was applied to the position of the sun. The Astronomer Royal, Sir Frank Dyson, has quoted the corrections to the longitude of the sun and moon derived from recent Greenwich observations as +1″·5 and +6″·5 respectively. When these corrections replace those formerly used, the effect is very slight; it amounts to a displacement of the central line and the zone of totality as shown on the Ordnance Survey Eclipse Map, the data for which were computed from the original elements, by just one mile in a north-westerly direction.

The residual uncertainty, after the application of these corrections, should be less than half a mile in the case of the central line, and not more than a mile in the case of the northern and southern limits of totality.

The co-ordinates of the central line, and the circumstances of the eclipse along this line, are given in the table below:

G.M.T.	Longitude.	Latitude.	Sun's Altitude.	Sun's Azimuth.	Duration.
	° ′	° ′	°	°	m s
5h 23m 0s	+4 55·0	52 32·1	9·8	64·2	20·9
10	4 35·6	52 43·3	10·1	64·5	21·2
20	4 16·7	52 54·3	10·3	64·8	21·5
30	3 58·3	53 5·0	10·6	65·1	21·7
40	3 40·3	53 15·5	10·9	65·4	22·0
50	3 22·8	53 25·8	11·1	65·7	22·3
5 24 0	+3 5·7	53 35·8	11·4	66·0	22·6
10	2 48·9	53 45·7	11·6	66·3	22·9
20	2 32·5	53 55·4	11·8	66·5	23·2
30	2 16·4	54 4·9	12·1	66·8	23·5
40	2 0·6	54 14·2	12·3	67·1	23·7
50	1 45·1	54 23·4	12·5	67·3	23·9
5 25 0	+1 29·8	54 32·5	12·7	67·6	24·2
10	1 14·8	54 41·5	12·9	67·8	24·4
20	1 0·0	54 50·3	13·2	68·1	24·6
5 25 30	+0 45·5	54 59·0	13·4	68·3	24·9

[1] Since the above was written, in 1918, several astronomers have suggested that the earth's period of revolution is variable, and have adduced evidence of a correlation between the anomalies in the motions of the Sun, Moon, Mercury, Venus, and Mars.

The Recurrence of Solar Eclipses.

By Dr. J. Jackson.

AMONGST the most remarkable of discoveries made by ancient astronomers was that of the recurrence of eclipses at intervals of 18 years and 10 or 11 days. We have no knowledge of the discoverer of this period, known as the Saros, but it was certainly known to the Chaldeans. In view of the irregularities of the early calendar, such a discovery must have presented great difficulties. The fact that the interval has an odd third of a day, so that the region of visibility of an eclipse is shifted about 120° in longitude at each return, greatly increases the difficulties of discovery, and it is possible that a period three times as long as the Saros was first discovered. As the area of the earth from which an eclipse can be seen extends over a large arc in longitude, it is possible for two consecutive members of a series of eclipses to be seen from the same place. The total eclipse visible in England on Aug. 11, 1999, is indeed four Saroses later than that of June 29 of this year, but whereas this year's eclipse is in the early morning, the eclipse of Aug. 11, 1999, will be visible in England shortly before noon.

The circumstances connected with the recurrence of eclipses depend on several variables with different periods, and the apparent irregularity with which eclipses occur results from the incommensurability of the periods and differences in their relative importance. The most important period is that between successive new moons, which on the average is 29·5306 days. An eclipse of the sun would take place at every new moon if the orbital planes of the sun and moon coincided,[1] but as the inclination of the two planes is considerable—varying round 5°—it is only when new moon occurs near the line of intersection of the two planes, known as the line of nodes, that an eclipse can take place. On account of the motion of the plane of the moon's motion, the sun passes through the nodes at intervals of less than six months, the average time being 173·310 days, and this is the second important period in connexion with eclipses. Eclipses take place at intervals which are very nearly multiples of 29·5306 days and are approximately multiples of 173·310 days.

The maximum angular distance which the sun

[1] If this were the case, however, all central eclipses would take place within the tropics, and the only eclipses that could be seen from England would be extremely small partial eclipses at the new moons near midsummer.

can be from the node at the time of an eclipse (known as the eclipse limit) depends on the distances of the sun and moon from the earth and the actual inclination of the orbital planes. It varies from $15\frac{1}{3}°$ to $18\frac{1}{2}°$. As the sun moves on the average almost exactly $2 \times 15\frac{1}{3}°$ relative to the nodes between successive new moons, and as it is moving most slowly when the eclipse limits are smallest, an eclipse occurs near every passage of the sun through a node. There are thus at least two solar eclipses every year, and there may be as many as five, the latter only occurring when the sun passes through a node near the beginning or end of the calendar year. Eclipses of the moon may take place at the full moons preceding and following eclipses of the sun, although for them the eclipse limits are smaller.

The Saros is connected with the two periods we have just mentioned. We have in fact

$$223 \times 29{\cdot}5306 \text{ days} = 6585{\cdot}32 \text{ days.}$$
$$38 \times 173{\cdot}310 \quad ,, \quad = 6585{\cdot}78 \quad ,,$$

The Saros is 6585·32 days. As the sun travels on the average about 1° a day, it describes in a Saros only about 28′ less than 19 revolutions relative to the nodes. As 28′ is a small fraction of the eclipse limits, we find a large number of eclipses recurring in a series.

The number of eclipses in a series varies one or two either way from seventy and extends over a period of 1200 years. Of these, about twelve or thirteen at each end are only partial eclipses, as the sun is so far from the node that the line going through the centres of the sun and moon passes clear of the earth. For the middle, forty-five or so, this line comes to earth, giving rise to a central eclipse which is total or annular according as the angular diameter of the moon or sun is the larger.

The eccentricity of the apparent orbit of the sun is small, so that the angular semi-diameter of the sun varies only from 15′ 46″ to 16′ 18″. Also we have seen the Saros differs from an exact number of years by about 11 days, so that at the recurrence of an eclipse the apparent diameter of the sun cannot have altered more than 3″. The eccentricity of the lunar orbit is larger, causing the apparent semi-diameter of the moon to vary from 14′ 42″ to 16′ 46″. On account of the rather rapid motion of the moon's apse, amounting to a whole revolution in about nine years, the interval between successive nearest approaches of the moon to the earth is on the average 27·55455 days and

$$239 \times 27{\cdot}55455 \text{ days} = 6585{\cdot}54 \text{ days.}$$

This differs from the Saros by only 0·22 of a day. This is a remarkable and important coincidence. It means that after a Saros the mean anomaly of the moon has altered by only about 2°·8 (decrease), and the apparent diameter of the moon, like the sun, has not altered by more than 3″. The con-

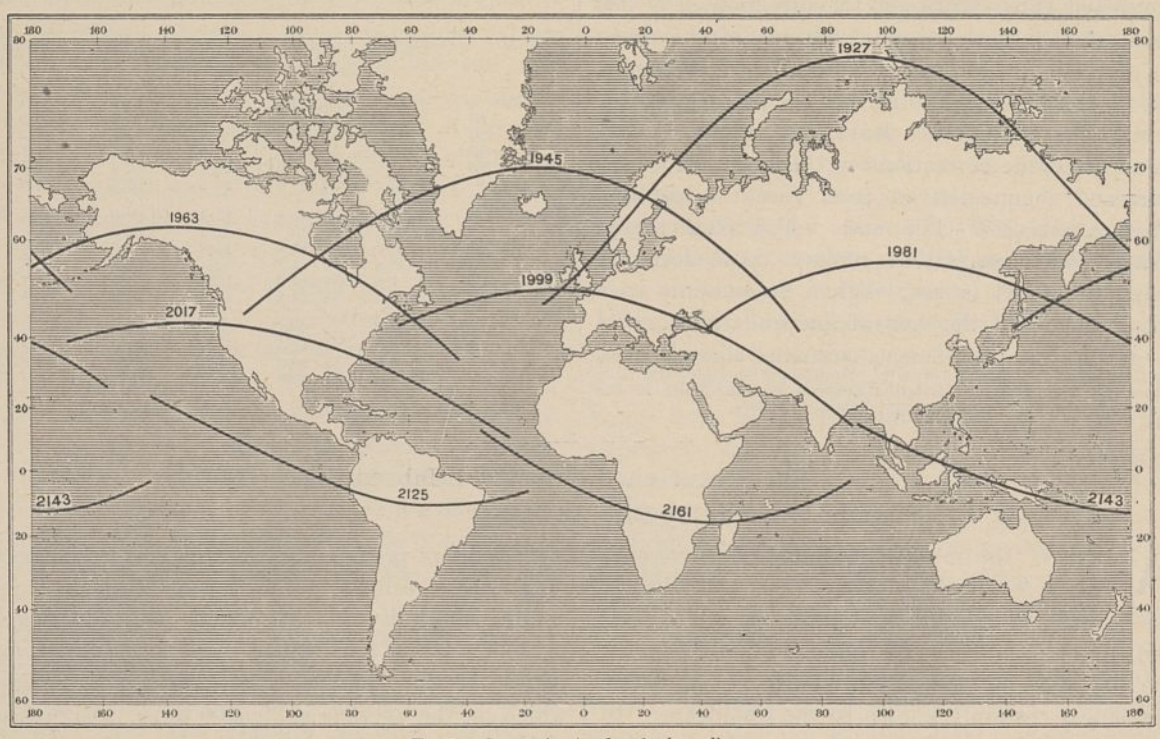


FIG. 1.—Successive tracks of solar eclipses.

sequence of all this is that the duration of totality in a series of eclipses varies slowly from one eclipse to the next, and that we have a series of total eclipses, or of annular eclipses. If the period of rotation of the lunar apse were twelve years instead of nine years, annular and total eclipses would alternate. It might be noted here that as a result of the moon returning to approximately the same distance from the earth after a Saros, its parallax is only slightly altered, and so the eclipse limits only slightly altered.

Let us now consider the series of eclipses to which that of June 29 of this year belongs. At the new moon of May 26, 1873, the central line from the sun to the moon passed just north of the earth and there was a large partial eclipse near the north pole. If we work backwards from this date at intervals of 18 years and 10 or 11 days, we find a series of decreasing partial eclipses near the north pole. Going forwards, we find that on June 6, 1891, the central line passed over the north pole but came to earth in northern Asia, producing an eclipse at midnight. This was an annular eclipse very nearly total, and was the first central eclipse of the series to which the eclipse of this year belongs. Eighteen years later, on June 17, 1909, there was an eclipse which crossed the earth near the pole. This eclipse was just total, although it was scarcely certain beforehand that it would be so. We then come to the total eclipse of this year. Proceeding onwards, we get a series of eclipses gradually lengthening in duration and working equatorwards, while the longitude on the earth where the eclipse takes place moves about 120° westward from each eclipse to the next.

The "Nautical Almanac" gave the semi-diameters of the sun and moon as seen from the centre of the earth for the eclipses of 1891, 1909, and 1927 as follows :

	Moon.	Sun.
1891 June 6 . .	15′ 42″·2	15′ 47″·5
1909 June 17 . .	43″·1	44″·3
1927 June 29 . .	46″·7	44″·0

These figures indicate the way in which the apparent diameter of the moon is gradually increasing relative to that of the sun. Also on the eclipse track the apparent diameter of the moon must be larger than from the earth's centre, so that the total eclipses of this series will be steadily lengthening.

The following table indicates the change of position of the point on the earth where central eclipse occurs at noon, for a few eclipses belonging to the series of the eclipse of this year. The longitudes are measured towards the east. It will be seen that the track moves about 8° southward each year and a little more than 100° in longitude. After two hundred years, when the track is near the equator, the movement is about 5° southward and 120° westward each year.

	Longitude E.	Latitude.
1909 June 17 . .	187°	+88°
1927 June 29 . .	84	+78
1945 July 9 . .	340	+70
1963 July 20 . .	234	+62
1981 July 31 . .	127	+54
1999 Aug. 11 . .	18	+46
.....	.....	.....
2107 Oct. 16 . .	39	+ 2
2125 Oct. 26 . .	276	− 4
2145 Nov. 7 . .	150	− 9
2161 Nov. 17 . .	23	−14

The map (Fig. 1) shows the track of the approximate central line for the eclipses of 1927, 1945, 1963, 1981, 1999, 2017, and 2125, 2143, 2161. In each case the eclipse begins at the western end of its track at sunrise and finishes at the eastern end at sunset.

Future Total Solar Eclipses in the British Isles.

By Dr. A. C. D. Crommelin.

An article by Dr. W. J. S. Lockyer in Nature for Jan. 15 last described and illustrated the total solar eclipses in the British Isles from A.D. 878 to A.D. 1999. The present article continues this investigation for another thousand years. In view of the very long interval of two centuries that has elapsed since there has been a British totality, it is interesting to determine the average interval between these events. Mr. J. Maguire's list, used by Dr. Lockyer, has a few omissions. I therefore had recourse to the maps in Oppolzer's Canon of Eclipses. These indicate 63 British totalities in 3370 years (1208 B.C. to A.D. 2161), or 19 in a thousand years, giving an average interval of 54 years between totalities. I am aware that the maps in the Canon show the tracks as circular arcs not quite agreeing with the true ones, but for statistical purposes this is of no importance ; we clearly gain as many as we lose by the distortion.

As a check I find that Otto Schrader gives 21 eclipses as total in the British Isles in the period A.D. 2133 to A.D. 3045. Four of these are doubtful ; the central line lying outside these islands : giving

these half weight, we have 19 in 900 years, or 21 in a thousand years. So we are safe in concluding that the average number in a thousand years is 19 or 20, giving an average interval of 53 years. I have here included the Shetlands in the British Isles. If we exclude them (they were not included in Dr. Lockyer's map, reproduced in Fig. 1) we may take the average interval as about 58 years.

If instead of a large area we consider a point on the earth's surface, we have on the average 3 total

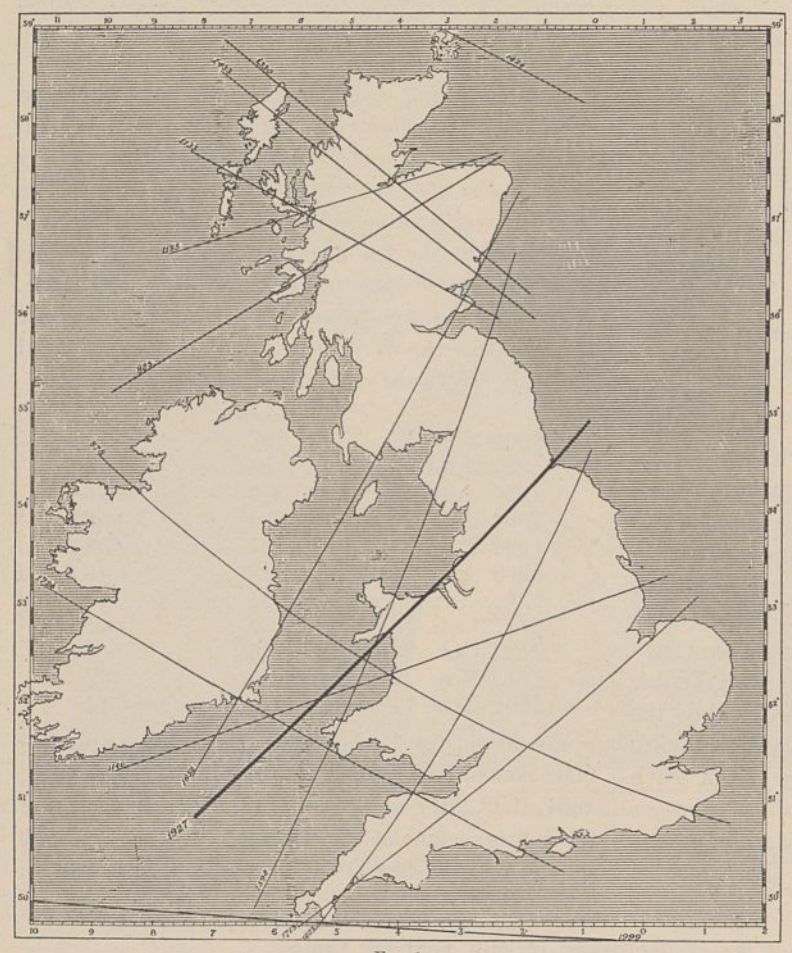


FIG. 1.

eclipses, 4 annular ones, and nearly 400 partial ones visible there in 1000 years. But we should have to take several thousands of years to make the average numbers for totality and annularity correct. In shorter periods we find some striking anomalies; thus a small region in Scotland round the point 3° 40′ W., 55° 30′ N., will have three totalities all under favourable conditions within 61 years (A.D. 2381, 2426, and 2442). Also, the grouping of totalities in the British Isles as a whole is much less regular than we might expect as a result of three such uniform motions as the rotation and revolution of the earth and the revolution of the moon. They bunch at one epoch and spread out at another in a manner that recalls the service of tram-cars. The blank period of 203 years that is now ending is the longest between A.D. 800 and A.D. 3100. The gap between A.D. 2200 and A.D. 2381 comes second, and that between A.D. 1433 and A.D. 1598 third.

On the other hand, the most striking example of bunching is between A.D. 2081 and A.D. 2200; we have here seven certain totalities and two others that are likely to reach the shores of Great Britain within 119 years.

The following are the data from which the tracks in the accompanying map (Fig. 2) were laid down:

(1) For the period A.D. 2000 to A.D. 2161 they are from my own calculations, using the elements in Oppolzer's Canon.

(2) For A.D. 2189 from my own calculations, using Hansen's tables of the moon and Newcomb's of the sun. This eclipse was inadvertently omitted by Schrader.

(3) From A.D. 2200 to the end from Otto Schrader, "Die bedeutenden Sonnenfinsternisse und die grossen Mondfinsternisse für Mittel-Europa" (P. Stankiewicz, Berlin, 1913).

It is to be remembered that the lunar tables used by Oppolzer omit many small terms; consequently the eclipse tracks calculated from them are uncertain by about 25 miles at the present time; and since the accelerations used in them differ considerably from those now accepted, the uncertainty becomes markedly greater after an interval of several centuries either in the past or the future. I understand that the tables used by Schrader are simply an extension of Oppolzer's, so they are subject to similar uncertainty, and tracks several centuries ahead can only be taken as approximate.

A few notes follow on some of the eclipses the central lines of which are shown on the map. The eclipse of A.D. 2081 is a return after seven Saroses of the Philippine Islands' eclipse of 1955, which has the remarkable duration of totality of $7^m\ 6^s$. If Oppolzer's data are accurate totality should reach the Lizard. Although the central line in A.D. 2090 is some distance from the shores of the British Isles, the track is so wide through foreshortening

that the shadow will reach the south-west coast. In A.D. 2142, totality may reach Dungeness. In A.D. 2151, Oppolzer's elements would give totality in London, but those of Hind, Maguire, and Johnson do not; their tracks are farther north. The eclipses of A.D. 2381, 2681, and 2726 are remarkable for long totalities. The latter seems to be a record for Europe, reaching 6 minutes. The Lizard will probably be within the shadow; the Channel Islands certainly will.

The following table gives the dates of all total eclipses that may reach the shores of the British Isles, the approximate hour, the sun's altitude and the duration on the central line. I have diminished the durations given by Oppolzer's and Schrader's elements by 0·2m, since they use too large a diameter for the moon.

Date.	Hour.	Sun's alt.	Dur.
2081 Sept. 3	7 A.M.	18°	3·5m
2090 Sept. 23	5 P.M.	6	2·8
2133 June 3	9 A.M.	40	3·5
2135 Oct. 7	8 A.M.	7	2·7
2142 May 25	9 A.M.	43	2·9
2151 June 14	6 P.M.	15	2·6
2160 June 4	6 P.M.	22	2·1
2189 Nov. 8	8 A.M.	8	2·5
2200 April 14	5 P.M.	17	0·4
2381 July 22	10 A.M.	48	5·0
2426 Sept. 2	8 A.M.	25	3·9
2442 April 11	9 A.M.	33	1·7
2545 April 12	5 P.M.	15	0·2
2600 May 5	6 A.M.	12	2·7
2681 June 8	2 P.M.	50	4·5
2726 July 21	11 A.M.	58	5·7
2808 Aug. 13	6 A.M.	8	0·3
2817 Sept. 2	4 P.M.	21	0·9
2864 Feb. 28	1 P.M.	29	2·8
2911 Aug. 15	2 P.M.	37	3·0
2927 Mar. 24	2 P.M.	31	3·0
2972 May 4	3 P.M.	37	3·8
2974 Sept. 7	1 P.M.	35	4·1

The central lines of 2081, 2090, 2726 pass respectively 70, 140, and 93 miles south of the Lizard; that of 2974 passes 44 miles north-east of Unst (Shetlands).

In the above list the eclipses of A.D. 2081, 2135, and 2189 illustrate the triple Saros; those of A.D. 2133, 2151, and 2142, 2160 the simple Saros; those of A.D. 2864, 2972 the sixfold Saros: the intermediate eclipse in 2918 passes north of the Shetlands. Those of A.D. 2081, 2381, and 2681, also A.D. 2142, 2442, also A.D. 2426, 2726, illustrate the 300-year cycle: those of A.D. 2160, 2681 illustrate the 521-year cycle.

Taking the present list and Dr. Lockyer's together, there are two examples of a 2-year interval between British totalities: A.D. 2133, 2135, and A.D. 2972, 2974; three of a 7-year interval: A.D. 878, 885, and A.D. 1133, 1140, and A.D. 2135, 2142; six of a 9-year interval: A.D. 1424, 1433, and A.D. 1715, 1724, and A.D. 2081, 2090, and A.D. 2133, 2142, and A.D. 2151, 2160, and A.D. 2808, 2817.

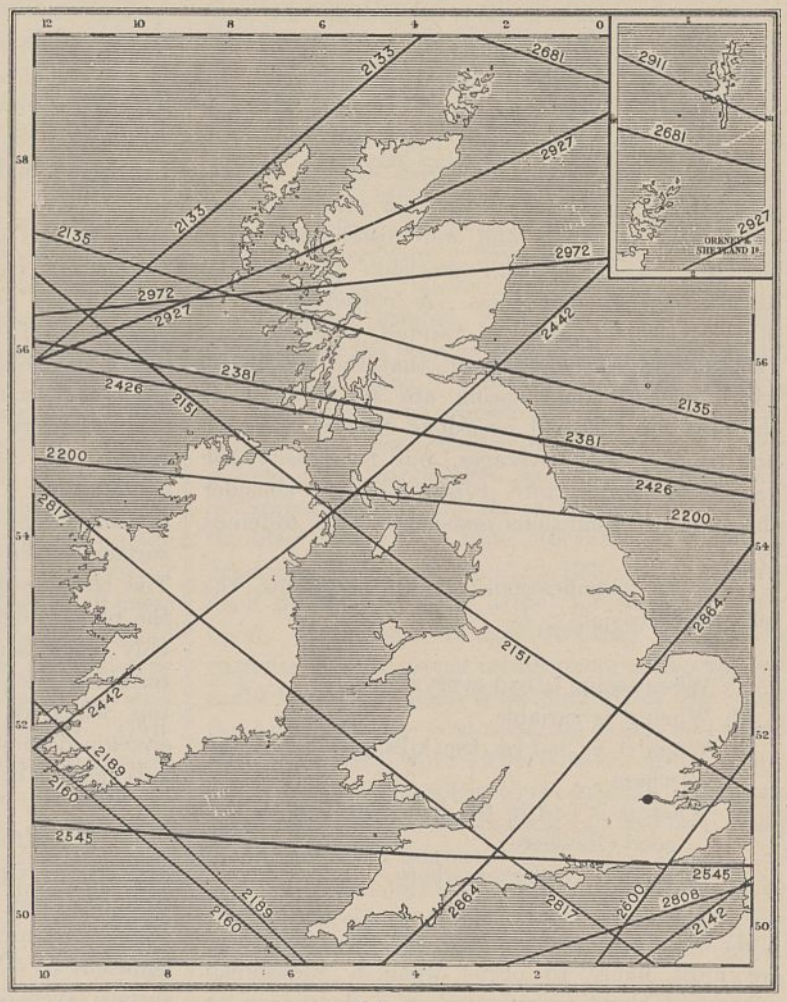


FIG. 2.

Meteorological Conditions in Relation to Eclipse Observations.

By R. CORLESS.

THE eclipse of the sun which will occur at about 5 h. 23 m. G.M.T. (6.23 A.M. summer time) on June 29 will appear total to observers stationed upon a strip of country 28 or 29 miles wide, of which the central line stretches from Criccieth in North Wales to Hartlepool in Durham. The character of the country included in this strip is very varied. There are coastal areas on the Lleyn Peninsula and North Wales, in Lancashire and between Sunderland and Salt-

burn on the east coast; there are, on the other hand, the mountain peaks of Snowdon, Whernside, Penyghent, and many others; and there is a considerable gradation of hill, plateau, valley, and plain between these extremes.

It is worth consideration whether the climatological records suffice to indicate which type of country in the belt is likely to provide the most favourable weather conditions for viewing the eclipse. The question resolves itself into the identification of the places which, on the average, are most free from cloud, mist, and fog. The records do not furnish a direct answer to this question, because observations of cloud are not sufficiently numerous and well distributed along the belt to define with precision the average distribution of cloudiness. A consideration of other records, notably of rainfall, sunshine, and visibility, indicates, however, that the conditions which produce bad seeing are so different in character on different occasions, that it is better not to deal with averages, but to classify the various occasions into types, and to consider the physical conditions associated with different types.

A broad classification can be made into the following occasions:

(1) When seeing is bad everywhere.
(2) When it is variable.
(3) When it is bad on the hills and good elsewhere.
(4) When it is bad in the low-lying valleys and good elsewhere.
(5) When it is good everywhere.

(1) Occasions when seeing is bad everywhere are most likely to occur when a widespread canopy of cloud is produced in a depression or region of relatively low barometric pressure. But they also occur in certain anticyclones where an inversion of temperature at a moderate height prevents vertical motion of air, and so favours the development of a layer of cloud just below the inversion. In the latter case the summits of mountains may be places from which a good view can be obtained.

(2) The condition in which seeing is variable and changeable is characteristic of a depression of less intensity than that of the previous case. Especially in the rear of the disturbance the weather may be showery, and bands of cloud may alternate with stretches of relatively clear sky.

(3) The third case, in which seeing is bad on the hills and good elsewhere, is in general due to the formation of persistent cloud on and above the hills as a result of the lowering of temperature in a current of rather moist air, which is forced upwards by the obstacle of the hills themselves. The clouds disappear on the lee side of the hills because the temperature of the air-current increases again in its descent after surmounting the crest. In this case a definite air-current is an essential part of the process, and as wind is detrimental to fog formation, mist and fog are not normally found at low levels.

(4) In this case seeing is bad in the low-lying valleys, in consequence of the development of mist or fog, but good elsewhere. This condition is characteristic of the early morning in anticyclonic, cloudless summer weather. It arises from the cooling of the ground by radiation to the clear sky during the previous night, which leads to the cooling of the surface layers of air by conduction. Conditions being anticyclonic, there is usually little or no wind, consequently the cold surface air flows into the valleys by gravitation. The temperature of this air continues to fall as the night progresses, until by daylight it is probably below the dew-point, and the cold air is coterminous with a sea of fog with a flat, well-marked top, which is fatal to good seeing for observers enveloped in it. Above the fog the air is clear and cloud is usually absent.

(5) The fifth case provides the most favourable conditions for good visibility everywhere. It differs from the last in that fog is not formed in the valleys because air movement in the anticyclone is sufficient to overcome the tendency of the chilled surface layers to gravitate into the valleys. Mixing of the lower layers by turbulence takes place and prevents the temperature from falling to the dew-point. Meteorologically the two cases are not readily distinguished, but the results are very different to observers stationed in deep valleys.

In the absence of information as to the probable distribution of barometric pressure on the morning of the eclipse, the only practical conclusion that can be drawn is that it is advisable to avoid both high ground and very low ground. But on the day prior to the eclipse it should be possible, with the aid of the current weather map, to form an opinion as to which of the five general conditions of weather described above is likely to be experienced on the following morning.

Naked-Eye Observations of an Eclipse of the Sun.

By Annie S. D. Maunder.

NO observer of the partial phase of a total solar eclipse should look at the sun with the naked eye. During this phase some people advise the use of coloured gelatine spectacles, smoked glass, or darkened photographic film; others advocate a graduated screen, using always the densest possible part of it. A very serious attitude is taken in the *Lancet* of April 30, where two ophthalmic surgeons urge that the public must be made to understand that neither smoked glass nor fogged photographic film are safe screens even when well prepared, seeing that they do not absorb the irritant ultra-violet rays, and to avoid the risk of 'eclipse blindness' use must be made of a photographic film which (after fogging so as to obtain the necessary density) has been treated by a special process which excludes wave-lengths shorter than 4000 Å.U.

My own precautionary method is at once safer, cheaper, and more effective. It is this: Do not look at the sun at all—either with the eyes screened or unscreened—until totality is just about to begin. During the partial phase there is nothing on the sun of interest that cannot be seen better by looking on the earth. In other words, project in all cases the sun's image on a screen—white card, ground glass, pavement, or wall—whether the projection be through a telescope, or the 'pinholes' made in a cardboard, or between the leaves of a tree. (Projection, on ground glass or white cardboard, through a telescope, is of course the best way for timing the four contacts of sun and moon.) The little 'decrescent' or 'crescent' suns upon a wall or pavement are very pretty to watch and can easily be photographed. Nor is it the image only of the sun itself that becomes bow-shaped, but also the shadows cast by it. I first noticed this in the very large partial eclipse of 1912, seen in Paris, as an eclipse something between total and annular, when the sun was high in the heavens at noon, and standing on the flat roof of a house in Greenwich, I looked down on my shadow far below on the pavement. This showed my ears pointed like the traditional faun's; and, more curious still, when I stretched out my open hand, all my finger-tips were drawn out and bent like a bird's claw.

By the time that the sun has become a narrow bow in outline, and there remain but a few minutes, perhaps three or four, before the actual beginning of totality, the shadow-bands should begin to dance in streaks or wavy lines. I have heard these compared to many things, but I have never had the good fortune to see them myself; to the shadows of the ripples on the surface of the clear water dancing on the shingly beach below; to the shadows cast on the wall of a room from rippling sunlit waters outside. In the words of Mr. C. L. Brook (at the 1900 eclipse), "ripples raised on water by a bright breeze represent best what may be termed the structure of the shadows; they all move in the same direction, each ripple element is linear in character but retains its individuality only for a moment, appears to dissolve away and others take its place." In the Australian eclipse of 1922, some observers saw a flickering shadow hovering *over* distant trees eleven minutes before totality; later, on the ground, round their feet: "they flitted under the trees as the shadow of a bird might when flying above." Immediately after totality, the whole light was crimson for about ten seconds, and *red* and *black* shadow-bands raced over the ground. The bands were seen by chromospheric, not by sunlight. From the scientific point of view, the ideal occasion for their observation was in the American eclipse of January 1925, when Nature itself provided a white carpet for them to dance upon. It has been thought that they were due to currents in our upper atmosphere and that we could learn from them something about this; but the Americans observed them too closely and found that they were wind swirls—little 'devils' they are called in India—close to the ground, and in one place were seen to be chasing one another in all directions round a tree.

Whether the onrush of the moon's shadow can be seen at the coming eclipse will depend on whether the weather is clear or hazy. At the American eclipse it was looked for, but was undefined because of the haze. Major Hepburn says that this is the most impressive feature of the spectacle: "the onrush from a certain direction of rapidly spreading and engulfing darkness." But those who have work to do during totality have to forgo this experience.

The eclipse of June 29 is a young one; it is total—and not very much total at that—for the first time; when it is a Saros older it will be better. As a consequence, the chromospheric ring will probably be visible throughout the whole period that the sun's disc is covered. The form and size of the corona will depend on the actual state of activity of the sun at the moment. If there are many and great sunspots and prominences, and if these are near the sun's edge, then we may expect a complex

inner corona, which, however, will only show to the naked eye as a bright silver ring surrounding the narrow pink circlet of the chromosphere, with long coronal streamers extending in all directions; if there are no spots and insignificant prominences on the sun, then the coronal wings will lie folded along the sun's equator. Prominences, of course, will be visible to the naked eye only if large enough; keen sight could detect a prominence of 40,000 miles height; one of 200,000 miles should be easily visible. The corona will be ivory or white in colour; the chromosphere will be rosy; prominences will probably be red, but they may be white.

We would wish for June 29, that the weather on the sun should be stormy with many eruptions; that—for naked-eye observers—there should be deep lunar valleys near the points of second and third contacts; and that great red prominences should show up where these lunar valleys are.

In the American eclipse of 1925, New York City had a very beautiful aspect of the eclipse, which there was of short totality. The eclipsed sun showed as a faint circle of light with an intensely brilliant place at one spot, the rays from which spread out and gave the impression of a ring with a big diamond inserted in the usual way. There was a depression in the moon's edge which grazed the edge of the sun for some time, as seen from New York, which lay on the edge of the shadow track, just as Liverpool lies (probably) on the edge of the shadow track on June 29 next. In one of the Russian chronicles there is a description of the eclipse of May 1, 1185: "In the evening there was an eclipse of the sun. It was getting very gloomy and stars were seen, and in the men's eyes was a green light. The sun became similar in appearance to the moon, and from its horns came out somewhat like live embers"; which seems to point to something like the 'diamond ring,' perhaps a prominence as well as sunlight.

I have myself only once seen the eclipsed sun with the naked eye, and then it seemed small, much smaller than the full sun and moon to which I have been accustomed. But this was in India, with the sun high in the heavens. Mr. H. B. Adames saw the beginning of the eclipse of 1905 as the sun rose over Lake Winnipeg, and to him the entire body of the moon, which suddenly appeared with a blood-red prominence on either side, was a "huge black ball immensely exaggerated."

The effect of the rapidly diminishing sunlight on land and sky is weird and uncanny; all life and warmth fade out of the landscape; the flowers look withered, the grass and trees lose all trace of their living green and become of a dull lead colour; even the very faces of the observers become livid. If the sky is blue, it changes to a deep funereal purple. If there are small clouds near the sun, the iridescent colours, which are always there but not always easily seen, stand out vividly as in a spectrum. Round the horizon—which is near or beyond the shadow's edge—there is a glow of an angry gold, a sulphur light, not untinged with red. These are sunset effects, perhaps, which become visible when the daylight is cut off, but they may owe something also, as Mr. C. T. Whitmell suggested, to the red chromospheric light. If clear, it will be well to glance at the shadows cast by the corona; in 1922, Miss Miriam Chisholm found that these, though present, were undefined.

In my opinion, all naked-eye observers who are artists should make the painting of the colour effects on land, sky, and sea their chief study at this eclipse. It is not, of course, possible to do this work actually in the short totality, but the outline should be drawn before the eclipse, the colours noted during the total phase, and the painting finished afterwards while the tints are still fresh in the memory. Like meteorologists, artists get their results, whether the eclipse is clear or cloudy.

Eclipse Photography.

By C. P. Butler.

ALTHOUGH the total solar eclipse on Wednesday, June 29, will be one of short duration—about 23 seconds total obscuration in England, and 30 to 40 seconds in Norway—the improvements in sensitivity of photographic materials and design of optical equipment warrant the attempt to obtain photographic records of various stages of the phenomenon. In order to give information wanted by observers having diversity of equipment, we may briefly summarise the various means with which observations may usefully be undertaken.

Ordinary Cameras.—These may range from the modest hand-camera to the largest field or studio apparatus, preferably fitted with some controllable exposing apparatus other than merely the lens cap. These may all give interesting pictures, but the scale of the result will be strictly proportional to the focal length of the lens employed. The diameters of the sun and moon are about half a degree of arc on the sky, so it is a simple matter to calculate what the actual linear diameter of the image of the eclipsed sun will be with any given

lens; an ordinary camera of, say, 7 inches focus, will give an image about $\frac{1}{16}$ inch diameter; one of 12 inches focus an image about $\frac{1}{10}$ inch diameter. In spite of the small scale, such lenses in previous years have given very beautifully defined pictures of the eclipsed sun and the surrounding corona. For the delicate outer streamers of the corona such apparatus is very efficient, and possibly more suitable than the larger scale instruments. This was illustrated by the success of Mrs. Maunder at the eclipse of 1898 in India, when the photographed coronal streamers extended about eight solar diameters from the edge of the moon. In this work of photographing an illuminated *area*, the power of the lens is regulated by the ordinary *f* value, *i.e.* the ratio of aperture to focal length, so that lenses with the largest *a*/*f* value available should be chosen for this occasion.

Telephoto Cameras.—By means of an auxiliary lens, generally concave, to reduce the bulk of the apparatus, increased focal lengths may be obtained with a given camera. Photographers having telephoto attachments to their lenses will be able to obtain large-scale pictures, but if the equivalent focal length is more than about 20 inches, some method of moving the camera with the sun will be necessary for exposures longer than a few seconds.

Long-focus Lenses or Telescopes.—These instruments are usually of larger aperture than a telephoto lens of similar focal length would be, so that, even when stationary, a useful picture may be possible with a snap-shot or short-time exposure. If furnished with clock-work drive, they provide perhaps the most important means of obtaining details of the structure of the eclipsed sun. Good results may be obtained by adjusting an ordinary camera, with lens set for infinity, immediately behind the eyepiece of a visual telescope which has also been adjusted on the distant object. If this arrangement is selected, it would be best mounted on a long, stiff board, and the whole fixed on a firm support pointing to the sun. The exposure should be made by rubber tube or antinous release, to avoid vibration.

Stationary or Clock-driven Apparatus.—With such a short eclipse it is doubtful if anything will be gained by installing temporary driving apparatus to follow the movement of the sun. Unless the utmost rigidity is secured, the small errors in fixing, driving, etc., may be greater than the actual movement of the object. The best advice appears to be that the camera should be firmly fixed on some rigid support, provided with a wedge adjusted to the elevation of the sun (about 11° in England). With instruments of moderate focal length the movement during the possible exposures will be scarcely perceptible. The movement may begin to be effective when focal lengths of more than 20 inches are employed.

Alteration of Eclipse Track.—Notice should be taken of the recent alteration of the track of the eclipse and its time of occurrence. The latest calculations, kindly furnished by Dr. Comrie, of the "Nautical Almanac" Office (*Monthly Notices, Royal Astronomical Society*, vol. 87, April, p. 496), place the central line about *one mile farther north* than the previously published track, so that observers located near the southern limit as shown on the Ordnance Survey Map should move to some station at least two or three miles northwards, to be certain of complete obscuration. Observers near the northern limit of totality will be better situated in consequence of the alteration. The time of occurrence is only about 4 seconds later than the published time.

Perhaps a word here as to the actual method of observing the instants of totality will be welcome to those who have not previously seen a total eclipse of the sun. The moon commences to enter on the sun's north-western edge, about the position of 2-hours on a clock face as one faces the sun, and will gradually cross the disc in a slanting direction, roughly towards the 8-hour position. When near totality, about an hour after first contact, the sun will be 25° north of the east point of the horizon and at an elevation of about 11° above the horizon, these figures being slightly different at various localities. As the advancing edge of the moon gradually approaches the eastern edge of the sun, the intense white arc of sunlight will be broken into small beads, produced by the rough mountainous edge of the moon. The instant when the last of these bright spots disappears is the time of second contact, and denotes the beginning of totality. Unless the observer wishes to obtain a series of records, the exposure should not begin until this instant of second contact, otherwise the delicate features of chromosphere and corona will be lost in the bright glare.

It is advisable to protect the eyes with dark glasses, such as may be made from a densely fogged photographic plate, or ordinary deep-tinted neutral glass, until totality occurs. From second contact to third contact is the period of totality, which in England is expected to last for about 23 seconds. This is the time available for securing pictures of the corona, which can never be seen except in these special circumstances, and the exposures to

be given will depend on the number of pictures to be taken. In general it would be advisable to limit the number to three:

(i.) A snap-shot just after the last beads of sunlight are seen to disappear at the moon's eastern or advancing edge. This will give the prominences and perhaps the inner corona.

(ii.) A longer exposure of, say, 15 to 20 seconds, depending on the time occupied in changing plates.

(iii.) Another snap-shot just as the bright beads appear at the western edge of the black moon.

Cinema Record.—The eclipse, being of short duration, may be specially suitable for the taking of a cinematograph film of the various stages, in which case the exposures would be started some time before totality, to show the transition from partial to total phase.

Intending observers who are able to go farther afield will find the photographic conditions somewhat more promising in Norway, where the altitude of the sun during totality will be about 21°.

Photographic Plates.—In general it will be best for the photographer to use the plates to which he is accustomed. All the well-known brands of material, glass plates and films, are now so uniformly good with regard to clean working that any choice may be governed by whatever special features it is desired to obtain. If only one exposure is to be attempted, the most rapid emulsion is to be recommended. All the chief makers list plates from 350 to 650 H and D. For the corona much of the light is concentrated in a few special colours, violet, blue, green and red, the combination giving the silvery white sheen characteristic of the solar envelope. Ordinary plates, of whatever speed, will record only the violet and blue portions. To get the advantage of the visible colour action, panchromatic plates may be used. The outstanding plates of this variety are the Ilford Iso Zenith, Iso Wellington, and Imperial Eclipse Ortho, all being of the highest sensitivity and very clean working. Most makers also supply Spectrum Panchromatic Plates, which are of somewhat lower speed, but give a more equable representation of the spectrum colours. When the apparatus is fitted with lenses of large relative aperture, these plates may be used instead of those of greatest rapidity. The easiest way of treating these colour-sensitive plates is to develop in darkness for six minutes with the metol-hydroquinone solution recommended by the makers. For those, however, who cannot resist the temptation to enjoy seeing the image gradually built up, use may be made of one of the various desensitising solutions which are now available. Before development, and in darkness, bathe the exposed plate in a weak solution of the desensitiser, such as phenosafranine, for about one minute. Then add the developer, and continue for a further six minutes, during which an ordinary safelight may be used to see the progress of development.

There is one possibility of difficulty, owing to the early hour (6 h. 23 m. A.M. British summer time) at which the eclipse will take place. If the sky is slightly hazy, the contrast of the silvery-white coronal structure may be lessened with respect to the sky background. With ordinary plates this cannot easily be remedied. But if panchromatic plates are employed, much of the sky glare may be eliminated by using a moderately tinted colour screen, of the type known as K_3, which will cut out much of the blue glare, and yet pass sufficient of the green, yellow, and red to the panchromatic plate to give good density in the image.

Supersensitised Plates.—For observers with more experience, most varieties of plates may be hypersensitised by a preliminary ammonia bath. The plates are simply bathed in a weak solution of ammonium hydrate (about 1 per cent.) for one minute, at a temperature of about 50° F. (14·5° C.). Then dry the plate as quickly as possible, either by a centrifuge or a fan. All this should be done in darkness. If an alcoholic solution is preferred, the plate will dry much quicker, but the resulting sensitivity will be slightly lessened.

Films.—Observers desiring to use films may do so with every confidence; and as many film emulsions are now made colour-sensitive, the remarks already made as to using colour screens, if glare is present, also apply to films.

Colour Photography.—Many observers intimate their intention to try for colour records of the eclipse phenomena, for which several processes are available.

Backing.—It is advisable that all plates should be backed, as any traces of halation due to bright portions of corona, prominences, or slight cloud may otherwise diminish the delicacy of detail.

Shadow Bands.—In addition to the corona and prominences, there are several other features peculiar to a total solar eclipse which may be of interest to photographers wishful of a more extensive programme. Just before totality, and immediately after, a series of moving wavy shadows are usually seen on the ground or sides of buildings facing the eclipsed sun. The cause of these is not yet known with certainty, but they appear to have some relation to prevailing atmospheric conditions. If a white sheet or a whitewashed wall can be used,

photographs of these shadow-bands will be of value. Exact details of the position of the flat surface, whether horizontal or vertical, its direction with regard to north, south, etc., should be carefully noted. Also the actual width, rate of motion, and general direction of the bands on the white surface, and which way they move.

The Moon's Shadow.—This applies chiefly to observers who may be fortunate in occupying a hill station in Wales, Lancashire, or Yorkshire. The dense black shadow may be seen travelling over the landscape, and would form an interesting photographic study wherever possible. Only snap-shots may be made on this, owing to the great velocity of the moon's shadow over the earth's surface.

Landscape Colours.—Very varied descriptions of the remarkable changes of colour of landscape features have been noted during previous eclipses. Those provided with panchromatic plates or colour plates may do useful work in recording any of these changes. In such cases photographs of the same landscape under ordinary daylight conditions should be obtained to indicate changes due to the eclipse.

Spectroscopic Photographs.—So far we have only considered the photography of the eclipsed sun as a picture. There must be many observers who could photograph the spectrum of the phenomenon, and quite valuable records may be made with simple equipment. Either a prism or diffraction grating may be used, adjusted in front of the camera lens. In general this will involve some deviation of the pointing of the camera, which will have to be directed away from the line of the sun by an angle equal to the deviation produced by the prism, etc. Prisms and gratings can, however, be obtained which are arranged to give direct vision, and in such cases the procedure is exactly the same as with the camera lens alone. Very good results can be obtained with the replica gratings produced by the Thorp process, an additional feature being their relatively small cost compared with that of an original ruling on speculum metal. The photographic manipulation is identical with that for ordinary pictures, except that it is scarcely worth using any except panchromatic plates, which will record the whole of the visible spectrum.

Time Records of Exposure.—The scientific value of any records obtained will be greatly enhanced if the instants of exposure are noted as accurately as possible. The track of the eclipse passes through such populated areas that few observers will be far away from some place where it should be possible to get facilities for listening to the standard time signals which will be broadcast from Greenwich and Paris. The well-known Greenwich six dots, the sixth indicating the time to be noted, will be broadcast at 6 h., 6 h. 15 m. and 6 h. 30 m. A.M. British summer time on June 29. (The latest arrangements for the broadcast time-signals will be found in "Our Astronomical Column.") Perhaps it would be a general convenience if the present 1.0 P.M. signals from Big Ben (12.0 G.M. noon) were given as Greenwich dots for the week preceding the eclipse. The Paris Observatory is also broadcasting from the Eiffel Tower (FL) rhythmic and other time signals specially for the eclipse on both spark and continuous wave.

Any records which can be made to the nearest second will be comparable in accuracy with the determinations of actual beginning and ending of the eclipse itself.

To summarise briefly:

(1) Arrange for a steady support for the camera directed to the sun, special care being taken if there should be a high wind.

(2) Provide the camera with a lens of as large a relative aperture as possible.

(3) Use rapid plates, preferably panchromatic, with a light-yellow screen, and have the plates backed.

(4) Exposures should be from snap-shot to about 10, 15, or 20 seconds for cameras up to 20 inches focal length. For longer cameras it is better to confine exposures to about 5 seconds, except in the case of clock-driven instruments.

(5) For clock-driven apparatus take three exposures: snap for prominences at beginning, 15 to 20 seconds during totality for corona, and snap for prominences at end of total phase.

Radio Telegraphy and the Eclipse of the Sun.

SINCE 1912 observations have been made from time to time on the effect of solar eclipses on wireless signals. Up to 1925, however, the data obtained from the observations made was untrustworthy and contradictory, the reason for this being that the observations depended on estimates by the ear of the intensity of signal strength. Apart also from the absence of accurate and suitable measuring apparatus, it is only in recent years that the mechanism of the propagation of waves round the earth has been understood to a sufficient extent to indicate the type of observation likely to yield positive results. The path of totality of the eclipse which took place on Jan. 24, 1925, crossed the United States, and the opportunity was then taken of arranging for a

network of observing stations on a comparatively large scale. At several of these stations galvanometer-recording methods were employed. During the same eclipse, observations of the field strength and direction of arrival of wireless signals transmitted from America were made in Great Britain. By that date also the theoretical work of Eccles and Larmor had provided a hypothesis of wave propagation by which the results obtained could be tested.

To understand the effect a solar eclipse is likely to have on wireless signals it is necessary to review briefly the manner by which it is now believed that electromagnetic waves are propagated through space. From any transmitting aerial part of the energy emitted is propagated horizontally along the surface of the ground and part is propagated in an upward direction into the atmosphere. The resistance of the earth has an absorbing action on the waves travelling over its surface. This absorption is least with long waves, and becomes very great in the case of what are known as ultra-short waves, that is, waves below, say, 100 metres. Owing to various cosmic influences, particularly radiation from the sun, the earth's atmosphere is ionised. During the daytime ionisation occurs at comparatively low levels, but with sunset recombination takes place in portions of the atmosphere where the gas pressure is fairly large, and by night, only the upper atmosphere at a height above 70 kilometres is left in an ionised state.

The effect of the ionisation of the atmosphere on electromagnetic waves has been shown by Eccles and Larmor to be twofold. First the electrons or ions present are set into vibration by the waves. As the electrons move they set up small electromagnetic waves out of phase with the original wave. The combination of the electric forces of these two waves causes the upper portions of the waves to appear to travel with a greater velocity than the lower portion, so that the wireless waves in the ionised medium are bent towards the earth. The amount of bending produced has been shown to depend on the intensity of ionisation and upon the square of the wave-length. Larmor has shown, however, that another effect of the ionisation present must be taken into account. This factor is the loss of energy due to collisions between electrons and gas molecules. This loss produces an absorbing effect on the waves passing through the medium, and in order that the effect may be small, the electrons must have a long mean free path ; therefore the bending effect on the waves can only take place in the upper regions of the atmosphere. It would be expected on this theory that the absorption due to the ionisation in the atmosphere would be less with very short waves of high frequency than with longer waves, since the time between a collision of an electron and a molecule will be greater than the frequency of the wave.

The general result is that upward radiation from an aerial may be pictured as struggling upwards through the absorbing lower atmosphere until it reaches a level at which it is bent round the earth without loss, again enters the absorbing layers, and finally reaches the earth once more. At night the absorption will be less, since the ionisation due to sunlight in the lower levels will be absent. Thus in general, wireless waves are propagated to greater ranges at night except in the case of extremely short waves, less than, say, 16 metres, the frequency of which is so great that the absorbing action is small, and a considerable intensity of ionisation is necessary to bend them round the earth. Such very short waves will therefore travel better by day than by night. It will thus be seen that, at short distances, a wireless receiver will be affected chiefly by waves which are directly transmitted along the earth's surface or through the lowest levels of the atmosphere ; at intermediate distances the received signal will be the resultant of the direct ground wave and a wave travelling by the upper atmosphere ; while at very long distances the effect on the aerial will be solely due to waves travelling through the upper layers of the atmosphere.

It follows from the above that the general effect of a solar eclipse should be similar to that of a sudden and very rapid sunset, followed by a sunrise. As the moon's shadow sweeps through the atmosphere, a recombination of the ions present will take place, with the result that the agencies producing the bending and absorption of the waves become confused and unsettled. A short time later, however, the lower atmosphere becomes clear of ions and night conditions prevail until the shadow passes on. The effect on the intensity of wireless signals during the eclipse should therefore be first a decrease in the average intensity followed by an increase. Broadly speaking, this was the result generally obtained in the 1925 experiments. The relative and absolute amplitudes of the drop and rise in signal strength were found to depend, however, on the position of the transmitting and receiving stations to the path of the shadow and on the wave-length used in the observations.

It appeared to the Radio Research Board of the Department of Scientific and Industrial Research that it was desirable that every endeavour should be made to use the opportunity offered by the eclipse on June 29 next for carrying out further observations on its effect on radio telegraphy. After discussion with other interests involved, a programme of observations has been drawn up which it is hoped will yield useful results. A point brought to the notice of the Board by Dr. E. H. Rayner, of the National Physical Laboratory, which has not previously been taken into account in eclipse observations, is that, as the altitude of the sun is low, the line on the earth's surface vertically over which that portion of the ionised layer lies in which the bending of the wireless waves probably takes place, is about 100 miles to the south-east of the line of totality on ground level. In the experiments to be carried out this fact is being borne in mind. In one set of experiments which are to be carried out under the supervision of Prof. E. V. Appleton, observations will be made by photographic recording apparatus on wireless signals crossing the line of ground totality—transmitted from Newcastle and received at Liverpool. Similar simultaneous observations will be made on transmissions from a station to the south of the ground totality line and received at the Radio Research Station at Peterborough.

The object of the experiments is in particular to investigate the height at which the bending of the waves by the ionised layer takes place during the eclipse and to endeavour to note the changes in the height of this layer. The method to be used is that described by Prof. Appleton in his paper in the *Proceedings of the Royal Society* (vol. 109, A, p. 621, 1925), whereby the wave-length of the transmitting station is varied through a small known amount (for example, 5-10 metres) in a given time (for example, 10-30 seconds), and the height of the layer is calculated by counting the number of interference fringes produced by the interference of the ground and atmospheric rays. The number of fringes produced depends on the path difference between the rays. From this number a simple calculation gives the height at which the bending of the rays takes place. It has been possible to arrange for the necessary transmissions for these experiments by co-operation with the British Broadcasting Corporation.

In connexion with previous work of the Radio Research Board, long-wave signal-strength measuring apparatus has been developed by Mr. J. Hollingworth and installed at the Radio Research Station at Slough, at the University of Aberdeen, and at University College, Exeter. This apparatus will be employed for accurate signal-strength measurements on long-wave stations during the eclipse. The distance at which the ionisation of the atmosphere comes into play is greater in the case of long waves than with short waves. The necessary transmissions for observations on long waves are, accordingly, being arranged from continental stations under the auspices of the Union Radio-Télégraphique Scientifique Internationale. Long-wave intensity observations are also to be carried out with the apparatus developed by Prof. E. W. Marchant at the University of Liverpool.

Recent research has shown that the variable errors in radio direction-finding are due to the interaction of the magnetic fields of the ground and atmospheric waves. Under certain conditions these two forces give a resultant magnetic field not at right angles to the direction of the transmitter, and therefore an error in radio direction-finding apparatus is produced. The direction of the magnetic field of the atmospheric wave depends, it is believed, on the ionisation of the upper atmosphere and on the relation of the direction of transmission to the magnetic field of the earth. To test this explanation of directional errors, observations are to be carried out by a network of direction-finding stations observing transmissions from the London and Manchester broadcasting stations. Finally, accurate records of the intensity of atmospherics on a selected wave-length and of the direction of arrival of individual atmospherics are to be made at the Radio Research Station, Slough, and in Scotland.

In addition to the above experiments, which are being carried out directly under the supervision of the Radio Research Board, the Radio Society of Great Britain is arranging for observations by its members on transmissions on 90 metres from a station at Caterham and on transmissions on 100 metres from a station in Iceland. Arrangements are also being made for transmissions on 23 metres and on a wave-length between 44 and 46 metres. These two latter stations will be situated one to the north and one to the south of the line of totality on the ionised layer.

A difficulty which presents itself in connexion with the present eclipse is that totality takes place so early in the morning that ordinary sunrise effects may not have entirely ceased and may mask to some extent the eclipse effects proper. In order to prevent the confusion of any eclipse effects with those due to other causes, all the

observations proposed will be carried out on the mornings of the two days preceding the eclipse and on the two days following, in addition to the actual morning of the eclipse. The transmissions on which observations are made will extend for a period of two to four hours on each of these days.

How far the results of the experiments proposed will be valuable in checking present hypotheses of the propagation of wireless waves or in providing new information on this subject cannot, of course, be definitely stated beforehand.

O. F. B.

Astrophysical Eclipse Problems.

By Prof. H. Dingle.

If direct observation of the sun were our only means of investigating the form of our luminary, we should learn little more than that it is an incandescent rotating sphere. The spectroscope makes possible the beginnings of a structural analysis by revealing an absorption spectrum —that is, a continuous spectrum crossed by relatively dark lines. This assures us that, broadly speaking, the sun consists of two portions—an interior responsible for the continuous spectrum, and an atmosphere the constituents of which selectively absorb some of the light of the interior, each according to its kind. Whatever can be learnt from the continuous spectrum characterises the interior, while the study of the dark lines—the Fraunhofer lines—is the study of the atmosphere. In the ordinary solar spectrum, of course, both continuous and dark line spectra appear together. Neither can be obtained, in the first instance, apart from the other, so that the separate analysis of 'interior' and 'atmosphere' is greatly complicated. Some measure of success has nevertheless been achieved; for example, the effective temperature corresponding to the light from the interior has been determined from the continuous spectrum, while the spectroheliograph affords some knowledge of the distribution of a few types of atom in the solar atmosphere. But on the whole it may be said that the inevitable association, in the ordinary solar spectrum, of the atmospheric lines and the photospheric background is a great hindrance to the complete study of the respective regions of the sun—and particularly that of the atmosphere.

Observations of the sun's limb, where the atmosphere might be expected to appear alone and to show a bright line spectrum, reveal only that it is too thin (in angular measure) to do so. Even the spectroscopic method devised independently by Lockyer and Janssen in 1868 shows only the higher reaches of the atmosphere at the limb, and it was not until 1896 that it was finally established that there exists a bright line limb spectrum at all comparable with the Fraunhofer lines. Since that time the long-focus instruments at the Mount Wilson Observatory have given images of the sun with sufficient depth of atmosphere for the bright line spectrum to be observed, but when produced in this way the lines are still encumbered by the Fraunhofer spectrum, and the facilities afforded for detailed study of the solar atmosphere leave much to be desired. Only during a solar eclipse, when the photosphere is at least partly obscured by the moon, can a pure atmospheric spectrum be obtained, so that for our knowledge of the structure of the sun's atmosphere—the solar meteorology, as it may be called—we still rely mainly on eclipse observations.

Three aspects of the bright line, or 'flash' spectrum, are studied in modern eclipse research; namely, the wave-lengths of the lines, their relative intensities, and the distribution in the solar atmosphere of the atoms or ions responsible for them. It appears probable that the determination of wave-lengths will in future be attempted only by the method described below (p. 91) by Prof. Fowler, for which totality is not necessary. It need not, therefore, be referred to here except to point out its uses in the identification of the lines and the recognition of disturbing influences in the event of displacements being established with respect to terrestrial standards or the Fraunhofer spectrum. Two facts must be borne in mind in this connexion. First, the Fraunhofer spectrum is observed more or less radially, and the flash spectrum tangentially, so that there may be differences in the thickness and state of motion of the regions of the atmosphere observed; secondly, the lowest layers of the atmosphere can be observed only through an envelope of the higher layers, and any difference of wave-length at different levels will broaden the lines and possibly give rise to unsymmetrical reversals when the lines are examined microphotometrically.

The question of the relative intensities of the lines has greatly increased in importance with the development of modern spectroscopic theory. It is intimately bound up with the question of the distribution of atoms and ions in the sun's atmosphere; for the intensity of a spectrum line depends

both on the number of atoms of the proper kind which are present, and on the physical conditions tending to make them emit that particular line. It is necessary, therefore, not only to compare the relative intensities of different lines, but to investigate also the variation in intensity of each line in different regions of the atmosphere. Since it is only the atmosphere at the limb which is being studied, this is equivalent to a determination of the variation of intensity along each line, supposing a radial or tangential slit to be employed.

This investigation is attended by considerable difficulties. Not only is there the complication already referred to (namely, that the ends of the lines representing the lowest levels may contain light from the higher levels also), but also the diffused light in the earth's atmosphere tends to fill the slit and make the distribution of light in the spectrum line differ from that in the corresponding regions of the sun's atmosphere. This effect is very pronounced in misty weather, and on such occasions, when a radial slit has been used, bright lines have been observed to extend even over the whole diameter of the dark moon. Objective prism spectrograms (*i.e.* spectrograms obtained by placing a prism before the object glass of an astronomical telescope, and using neither slit nor collimator) in which each 'line' is a crescent image of the region of the solar atmosphere emitting the corresponding wave-length, do not suffer from this defect, for the diffused light, entering the telescope from all directions, is simply spread over the photographic plate to produce an imperceptible fogging. In these spectra the lengths of the arcs measure the heights in the sun's atmosphere reached by the corresponding emitting sources, but irregularities in the moon's limb and other interfering agencies invest the results with a considerable amount of indefiniteness. All photographic methods of attacking this problem have to cope with the further difficulty of non-uniform sensitivity of the plates to light of different wave-lengths; thus, two lines of the same length in different parts of the spectrum do not necessarily arise from emitting sources similarly distributed in the sun's atmosphere. Results obtained from many eclipses will have to be carefully analysed and compared before trustworthy conclusions in any degree of completeness can be reached.

The beautiful photographs obtained by Merfield at the eclipse of January 1926 suggest that the method employed by him (it was in part proposed also by Lockyer in 1896, but clouds prevented the trial) might yield valuable results. It consists in photographing an objective prism flash spectrum on a plate moving uniformly at right angles to the direction of dispersion, immediately in front of the plate being a narrow slit, lying along the spectrum, so as to reduce the instantaneous image of each 'arc' practically to a point. The resulting spectrum then appears as a set of parallel lines of various lengths, and it is proposed to determine the heights reached by the corresponding emitting sources from a measurement of the rate of change of intensity along the lines. It remains to be seen what degree of success the method is capable of yielding when the actual determinations have been made.

When the general distribution of the various types of atom and ion in the solar atmosphere has been reliably determined, the application of recent spectrum theory will give much information concerning the physical conditions existing there. A particular investigation of this character is being undertaken on June 29, in which attempts will be made to determine the relative intensities in the chromosphere of the Ca^+ diffuse 'doublet' at λλ8498-8662 in the infra-red, and the bright counterparts of the well-known H and K Fraunhofer lines in the violet. The result should have considerable significance in connexion with the theory of the calcium chromosphere proposed by Milne. Photographs extending still further into the infra-red, up to about λ15,000, are also to be attempted.

These eclipse researches into the constitution of the sun's atmosphere are of great interest and importance, but they must always play second fiddle to the study of the corona, because it is only during a total eclipse of the sun that the corona can be observed at all. The investigations referred to above are greatly facilitated by the intrusion of the moon, but they could be carried out in some manner if the moon did not exist. (It must not be forgotten, however, how much the methods employed on the uneclipsed sun owe to knowledge gained originally from eclipse observations.) But if there were no moon, or if the moon were slightly farther from the earth than it is, we should not to this day suspect even the existence of the corona. It is obvious, therefore, that whatever else may be neglected at a total eclipse, all possible information must be obtained with regard to the corona.

Our absolute knowledge of the corona may be summed up very briefly. It is an intricate solar envelope the form of which varies with the phase of

the sunspot period, while its light, which is partly polarised, consists of a combination, in varying proportions, of unknown bright lines, continuous spectrum, and Fraunhofer spectrum. Considering that the corona is observable, on the average, for at most about three minutes every two years or so, it is not surprising that our knowledge of it is so rudimentary. Single observations have no definitive value; they need confirmation at subsequent eclipses. In the case of the corona they have perhaps more often been contradicted, so that uncertainty exists whether the observations are at fault or whether the corona has changed. In these circumstances progress is necessarily slow, and many records must be accumulated before conviction can be reached.

A record, as complete as possible, of the form of the corona at each observable eclipse has been kept for some years, and must of course be continued indefinitely. In time this should reveal any obvious periodic changes of form or structure which may exist in addition to the already known relation with the sunspot period. The connexion between the corona and the solar prominences might also be elucidated from such a record. The difficulties, however, are enormous, for not only are there long gaps between successive photographs or drawings, but also at each eclipse the coronal light seen is at each point an unanalysable integration of light emitted along a chord of the coronal shell, and does not represent a simple plane section of the shell. The changes in the form of the corona appear to be slow. Attempts have been made to detect them by observing the same eclipse near sunrise and sunset, but the results are inconclusive. Further attempts are desirable. For such observations to be successful there must be convenient sites near the two ends of the belt of totality and the sun must be unclouded at both stations—a combination of circumstances which very rarely occurs.

The total light of the corona still awaits a satisfactory determination. It no doubt varies from one eclipse to another, and might be correlated with the sunspot period. Still more important, perhaps, is the law of variation of light with distance from the sun's limb. Several widely differing formulæ have been proposed, and here again there are probably changes from one eclipse to another. The heat radiation of the corona was measured by Abbot in 1908, but further determinations would be of much value. The very delicate apparatus designed by Callendar for use in the 1905 eclipse, which was spoilt by clouds, might give valuable results in this direction of research.

The spectrum of the corona and its connexion with the sunspot period are as yet very imperfectly understood. The portion of the light which gives a Fraunhofer spectrum comes from the middle and outer corona, and is undoubtedly reflected or scattered sunlight. Experiments on the amount and kind of polarisation of this light at different distances from the sun's limb are necessary to afford an insight into the mechanism of the reflection or scattering, and hence into the physical constitution of the corona. Such experiments have been made at many previous eclipses, but the difficulties of interpreting the results are so great that further investigations by the most trustworthy methods are necessary. The continuous spectrum of the inner corona may also be due to photospheric light, but there are reasons for thinking that it originates in the corona itself. Confirmation is difficult, but the evidence most obviously necessary is that of the curve of distribution of energy throughout the spectrum.

The line spectrum of the corona offers perhaps the largest field for investigation. None of its lines has yet been recognised in the laboratory, and its composition is very uncertain. Much progress has been made in disentangling it from the chromospheric spectrum, but finality has not yet been reached, and the faintness of the spectrum makes it almost certain that the present lists of lines are far from complete. Variations in the relative intensities of the lines at different eclipses suggest that it is a superposition of two or more spectra. Several attempts, on numerical as well as observational bases, have been made to classify the lines into groups, but the results so far are not consistent. The spectrophotometric measures initiated by the British expedition to Sumatra in January 1926 indicate a promising method of classification in terms of the variation of intensity along the lines. When such data have been obtained at a number of eclipses, accidental similarities can be eliminated and possibly definite conclusions arrived at.

The precise wave-lengths of the coronal lines are important for both laboratory identification and measurement of motions in the line of sight. There is so little agreement as yet between the various sets of measures available that further determinations with the highest possible degree of accuracy are of the greatest importance. It may be hoped that Prof. Fowler's experience this month

with high-dispersion photographs of the 'flash' spectrum will show that the same method is practicable with the corona—at least so far as the brighter lines are concerned. The line spectrum of the corona appears to be relatively brighter at maximum than at minimum of the sunspot period, so that the coming eclipse should be favourable for the various investigations connected with it.

It will be realised that the outstanding astrophysical eclipse problems are 'many and various.' We may reasonably hope that, granted fair weather, our English eclipse will lead to important extensions of our knowledge of the sun.

Spectroscopic Observations during a Partial Eclipse of the Sun.

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

It is common knowledge that the chromosphere and prominences which surround the visible surface of the sun cannot be seen in the telescope at ordinary times because they are less bright than the diffused light of the sky on which they are superposed. They can, however, be observed by combining the telescope and spectroscope in the manner discovered by Lockyer and Janssen in 1868. The spectroscope being adjusted on the bright red line of hydrogen (Hα), and an image of the sun being focussed tangentially to the slit, the diffused sky light is spread out into a continuous spectrum (crossed by dark lines) and is thereby so much reduced in intensity that the bright hydrogen line from the chromosphere, or from a prominence, becomes easily visible. To see the actual forms of the chromosphere and prominences, it is only necessary to open the slit rather wide.

Other bright lines besides Hα, including the yellow line of helium, D_3, and the hydrogen line Hβ, may be observed in the same manner, but they are not numerous when instruments of moderate size are employed. Spectroscopic observations with large telescopes at ordinary times, or with ordinary instruments during total eclipses, however, have shown that as the sun's edge is approached the bright line spectrum increases in complexity and finally exhibits a multitude of bright lines which originate in a region extending less than two seconds of arc above the photosphere, the apparent diameter of the sun being nearly two thousand seconds of arc.

When observations are made near the central line during a total eclipse, the spectrum of this shallow layer suddenly bursts into view at the beginning of totality, and almost as quickly disappears; it reappears for two or three seconds just before the end of totality, at the point of contact of the sun and moon. On account of its brief duration under these conditions, the spectrum of this shallow layer which surrounds the sun has been called the 'flash spectrum,' and the layer itself the 'flash stratum.' It is here that a large proportion of the absorption which produces the dark Fraunhofer lines of the ordinary solar spectrum takes place, and the flash stratum is accordingly also known as the 'reversing layer' of the sun.

Overlying the reversing layer, but not sharply divided from it, to a total height of about ten seconds of arc above the photosphere, is the chromosphere. This has not a smooth continuous surface,

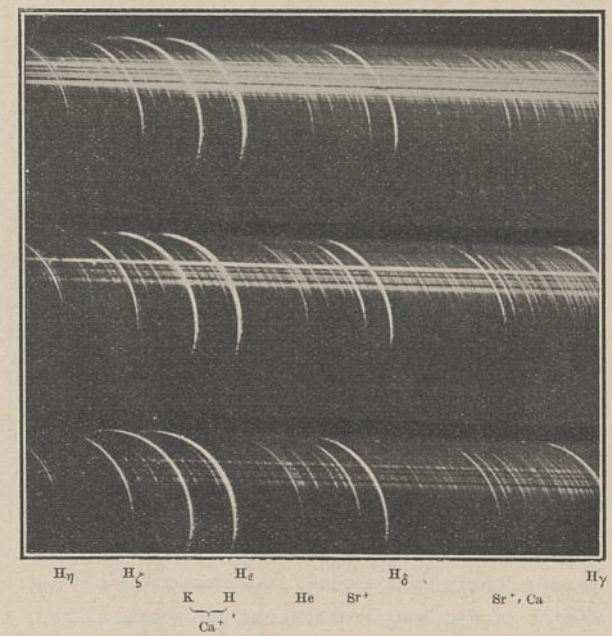


Fig. 1.—Flash spectra: portion of the first large plate taken with a 6-in. prismatic camera in India, 1898. By Prof. A. Fowler.

but is roughly serrated, and the prominences, which are sometimes very brilliant and reach to enormous heights, rise out of the chromosphere.

On ordinary occasions, with telescopes of moderate size, it is not possible to observe the spectrum of the reversing layer, because of the 'boiling' due to atmospheric tremors, which blends the bright lines from the thin stratum with the brighter spectrum of the edge of the sun's disc. Occasionally, however, there is a disturbance at some place near the sun's limb, and the reversing layer may then be so far elevated that a large number of bright lines can be differentiated from the photospheric spectrum. With the large instru-

ments available at the Mount Wilson Observatory, bright lines have been photographed in large numbers without an eclipse, but even here the flash spectrum is somewhat confused by that of superposed sunlight.

It is during total eclipses of the sun that the flash spectrum can be most effectively observed. The reversing layer is then revealed for a brief time on a comparatively dark background, with no interference from the bright disc of the sun. Its spectrum has frequently been successfully photographed by the use of slit spectrographs of ordinary type, and by the use of prismatic cameras or slitless spectroscopes. With the latter form of spectrograph a spectrum taken near the beginning of totality consists of a succession of curved images of the portions of the chromosphere and reversing layer visible at the moment of exposure, each representing a spectrum line, and having a length depending on the height of the gas or vapour which produces it. The nature of such photographs will be gathered from Fig. 1, which reproduces a small part of a plate containing ten such spectra taken at intervals of about one second, beginning a few seconds before the commencement of totality in India in 1898. In these photographs the reversing layer is represented by the numerous short arcs which appear in the middle of each spectrum, and the chromosphere by the longer arcs, among which those of calcium H and K, hydrogen and helium are very conspicuous. The bright streaks of continuous spectrum originate from specks of the sun's disc which were visible through irregularities in the edge of the moon.

Such photographs bring out many important features of the bright line spectra, but for various reasons they do not yield wave-lengths of a high degree of accuracy. Excellent photographs have also been secured with slit spectrographs, but in observations during totality, the dispersive power which can be utilised is limited by the short duration of the phenomena.

In order to obtain an increased duration of the flash spectrum, Evershed, in the eclipse of 1900, selected a station near the edge of the zone of totality. In these circumstances it will easily be understood that the dark moon must glide tangentially with respect to one point on the sun, so that the flash spectrum can be effectively observed near that point for a considerably longer time than from a place near the central line. Thus, using a prismatic camera, Evershed succeeded in obtaining good photographs of the flash spectrum during a period of about half a minute, and the illumination of the sky throughout this period was sufficiently reduced to allow of the fainter lines being registered on the plates.

Observations of the large partial eclipse which was visible in England on April 17, 1912, indicated another means of observing the flash spectrum for a comparatively long time, and suggested that photographs might be taken with instruments of large dispersion, comparable with those used for the sun itself. This possibility is opened up by the fact that at the cusps of the partially eclipsed sun the flash and chromospheric layers project to a greater distance than their radial depths. This will readily be understood from the diagrammatic representation in Fig. 2.

At South Kensington the magnitude of the

FIG. 2.

eclipse of 1912 at central phase was 0·92, and visual observations by Fowler showed that the flash spectrum could be effectively observed at the cusps during about thirty minutes. Some gain in visibility of the bright lines was first noted when the magnitude of the eclipse was 0·55, while the apparently complete flash spectrum was visible when the magnitude of the eclipse was 0·8 or greater (*Monthly Notices, R.A.S.*, **72**, 538). Similar observations were made at Cambridge by Prof. Newall (*Monthly Notices, R.A.S.*, **72**, 536).

In view of these observations, it seems possible to employ spectrographs of greater power than any hitherto used in eclipse work, and to impress comparison spectra for the accurate determination of wave-lengths. It may thus be hoped to obtain data for the investigation, among other things, of possible small displacements of the bright lines such as are already known in connexion with the Fraunhofer lines.

It was intended to make this experiment in Russia on Aug. 21, 1914, but owing to the outbreak of the War the expedition had to be abandoned, and the instruments were not returned to England until 1924. It is now planned to employ practically the same equipment during the eclipse of June 29 this year.

Although slightly better conditions might be obtained by the occupation of a station somewhat nearer the central line of eclipse, the instruments are being erected on the roof of the Imperial College of Science at South Kensington. The magnitude of the eclipse there at central phase will be 0·96, and the experience of 1912 indicates that this will be ample for the purpose in view. Any advantage likely to be gained by going farther north would, it is thought, not sufficiently compensate for the loss of the facilities afforded by the College laboratories and workshops. Prof. Sampson has also taken this view and will attempt similar work at the Royal Observatory, Edinburgh, where the greatest magnitude of the eclipse will be 0·98.

A large partial eclipse also provides a very favourable opportunity of investigating the spectrum of the sun near the limb. The observations at Mount Wilson have already shown that this spectrum differs very considerably from that given by the centre of the disc, but observations during a large partial eclipse may have the advantage that there will be no scattered light from the central parts of the disc superposed on the light emanating from near the sun's edge.

The spectrograph to be employed at South Kensington has a concave grating of 10 feet radius in an Eagle mounting, and will be adjusted for the second order spectrum so as to avoid undue astigmatism. An image of the sun about 2 inches in diameter will be formed in the plane of the slit by a 6-inch objective, which will receive light from a cœlostat after reflection from a second mirror. Adjustments are provided for maintaining the image of a cusp on the desired part of the slit, and it is expected that the exposures required will not be so long as to cover an undesirable range of solar latitude as the cusp changes its position on the sun. The requisite astronomical data for South Kensington have been specially computed by Dr. L. J. Comrie of the "Nautical Almanac" Office.

The Forms of the Solar Corona and their Origin.

By Dr. William J. S. Lockyer.

IT is only during total solar eclipses, when the moon comes exactly between the earth and the sun, and cuts off all the brilliant light of the disc, that an outer solar atmosphere of an exquisite pearly hue known as the 'corona' is revealed. Without such eclipses, this atmosphere, even with the aid of any of the great and ingenious optical means available to-day, would still be unknown. The corona is of very considerable extent, far exceeding, in proportion to the size of the solar disc, that of our own in relation to the size of the earth.

It is well known that the form of the corona varies in shape and brilliancy very considerably. Sometimes the form is very irregular, the coronal matter being extensively distributed all round the solar disc, embracing both the solar poles and the equator. This form is termed 'polar,' 'irregular,' or 'maximum,' as coronal streamers are situated near the solar poles (Fig. 1).

On other occasions the polar regions are conspicuous by the complete absence of streamers, and in their place beautifully curved rifts or plumes are seen, the long streamers being restricted more to the equatorial regions. This type of corona is termed 'equatorial' or 'minimum,' and is sometimes referred to as of a 'wind-vane' form, as it resembles this object (Fig. 2).

Finally, there is a third and also very pronounced shape which is intermediate between the above two forms. This is termed the 'intermediate' type or 'square' corona. In this case the streamers are generally concentrated in mid-solar latitudes, leaving the poles and equator comparatively free from any large coronal extensions.

The use of the terms 'maximum' and 'minimum' with regard to the shape of the solar corona referred to the epochs of sunspot maximum and minimum, and it suggested a connexion with the periodic variation in the spotted area of the sun's surface. Until a few years ago, it was generally concluded that sunspots were therefore the origin of the coronal forms, and their waxing and waning was reflected in the changes of these forms.

Sunspots, however, do not appear at or anywhere near the solar poles; the highest latitude they ever attain is only 45°, and then they are only of very small area. On the other hand, large coronal streamers and prominent rays are sometimes situated in very high latitudes; in fact, at times they are very near or at the poles, and consequently quite outside the regions of spot activity.

Moreover, at the epochs of greatest spotted area, the mean latitude of spots is only about 18°; yet it is precisely at about those epochs that the coronal streamers appear at the poles, and the coronal forms are described as 'maximum' or 'polar.'

These facts suggested to me in 1903 that the prominences, which are not only very important factors in the mechanism of the solar atmosphere, but also can and do appear in all solar latitudes, might be directly responsible for these changes of form of the corona.

FIG. 1.—Solar corona, Aug. 30, 1905. Maximum type. Exposure 20 sec. By C. R. Davidson. By permission of the Astronomer Royal.

The crucial test resolved itself into demonstrating that the epochs of the occurrence of all those forms of the corona which exhibited streamers at or near the solar poles should be coincident with those epochs when prominences were known to be in very high latitudes. To do this it was necessary to study all the trustworthy data relating to the more modern records of solar activity.

It is well known that the area or number of the spots on the sun varies from year to year, and that about every eleven years or so this number reaches a maximum value. This cyclical change of spotted area is shown at the top of Fig. 3. Sunspots are not formed on all parts of the solar disc, but are strictly confined to a belt which lies approximately between latitudes 45° and 5° on both sides of the equator. Sunspots, therefore, never occur at or near the solar poles. The mean yearly positions of these belts are shown in the third series of curves illustrated in Fig. 3. The latitudes of sunspots are closely associated with sunspot frequency. When there are most spots their mean latitude is about 18° : when there are fewest spots their mean yearly latitudes are about 22° and 8°. The formation of high latitude spots near a sunspot minimum heralds the commencement of a new cycle of spot activity.

In the case of solar prominences, their appearance waxes and wanes very closely with the sunspots, as is indicated in the second curve of Fig. 3. When there are numerous spots there are many prominences, and vice versa. There is, however, a very big difference between their behaviour as regards solar latitude. Prominences can occur in any part of the sun, and they can be as large and conspicuous at the poles as they may be at the equator.

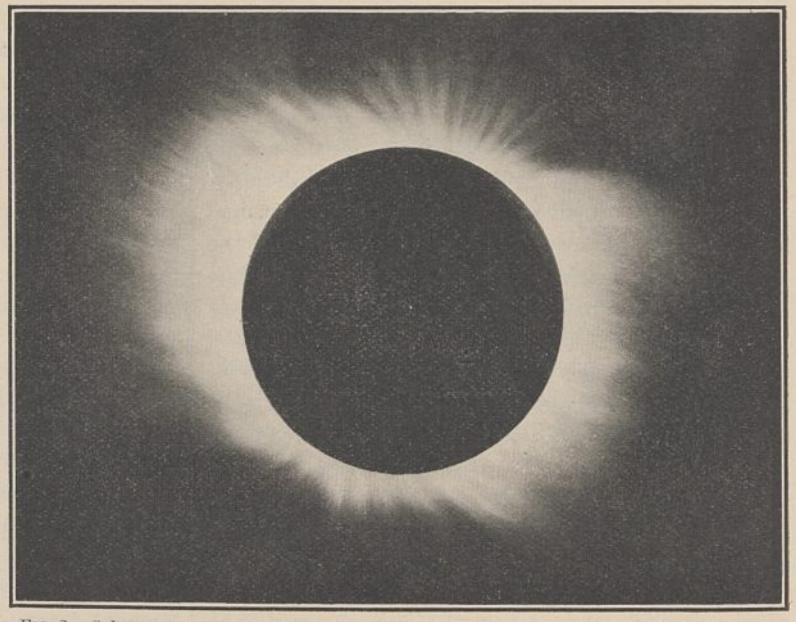


FIG. 2.—Solar corona, May 28, 1900. Minimum type. Exposure 30 sec. By E. E. Barnard.

To illustrate the striking difference between the extent of latitudes covered by spots and promi-

nences, the accompanying diagram (Fig. 4) has been made showing this distribution for the years 1892, 1893, and 1894, the year 1893 being a year of sunspot maximum.

The central vertical line represents the solar equator or latitude 0°, and the black areas on each side of it indicate the areas of prominences for each of the three years (all drawn to the same scale) plotted for every five-degree zone of latitude on the scale given at the bottom for both north and south solar latitudes. It will be seen that prominences are distributed in all solar latitudes in these years, and in some cases are very pronounced in high solar latitudes in both hemispheres, as indicated by the pronounced peaks in the area curves.

The smaller white areas represent the areas of sunspots for the same years. They are all drawn to the same horizontal scale as regards latitude distribution as the prominences, but the vertical scale for their areas, while the same amongst themselves, is different from that of the prominences.

The diagram clearly shows, in the first place, the insignificant distribution of the spots in latitude compared with that of the prominences, and in the second place, that the zones of maximum spotted area, in these years about sunspot maximum, lie within 20° of latitude on either side of the equator.

A study of the fourth series of curves in Fig. 3 shows that when prominences are at their maximum frequency they occur in two zones, the mean yearly latitudes of which are about 70° and 25°. When they are fewest in number their mean yearly latitude is about 40°. This cyclical change of latitude from year to year is shown in the diagram.

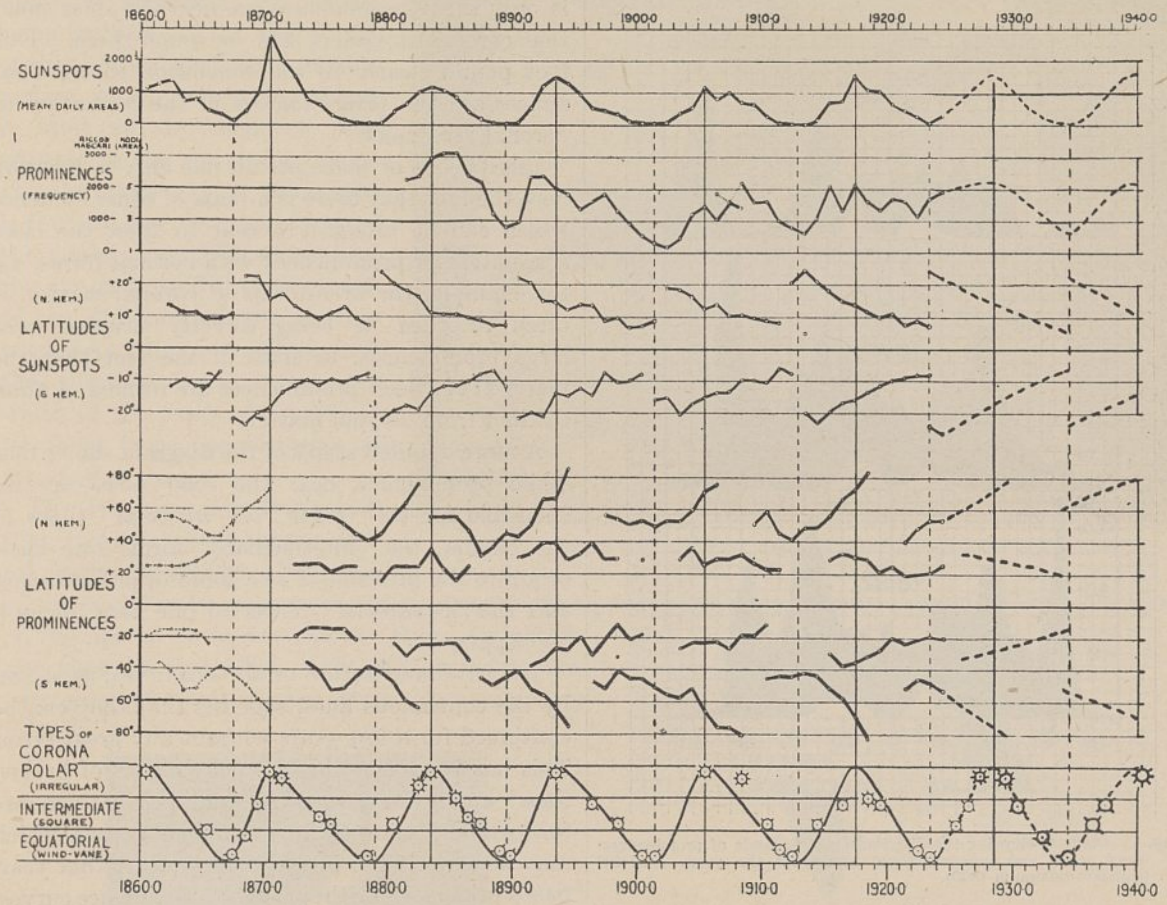


FIG. 3.—Diagram showing the relationship between the different forms of the corona and the latitudes of prominences.

Thus while the epochs of sunspot and prominence maxima are practically coincident, the spots at these times are most active in latitude about 18°, while prominences exhibit their greatest activity in about latitudes 70° and 25°.

Now from the prominence curves for both hemispheres it is quite easy at a glance to distinguish the years when these phenomena attain high latitudes, such as 60° or more. The question is, do these years pick up those cases in which the corona has been observed, and described as of 'polar,' 'irregular,' or 'maximum' type?

To answer this question easily, the various forms

of the corona, as recorded by different eclipse observers since the time of routine prominence observations first began, namely, in the year 1872, are brought together at the bottom of Fig. 3. Thus, for example, all the forms termed 'polar' are placed in the first horizontal strip in their respective years of observation according to the time-scale indicated at the bottom. All those designated 'intermediate' and 'equatorial' are also placed in lower strips at their observed years. It is found that a curve can be drawn through them

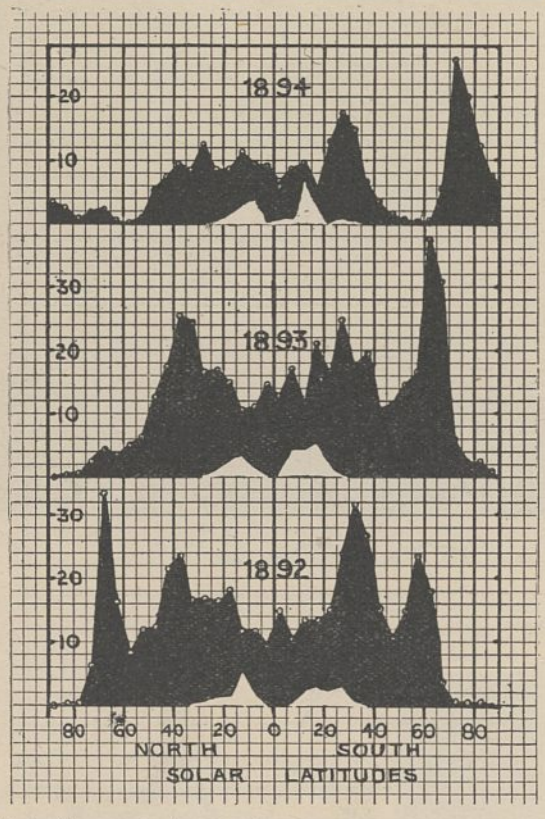


FIG. 4.—Diagram showing the distribution in latitude of prominences (dark areas) and sunspots (light areas) for the years 1892–94 (sunspot maximum 1893).

approximately resembling the sunspot and prominence curves at the top of the figure. Thus it is seen that the forms of the corona follow one another in the following sequence, namely, polar, intermediate, equatorial, intermediate, polar, etc.

Comparing these coronal types with the curves immediately above them, it is fairly obvious that 'polar' forms are coincident with 'high latitude' prominences in every case except one, namely, in the year 1883. A re-examination of the prominence data for that year discloses the fact that their presence was recorded up to latitude 65° in the northern and 75° in the southern hemisphere; the yearly curve did not, however, exhibit distinctive peaks in either hemisphere at those latitudes, but only a gradual reduction in area from the prominent peaks in latitudes 25° north and south. There were therefore high latitude prominences in that year, so that 1883 is no longer an exception as expressed above.

It is important to point out further that there is no case of an 'equatorial' or 'intermediate' form of corona being recorded when the prominences were in high latitudes.

The deduction to be made is, therefore, that it is only when prominences are near the solar poles that coronal streamers will be found there. This fact points clearly to the conclusion that prominences are the prime factors in the formation of coronal streamers.

Limitations of space permit one only to mention here the fact that there is a mass of other evidence which can be brought to bear to show the close association of prominences with coronal forms, as, for example, the arch-forms of coronal matter so often recorded as being directly situated over large prominences, in spite of the fact that the material of which prominences are formed is quite distinct from coronal matter.

A more detailed study of the diagram shows that while prominences near the solar poles are responsible for the 'polar' or 'irregular' types of the corona, the 'intermediate' forms owe their origin to the presence of two zones of prominences, and the 'equatorial' forms to one zone in each hemisphere.

The rhythmic nature of all the curves, as shown by the continuous lines, suggests that they can be continued for a few years without any great error. This has been done in Fig. 3 by means of broken lines[1] up to the year 1940, and below them are forecast the various forms of the corona which may be expected in future eclipses up to that year, based principally on the probable prominence curves. The corona of the present year should therefore be 'polar' or 'irregular,' corresponding to a very disturbed state of the sun's atmosphere. It should thus be irregular in form, devoid of pronounced polar rifts, and should be very bright. It may exhibit long streamers in any solar latitude. Its brilliancy will probably prevent any but the brightest stars from being seen, but on the other hand it lends itself very favourably to special studies of its composition by means of the spectroscope.

[1] There have just been published the latitudes of the mean areas of prominences for the first half of the year 1926. This shows that the zones of maximum area lie at latitudes 40° and 70° in the northern and 38° and 60° in the southern hemisphere, thus closely endorsing the points forecast in Fig. 3 for that year.

The Moon's Shadow in Relation to the Earth on June 29.

By Dr. E. H. Rayner.

THE shadow of the moon, considered as a slightly conical cylinder about 240,000 miles long, intersects the earth at Cardigan Bay at 5^h 23^m G.M.T. At this moment the imaginary point of the shadow is about 1500 miles within the earth. The average diameter of the shadow as it crosses England is about 15 miles where it intersects the earth, being the value of the minor axis of the elliptical area of the earth's surface within which the eclipse is total at any moment. The altitude of the sun being about 11°, the major axis of the ellipse is four to five times as long as the minor axis. The azimuth of the sun is some 20° to the south of the direction of the shadow track; and this, combined with the elliptical form, causes the width of the track of totality to be about twice the diameter of the shadow cone.

The accompanying illustration (Fig. 1) shows a model of the conical shadow at 5^h 23^m. The scale of the model is 10 miles to the inch, which is that of the special Ordnance Survey Map. It will be seen that the centre line of the shadow crosses the east coast of England over south Yorkshire at a height of about 45 miles. An important height from the point of view of radio transmission is about 100 kilometres, or 60 miles. The intersection of the centre of the shadow with this level has therefore passed over England towards the east before the intersection at the earth's surface has arrived at Wales from the south-west. The plan position of the intersection at a height of 60 miles has been specially computed by Dr. L. J. Comrie on behalf of the Radio Research Board, to whom I am indebted for much of the information of a numerical character.

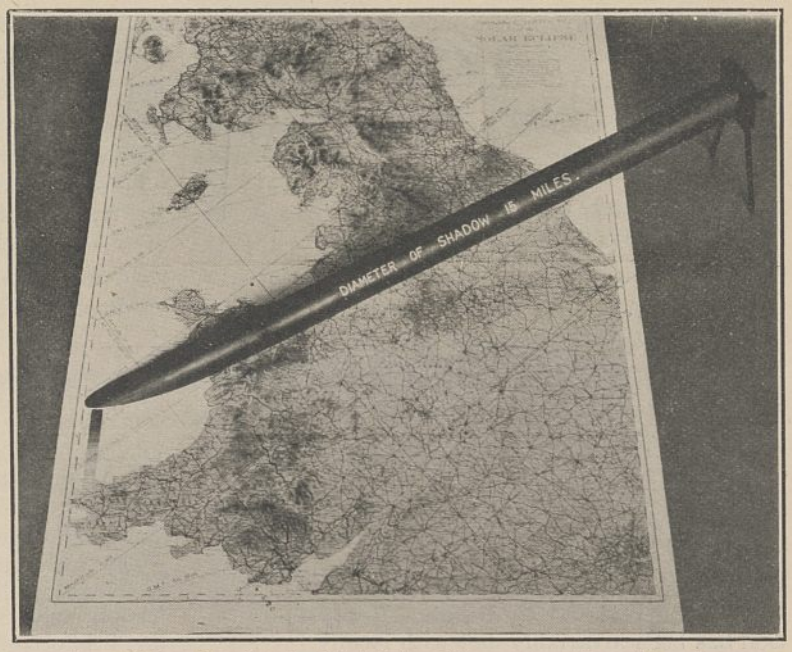
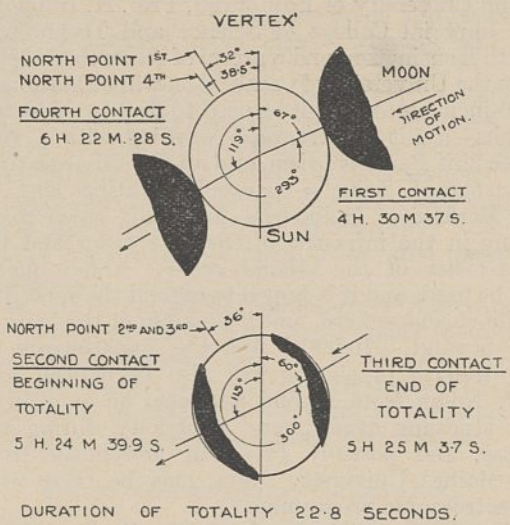


Fig. 1.—Three-dimensional model of shadow of the moon near the earth's surface.

Fig. 2.—Position and orientation of England during the eclipse.



TIMES OF CONTACT AND POSITION ANGLES FOR LAT. 54° 24·6′ N. 1° 45·5′ W. BEING THE POSITION OF THE S.W. CORNER OF RICHMOND RACE COURSE.

Fig. 3.—Circumstances of the eclipse for Richmond, Yorkshire.

Over England the plan position of the intersection at 60 miles high runs nearly parallel to the 0·98 totality line to the south of the central track. It is for most of the distance between the Bristol Channel and the North Sea, within 2 to 5 miles of this line and to the south of it. The location at $5^h\ 20^m$ is shown in the lower margin of the illustration, and that at $5^h\ 22^m$ is near the east coast. It is interesting to note that according to the data used in the computation, the centre of the shadow has not reached the earth's surface at $5^h\ 20^m$, its nominal time of contact being $5^h\ 20{\cdot}1^m$.

The season and the early time of day at which the eclipse takes place, being before 6 A.M. by solar time for first, second, and third contacts, causes the lines indicating simultaneous maximum phase on the map to be displaced more than 90° from the lines of longitude to which they approximate later in the day where the eclipse takes place at local noon. The map (Fig. 2) shows the shape of England as viewed in the direction of the shadow axis, the plane containing the earth's axis being imagined to indicate the vertical.

Arrangements have been made for the party organised by the Physical Society of London to have the use of accommodation at the Race Course at Richmond. The times of the contacts and position angles are shown in Fig. 3. The computation has been made taking into account the corrections given by Dr. Comrie, as a result of the information recently provided by the Astronomer Royal. The difference between the position angles of second and third contacts, 185°, being larger than 180°, shows that the point is a few hundred yards to the north of the centre line.

Astronomical Programmes of Eclipse Work.

By F. J. M. Stratton.

ALTHOUGH the Joint Permanent Eclipse Committee has organised no special expedition to observe the eclipse of June 29, it has arranged that all instruments in its charge should be employed at the eclipse and has acted as an intermediary in securing instruments and local facilities for various expeditions. Ready co-operation has been invariably met with locally.

The first eclipse camp on the track of which the programme details are available is at Llysfaen Head, near Colwyn Bay. Here Dr. R. J. Clark, of the University of Edinburgh, Prof. H. Dingle, of the Imperial College of Science and Technology, South Kensington, and a group of research students from the University of Cambridge, will be stationed. A 16-inch cœlostat will be used to feed two spectrographs—a slit spectrograph working with a very dense flint Parsons prism, and an objective grating-spectrograph using a parabolic grating lent by Mr. Merfield of Melbourne, especially ruled to be strong in the infra-red of the first order and the ultra-violet of the second order. Abney plates will be used, and it is hoped to extend the spectrum of the chromosphere, and if possible of the corona, well beyond λ 10,000. Wireless experiments on the strength of signals will also be carried out. Prof. Nolan from Dublin will also be at Colwyn Bay studying atmospheric electricity during the eclipse, and possibly President Morehouse from Des Moines University, Iowa, may be there with a spectroscopic programme.

Where the eclipse track strikes land again at Southport, the Oxford expedition under Prof. H. H. Turner and Dr. H. Knox-Shaw will be stationed. Their programme consists of direct photography of the corona together with photographs in polarised light. At Stonyhurst, Father O'Connor will also be taking direct photographs of the corona and flash spectra, working so far as possible into the infra-red. It is understood that Prof. da Costa Lobo, Director of the Coimbra Observatory, Portugal, will be at Stonyhurst with a cinema camera and spectroscopic apparatus.

The expedition from the Royal Observatory, Greenwich, will be in the grounds of Giggleswick School, near Settle. Its programme consists of direct photographs of the corona with a 6-inch lens of 45 ft. focal length, the spectrum of the chromosphere in the extreme red and a comparison of the intensities and heights of H and K and of the Ca^+ triplet $^2D - {}^2F$ at λλ 8498, 8542, 8662.

Mr. Evershed will be at Tunstall, about five miles from the central line, working with a large prismatic camera with two 6-inch prisms of 45° angle and a lens of 21 ft. focus. He will be studying the cusp spectrum before and after totality and the flash spectrum, and will be largely concerned with the height of the various gases. The Norman Lockyer Observatory expedition will be between Gilling and Richmond with a programme of direct photographs of the corona and small-scale spectra. Other observers who are expected to carry out observations in the belt of totality in Great Britain include Mr. Albert Taylor at Llanbedrog, Prof. E. A. Owen at Bangor, Mr. Harold Thomson and Mr. F. Sargent, of the Observatory of Durham, at Catterick, Dr. F. W. Aston and Mr. Wilfrid Hall also in Yorkshire. Prof. A. Fowler at the Imperial College of Science and Technology, London, and Prof. R. A. Sampson at Edinburgh, are proposing to study the cusp spectrum with high dispersion spectrographs during a considerable interval on either side of the time of maximum eclipse.

The other British expedition is that of the Solar Physics Observatory, University of Cambridge, which proceeds under Prof. H. F. Newall to Aal, in the Hallingdal in Norway. In addition to direct

photographs of the corona the programme includes spectroscopic observation of the chromosphere in the ultra-violet and the infra-red, with special application to the relative intensities of the red calcium triplet and of H and K. The intensities of lines at different heights will also be studied. Spectrophotometric work will figure largely in the programme, and there will also be polariscopic observations and interferometer photographs of the corona.

The American expeditions are all, except that of President Morehouse, to be stationed in Scandinavia. Prof. H. T. Stetson, of Harvard Observatory, and Mr. Weld Arnold, will be doing photometric work on the total brightness of the corona at Fagernas, where Prof. S. A. Mitchell, of the Leander McCormick Observatory, will also be stationed. Farther north, possibly near Gellivare, will be the Dutch expedition, including Dr. Minnaert, with the spectrophotometric programme which they were prevented by clouds from carrying out in Sumatra last year. Dr. Luyten will accompany this party. In addition to Prof. Stetson's photometer and the Dutch instruments, it is understood that Dr. Anderson's eclipse spectrograph, which was also blocked by bad observing conditions in Sumatra, will again be brought into use, in the hands of Dr. S. Rosseland. Finally, an Italian expedition under Prof. Horn d'Arturo may be stationed in Norway, and it may be assumed that there will be several Scandinavian expeditions and German expeditions in Scandinavia also. Details of their plans have not come to hand.

Nowhere along the track can it be said that weather prospects are very good. On the other hand, they are not so bad that we may not expect fairly confidently results of value from some of the many expeditions that will be observing the eclipse.

Observing Parties and Stations.

The Norman Lockyer Observatory.

DR. W. J. S. LOCKYER, director of the Norman Lockyer Observatory, informs us that the expedition from the Observatory will occupy a site on the eastward and adjoining side of a good road connecting Richmond with Gilling village, and distant one mile from the market place of the former town. It is on the Marquess of Zetland's estate, and he has very kindly given permission for the Observatory's party to take up its position there. The site is situated on a 600-foot contour line, and looking away from it towards the north, through the east and to the south, the ground falls away sharply at first and gradually afterwards. In fact, there is no land reaching anywhere near 600 feet within twenty miles of a line drawn due east and twenty-five miles a little north of east.

The programme of work to be attempted at Richmond is to secure large- and small-scale photographs of the corona, chromosphere, and prominences, and also a photograph of the spectrum of the corona.

The conditions of the eclipse are not sufficiently favourable to warrant the transport of a large spectrograph for photographing the chromosphere at second and third contacts. As such photographs can be obtained at stations where the partial phase is very large, arrangements have been made to accomplish this at the Sidmouth Observatory, where a large spectrograph is available.

Time determinations of the contacts will also be attempted, use being made of the broadcast time signals for checking the rate of the chronometer. The large-scale photographs of the corona will be taken with a camera the lens aperture of which is 6 inches, having a focal length of 31·5 feet, giving a solar image 3·3 inches in diameter. This instrument will be rigidly oriented to the eclipsed sun, the photographic plate only being moved by mechanism. One exposure only will be made.

Two smaller coronagraphs will in addition be mechanically driven, one having a 6-inch aperture and 4 feet focal length and mounted equatorially, and another a $3\frac{1}{4}$ inch Dallmeyer rectilinear lens of 15 inch focal length mounted on a 12-inch siderostat. One plate will be exposed in the latter and two or more in the former.

Four or more other coronagraphs from 4 inches aperture or less, including a Zeiss triplet aeroplane lens working at f 4·8 and an Aldis triplet aeroplane lens working at f 5·6, will be fixed in position, and two or more plates will be exposed in each, with exposures of two seconds or less.

The large-scale photographs of the chromosphere and prominences will be taken with a 30-foot coronagraph, giving an image of about 3 inches. This instrument will be fixed in the direction of the eclipsed sun, and the exposures given will be very short. Altogether about eight exposures will be attempted.

To secure the spectrum of the corona on a small scale, a Thorp transparent grating mounted in front of a Zeiss triplet aeroplane lens working at f 4·8 will be used. This instrument is mounted on the upper end of the polar axis of a 12-inch siderostat and is clock-driven. One exposure only will be made of the coronal spectrum in the first order of the grating.

The party from the Norman Lockyer Observatory will consist of Lieut.-Col. Sir Francis McClean, Capt. W. N. McClean, and Dr. W. J. S. Lockyer, but much additional volunteer assistance will also be available to manipulate several of the smaller instruments and undertake other observations.

Royal Observatory, Greenwich.

THE headmaster of Giggleswick School has kindly placed a field at the disposal of the Greenwich expedition. The observing party will consist of the Astronomer Royal, Dr. Jackson, Mr. Davidson, Mr. Melotte, and Mr. Woodman. Three different observations will be attempted.

(1) A large-scale photograph of the corona will be taken. For this a 6-inch lens of 45 ft. focus,

kindly lent by Mr. Worthington, will be used. This gives an image of the sun 5 inches in diameter. There is only time for one exposure of approximately 20 seconds.

(2) With a spectroscope of Littrow type, using a prism of 40° angle and 7 inches in height and a lens of 11½ ft. focus, the spectrum of the chromosphere in the red and infra-red will be photographed. Plates dyed with dicyanin will be used, and the spectrum will extend from the magnesium triplet in the green well into the infra-red.

(3) Prof. Milne has shown the importance of a photometric comparison of the H and K lines in the chromosphere; that is, the doublet $1^2S - 1^2P$ of ionised calcium, with the calcium lines at λ8498, 8542, and 8662; that is, the doublet $1^2D - 1^2P$ with its satellite. A spectroscope of reflecting Littrow type has been arranged to give these lines on the same plate. Neocyanin plates recently introduced by the Kodak Company will be employed. By the use of a coarse grating on the solar spectrum the intensity scale will be determined for different parts of the spectrum.

The times of beginning and end of totality will be observed with a direct-vision spectroscope on a 3-inch telescope.

University of Oxford.

The expedition to observe the eclipse at Southport, on the cordial invitation of the Mayor and Corporation, will be a joint expedition from the University and Radcliffe Observatories, Oxford, arranged by Prof. H. H. Turner and Dr. H. Knox-Shaw in collaboration.

The astrographic object-glass of the University Observatory, fitted to a temporary mounting used previously in Egypt in 1905, and pointed to the 16-inch cœlostat, recently purchased from the Royal Society, will be used to take two or three photographs of the corona. (The purchase of the cœlostat, and its renovation, were rendered possible by timely grant from the trustees of Lord Leigh's Fund.) In addition, two photographs will be taken in light polarised in planes at right angles by means of reflection from plane glass plates blackened on the back: the lenses are the similar components which made up the Abney lens used in many eclipse expeditions, and the reflecting plates will be placed near and within the focus. These two cameras will be mounted equatorially.

During a preliminary visit last January, when the kind help and advice of Mr. C. Davidson, of the Royal Observatory, Greenwich, were available, the site for the observations was fixed in the grounds of King George V. School, on the invitation of the headmaster, Mr. G. A. Millward, who has also extended his hospitality to 100 boys who will come from London under the care of the *Daily News*.

Stonyhurst College.

At Stonyhurst College arrangements are being made by Father O'Connor, director of the Observatory there, to take direct photographs of the corona with the 4-inch coronagraph lens belonging to the Royal Irish Academy, of 19 ft. focal length, a 6-inch Dallmeyer portrait lens of about 30 inches focal length, and a Dallmeyer telephoto lens.

An attempt will be made to photograph the corona with the 15-inch equatorial, using a green screen with maximum transparency at λ5300.

Flash spectra, as far into the red as possible, with the 19-ft. lens used as a prismatic camera, will also be attempted.

With the Hilger spectrograph, work will be carried out on the cusps before and after totality.

Quick runs on the magnetographs, and meteorological observations during the course of the eclipse, will complete the Stonyhurst official programme.

Solar Physics Observatory, Cambridge.

The altitude of the sun will not exceed 13° in any site in England at the time of the total phase, and accordingly the conditions in Norway were investigated. It was found that the altitude will be nearly twice as great in Hallingdal and the neighbouring valleys, and the local conditions thereabouts were examined. Prof. Newall and Mr. Carroll went over to Norway in September for three days, and had the great advantage of enlisting the kind help of Prof. V. Bjerknes, who met them at Aal (Hallingdal) on the railway between Bergen and Oslo. Here, after considerable exploration, a site was found in all respects convenient, though, as had been anticipated, the difficulty in that rocky and wooded region was to find a level site which was not already occupied by a house or a farmstead.

The observations which will be aimed at are the following:

Spectroscopic observations of the chromosphere in the ultra-violet (Prof. Newall). Spectroscopic observations of the red calcium lines in the chromosphere, high dispersion, and of both red and violet calcium lines in the chromosphere, low dispersion (Mr. Carroll and Mr. Stratton). Spectroscopic observations with objective grating and moving photographic plate (Mr. Butler). Photometric work in connexion with each of the above. Interferometer observations of the corona (Prof. C. Bryant). Large-scale coronagraph photographs (Mr. W. M. Smart). Polariscopic observations of the corona (Prof. Newall).

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