SATURDAY, OCTOBER 3, 1931.

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Editorial and Publishing Offices :
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.

Editorial communications should be addressed to the Editor.
Advertisements and business letters to the Publishers.

Telephone Number: GERRARD 8830.
Telegraphic Address: PHUSIS, WESTRAND, LONDON.

Racial Prejudice.

PROF. FRANZ BOAS showed his usual courage in taking " Race and Progress " as the subject of his presidential address to the American Association for the Advancement of Science, at Pasadena on June 15 last. He essayed once more to raise the complex question of the intermingling of racial types from the slough of political controversy into which it has fallen in the United States and to discuss it dispassionately in the ' dry light ' of scientific evidence.

Unfortunately, in this matter, science, or perhaps it would be more correct to say those who seek to interpret scientific data and apply their interpretations to practical affairs, speak with no united voice. Prof. Boas, looking on Europe with a cosmopolitan eye, views it as a whole, a congeries of peoples, each of no single fixed and determinate type, or able to lay claim to be regarded as a pure race—racial types, in fact, being largely ideal. Thus, he pointed out, it would be " a rash undertaking to determine the locality in which a person is born solely from the bodily characteristics ". In the populations of the various parts of Europe many individuals might as well belong to one part of the continent as another. Yet, he goes on to argue, while it is not necessary to consider the great difference in type that occurs in a population as due to mixture of different types, it is easy to see that intermingling has played an important part in the history of modern populations. Further, there is no evidence that mating between individuals of different descent or different type results in progeny less vigorous than that of their ancestors. After dealing with the effects of heredity, environment, and selection upon bodily form, Prof. Boas surveyed the data of physiology and psychology from the racial aspects, and arrived at the final conclusion that the biological difference between races is small and that it is the social setting with which we have to reckon. Race antagonism is thus resolved into a matter of social group consciousness.

In this conclusion, Prof. Boas inevitably challenges comparison with the view taken by Sir Arthur Keith in his recent rectorial address in the University of Aberdeen. Sir Arthur, naturally preoccupied with the political and economic situation as it is in Europe to-day, and looking upon it as a phase in a long course of an evolutionary process, gives the fullest weight to the survival value of the concept of race. While he would agree with Prof. Boas that ' racial type ' in its complete implication is an ideal rather than an observed fact, he views ' racial prejudice ' as a potent factor of progress in human affairs. Prof. Boas does not ignore the opposition in their respective views. Not only does he explicitly disagree with Sir Arthur in his view of the beneficial effect of war, but he also traverses his dictum that " race antipathy and race prejudice Nature has implanted in you for her own end—the improvement of mankind through racial differentiation ". Of this Prof. Boas says, " I challenge him to prove that racial antipathy is ' implanted by Nature ' and not the effect of social causes which are active in every closed group ".

In reality, Prof. Boas is by no means so far removed from Sir Arthur Keith's position as he would have us believe. In the practical problem Prof. Boas has specially in view, racial and social group tend to coincide. In Europe the lines of demarcation are geographical. In the United States the conflict is internal ; the races are not segregated within national boundaries as they are, broadly speaking, in Europe. Sir Arthur Keith has expressed the view that every nation is a potential race. Hence the conflict that presents itself to Prof. Boas as calling for the consideration of anthropological science is both simpler and yet in some ways more difficult of solution than it is in Europe. He points out that the difference between racial groups is an important element in establishing racial grouping and in creating conflicts—there are no ethnic groups in Europe so widely diverse as negro and white; but the actual relation is identical whether the grouping be racial, national, or denominational. The group is idealised and there is an emotional desire for its perpetuation. This leads to group endogamy in the desire to keep the race or group pure.

Here it will be seen that Prof. Boas is virtually in agreement with Sir Arthur Keith, in so far as the latter would not exclude social factors from the influences which mould the potential race. This would seem to be the line upon which the negro problem is at present developing in the United States. However, regarding the situation as it stands, Prof. Boas' conclusion is that while society is stratified in social groups which are racial in character, there will be racial discrimination; but that wherever members of different races form a single social group with strong bonds, racial prejudice and racial antagonism will lose their importance and eventually disappear. Applying the terms of a general conclusion to a particular instance, Prof. Boas' address virtually sets out the argument for the case that so long as the United States insists upon a social stratification in racial layers, the penalty must be paid in the form of a racial struggle.

In effect, then, Prof. Boas interprets the evidence of anthropological science as favouring the ' melting pot ' view of population problems—that is, racial fusion, as against the conception of a dominant superior racial type, the theory which at present holds the political field. Although he might not admit it, on his view the United States might well qualify to be regarded as at a stage in Sir Arthur Keith's evolutionary process on its way to becoming a ' potential race '.

Symbiosis.

Tier und Pflanze in Symbiose. Von Paul Buchner. Zweite völlig umgearbeitete und erweiterte Auflage von " Tier und Pflanze in intrazellularer Symbiose ". Pp. xx + 900. (Berlin : Gebrüder Borntraeger, 1930.) 96 gold marks.

THE growth of knowledge in this subject since the first edition of this work in 1921 is reflected in the present edition of 900 pages as compared with its predecessor's 462 pages. In an introduction of 18 pages the main branches of the subject are briefly surveyed. The oldest of these dates from the fifties of last century, when attention was directed by several observers to the presence of chlorophyll in infusoria, *Hydra*, Turbellaria, and the fresh-water sponge (*Spongilla*) ; but the green colour was regarded by some authorities as due to a special kind of ' animal chlorophyll ' or to the minute plants taken into the respective animals from without and living as parasites or serving as food. When Hamann (1882) showed that the green bodies in the egg of *Chlorohydra* do not arise there but wander in from the parent, he established the transmission of symbionts, and further work demonstrated that the green bodies are complete cells. Other investigations showed that the yellow cells in the Radiolaria issue after the death of the animal and a flagellate stage ensues.

In a section of about 180 pages the author considers the cases in which symbiotic Algæ are concerned, beginning with the Protozoa and working systematically through the phyla up to the Tunicata. For each group of animals the history of our knowledge of the symbiosis is briefly surveyed, and the position occupied by the symbiont, the mode and course of infection of the animal and the resultant effects are described. In his comment on the published observations upon the relations between Algæ and corals, the author states his belief that the amount of animal food taken by corals has been generally underestimated, and this is substantiated by the recent observations of Dr. C. M. Yonge on the feeding of corals on the Great Barrier Reef. A particularly interesting part of the volume is that on the artificial suppression and on the artificial establishment of symbiosis of Algæ with Protozoa, *Hydra*, and *Convoluta*, with a discussion of the factors necessary for these partnerships.

The first observations on the symbiotic relations of fungi with animals were those upon the culture, by ants and by termites, of fungi as food. Modern work on intracellular symbionts of fungal nature dates from 1910, when Pierantoni and Šulc independently explained the true significance of the so-called pseudovitellus of Homoptera—up to that time regarded as a food reserve, but then shown to be a complicated structure, termed the mycetome, harbouring the symbionts. All Homoptera that have been investigated have been found to live in more or less complex symbiosis. Some have two, three, or even four different sorts of symbionts. Following the discovery of symbionts in insects which feed on plant juices came that of symbionts in blood-sucking animals—tsetse flies, lice, ticks, mites, leeches, and more recently in bed bugs and the Pupipara—which the author suggests may prove to be of medical interest as some of the symbionts perhaps belong to the Rickettsias.

The author gives a number of interesting recent observations on insects which feed on wood or on a diet rich in cellulose, and carry yeasts, bacteria, and other organisms, the systematic position of which remains uncertain; for example, in the mature female of the cerambycid beetles tubular intersegmental glands associated with the vagina are organs filled with the symbionts, clusters of which are expelled as the eggs are being laid and can be demonstrated on the outer surface of the eggs.

In a chapter of 90 pages are brought together the observations on bacterial symbionts concerned in the production of light in animals, especially by the luminous organs of *Pyrosoma*, of fishes and of cephalopods, and by the 'accessory nidamental glands' of certain cephalopods.

The author traces the steps in the modes of transmission of symbionts, beginning with insects in which the organisms are present in the rectum, from which they are readily passed out as eggs are laid. In other cases anal folds or sacs, or vaginal and intersegmental sacs filled with bacteria, are responsible for infection of the eggs, while in *Glossina* and the Pupipara the symbionts are transmitted to the larva by the uterine 'milk glands'.

In discussing the part played by symbionts in development, the author points out that in many cases the presence of these organisms causes little or no modification; but in the viviparous aphids the abundant flow of symbionts into the developing embryo brings about far-reaching modifications.

While the work of Cleveland and others has elucidated the part played by the Protozoa in the intestine of termites, there appears to be no definite conclusion as to whether the numerous ciliates in the stomach of ruminants—in 1 c.c. of the contents of the rumen of the sheep nearly a million ciliates were found—or in the cæcum of the horse are helpful to the host.

The volume concludes with a list of works on the subject occupying 47 pages, an index of authors referred to, and an index of the genera of animals and plants considered in the text.

Dr. Buchner, who is to be warmly congratulated on his thorough treatment of the subject, has produced a volume of great interest. With justifiable pride he states that what he describes he has in large part seen himself, and that considerable portions of the subject have been investigated either by him or with the help of his pupils, to a score of whom he expresses his thanks. The 336 illustrations are beautifully reproduced and many of them are original. A statement of the magnification and, in a number of cases, additional lettering of the parts, would have made the drawings of still greater value.

Plants and Geology.

Plant Life through the Ages: a Geological and Botanical Retrospect. By Prof. A. C. Seward. Pp. xxi+601. (Cambridge: At the University Press, 1931.) 30*s*. net.

In this book, Prof. Seward fulfils his promise to supplement his four volumes on fossil plants by a general review of the floras of the past, more intelligible to the general reader than the textbook. The result is an admirable treatise, which perhaps no one but Prof. Seward could have written, bringing the records of fossil plants into constant relation with the geological changes in their environment. As he says: "It is one thing to study the fossils by themselves; it is another and a more attractive thing to think of them as living plants in a real world".

The book is abundantly illustrated by pictures, maps, and tables of distribution. A striking and novel feature is introduced in the ten reconstructions of ancient landscapes, drawn for the author by a skilled artist, Mr. Edward Vulliamy. These views, at once accurate and picturesque, are probably the best restorations of past floras hitherto attempted. As in some of the author's earlier writings, every chapter is preceded by an appropriate motto, sometimes rather cynical, as in that of the chapter on classification of plants, " We do but learn to-day what our better advanced judgments will unteach to-morrow " (Sir Thomas Browne) ; sometimes poetic, as in the quotation from Isaiah, introducing the barren Triassic period : " And the desert shall rejoice, and blossom as the rose ".

The first four chapters are purely geological, setting the stage, as it were, for the mysterious drama of plant evolution. The discussion of Wegener's famous hypothesis of shifting continents shows that no decision is possible, though the palæobotanist may be inclined to favour a supposition which would help him out of some of his difficulties.

Referring to the petrified remains with structure preserved, the author says : " We see in the architecture of stem and leaf the same accuracy of correlation between structure and function as in plants of the present day " (p. 48)—an important and true conclusion, which has not always been recognised.

In considering the Cambrian, Ordovician, and Silurian records, the author points out that the almost exclusively marine strata of these periods lead us to exaggerate the suddenness of the creation of a land-flora when we reach the continental Devonian sediments. " Land-plants may well have existed long before, but their remains had no fair chance of preservation " (p. 101). Speaking of the early Devonian land-flora he says : " The probability is that some of the older Devonian plants are examples of transformed Algæ ; others . . . are more likely to be descendants of simpler ancestors which had long been accustomed to live above the sea " (p. 112). In connexion with this subject, one of the very rare slips in description must be mentioned. In describing Lang's very early *Dadoxylon Hendriksi*, from Cornwall, it is stated that the secondary tracheids are pitted on all the walls, not, as in recent Gymnosperms, on the radial walls only. This is true of *Palæopitys Milleri* but not of the Cornish plant, which Lang has shown to be a true *Dadoxylon*, with the typical Araucarian structure.

Going on to the much richer and more advanced Upper Devonian flora, we are at once confronted with difficulties of distribution. The existence of a luxuriant vegetation so far north as lat. 77° N. is one of the many unsolved problems of geological history.

The earlier Carboniferous vegetation was comparatively uniform all over the world, as shown by the occurrence of practically identical forms of *Lepidodendron* in Australia, Spitsbergen, Europe, and North America. The subject of the abundant later Carboniferous vegetation is introduced by the excellent reconstruction of a Coal Age landscape. The author warns us against supposing that the giant Calamites and Lepidodendra of the Coal-forests were the ancestors of our modest horsetails and clubmosses. The latter groups probably owe their origin to such extinct forms as *Equisetites* and *Selaginellites*, which were always comparatively small plants.

Attention is directed to the important work of Prof. Halle on the Permo-Carboniferous flora of northern China. It is interesting to find that this flora presents more points of contact with Mesozoic vegetation than that of more western lands. Coming to the close of the Carboniferous period, the somewhat meagre *Glossopteris* flora of Gondwanaland is contrasted with the rich contemporary vegetation of the north ; the latter is compared to the Dismal Swamp forest of Virginia, the former to the arctic vegetation of Greenland or Alaska. This comparison, though admittedly an exaggeration, brings out the relation of the *Glossopteris* flora to the extensive southern glaciation at that period. " A Scene in Gondwanaland " is pictured.

The chapter on the Triassic period is of special interest as it covers the transition from the Palæozoic to the Mesozoic vegetation, in some respects the most striking transformation in the history of the world's flora. While the earlier phases of the Triassic period were characterised by almost world-wide desert conditions, the abundant remains of plants in some Upper Triassic deposits indicate a renewed spread of forests. It is then that we discover the magnitude of the change in the facies of the vegetation since Palæozoic times. In the southern hemisphere, however, the two eras shade more gradually into one another.

The late Triassic and Rhætic floras show a rich vegetation, even comparable in some districts with the luxuriant forests of the Coal Age. The author inclines to the view that some Carboniferous types still persisted, regarding such genera as *Thinnfeldia* as probably Pteridosperms rather than true ferns. In coming to this conclusion, Prof. Seward is probably relying on work by Dr. Hamshaw Thomas not yet fully published. In Rhætic times the highly organised Cycadophytes, typical of the

Mesozoic age, first appear, while the maidenhair trees already occupied a strong position. "Before the end of the Triassic period the vegetation had put on a new dress, the dominant genera were of a much more modern type, and most of them bore no obvious marks of direct relationship to the trees in the Palæozoic forests" (p. 331).

In the succeeding Jurassic period, Mesozoic vegetation is seen in its most typical phase; fully developed, and not yet appreciably modernised. It was a period of stability, free from the violent movements of the earth's crust which disturbed the world both before and after. Though the Jurassic vegetation was not absolutely uniform throughout the world, it appears "less diversified and less affected by geographical position than that of any other stage in geological history" (p. 342).

Speaking of the great class of the Cycadophytes, the most characteristic plants of the era, the author rightly emphasises the total dissimilarity of Mesozoic and modern types of Cycads, as regards their fructification. He scarcely refers, however, to the evidence, scanty it is true, for the presence of a few Mesozoic Cycads of the recent family. Ferns, maidenhair trees, and conifers were other prominent groups at that period. The author suspects that even in the Jurassic some survivors of the old race of the seed-ferns still persisted.

Dr. Hamshaw Thomas's striking discovery of *de facto* Angiosperms (*Caytoniales*) is recorded. A critical discussion is postponed to the concluding chapter. The author seems scarcely to do justice to the hypothesis maintained by Wieland himself, and ably supported by Arber and Parkin, of an affinity between the Mesozoic Cycadophytes and the Angiosperms.

The Cretaceous period witnessed a profound change. While the Wealden, the oldest formation referred to this period, had an old-world flora, persisting from the Jurassic, "the late Cretaceous Floras are essentially modern, the flowering plants had already assumed the dominant position which they still hold" (p. 382). In Greenland, however, the oldest Cretaceous flora contains very modern-looking flowering plants (for example, magnolias, plane-trees, and bread-fruits) side by side with Cycadophytes, maidenhair trees and ferns still of a Jurassic type. Such facts have led to the hypothesis that Angiospermous vegetation came from the north. It is remarkable that the earliest Angiosperms, if rightly determined, belonged to well-characterised families, still flourishing in our own time.

Throughout the Tertiary period the dominant plants were Angiosperms, much as they are now. The author considers that "palæobotanical evidence supports the view that herbaceous flowering plants as a class are the more recent product of evolution", trees being older (p. 429).

The older Tertiary floras of North America and Europe point to the conclusion that from the beginning up to the early Pliocene, the climate was warmer than at present. This, however, does not apply to more eastern regions, where the fossils indicate a temperate, or even somewhat cold, climate in Tertiary times. The succeeding Ice Age destroyed most of our vegetation, and it has never quite recovered, though gardeners now endeavour to restore a few of the innumerable treasures then lost (p. 463).

There is a chapter on the Quaternary period, but this division of time is admittedly artificial—it is really the Tertiary continued. The occurrence of the great Ice Age is its only justification. Prof. Seward finds evidence that the destruction at that terrible time was not quite complete—a few species survived the cold.

The final chapter is devoted partly to questions of evolution, partly to the evidence for past climates. "Through the whole course of geological history . . . cyclic disturbances of the earth's crust were powerful factors in directing the course of evolution in the organic world" (p. 518). To such causes is due, for example, "the difficulty of discovering connecting links in the chains joining the Palæozoic to the Mesozoic world".

The evolution of the Angiosperms is left, as it must be, "an unsolved problem". Of Dr. Thomas's *Caytoniales* the author says: "They may be representatives of a branch from some ancestral stock from which was evolved, possibly at a later date, the whole Angiosperm alliance" (p. 521). He inclines to the view that possibly the Pteridosperms and the Angiosperms may be on the same line of evolution, an interesting hypothesis which may well be fruitful in leading to further research. "Evolution", he says, "has not been a simple progression; it has been a process of trial and error, a series of experiments" (p. 529).

The subject of the climates of the past is one long associated with the name of the author. The difficulties are serious and proportionate caution is shown. Yet the changes in distribution are so great and obvious that the palæobotanist is almost compelled to take refuge in Wegener's theory of continental drift.

The book concludes with an impressive passage on the æsthetic charm of the contemplation of the plant world, past and present. "The more we know the more conscious we become of the little we really know: the passion for the search grows as we read the story of creation" (p. 544).

D. H. S.

Science at a New Angle.

Novius Organum: Essays in a New Metaphysic. By James Clark McKerrow. Pp. ix + 277. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1931.) 9*s.* net.

Mr. McKERROW says that his book exhibits "a heterodox metaphysic in relation to some scientific problems". In other words, he tries to see some old problems from a new point of view—one which is primarily scientific. But he differs from a good many students, in that he knows what to expect from science, and what not to expect. He perhaps under-rates his own acquaintance with scientific theory, in speaking of his knowledge as "very limited, second-hand and 'popular'". At any rate, the present volume is evidence that the author is able to handle difficult problems with an adroitness which argues grasp and originality.

One of Mr. McKerrow's objects is to solve the ancient dualism which regards necessity as being the law of inanimate Nature, whereas man is a law unto himself. He uses the conception of 'habit' to achieve this. "The appearance of necessity is either due to the relative fixity of habit, or is a statistical effect, or is due to the organisation of a system." An organism is "a system of habitual activity". The living creature is not something animated by habit; the habit *is* the organism, and the organism *is* the habit. Its essence is not substance but activity. Yet the biologist or physiologist, in his zeal for the study of structure, thinks in terms of "cross-sections of duration" and of events determined by conditions. According to the author, this is to think in terms of fictions.

Mr. McKerrow admits (p. 53) that his point of view often involves the profession not so much of beliefs as of various unbeliefs. He believes in 'activity' and 'habit', but not in 'cause', or in 'mind' (though he is not a behaviourist), or in 'events'. Even time is a useful and necessary fiction—"We do not live in time, we simply live and invent time to be lived through". Fictions are only dangerous, however, when they are taken seriously, and when the attempt is made to explain them in terms of fact—as when we seek physiological explanations of 'mind'. Similarly, "there is no explanation of 'mass', because it is a fiction invented to explain the behaviour of material bodies". As a matter of fact, the 'being' of a massive body is to move. "It enters into spatial relations, becomes aware, as it were, of being somewhere and naturally prefers anywhere else." The trouble with scientific explanations is that they mingle fact and fiction. "With diffidence we venture to suggest that the scientific superiority of Einstein's view over Newton's is due to the fact that it is more completely divorced from reality, Newton's time being comparatively real, the harmless, superfluous fiction, duration—and Einstein's a mathematical abstraction, a succession—a causal series ?—of cross-sections of duration. Fact and fiction ought not to be mixed."

This is a stimulating book, and is written in a vigorous and occasionally epigrammatic style. Most students of science will profit from reading it. They will be sure of meeting a number of ideas, a good many of them challenging some accepted notions. A study of the metaphysical side of his subject need not necessarily dispose the man of science to scepticism and distrust of his own methods. It will only teach him the useful truth that we cannot get more out of a pint pot than we put into it. "There is no such thing as mathematical truth; there are only right and wrong equations," says the author. This remark may have a wider application than we think.

J. C. H.

Short Reviews.

The Subject Index to Periodicals, 1929. Issued by the Library Association. Pp. x + 318. (London: The Library Association, 1931.) 70*s.* net.

The "Subject Index to Periodicals" issued by the Library Association is a valuable key to papers scattered among a large number of journals. Many of these papers, though containing useful information and suggestions, are in some danger of being overlooked because those interested in their subjects would not find any reference to them in the literature they are accustomed to read. Although the "Subject Index" is not confined to science, yet so large a number of subjects of interest to readers of Nature are dealt with, that the "Index" should be placed on the shelves in every good scientific library.

The "Index" was begun in the year 1915 and has since been published for every year with the exception of the years 1923–1925.

The present volume indexes the literature for 1929 as it appears in about 550 English and

American periodicals, 24 French, Belgian, and Swiss periodicals, 21 German and Dutch, and 2 Italian periodicals. It must not, however, be assumed that the " Index " is complete, even as regards English and American periodicals; for in order to avoid overlapping, and also to restrict the size, no attempt has been made to index periodicals covered by certain named publications, such as *Science Abstracts*, sections A (Physics) and B (Electrical Engineering), *Journal of the Society of Dyers and Colourists, Revue de Géologie, Minéralogie et Crystallographie*, etc.

We do not think that the exclusion of papers already indexed in publications readily accessible to the scientific investigator will be considered a disadvantage. In any event, the " Index " for 1929 contains references to some 24,000 articles arranged under alphabetical subject headings. Verse and fiction are excluded from this catalogue.

The general editor is Mr. E. E. G. Tucker, who has been assisted by a very large number of voluntary contributors, including the chief librarians and staffs of a large number of important British libraries.

Astronomy: an Introduction. By Prof. Robert H. Baker. Pp. xix + 521. (London: Macmillan and Co., Ltd., 1930.) 16s. net.

THIS book is intended for use as a text in introductory college courses in astronomy. It covers a very wide field, but the subject is so large that, in spite of the considerable size of the volume, only the most cursory treatment of the material is possible. Problems of practical astronomy, as the preface states, have for this reason been almost entirely excluded. Bearing this general and inevitable characteristic of the book in mind, it may be recommended as a thoroughly sound and well-constructed textbook, as far up to date as the time of publication allowed, and enriched by a large number of excellent, well-chosen, and well-reproduced illustrations. It demands little previous knowledge of physics or mathematics, and is clearly and interestingly written.

The economy in expression is well exemplified by the title. Roughly about half the book is devoted to the solar system and the remainder to the stellar universe—perhaps a fair distribution of space among applicants to consideration whose claims are of such widely different character. As a reference book it will be of value to a much larger public than that formed by elementary college students. The only point of criticism serious enough to refer to relates to the method of numbering the paragraphs. Each paragraph is indicated by the number of the chapter containing it, followed, after a dot, by the serial number of the paragraph in that chapter; for example, 11·16 is the 16th paragraph in chapter 11. This is quite clear when the system is grasped (it is not explained in the preface), but the dot is so reminiscent of a decimal point that one would naturally expect to find 11·16 before 11·3, and accordingly may fail to locate a reference. This defect should be remedied in some way in future editions.

A Manual of the Slide Rule: its History, Principle and Operation. By J. E. Thompson. Second printing. Pp. vii + 220. (London: Chapman and Hall, Ltd., 1931.) 5*s*. net.

MANY users of the slide rule will be surprised to find that it can provide enough material for a book of 220 pages.

The first of the five chapters is perhaps the most interesting; in it the history of the slide rule is given in full. Most of the information in Chap. ii., which deals with the elementary theory and operation of the slide rule, will be familiar to many users of the instrument.

The remaining chapters of the book deal with special forms and typical settings of the slide rule. In this part of the book the solution of right-angled and oblique triangles is explained. This particular use of the slide rule is of special interest in gunnery and the solution of the *BOT* triangle might have been included. Incidentally, the solution of triangles deserves a place in Chap. ii., for most readers will be more interested in the first two than in the remaining chapters.

The Treatment of Chronic Deafness by the Electrophonoïde Method of Zünd-Burguet. By Dr. George C. Cathcart. (Oxford Medical Publications.) Second edition. Pp. xiii + 111. (London: Oxford University Press, 1931.) 5s. net.

THE successes obtained by Dr. Cathcart in the treatment of 665 cases of deafness by re-education are of peculiar interest to otologists and to patients with this crippling affliction; he obtained definite improvement in three-quarters of his cases of nerve-deafness, two-thirds of the cases of chronic otitis media, and in a half of the cases of otosclerosis. The treatment involves one or two exercises of five minutes' duration daily. He used the electrophone as the source of sound; this is an electro-mechanical oscillator of the vibrating reed type, with controls for variation of pitch and intensity. Nowadays, an audio-frequency oscillator incorporating two or more thermionic valves would be found easier to handle, but the arrangement of the exercises might well follow the plan of Dr. Cathcart, which has already proved so successful.

An Elementary Course in General Physiology. Part 1: *Principles and Theory.* By Prof. G. W. Scarth. Part 2: *Laboratory Exercises.* By Prof. F. E. Lloyd and Prof. G. W. Scarth. Pp. xxi + 258. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1930.) 13*s*. 6*d*. net.

THE best avenue of approach to the study of biology and medicine is by way of the physical chemistry underlying the general principles of plant and animal physiology. For students who have not had the advantage of a preliminary training in physical chemistry, the first part of this book, which is written by Prof. Scarth, will just supply the deficiency. The second part of the book, under the combined authorship, provides a course of carefully planned laboratory exercises in general physiology suitable for class use.

Faraday Centenary Exhibition.

WITH the possible exception of Italy, which in 1899 and 1927 organised the notable exhibitions to commemorate, first, the centenary of the invention of the voltaic pile, and secondly, the centenary of the death of Volta, no country, we believe, has arranged so interesting and striking a display of scientific instruments, apparatus, and appliances in honour of one man as that which is to be seen in the Faraday Centenary Exhibition at the Albert Hall, formally opened by the Right Hon. J. C. Smuts on Sept. 22, just after his inauguration as president of the British Association.

It is in every way an exhibition worthy of the man and of the occasion. But however important we may regard Faraday's discovery of electromagnetic induction which has given rise to the present celebrations, and however much interest may be felt in the apparatus with which he made that discovery, the exhibition as a whole is an eloquent reminder that the world's debt to Faraday is not confined to a single discovery in one branch of science, but to that very remarkable series of investigations which, spread over more than a quarter of a century, opened up new fields of inquiry and led to an immense increase of natural knowledge and of its application to the needs of mankind. That the origin of so many of the most important developments in communication, transport, and industry can be traced to the work of a single man is an extraordinary tribute to the genius of Faraday, and whether the visitor starts with an inspection of the inner circle of exhibits, which illustrate the various branches of Faraday's researches, and then proceeds to examine the outer circles of exhibits where the modern developments are shown, or reverses the order of his examination, he cannot but be impressed with the truth of the statement, so often made, that Faraday was the greatest experimental philosopher the world has ever seen.

The arrangement of the exhibits is simple and admirable. In the centre on a raised platform stands a replica of Foley's statue of Faraday which is in the Royal Institution, and around this are grouped some of Faraday's apparatus and his notebooks, diaries, manuscripts, and letters. From this platform radiate eight avenues, between which, in three concentric circles, are arranged twenty-four stands, the inner eight of which illustrate Faraday's various researches, while the remaining sixteen are devoted to the branches of industry and science which owe so much to his original work.

The display of Faraday's apparatus and the illustration and demonstration of Faraday's inquiries have been arranged by the staff of the Royal Institution, but the exhibits of apparatus and machinery on the other stands have been arranged by various institutions and organisations connected with the electrical and chemical industries. Like all the events arranged in connexion with the Faraday centenary celebrations, the exhibition is a result of the co-operation, in the first place, of the Royal Institution and the Institution of Electrical Engineers, but the exhibition as a whole has been the work of the Exhibition and Publicity Sub-Committee, of which Lieut.-Col. W. A. Vignoles is the chairman and Mr. J. I. Bernard, of the British Electrical Development Association, is the secretary. Col. Vignoles is also the editor of the Souvenir Catalogue and Guide.

It has often been remarked that many of the most important discoveries in science have been made with the simplest of apparatus. The truth of this is exemplified by the work of such as Wollaston, Hughes, and Rayleigh, and it is well illustrated by many of the relics of Faraday's work as shown in the exhibition. Foremost among the relics is, of course, his iron ring with which he made his discovery of Aug. 29, 1831. Of this a large model is also shown, which, though it does not actually function, is made to appear as if it did so, thus enabling his experiment to be repeated on a scale suitable for the public to see. Many other pieces of apparatus are shown in the glass cases around the central platform, and then come the eight stands devoted in turn to electric science before 1831, Faraday's discoveries in 1831, effects of induced currents, Faraday's researches in magnetism, Faraday's researches in chemistry, Faraday's researches in electro-chemistry, Faraday's researches in electrostatics and the electric discharge. Each stand is lettered, each exhibit numbered, a staff of voluntary demonstrators is present to explain and demonstrate, and in the excellent Souvenir Catalogue and Guide are a valuable series of extracts from Faraday's writings, together with descriptive notes. The books shown include volumes of his Diary laid open at interesting pages, his MS. notes of Davy's lectures, a part of the MS. of Faraday's " Chemical Manipulation ", and his Commonplace Book. Some of his medals and orders are also on view.

PHYSICAL AND ENGINEERING EXHIBITS.

Leaving the exhibits intimately associated with Faraday, the visitor has a choice of examining the interesting collections of telegraphic or telephonic apparatus, electrical measuring instruments, dynamos, X-ray apparatus, and of plant used in the chemical and metallurgical industries, and for the generation and transmission of electricity, and for communication and broadcasting.

The displays illustrating the generation of electricity, electrical measurement, and transformers have been arranged by the British Electrical and Allied Manufacturers' Association (Inc.). Many of the early magneto-electric machines and dynamos are shown, including the little-known generator built by Woolrich of Birmingham in 1844 and used up to 1877 for electroplating. This appears to be the first industrial generator. The main exhibit, however, is a large model of a complete generating, transforming, and switching plant with a pulverised coal-fired boiler and a 25,000 kw. turbine.

On the stand illustrating the development of electrical instruments and transformers there are nearly 300 exhibits, dating from the early electroscopes down to the most modern instruments. They are grouped in chronological order, and contain examples of the work of many famous investigators.

An exhibit which will attract much attention is that arranged by the Electric Lamp Manufacturers' Association of Great Britain, Ltd., to show in as simple a form as possible the principal stages of lamp manufacture. The operations include the coiling and insertion of the filament, the sealing in, and the exhausting of the lamp of air. In the latter operation it is of interest to note that after the exhaustion of the air the bulbs are ' washed ' out several times with nitrogen, and argon is then admitted to about half atmospheric pressure.

The transmission and distribution of electricity is illustrated by a series of exhibits arranged by the Cable Makers' Association ; the Central Electricity Board has placed on view a large coloured map showing the complete ' grid ' transmission system in Great Britain; while electricity in transport is illustrated by models of electric locomotives, flying boats and aeroplanes, signalling apparatus, and a model of the s.s. *Viceroy of India*, the first turbo-electrically-driven vessel in the British mercantile marine. Electricity in the home and electricity for industry, in both of which electrical heating plays a chief part, are illustrated by displays of exhibits on two stands arranged by the British Electrical Development Association.

In the use of electricity for communication, first came land telegraphy, then submarine telegraphy, followed many years afterwards by wireless telegraphy, wireless telephony, and broadcasting. These are the sections in the exhibition which the General Post Office and British Broadcasting Corporation have arranged. The exhibits occupy the four stands *W*, *X*, *Y*, and *Z*. On *W* Stand the B.B.C. has arranged the actual transmitting units forming a part of a regional transmitting station capable of supplying a power of 75 kw. to its aerial system and of giving a nearly equal response to all frequencies between 30 and 8000 cycles per second; while another exhibit in three sections shows modern improvements in valves for radio broadcast reception. Stand *X* of the Post Office is devoted to telegraphy. About half the exhibits here have been provided by the Imperial and International Communications, Ltd., and relate to submarine telegraphy. Among the other half of the exhibits is a working and true reproduction of the electromagnetic telegraph installed by Gauss and Weber at Göttingen in 1833, which has been presented to the Institution of Electrical Engineers by the Elektrotechnischer Verein, Berlin, as a tribute to the memory of Faraday. Further exhibits of submarine cables are shown on Stand *Y*, where are also to be found an automatic telephone equipment and radio apparatus. One notable exhibit is the five-hundred-kilowatt thermionic valve manufactured by the Metropolitan Vickers Electrical Co. for the Post Office for use at Rugby. Described as " probably the most remarkable achievement in the development of wireless communication since the introduction of the three electrode thermionic valve in 1907 ", the valve is designed to handle the enormous output of 500 kw., thereby replacing fifty ordinary high-power valves in the main Rugby transmitter. Made mainly of steel, copper, and porcelain, standing ten feet high, and weighing more than a ton, the valve is " a robust piece of engineering construction ". Needless to say, its construction has only been rendered possible by that scientific research of which the whole exhibition is indeed the fruits. Side by side with these notable exhibits is a display of X-ray apparatus arranged by the Institute of Radiology; while on Stand *Z*, also arranged by the General Post Office, are further exhibits connected with telephony and wireless telegraphy.

Two other features in the exhibition may be briefly referred to. Many scientific workers in the past have made their experiments in kitchens and cellars and the like. Faraday's work, in the main, was done in the stone-floored basement of the Royal Institution. What that old laboratory was like is known from the water-colour drawing made of it in 1852 by Miss Moore. The laboratory has undergone many alterations, and the numerous bottles containing Faraday's chemicals and much of his apparatus have long since disappeared. But enough information has been forthcoming to enable a reproduction of the laboratory to be made, and thanks to the labours of Mr. Malcolm, the director, and of the staff of the Wellcome Historical Medical Museum, visitors to the exhibition can now picture in what surroundings Faraday made his discoveries. The reproduction of the laboratory has been arranged in the King's Room, on the first floor of the Hall.

Another interesting feature of the exhibition is that of the admirable system of lighting and decoration. From the roof of the building has been suspended a great roof canopy or velarium of cotton dyed primrose and cream. On to the under side of this the light from 200 concealed projectors is thrown, each projector having a 1000-watt lamp, and the hall is thus illuminated throughout by the light reflected from the velarium. A great tubular lantern also hangs in the centre of the hall, while there are half lantern lights on the pilasters. The result is that every exhibit is adequately illuminated, while the effect throughout is pleasing and restful.

Chemical Exhibits.

The organisers of the Faraday Centenary Exhibition did well to devote a portion of the space available at the Albert Hall to the commemoration of Faraday's chemical labours and to a demonstration of some of their fruits. Faraday was first and foremost a chemist; it was the fascination of chemistry which drew him to Davy and to the Royal Institution. By way of his epoch-making studies in electrochemistry, to which a stand is devoted, he climbed to the heights of his achievements in the study of electricity and magnetism. His greatness as a physicist rested on a secure chemical foundation. Nowadays we surfeit our physicists with quantum theory and relativity and starve them of chemistry. Thus trained, how can they have a balanced outlook on natural phenomena ? It would be well if some of our universities took Faraday's career to heart in mapping out the training of their students.

As Sir William Bragg said at the Queen's Hall in his eloquent eulogy, Faraday had a flair for fundamentals. This is revealed as much in his chemical as in his physical work. Whatever he touched—optical glass, alloy steels, rubber, sugar from beet, oil products—is a century later of first importance. His heavy lead borosilicate glass achieved importance at the time, and is of historic interest, since with a piece of it Faraday discovered diamagnetism, thereby breaking down the apparently insurmountable barrier between magnetic and non-magnetic substances. In his researches on alloy steels he was ahead of his time. Alloying iron with chromium, nickel, and some of the precious metals, he foreshadowed much of the modern work which has resulted in the production of all kinds of alloys essential to many latter-day engineering triumphs.

The annual world consumption of special steels to-day is five to six million tons. An aircraft engine may have as many as seven different kinds of alloy steels used in its construction, containing nickel, chromium, vanadium, and molybdenum in varying proportions, all specially adapted to the tasks they have to perform in different parts of the structure. Among the many achievements illustrated at the Albert Hall are the manganese steels, developed by Hadfield in the early 'eighties, heat-resisting steels, high electrical resistance steels (containing aluminium, chromium, and nickel), non-magnetic steels (containing manganese, nickel, and chromium), cobalt and tungsten steels for permanent magnets, tungsten steels for high-speed tools, and finally stainless steel and iron, the housewife's boon, the development of which goes from strength to strength.

From the discovery of benzene to the latest commercial dyestuff is a long and brilliant stage in the progress of chemistry. The whole edifice of organic chemistry has been built up in this period—surely one of the greatest achievements of the human intellect. It is difficult to put ourselves back into Faraday's condition of chemical thought, so secure are we now in our knowledge of the structure of organic compounds. He discovered benzene, the fundamental substance of hundreds of dyestuffs, of drugs, antiseptics, explosives, even of the secretions of the glands which regulate the functions of our bodies. The figure of Faraday, under the dome of the Albert Hall, appears to gaze with appreciation at the brilliant array of colours " at the sign of the Hexagon ", illustrating how from benzene and the other constituents of coal tar, succeeding generations of chemists have conjured dyestuffs of every hue for every kind of material. Our veteran chemist, Prof. H. E. Armstrong, conceived the idea of exhibiting these marvels, not in uninspiring bottles, but in their brilliant hues on delicate fabrics.

Never before, we believe, has it been made possible at a public exhibition in this way to trace the history of dyestuffs and follow the development of colours in terms of structure. More than a hundred different dyestuffs are shown. It is hoped to transfer this exhibit, which has been got together at great pains, and could not have been assembled at all without the generous assistance of a number of colour-making and textile firms, to another temporary home in South Kensington before it is dispersed.

Faraday, as is well known, discovered benzene, which he called bicarburet of hydrogen, in 1825, in the oil which accumulated in cylinders of compressed oil gas, made in the early days of gas-lighting by decomposing at a red heat—as we should say, cracking—whale oil. He isolated the crude benzene by fractional distillation, purified it by freezing, and determined its composition and vapour density. Not until twenty years later was it detected by Hofmann in coal tar, from which it is now obtained in millions of gallons annually. Faraday observed the almond-like odour when nitric acid acts upon benzene, but Mitscherlich first isolated nitrobenzene in 1834. Zinin first reduced nitrobenzene to a base, which he called benzidam, in 1841, and in 1845 Hofmann showed that this was identical with a base, aniline, obtained by Fritsche, also in 1841, from indigo. Thus was the relationship of benzene to a colouring matter first established. Nevertheless, it took Bayer twenty years to settle the constitution of indigotin, the colouring constituent of indigo. Many years of further research were required to establish the manufacture of indigotin as a commercial success; though its manufacture was commenced in 1881, it was not really successful until near the end of the century.

This, however, is a digression. Faraday has another claim to the homage of dyestuff chemists. In 1826 he discovered the two sulphonic acids of naphthalene, which he described in a communication to the Royal Society as sulphonaphthalic acids. This work is little known, but it very probably had considerable influence on the trend of investigation into the action of sulphuric acid on organic compounds. Reading Faraday's paper, one marvels at his skill in detecting the two acids, distinguishing them by the solubilities of their barium salts and the manner in which these burned. He worked out the whole technique which we still use for isolating sulphonic acids, analysed the two, and concluded that they had the same constitution. The phenomenon of isomerism had been discovered just before by Liebig and Wöhler (silver fulminate and silver cyanate), and Faraday had himself recently shown that acetylene and bicarburet of hydrogen (benzene) had the same empirical composition. He does not stress the point of the isomerism of the two sulphonates, but he makes a very shrewd guess at the mechanism of the sulphonation process, as we now call it. These two sulphonic acids are, of course, of first-rate importance in the dyestuff industry, the β-acid being the source of β-naphthol, one of the most important dyestuff intermediates. Sulphonation is used for rendering all classes of dye soluble in water.

The history of the development of dyestuffs, from Sir W. H. Perkins' discovery of mauve in 1856, by oxidising crude aniline from coal tar by means of sulphuric acid and bichromate, down to the latest discoveries of modern times, is extraordinarily well told in the catalogue of the exhibition. Perkins' mauve was a beautiful shade on silk (a dyeing of a preparation made by Perkin himself is shown), but it is fugitive and became superseded by better dyes. The primitive artificial dyes were safranine, the magentas, and the Manchester group (aminoazobenzene, Bismarck brown, Manchester yellow), then followed Witts' chrysoidine, the tropæolins, azo scarlets, and reds (from β-naphthol). A sensation was caused by the direct cotton dyes (1884), then followed the gay but fugitive triarylmethane dyes. Synthetic alizarin and some of its congeners were developed by Perkin in England and also by German chemists; later came the fast acid anthraquinone dyes, to be followed at the beginning of the twentieth century by the wonderfully fast anthraquinone vat dyes. Jade green, the most brilliant and fast of this series, is a British post-War development, as is also an improved form of indanthrene blue, the great discovery of Bohn. The indigoid dyes, sisters and cousins of indigo itself, in shades of yellow, blue, red, and violet, form a gay quartet and arouse speculation as to the influence of constitution on colour. In this connexion there is a remarkable series of dyes of the indolenine series, basic dyes containing two substituted indolenine groups joined by a chain of $(:CH\cdot)_n$ groups. When $n=1$ the colour is yellow; $n=3$, pink; $n=5$, blue; $n=7$, green. In other words, in this series an absorption band moves right across the visible spectrum as the length of chain increases. This series will interest students of the carotin series of natural dyes. Finally, mention must be made of Prof. Robinson's exhibit of preparations of synthetic flower colours and their chemical relationships.

Power.*

By Sir Alfred Ewing, K.C.B., F.R.S.

To explain the task of the Bramwell lecturer we must recall the meeting of 1881, when the Association was celebrating its jubilee in the heyday of Victorian prosperity and confidence. It was a jubilant jubilee. Never, perhaps, was applied science more actively progressive. From day to day its achievements compelled attention. Electricity was knocking at the door, bringing a wallet big with gifts, wonderful gifts that established new contacts between the sciences of the laboratory and the arts of social life.

Think for a moment of what the late 'seventies and the early 'eighties gave to mankind. The telephone, the phonograph, the incandescent lamp, the dynamo in a practical form, the electric motor, the storage battery, the transformer, the internal combustion engine using liquid fuel, cold-storage and refrigerated transport of food, the idea of public electric supply, the use of alternating currents, the first clear recognition of the potentialities of electricity as an agent for lighting, for traction, for the conveyance and distribution of power. There, indeed, was a dish to set before the potential rulers of a kingdom which was waiting to be explored, where every engineer in the bud might well fancy himself to be a coming king.

" Bliss was it in that dawn to be alive,
But to be young was very heaven."

Among those fertile years I would specially mention 1881, which was the date of Bramwell's prophecy as well as the jubilee of the British Association. Apart from that, it marks an epoch. For the world then realised that a problem was at last solved with which it had been much concerned, the problem called the subdivision of the electric light. Before that the electric light had meant the electric arc—a dazzling unit, brilliant, overpowering, capricious, admired out of doors, but quite unfitted for the home. It was a tiger burning bright which declined to become a domestic pet.

Then came Edison and Swan, who, working separately, taught us how to tame it by inventing the incandescent filament enclosed within a vacuum bulb. Near the end of 1881, Sir William Thomson (as he then was) lighted his house in Glasgow by means of Swan's lamps. For prime-mover he chose the new gas engine of Dugald Clerk, which completed its cycle in two strokes, unlike the already familiar Otto engine, which required four. Clerk's engine was itself a novelty the importance of which we have come to recognise. To this day all internal combustion engines use either the Clerk or the Otto cycle, and for large powers the Clerk cycle has advantages which tend to give it the favoured place.

Fifty years ago the gas-engine was much in the public eye. No engineer who gave the matter serious thought could fail to see the advantage of having heat developed within the working substance itself instead of being conveyed to it by conduction through a containing shell. Another obvious merit of internal combustion was one that Carnot had recognised in the immortal little treatise where he laid the foundations of thermodynamics —the advantage which you secure by supplying heat to the working substance at a much higher level of temperature than can be reached with steam. Finally, there was this broad difference: the gas engine had the indefinite promise of youth;

* From the presidential address to Section G (Engineering) of the British Association, being also the Bramwell Trust Lecture, delivered in London on Sept. 25.

the steam engine was an old servant the limitations of which were well known. Nobody expected that steam would change its ways. Small wonder then that the engineers of those days looked to the future of the gas engine with exaggerated hope.

It was in that spirit that Bramwell made the prophecy we have now, after fifty years, to review. At the jubilee meeting in 1881 he gave an address "On Some of the Developments of Mechanical Engineering during the last Half-Century". It reviews a great field with the lucidity of which he was a master, dealing specially with applications of the steam engine, and it includes a section relating to the transmission of power. Electrical transmission is barely touched on: it had, in fact, scarcely begun; but he speaks of transmission of power by means of gas, and in that connexion he remarks:

"I think there is a very large future indeed for gas engines. I do not know whether this may be the place wherein to state it, but I believe the way in which we shall utilise our fuel hereafter will, in all probability, not be by way of the steam engine. . . . I very much doubt whether those who meet here fifty years hence will then speak of that motor except in the character of a curiosity to be found in a museum."

Bramwell returned to the question when president of the British Association in 1888. In his address he repeated the forecast of 1881, and added: "I must say I see no reason after the seven years which have elapsed since the York meeting to regret having made that prophecy or to desire to withdraw it". It is evident that he took his 'prophecy' very seriously. He was the acknowledged sage and spokesman of the engineering profession, occupying, in that regard, a unique position, such as no one could possibly hold in the more complex conditions of to-day. He was a humorist, and doubtless there was a conscious touch of humorous exaggeration in what he said; but for all that it was an engineering judgment delivered *ex cathedra*, and his judgments were accustomed to command respect.

Finally, when within a few months of his death, at the age of eighty-five years, he wrote to the president of the British Association, saying that he wished to keep alive the interest of the Association in this subject, and for that purpose offered a sum, which was to be paid as honorarium in 1931 "to a gentleman to be selected by the Council to prepare a paper having my utterances in 1881 as a sort of text, and dealing with the whole question of the prime-movers of 1931, and especially with the then relation between steam engines and internal combustion engines".

That is the task I am now attempting to discharge. The prediction has, in great measure, failed to come true. Steam is neither dead nor dying. To-day, it is a much more efficient medium than it was for the conversion of heat into work, and we find it actuating engines of vastly greater individual and aggregate power than any that were even imagined when Bramwell spoke. But alongside of that we have wonderful achievements on the part of the internal combustion engine which go far to justify the enthusiasm that stirred him fifty years ago.

Looking back now, one is amazed at the boldness of his prophetic outlook. It was more than bold; it was almost foolhardy. Remember that he had nothing to go by except the performance of the gas engine, and that only in very small powers. Gas, whether the ordinary illuminating gas distilled from coal, or the cheaper product of the Dowson process, was the only fuel then in practical use for internal combustion. The oil engine in its various forms, the petrol engine, the Diesel engine—these were still to come.

The success of the Otto gas engine led makers to design engines operating in much the same way, but using for fuel a spray of oil instead of gas. Such engines found a place where gas was not available, as in the driving of agricultural machinery. For the most part their fuel was the safe and familiar oil of the paraffin lamp. Like the gas engine, they were heavy and they ran at very moderate speeds, such as 200 revolutions per minute. About 1883, Gottlieb Daimler set himself to produce an engine with much lighter working parts which should run at a far higher speed, five times as fast, or more, and should use for fuel an oil so volatile that a carburettor would serve to charge the incoming air with combustible vapour. After successful trials with a bicycle he applied his motor, in 1887, to drive a car on the road. That was the beginning of a new era in locomotion. The world discovered in Daimler's petrol engine an appliance such as it had not possessed before—a light, convenient, inexpensive prime-mover, yielding amounts of power which were ample for road vehicles, easy to start and stop and regulate, demanding little attention and no particular skill. Before long it gave city streets an altered character and country roads an unsuspected value. Man acquired a new mobility which changed his notions of distance and of time. In due course the petrol engine also achieved the conquest of the air. At the end of 1903, only a few days after Bramwell's death, the brothers Wright took their first flight in a motor-driven aeroplane. It is the petrol engine that must bear the responsibility—the grave responsibility—of having made it possible for man to fly.

The era of the road-motor began with Daimler's experiment of 1887, but a good many years were to pass before it took the dominant position it holds to-day. The horse was already in possession, and did not yield without a struggle. That sensitive animal had a frank dislike of the horseless car. To meet his objections our legislators ordained for mechanically-driven vehicles a speed not exceeding 4 miles an hour, and required each of them to be in charge of three persons, one of whom should carry a red flag in front. Not until 1896 was the Red Flag Act repealed. The sinister emblem has gone, and the horse has nearly gone too. But engineers will not let his memory perish. Thanks to the initiative of James Watt, they treasure his name in one of their most necessary words. The horse may become little more than an instrument of sport or an excuse for betting, but it is safe to say the horse-power will never die.

About 1895, Rudolph Diesel initiated another epoch-making change. Instead of compressing a combustible mixture, he compressed the air alone, bringing it to a very high pressure, and thereby making it so hot that when the charge of oil was forcibly injected at the dead-point there was instant ignition. This escaped all risk of pre-ignition and greatly augmented the efficiency of the action, as a thermodynamic consequence of the very high temperature at which the fuel gave up its heat. To force the fuel in, he at first employed an auxiliary supply of still more highly-compressed air, but this plan is now less common than the simpler one of using a high-pressure pump, which delivers the oil in a spray of exceedingly fine drops. The essential feature of the engine is that the fuel does not enter the cylinder until the air there is highly compressed and the working stroke is about to begin. It is this feature which has made the Diesel engine the most efficient of all known means of obtaining mechanical work from the combustion of fuel.

Imagine our prophet of 1881 brought back to earth so that he may see for himself in what measure his expectations have been fulfilled. He will come, of course, by aeroplane, and on the way the pilot will tell him of the part which the internal combustion engine played in the War ; of submarines and road-motor transport, and tanks and aircraft. He will be told of Zeppelins and air-raids, of the horrible superiority of attack over defence that characterises modern war. He will learn how prodigiously man has increased his power to kill his fellows and destroy their works. The old gentleman will be saddened to think that the world owes this to engineers, and especially to the internal combustion engine. It will grieve him to reflect that the island safety of England has departed, never to return. On the other hand, he will be told of air-mails to India and Australia and the Cape, and it will interest him much to learn that the engine which is bringing him so swiftly and comfortably to earth weighs no more than a couple of pounds per horse-power, and that engines of the same type, but lightened and tuned to the uttermost for racing, can develop more than a horse-power for every pound of weight. He will hear, perhaps with less enthusiasm, of speed records by air and sea and land, amazing records which are set up only to be broken. " Brief life is here our portion " might be said of the records, and also, alas, of many of the record makers and record breakers. As he approaches London our aerial voyager will note the highways thick with motor-cars, coaches, and lorries, and will wonder for a moment what has happened to the railway shares he left behind, doubtless selected as a secure investment of the terrestrial fruits of his industry and thrift. For in Bramwell's time there were still people who practised these now exploded virtues, and there were even Chancellors of the Exchequer who encouraged them.

We may imagine that the pilot brings him over the river and the docks, where he may see big motor-ships like the Nelson liners arriving with their frozen or chilled cargoes. One of his pet bits of engineering was mechanical refrigeration, and he will take particular satisfaction in noticing ships that are not only driven but also cooled by internal combustion engines. From the docks they will proceed over the City, where at every crossing he will observe the congestion of motor-cars and taxis, and the multitudinous motor-bus—but never a ' growler ', which was the vehicle he used to favour. I well remember his taking me to visit a cold store on the south side of the river ; we were on our way in a ' growler ' when the bottom fell out and we were left sitting in the road. He was, as I have hinted, no light weight ; my part in the comedy was only that of the last straw. The cab stopped without injury to life or limb, Bramwell forming an effective automatic brake. His genial dignity suffered no eclipse. His spirits were undamped—and his person too, for luckily the street was dry.

Finally, let us think of the pilot bringing him over Waterloo Place to revive his memories of the beloved club where he used to spend many placid hours. Below him will be the Athenæum, more than ever a haven of rest for the mature, but now on the outer edge of a vortex which is fed by torrents of one-way traffic from the Haymarket and Trafalgar Square—a veritable inferno of internal combustion—an inferno that would be intolerable were it not tempered from time to time by authoritative outstretchings of the arm of the law. As he watches the maelstrom, and perhaps sees a bishop trying to reach the club, he will thank the fate which has removed him from the present-day terrors of the pedestrian, from compulsions to unseemly agility and temptations to unseemly profanity. Such temptations are, of course, only for laymen, but life in Waterloo Place, even for bishops, must sometimes be furious as well as fast.

When all these things have been seen, we must not imagine Bramwell posing as the satisfied prophet who complacently remarks " I told you so ". He had too judicial a temper for that. He would want to know about other users of power, and would ask many questions. What about our navy, and other navies, the biggest liners, the railways and the great factories, and the coal pits with their plant for winding and ventilating, and what about the distribution of light and power from central stations—on what kind of prime-movers do these rely ? And the answer would be steam, and steam, and yet again steam. He would soon learn that steam still does a great part of the work of the world, and that one need not go to the Science Museum at South Kensington to find specimens of its remains. But if he did go to the Science Museum he would see admirably displayed there some remarkable engines. Side by side with the mementos of Newcomen and Watt, those fascinating heralds of the dawn, he would see engines of a far more recent type enshrined in the honour they so well deserve, not as relics of an obsolete past but as precursors of the modern era which was opened to the world by the genius of Charles Parsons. For among the treasures of our national museum of science is Parsons' first steam turbine, which dates from 1884, the first turbine to which he fitted a condenser, which dates from 1891, and also a part of his famous little craft, the *Turbinia*, by which in 1897 he demonstrated the applicability of the steam turbine to the propulsion of ships.

These dates are all subsequent to Bramwell's prophecy of 1881. Many factors have contributed to prevent that prophecy from being fulfilled, but none has been so potent as Parsons' development of the compound steam turbine. That invention was no mere throwing out of a happy thought. It was the life-work of a man who, to an extraordinary degree, combined creative imagination with energy and persistence and practical skill.

Such a man lives on in his achievements. To Parsons it was granted as to few men to see the fruit of his ideas and his labours. Long before he died the world recognised that he had revolutionised steam engineering. He had taught us how to generate power on a scale and with a concentration never before approached. Nothing, in a sense, could be simpler than his steam windmill with its successive rings of vanes, each in turn taking up a small fraction of the whole energy of the blast. To conceive such a device was one thing, to give it being and action was quite another. That meant many subsidiary inventions and years of toil; it meant the removal of mountains of prejudice and difficulty. But the triumph is complete. Engineers, all the world over, are whole-heartedly converted. They build their steam windmills on a colossal scale, crowding 50,000 or 100,000, sometimes even 200,000 kilowatts into a single unit, confident in the knowledge that no more trustworthy and economical prime-mover is available for the gigantic stations which play so important a part in modern civilisation as centres for the production and distribution of light and of power.

Review the great power stations of the world, and you find their method of manufacturing electric energy from heat is almost wholly through the medium of steam. To illustrate how small a place is taken in them by the internal combustion engine, let me quote some figures for British power stations. A return published in 1930 by the Electricity Commissioners gives the aggregate capacity of the generative plant of various types as follows:

	Kilowatts.
Steam turbines	5,531,952
Reciprocating steam engines . .	138,806
Oil engines	71,331
Gas engines	17,473
Water-power plant	42,208

Oil engines and gas engines together make up only 1½ per cent of the whole. Abroad, as well as at home, the steam turbine is dominant.

It is in great power stations equipped with large turbines and coal-fired boilers, using steam of high pressure and high superheat, that we find the most economical production of power from fuel. A modern turbine can generate one electrical unit with a consumption of barely 1 lb. of cheap coal, which means that it converts into electrical energy fully 30 per cent of the potential energy of the fuel. The internal combustion engine finds little favour in power stations, save as a stand-by to assist occasionally in meeting the peak load.

Turning now to another field, we find that in railway traction the supremacy of steam is maintained. Much attention has been paid to the Diesel engine as a possible alternative, but so far the number of Diesel locomotives that have found employment in main-line working is a negligible proportion of the whole. If the steam locomotive is to disappear, there is no indication that its place will be taken by an internal combustion rival. What is much more likely is that it will in time be driven out—wholly or in part—by electric traction, as Lord Weir's Committee has recently suggested for the British railways. But electrification will mean that the prime-mover is still steam, though acting at a central station—except, of course, in countries which have available reserves of hydraulic power.

Such a country is Switzerland, and there the transformation from the steam locomotive to electric traction is already almost complete. The playground of Europe has lost little or nothing of its charm through becoming dotted with hydraulic power houses. Already its exports to less favoured neighbours include many million units of electric energy, which it delivers through the graceful catenaries that girdle its mountains and span its valleys. The shrewd inhabitants doubtless demand a remunerative price for exported electricity, just as they quite properly do for the other amenities of their delightful land. A time may come when subterranean stores of coal and oil run low, but, so long as the sun shines and the rain falls, mankind will be able to continue its struggle for existence, though it may suffer a change in the centre of gravity of its industrial life. Industry will learn, like the Psalmist, to look to the hills whence cometh its help, and Geneva will be more than ever the natural rallying point of a community of nations, physically linked by a comprehensive ' grid ' on which they depend for whatever modicum of light and power they are still permitted to enjoy.

For road motors, and for the air, the internal combustion engine is, of course, supreme; it has created as well as supplied a vast demand. We ought, I think, to pay tribute to the constructive talent that has made these engines the convenient and reliable prime-movers they have in fact become.

Turning to the field of ocean navigation we find a situation which is puzzling, unsettled, and difficult to analyse. For in the selection of prime-movers for ocean-going ships, there are sharp differences of opinion and of practice; there is no sense of finality; there is even—so it seems to me —a good deal of fashion and caprice, and of the probability of change which one associates with such moods of the mind.

In our own navy and foreign navies there is a practical monopoly on the part of steam, except, of course, in submarines. But the mercantile marine is in a state of flux. Before the War there were almost no motor-driven ships. The *Selandia*, which dates from 1912, was the first conspicuous example of a large ship driven by Diesel engines. Her economy of fuel at once commanded attention. She was naturally hailed with delight by the powerful oil interests whose position, already strong in the mercantile marine through the extended use of oil under boilers, would become impregnable if the Diesel engine were generally adopted. In some important quarters the Diesel engine became the vogue. During the post-War years of marine reconstruction the number of oil-driven motor-ships rapidly increased, and it is still increasing. Of merchant vessels launched during the year 1930, considerably more than half the tonnage was motor-driven. At this rate, a superficial observer might fancy that steam was in process of being driven off the high seas. But if that were his conclusion I think he would be quite wrong.

None of the greatest and fastest ships is motor-driven—neither the *Leviathan*, which at present heads the list, nor any of the other leviathans of the deep, with their tonnages of 40,000 or 50,000 tons or more, and their speeds ranging from 20 to 28 knots. This is true not only of the older ships but also of the newest, such as the *Europa* and the *Bremen* and the *Empress of Britain*, and the giant Cunarder which is now on the stocks and is confidently expected to surpass them all. For such vessels, motors do not give the concentration of power that is needed, whereas turbines do give it, and give it easily.

When we turn to vessels of intermediate types, we find the liveliest contest between the steam turbine and the Diesel motor. Some nations, such as Denmark, Norway, and Sweden, conspicuously favour motors. Others, such as America, no less conspicuously favour steam. One feels that both cannot be right. Nor can British practice, which is much divided, be right either. The choice would sometimes seem to depend more upon the taste and fancy of a dominating personality than upon a careful weighing of arguments such as appeal to engineers. One finds some shipowning companies going strongly for Diesel engines and other companies going no less strongly for steam. A notable example in the steam group is the Canadian Pacific Company, the superintending engineer of which, Mr. J. Johnson, has communicated to the Institution of Naval Architects a very full statement of the grounds which have governed that company's engine policy. His paper deserves careful study; I have not been able to find any equally detailed and convincing statement on the other side.

When we attempt to appraise the merits of the rivals and to estimate their chances in the more distant future, we see that from the thermodynamic point of view the Diesel engine still has a small advantage. On the other hand, its oil is more costly than fuel oil for boilers; it must have lubricating oil, too, and the first cost of the engine is substantially greater than that of steam plant. In respect of weight and of space occupied there is not much to choose. As to durability, I cannot speak; so far as I know, there is still a dearth of published facts about the cost of upkeep with Diesel engines. *Prima facie*, the great number of reciprocating parts is a serious drawback. There must be a great number because the safe limit of cylinder size is soon reached, and it is only by having many cylinders that any large aggregate of power is developed. In a recent Diesel-engined liner of the luxurious type, 12 Diesel cylinders operate on each of four shafts, making 48 in all, to produce a speed of 18-20 knots. Besides these 48 main cylinders, there are 24 more which serve purposes that are auxiliary but essential to the working of the main engines. Consider the number of working joints, of valves, of valve-rods and tappets, besides pistons and connecting-rods, which this involves. Does such an accumulation of reciprocating pieces with their hammer-blow accelerations mark a real engineering advance as compared with the cosy hum of a turbine engine-room, and has it come to stay? Frankly, I think not.

Now, a final question. Can anything be done to re-establish the ancient connexion of the merchant service with the British coalfields? Remember that here, and in most other places, the cost of coal is substantially less than that of oil for the same quantity of heat. Where oil scores is in its greater convenience of handling. Much has been said and written about restoring prosperity to the miners by converting coal into oil. As a chemical operation it is quite possible to make oil from coal; as a commercial proposition it is impracticable, so long as Nature continues to supply oil directly from the bountiful stores on which man now draws with prodigal ease. Ships that burn oil must have it come to them from sources outside Great Britain. Can we expect ships to return to the use of coal as fuel? For some classes of ships I think we may, though not all classes. Neither in the navy nor in what one may call the upper division of the mercantile marine—the luxurious express liners which carry fastidious passengers and must keep to a timetable that means quick fuelling—can one expect a reversion to coal so long as oil fuel can be got at anything like its present price. But with cargo-liners and big cargo-boats the case is different. I think those engineers are right who contend that for such ships a highly economic mode of working would be to use pulverised coal for steam-raising in a small number of large boilers of the water-tube type, with a pressure of, say, 500 lb. and a temperature of 750° F., each boiler having its own pulverising mill and being fitted also for burning oil as an alternative fuel. In such a scheme there would be no untried elements, but the combination of the elements would be experimental, and a conclusive demonstration of its advantages can be obtained only by testing it out on a large scale in sea-going ships.

In taking leave of our prophet of 1881, if we were to catch from him the mantle of prophecy we should wear it ruefully; we should all be Cassandras or Jeremiahs, obsessed with the cheerlessness of the industrial outlook, and finding no escape from the conviction that the easy supremacy of Britain, as Bramwell knew it, can never be recalled. But my last word must not be an unqualified Ichabod. The engineers of to-day have as much courage and enterprise as their fathers, and they have an infinitely better understanding of the scientific principles on which, as on a smooth highway, the advance of engineering must steadily proceed. Moreover, to recognise evils, and the causes of evils, may be the first step towards their cure. The world has learnt, through a sharp lesson, that the gifts of the engineer are good gifts only if they are wisely used ; that the new powers he has evoked have brought new dangers against which mankind must resolutely guard if it is to save its soul alive. The malignity of individuals and the madness of nations now command forces of destruction such as more primitive communities never knew, and were happier not to know ; and apart from clamant and appalling abuses of gifts which ought to be beneficent, we have become aware of a more subtle and perhaps graver social menace. We see the mechanised arts of production overreaching themselves, supplying commodities in a volume which cannot be absorbed, and with a facility that tends to deprive man of his richest blessing to body and spirit—the necessity of toil.

But these thoughts take us too far afield. They point to problems now conspicuously urgent, which, for the salvation of society, the engineer, the economist, and the moralist must jointly set themselves to solve.

The British Association Centenary.

COMMEMORATIVE SERVICE AT LIVERPOOL CATHEDRAL.

THE Dean and Chapter of Liverpool lose no occasion to make their great Cathedral the scene of public commemoration, and the centenary meeting of the British Association for the Advancement of Science was celebrated there with a ceremony on Sunday, Sept. 20, which will remain vivid in the minds of everyone who assisted in it. It happens that this year's Lord Mayor of Liverpool, Alderman Edwin Thompson, was one of the Association's local secretaries for the meeting in Liverpool in 1923, and is the son of a local secretary of the meeting of 1896. He was therefore able in a special sense to express the feelings of Liverpool people on this occasion; he entertained the president and president-elect of the Association at the Town Hall, and conducted them in full state to the Cathedral, where representatives of the University of Liverpool, the medical profession, and other public bodies, in academical robes, made a bright mass of colour in the choir, and the nave was filled to the doors; indeed, the greater part of the service had to be repeated later in the day. The thanksgiving service fell into three parts. The Dean, with the two presidents, and other members of the Association, presented themselves before the Bishop at the junction of choir and nave, and the president-elect, General the Rt. Hon. J. C. Smuts, addressed him in the following words :

Sir,—Bid a Blessing on this congregation assembled to render thanks for the increase of knowledge by the devoted labours of men and women in many lands, and more especially for the British Association for the Advancement of Science. This body was established a hundred years ago to give more systematic direction to scientific inquiry, to promote intercourse between those who cultivate science in different parts of the British Empire with one another and with philosophers of other countries, to direct the general attention to the objects of science, and to remove disadvantages of a public kind which impede its progress. The Spirit of God has used it to interpret the process of Nature and the doings of man, and by unrestricted interchange of observations, projects, and beliefs, the outlook of the nations on the world in which they live has been transformed. Vain fears and anxieties have been assuaged by clear thinking and wise endeavour. The real dangers and perplexities of our daily lives have been relieved by forethought and mutual help. The amazing structure and intricate processes of the universe have been set forth for reverent and devoted contemplation by students young and old, of all sorts and conditions. In these several ways human sympathy has been widened in the common task of mutual enlightenment and public service, men's minds have been awakened to the revelation of that which works in all and through all, and their grasp has been strengthened on the principles and the meaning of life.

The Bishop replied to General Smuts in historic words, as follows :

May God, the Fountain of all knowledge, fill you, who have gathered in this house for commemoration, with understanding and joy. May He keep you steadfast and persevering in your search for truth. And may the blessing of the Lord come upon you abundantly.

O Thou, who in every generation hast moved Thy chosen servants to seek Thy truth : continue we beseech Thee, so to inspire us in this age that, searching the works of Thy hands, we may find Thee in all that Thou hast made, and finally may know Thee perfectly revealed in the Spirit of thy Son, Jesus Christ our Lord.

A lesson was read from Ecclesiasticus xliv., by the president, Prof. F. O. Bower, " Let us now praise famous men, and our fathers that begat us ", and an anthem was then sung :

Lord, who hast made us for Thine own, hear as we sing before Thy throne.
Alleluia, Alleluia.
Accept Thy children's rev'rent praise for all Thy wondrous works and ways.
Waves, rolling in on ev'ry shore, pause at His footfall and adore,
Ye torrents rushing from the hills, bless Him whose hand your fountain fills.
Earth, ever through the power divine, seedtime and harvest shall be Thine.
Sweet flowers that perfume all the air, thank Him that He hath made you fair.
Burn, lamps of night, with constant flame, shine to the honour of His name.
Thou sun, whom all the lands obey, renew His praise from day to day.
Alleluia, Alleluia.

The commemoration was delivered, in the form of a bidding prayer, by Prof. J. L. Myres, one of the general secretaries of the British Association, and formerly Gladstone professor of Greek and lecturer in ancient geography in the University of Liverpool. After each prayer the response of the Dean was "Bless ye the Lord", and of the congregation "Praise him and magnify him for ever".

Ye shall remember those who in all times and in all places have devoted their gifts of intellect and imagination to interpret the laws of thought, the place of man in the universe, and the nature of reality;

Such as were Aristotle, Da Vinci, Bacon, Descartes, and Kant.

Ye shall remember all who have explored the properties of numbers, and the mysteries of time and space;

Such as were Pythagoras, Archimedes, Newton, Leibniz, Gauss, and Poincaré.

Ye shall remember all who have determined the courses of the stars, the place among them of sun, moon, and this earth of ours, and have given to all those, whose business is in the great deep, sure guidance to the haven where they would be;

Such as were Ptolemy, Copernicus, Kepler, Tycho Brahe, Halley, Herschel, and Huggins.

Ye shall remember all whose profound vision and infinite patience have revealed the ever-changing uniformities of the great forces of Nature; and made light and sound, heat and cold, lightning, wind, and flood subservient to the purposes of man;

Such as were Galileo, Gilbert, Watt, Faraday, Joule, Clerk Maxwell, Rayleigh, Hertz, and Parsons.

Ye shall remember all who have distinguished the natural elements, verified their properties and affinities, and thereby compounded substances unknown before, serviceable to health and in the arts;

Such as were Paracelsus, Boyle, Dalton, Priestley, Lavoisier, Davy, Berzelius, and Mendeleeff.

Ye shall remember all to whose vision across the ages the mountains and the seas are but of yesterday; who have laid bare the foundations of the world, and revealed its hidden treasures surely and safely for our uses;

Such as were Hutton, Nicolaus Steno, William Smith, Lyell, Bouchier de Perthes, and Suess.

Ye shall remember all who, not sparing life or fortune, set forth to find and win new homes for the multitude of our folk, to build the waste places of the earth, so that the desert should rejoice and blossom, and the men who stood far off might see a great light; for all travellers and explorers, and for those who were moved by great thought to send them forth, and to set down and make known their discoveries;

Such as were Marco Polo, Prince Henry the Navigator, Christopher Columbus, Banks, Cook, Humboldt, Franklin, Livingstone, Nansen, and Scott.

Ye shall remember all who have set in order the lineage of all living things, animals and plants, observed their habits and haunts, their struggles and survivals through the long lapse of time, the wonderful variety, infinite beauty, and subtle adaption of each to its proper life; their coming to birth and passing away: who have distinguished among them the friends and the foes of man, and sought to diversify by human skill the manifold works of creation;

Such as were Hippocrates, Galen, Linnæus, Cuvier, Lamarck, Darwin, Hooker, Huxley, and Mendel.

Ye shall remember all who have applied the principles of the several sciences to the tillage of the soil, the avoidance of famine and pestilence, the breeding and sustenance of flocks and herds, and the abundant provision of our daily bread;

Such as were Jethro Tull, Daubeny, Liebig, Lawes, and Theiler.

Ye shall remember all who, by their intimate study of the functions of life, have made plain the mysteries of many diseases and abated their ravages; and brought knowledge of our bodily frame to the better study of the mind in sickness and in health;

Such as were Vesalius, Harvey, Hunter, Claude Bernard, Johannes Muller, Pasteur, and Helmholtz.

Ye shall remember all whose contemplation of the divers races of mankind, the manner of their lives, the ordering of their societies, their customs and beliefs, and their manifold dealings each with his neighbour, for the enjoyment of Nature's gifts and the fruits of reason and toil, to the increase of the wealth of nations, have contributed to mutual understanding among the peoples and peace on earth among men of good will;

Such as were Bodin, Locke, Montesquieu, Adam Smith, Quetelet, Galton, and Tylor.

Ye shall remember all by whose precept and example, schools, colleges, and universities have been founded, so that true religion and sound learning may ever flourish and abound; for all teachers of those who learn; for all guides and masters of those who teach;

Such as were Socrates, Plato, Herbart, and in our own land William of Wykeham, Colet, and Arnold, Thring, Sanderson, and all founders and benefactors of the University of Liverpool.

The Bishop, at the end, taking up the same theme in more general terms, said:

And lastly, let us remember all who in the wise use of their abundance or their power, by their gifts of tongue and pen, by their particular skill, industry, and patience, have contributed to the advancement of learning, the application of science to the common good, or to the spread of the new light of reason among dark places and cruel habitations. Line upon line, precept upon precept, here a little and there a little, the works of each proclaim the Spirit of Him who wrought in them.

Then, after a hymn, the sermon was preached by the Bishop of Birmingham, Dr. E. W. Barnes, on the words, "The things that are not seen are eternal".

Finally, after hymn and anthem, the congrega- was dismissed with blessing by the Bishop.

In the evening a more informal gathering, such as is customary in Liverpool Cathedral, was conducted by the Chancellor of the Diocese, and addressed by General Smuts and Sir Oliver Lodge. The Cathedral was full, and an even larger number was turned away.

Sectional Meetings and Discussions.

The meetings of the British Association have become part of our intellectual life as a nation and as an Empire. The general public awaits with an eager interest the messages of our leaders of thought about the actual trend of civilisation, while research students expect to find in their pondered pronouncements an indication of the landmarks in the unknown reached by science, and inspiring examples and methods for its own studies. The meeting of the British Association this year had, however, a wider interest, owing to the centenary celebrations of its foundation. When one looks back on the work of the Association during these hundred years from its first meeting organised at York by

Brewster and a band of enthusiastic men of science, one can only recognise the immense services it has rendered to science and the growing importance of its work.

The opening address of General the Right Hon. J. C. Smuts and summaries of the addresses of the presidents of sections have already appeared in Nature of Sept. 26. Taken together, they represent a broad survey of what science has done in recent years and what is to be expected of it in the near future. The problems of the constitution of matter, of the origin of life, of the various aspects of physiology, and of the increase and applications of mechanical power have been restated and broadly illustrated, while the papers read at the sectional meetings have considered special points of particular interest in the various branches of knowledge, from asymptotic partition formulæ to London tunnelling problems, the psychology of facial expression, or the early bronze age site in western Macedonia.

Questions dealing with integral calculus, higher pure geometry, and the application of mathematics to such problems as the relativistic wave equation, viscosity, and molecular physics seem to have been prominent among the mathematicians; while questions referring to the invention and use of powerful optical instruments and to the study of atmospheric conditions have been dealt with in the department of cosmical physics. The outstanding discussion in the department of Section A was one on the evolution of the universe, opened by Sir James Jeans at a crowded assembly in the Central Hall, Westminster. We propose to publish in a later issue the contributions to this discussion. In the Chemistry Section, much interest was shown in the study of the properties of electrolytes in various conditions, and also in the constitution and biological effects of vitamins, as well as in molecular and atomic structures. A fine collection of exhibits of various chemical compounds added to the practical value of this important section.

Geologists were interested to hear of the unknown prehistoric conditions of the London district. But the conflicting views of Sir Arthur Keith, Prof. H. L. Hawkins, Prof. H. F. Osborn, Prof. Swinnerton, Prof. A. E. Trueman, Prof. D. M. S. Watson, and Dr. W. D. Lang on the evidence of palæontology with regard to evolution could scarcely serve as a safe guide to the layman in one of the fundamental questions affecting the human race. Geological problems, however, are closely connected with geography; so that the transition between these two sciences appears to be easy and natural. The retrospect of geography at the British Association, sketched out by Dr. H. R. Mill, was a useful introduction. Yet the trend of the discussions has shown that physical geography rather than descriptive geography has the favour of the man of science. Perhaps we know already too much about what we have on our planet: what we want to know is how all this came about, or, to put it in technical terms, what are the origin and nature of the earth's crust.

As would be expected, zoology was dominated by inquiries on evolution, natural selection, genetics, and Mendelism, applied to the whole range of living organisms; while physiology dealt with the advanced aspects of the subject, especially with reference to human beings. A most interesting discussion in this connexion was that on problems of resuscitation from asphyxia, electrocution, drowning, etc., when the learned diagnoses of Sir Bernard Spilsbury, Prof. Y. Henderson, Prof. J. S. Haldane, Sir Francis Shipway, and other experts were given. Mechanical causes, inhalation of air deprived of oxygen, paralysis of the respiratory centres were considered under their various aspects as the chief causes producing asphyxia, and methods of resuscitation were suggested. Going further into the problems of the human complex, psychologists discussed the diverse questions pertaining to child psychology, analytical and abnormal psychology, and the experimental side of their inquiries. The delicate subject of mental deficiency and the psychology of the senses were also among the items considered. On the other hand, the ancient history of man was presented in a series of technical papers in the section of anthropology, in which primitive races and prehistoric man were studied side by side. Among the archæological theories put forth in this section, Dr. R. E. Mortimer Wheeler's paper on the excavations of Verulamium (St. Albans) was of a special interest.

Botany and agriculture received also full consideration. Plant morphology and plant diseases, especially the questions connected with wood preservation in forestry, were carefully analysed. At the same time the practical value of botany was the subject of a symposium on the training of botanists for economic and industrial positions, in which Sir Arthur Hill, Sir John B. Farmer, Prof. V. H. Blackman, Dr. W. B. Brierley, and Mr. J. Ramsbottom took part. Problems referring to agriculture proper were dealt with in a variety of papers which should prove of immense value to the practical side of farming, cattle breeding, and the allied arts of the countryside. The economic questions relating to agriculture in the British Empire were also discussed generally.

Economic science had naturally an important part to play in the meeting, and the sections devoted to economics and statistics, with the connected subjects of industry and engineering, scored high in the proceedings with some brilliant papers by experts and leaders of industry. A cursory remark may also be made about the section of education, in which the suggested establishment of a central institute for imperial education was thoroughly discussed.

On the whole, the addresses and papers read at the centenary meeting of the British Association show conclusively that if the scientific worker knows more and more about Nature, he is less and less inclined to present any clear-cut or definitive solutions to the major problems he sets forth to answer. A quarter of a century ago, the positivistic and materialistic conception of science allowed him a greater pride, almost a sense of infallibility, about his conclusions. Now, however, the very magnitude of his knowledge compels him to greater modesty. Perhaps that is the proper attitude he should adopt; if one admits that the final light that man seeks in this world should come from other sources which, though different from those of science, tend, however, to mould the human mind and its aspirations into a nobler and finer unity.

The freedom of the City of York was conferred on General Smuts when an invited party visited the city on Sept. 26.

At a reception given by the University of London on Sept. 28, the vice-chancellor delivered an address of welcome to the delegates to the centenary meeting, and then, by desire of the Senate, conferred the honorary degree of doctor of science, *Honoris Causa*, on the following:

General the Rt. Hon. Jan Christiaan Smuts, C.H., F.R.S.;
Prof. Sir Frederick Gowland Hopkins, P.R.S.;
Sir Joseph John Thomson, O.M., F.R.S.;
Sir Charles Scott Sherrington, O.M., G.B.E., F.R.S.;
The Rt. Hon. Lord Rutherford of Nelson, O.M., F.R.S.

OFFICERS AND COUNCIL.

Sir Alfred Ewing, lately principal and vice-chancellor of the University of Edinburgh, has been elected by the General Committee president of the Association for next year, when the meeting will be held at York. Hitherto the president has assumed office at the inaugural meeting of the Association and has then given his presidential address. By an alteration of one of the Statutes, recommended by the Council and adopted by the General Committee, the president will in future assume office on Jan. 1, will deliver his address at the annual meeting held during his year of office, and will retire at the end of the year. The advantages of these changes are stated by the Council as follows:

(1) The president will be responsible administratively for the major part of the preparation of arrangements for the annual meeting over which he is elected to preside, and his influence can be more directly brought to bear upon them.

(2) In particular, he will take the chair at the joint meeting of Organising Sectional Committees in the January preceding the annual meeting, which has now become a regular and principal part of the mechanism of preparing the programme.

(3) As a point of minor but still recognisable importance, he will arrive at the place of the annual meeting as president, not as president-elect, and possible confusion in the local public mind will be avoided.

(4) After the annual meeting he will still be in office to preside over those meetings of the Council at which matters arising out of the annual meeting are principally dealt with.

The new members of Council are Dr. J. Drever, Prof. T. E. Gregory, Prof. H. S. Hele-Shaw, Prof. E. B. Poulton, and Prof. A. M. Tyndall. Considerations of health would not permit Prof. F. J. M. Stratton to take full part in the preparations for the centenary meeting; and he cannot be present at next year's meeting. Prof. P. G. H. Boswell was therefore appointed as an additional general secretary. Prof. J. L. Myres, who has been one of the general secretaries of the Association since 1919, has intimated that he will not seek re-election after next year.

Obituary.

PROF. A. S. PRINGLE-PATTISON.

BY the death of Prof. Andrew Seth Pringle-Pattison on Sept. 1, at the age of seventy-five years, philosophy lost one of the outstanding figures in a period of remarkable activity in that department. He was one of the first to see the significance for English thought of the impulse that came from the sympathetic study of Kant and Hegel in the 'sixties and 'seventies of last century. With the late Lord Haldane he organised the epoch-making manifesto contained in "Essays in Philosophical Criticism" which appeared in 1883 and included contributions from others who afterwards became famous in their several lines of research, J. S. Haldane, Bernard Bosanquet, W. R. Sorley, W. P. Ker, Sir Henry Jones, and James Bonar.

More cautious and more determined to make sure that no vital element in experience was being sacrificed to a first enthusiasm than some of his more ardent colleagues, Pringle-Pattison came forward in the next period of his philosophical development as a trenchant critic of what he held to be sinister features of the new movement. The doubts expressed in "Hegelianism and Personality" in 1887 seemed to be confirmed by the publication of Bradley's "Appearance and Reality" in 1893, and his essay in criticism of this work in "Man's Place in the Cosmos" seemed to separate him more widely still from his former idealistic associates. But the apparent recoil was only the preliminary to a more confident advance to the more personalistic form of that doctrine that found full expression in his Gifford Lectures in 1912–13 on "The Idea of God in the Light of Recent Philosophy" and has since had a growing influence both in England and America.

The general line of Pringle-Pattison's thought is indicated in the phrase which, so far as I know, he was the first to use of philosophy as "Criticism of Categories". The category prominent in nineteenth century thought was that of mechanical causation—the attempt to resolve everything into elements with which, as *effect*, it could be equated. This he held to be applicable (and possibly adequate) in certain limited spheres of phenomena, as in mechanics. But as we pass to other orders of fact, as to that of life, no preceding set of facts can account for their combination in a phenomenon essentially different from them. Here on the contrary "the true nature of the cause only becomes apparent in the effect". Equally certain was the insufficiency of any merely biological interpretation of the world of moral and religious experience. It is impossible to do justice to the sense of obligation and the instinctive admiration of unselfish devotion to far-reaching ends such as truth, beauty and moral perfection on any theory which takes the survival and material well-being of the species as the supreme goal and all else as instrumental to them—incidental results and by-products of the cosmic system. All explanation in a word of the higher by the lower is philosophically a *hysteron proteron*. Everything remains unintelligible until we invert the order of naturalistic explanation and go to work on the supposition that a purposeful moral intelligence is in reality the key to the world's meaning, the fact in the light of which all other phenomena must be read. In his own words, "every true philosophy is an attempted theodicy"—the vindication of a divine purpose in things.

However extravagant this claim may seem to those wedded to another order of thought, its vindication has been the dream of a long line of great thinkers since the time of Plato who found alone in the Good the adequate principle at once of the being of things and of our understanding of them. Pringle-Pattison's interpretation and defence of this thesis against prevalent forms of naturalism on one hand and forms of idealism, which sought for the principle of reality in a sphere beyond Good and Evil, on the other, ranks him with the great teachers, including Sir William Hamilton, who preceded him in the chair he so long occupied in Edinburgh.

An account of Pringle-Pattison's opinions gives, however, an imperfect idea of his work as a writer. It was the way in which he developed them out of a singular fullness of knowledge of contemporary philosophy, and the command of a peculiarly graceful style derived from an equally wide knowledge of the best in literature, that gave that work its peculiar distinction. Added to this he was known to his friends and his fellow-townsmen as a man of singular gentleness of manner and dignity of presence. He lived and looked the philosopher. Yet when called upon by the inheritance of an estate in the country to play the part of a Scottish laird, he surprised his friends by the firmness and efficiency of his management. Without the interest of his brother and colleague Prof. James Seth in the practical life of his city, and contrasting with 'Prof. Jim' in the more formal method of his teaching from written lectures, these self-limitations enabled him to give a certain completeness to the literary expression of his ideas in a long series of works of uniform distinction, closed only last year by the publication of his "Studies in the Philosophy of Religion", described by the *Times* of Sept. 2 as "among the best in the apologetics of rational theism".

Pringle-Pattison was LL.D. in his own university, honorary D.C.L. of Oxford, and a fellow of the British Academy. Among his early friends, besides those already mentioned, were Ambassador J. G. Schurman and the late Lord Balfour, who founded the lectureship under that name in the University of Edinburgh with the express purpose that Andrew Seth, as we then knew him, should be the first to hold it. Seldom have youthful appointments been better justified.

J. H. MUIRHEAD.

WE regret to announce the following deaths:

Sir Gregory Foster, Bart., formerly provost of University College and vice-chancellor of the University of London, author of many educational works, on Sept. 24, aged sixty-five years.

Dr. Charles A. Keane, formerly principal of the Sir John Cass Technical Institute, Aldgate, on Sept. 18, aged sixty-seven years.

News and Views.

As we go to press, we have received the following radiogram, dated Sept. 28, from Sir C. V. Raman, F.R.S., and S. Bhagavantam: "Experimental demonstration of spin of light.—The depolarisation of Rayleigh scattering of monochromatic light in carbon dioxide gas does not diminish to one quarter of its value when spectroscopically separated from rotational scattering, as demanded by existing theories of radiation. The actual observed diminution, from 10 per cent to 6 per cent, is quantitatively explicable, assuming that common light consists of spinning quanta possessing one Planck unit of angular momentum.—C. V. Raman and S. Bhagavantam."

THIS is the centenary of the discovery of miners' safety fuse—more generally known as Bickford fuse—by William Bickford. He was a Devonshire man, but having married a Cornishwoman, he went to live in the little village of Tuckingmill in the mining area of Cornwall, and there he first started his experiments on safety fuse. In this he was actuated by humanitarian motives, for he had nothing whatever to do with mining, his business being that of a currier. Blasting operations as conducted one hundred years ago were exceedingly difficult and dangerous. The only explosive then known was gunpowder, and though the handling did not involve any great risk, the methods in use for conveying the fire to the charge were definitely dangerous. It was at this stage that accidents were of such frequent occurrence, and the old records in Cornwall and elsewhere show that the fatalities were very great. But it was the number of permanently maimed men utterly incapacitated for work through the loss of fingers, an arm, or a leg, visible evidence of the hazardous nature of mining, which spurred Bickford on with his work. The most effective and possibly the safest device employed in Cornwall for conveying the fire to the charge was to fill goose quills with crushed gunpowder, after nipping off the thin ends. Thus a thin end of one quill was fitted into the wide end of another, and by this means, a column of powder was built up which, though fragile, was fairly effective but very uncertain. This in turn was set off by touch-paper.

Bickford had naturally many disappointments and failures when carrying out his experiments, and indeed was just on the point of abandoning the whole thing when in visiting a friend in his rope-walk he had the idea that the fibre of the rope might be so spun as to enclose a core of powder fed from a funnel. He achieved success in the end mainly with the assistance of a mechanical genius called Davey, who must share the credit. Application was in due course made for a patent, and the specification, which is dated Sept. 6, 1831, reads as if it had been drafted yesterday, so minutely and correctly are the operations described. Unfortunately, Bickford did not long survive his invention, but his family carried on the work. The little workshop where the first manufacturing operations were carried out still exists, but around it has grown a fine up-to-date works. Through the safety lamp invented by Sir Humphry Davy, one of the two great causes of accidents in mining was removed, and through Bickford fuse the other was, after a time, definitely eliminated. These two inventions have probably done as much as any other to conserve human life. Bickford reaped no financial reward from his invention, and it was only after many years that the fuse was known outside of Cornwall. Nevertheless, his name is worthy of a passing thought even in these crowded days.

The discussion on human population which was held in Section D of the British Association on Sept. 26 is of peculiar interest in view of the general theme of Prof. E. Cannan's presidential address to Section F. Prof. Cannan's argument is that the population of the world is almost stationary. He, like Prof. J. S. Huxley in the discussion, points out that migration is rapidly coming to an end. With contraception affecting all countries a new problem is arising—that of either over- or under-population. Prof. Huxley also emphasised the effect of progress in medicine, sanitation, and so forth in lessening the rigour of natural selection. The fertility and possible sterilisation of individuals is also receiving much attention now, thus placing the problem of population on biological bases. Prof. A. M. Carr-Saunders considers that there is not so much cause for concern over the decline in birth-rate as there is in the connexion between this decline and western civilisation and culture. Prof. L. T. Hogben made a plea for more intensive physiological research into human reproduction. The recent decline in the European birth-rate is undoubtedly due to limitation of parenthood owing to the spread of contraceptive measures, but Prof. Hogben is not prepared to place all the responsibility on contraception.

Prof. E. W. MacBride considers that, now the problem of over-population cannot be settled so easily by migration to unoccupied territories, one of two things is possible: either war or internal degeneration. Prof. F. A. E. Crew looks upon the problem from the point of view of the geneticist. He emphasised the inability of pure-bred British stocks to claim biological harmony with habitats outside the temperate zones. If, therefore, parts of Australia cannot be colonised by the Australians, but can be by Italians, Japanese, or Chinese, then the latter have he prior right. Similarly have the Indians preferential claim for the greater part of East and South Africa. Nevertheless, being of such mixed racial composition ourselves, it might be possible finally to suit the whole Empire by a better distribution of our migrants among its diverse parts. In this connexion it is interesting to note Prof. Cannan's conclusion, that the remedy for unemployment is mobility in regard to both place and occupation.

A group of biologists of the University of Minnesota has filed a memorandum with the White House Conference on Child Health and Welfare, suggesting that a special conference of experts on heredity be called, to see what can be agreed upon as a positive programme looking to the application of knowledge of heredity to the human species, and to recommend how such a programme should be carried out. In this connexion, Dr. E. P. Lyon, dean of the Medical School, University of Minnesota, has issued through Science Service, Washington, D.C., a statement in which he points out that man has enormously improved domestic animals by the intelligent application of the laws of heredity, and should be able to apply the same intelligence to similar ends in regard to his own species. Human rights are involved, but the right of every individual to have children is opposed by the right of the hopelessly diseased baby to remain unborn. It is not necessary to have any model towards which to aim, but progress can begin with elimination of the manifestly unfit by breeding only from the fit. He suggests that public opinion should be educated on this matter, and that a programme might be adopted extending over one hundred years. This would be further ahead than the human race has ever planned before. At present, very large expenditure and enormous social effort are directed to the environmental side, while the practical aspects of heredity as applied to man are comparatively neglected.

The twelfth Annual Report of the Ministry of Health, which relates to the year ended on March 31, 1931, has recently been issued. (London: H.M. Stationery Office. 5*s*. net.) The subjects dealt with fall under the main heads of public health, local government and local finance, poor law, national health insurance, and contributory pensions, the Annual Report of the Chief Medical Officer of the Ministry being published separately. During 1930, 136,515 samples of food and drugs were analysed, of which 6496 were reported against, a percentage of 4·8, which is the lowest recorded. A notable feature of the year was the considerable decline in the number of notified cases of, and in the deaths from, pneumonia; there has also been a steady decline in the number of cases of encephalitis lethargica, but the prevalence of mild smallpox continues. With regard to housing, the average cost of non-parlour houses, £344, is only £18 less than that in 1928, and dissatisfaction is expressed that there should not have been a more substantial reduction. Attention is directed to the serious lack of reliable information regarding the flows of rivers and streams, and a sub-committee of the Advisory Committee on Water has been appointed to consider what measures can be taken for the accurate gauging of rivers and underground water.

THE activities of local authorities in Great Britain in the sewering of their areas have, according to the Annual Report of the Ministry of Health, been more than maintained during the year, and loans sanctioned for this purpose amounted to nearly nine million pounds, and the total sum for this purpose since the War is approximately fifty-two million pounds. The report by Mr. Owen Llewellyn, inspector under the Canal Boats Acts, is of the nature of a retrospect, for he is retiring after thirty-two years' service. He remarks that during his period of office many hundreds of miles of canals have become derelict or have fallen into disuse. Motor-engined boats are taking the place of steamers and of horse-drawn boats, though the last-named are the most economical form of transport in many, especially hilly, districts. On canals as a whole, there seems to be no decrease in the number of children found on boats, and the 'floating school' at West Drayton for canal-boat children has proved a success. It is impossible to state with any certainty how many boats exist and are at work, for there is no legal obligation to report the end of once-registered boats. The last portion of the volume contains the report of the Welsh Board of Health, with a number of appendices.

IN his evening discourse to members of the British Association on Sept. 24, entitled "Zoos and National Parks", Sir Peter Chalmers Mitchell described the problems of and need for three types of animal reserves—zoological gardens, zoological parks, and national parks. There are many popular ideas of how various animals should be kept; but Sir Peter pointed out some of the difficulties of keeping animals under conditions resembling so far as is possible their natural habitat. Such problems are not relieved by the diverse nature of the different species of animals seen at our great zoological gardens. Experience in the keeping of animals under such conditions brings out some surprising facts. Examples are the necessity for sunlight and a suitable temperature. Nearly all animals love sunlight, even polar bears and owls; given the chance, they bask in the sun and benefit from it. A constant temperature is not desirable for any kind of animal; variations should be made for the well-being of all animal types. Another great asset, to nearly all animals, is plenty of opportunity to obtain fresh, open air.

ONE point especially emphasised by Sir Peter is the fact that the zoological garden should not be looked upon merely as an adjunct to the amusement and general instruction of the public, but should be regarded as a splendid field for research. Much more should be done in this respect. An example of this is the behaviour of the kangaroo when under an anæsthetic. The kangaroo is never known to utter any kind of sound normally, yet when subjected to an anæsthetic, probably partly through fright and partly due to the anæsthetic, the animal utters a cry similar to that of the marsupial wolf. Here is an opportunity for research into the cries of animals under various conditions. Many other such problems are still awaiting investigation, which can be carried out advantageously only in a zoological garden. Zoological parks present a still further difficulty in that they allow much more freedom, and therefore only animals with a considerable range of adaptability can be chosen. National parks are useful for the preservation of types of fauna in danger of extinction, the American bison being now a historical example. The chief agent in animal extermination is the advance of civilisation and not sportsmen or scientific collectors.

THE Trustees of the British Museum celebrated on Sept. 29 the fiftieth anniversary of the opening of the Natural History Museum building at South Kensington. The exact date of the opening was April 18, 1881, but the celebration was deferred so as to come within the period of the centenary meeting of the British Association. About a hundred and fifty delegates of museums and learned societies at home and abroad were received by the Trustees at the afternoon meeting. The Earl of Crawford and Balcarres, chairman of the Jubilee Celebration Sub-Committee of the Trustees, presided, and was accompanied on the platform by Lord Rothschild, Sir David Prain, Mr. F. Cavendish-Bentinck, and other Trustees, as well as by the director of the Museum, Dr. C. Tate Regan. Lord Crawford, in opening the proceedings, welcomed the delegates and expressed the pleasure which the Trustees felt that so many had been able to attend the celebration in spite of the world-wide financial difficulties which were then prevailing. Dr. Regan then gave a brief account of the history of the Museum and of the development of the collections contained in it. The delegates were then individually received by the Trustees. In the evening, the Government gave a reception at the Museum, which was attended by the delegates, as well as by a large number of naturalists and other scientific workers attending the meeting of the British Association. The guests were received by the Prime Minister, Rt. Hon. J. Ramsay MacDonald, M.P., and Miss Ishbel MacDonald.

A RECENT writer in the American journal *Forest and Stream* gives an account of a lion farm at El Monte, U.S.A., the property of Mr. and Mrs. Gay. As an adult lion is worth a thousand dollars even untrained, the domestication of the lion—long known as the readiest of sensational 'wild beasts' to breed in captivity—is evidently a paying proposition; and, apropos of this, it may be as well here to give a tentative list of the known domestic mammals, as no such list, embodying all the latest results, appears to exist. The only other feline domesticated is the common cat ; of the dogs, we have now, besides the ordinary dog, the common and arctic foxes ; of the weasels, the ferret, mink, and skunk. The domestic rodents comprise the rabbit, guinea-pig, rat (*Mus decumanus*, not *rattus*), mouse, and musk-rat, probably also the coypu and the Patagonian cavy (*Dolichotis patagonica*). Of ungulates, nearly all the known species of *Bos* have been domesticated—the common ox, zebu (if this be really distinct), water-buffalo, yak, gaur (the domestic form being known as gayal or mithan), and banteng, while the two bisons are at any rate emparked ; other domesticated hollow-horned ruminants are the sheep and goat and probably the Barbary sheep (*Ammotragus lervia*) and blackbuck (*Antilope cervicapra*), and in East Africa, at any rate, the eland. Among the deer, the milou (*Cervus davidianus*) has never been known except as a park animal ; while the reindeer and fallow deer are well known as domestic, and there are park races of the red deer and doubtless others. The two camels (only known certainly as domestic), the llama (the domestic descendant of the guanaco), the pig, the horse, the ass, and Bennett's wallaby, a well-established park animal, complete the list, in which it is to be noted that among the recent achievements in domestication only that of the eland has practical utility as its object.

Mr. Denis Butler, of Goodhart Way, West Wickham, Kent, has sent an account of curious behaviour in a North American corn-snake (*Coluber guttatus*) in reference to moles. The snake, which had been kept in an open-air cage, escaped, and on recapture, after about a week, showed by a bulge in the stomach-region that it had fed well. When the cage was next visited, three decomposing moles were found there, which the snake had eaten while at large ; most of the flesh seemed to have been digested, but the skins and bones were intact. After about a week, the body of a fourth mole, which must have burrowed in and been swallowed, was found in the cage. It is suggested that this apparent inability to digest moles, when other animals, such as mice, are digested bones and all, is strange ; but in the case of the first three found the disturbance of the snake's system caused by recapture no doubt caused them to be disgorged when half-digested. The case of the fourth specimen is more difficult to understand, but though moles are eaten by the common adder and by the four-rayed snake (*Coluber quatuor-radiatus*) of the Continent, it may be that lowering of the digestive powers caused by captivity was just enough to prevent any digestion of a new prey by a snake the natural diet of which is rodents and birds; and one is reminded of the belief of falconers that the eating of a moorhen puts the trained goshawk out of working condition, though it is not likely that the free bird abstains from such prey. But in any event, it is interesting to find that a reptile coming from a country where the summer is so much warmer than that of Great Britain can not only do well in an outdoor cage, but have sufficient energy to escape and find prey for itself, in such a poor summer for warmth as we have had this year.

The strange acquirement of a Central Australian parrot, the Corella (*Kakatoa sanguinolenta*), is described by A. W. Mullen in the *Australian Museum Magazine* for July. The individual in question is now twenty-six years old. When it was a year old, the owner's children were firing off crackers close to the bird's cage, when in terror it seized its loose drinking tin (a shallow preserved-meat tin) and placed it over its head—the writer says, "to hide what was to the parrot a terrifying scene ". The action in itself was curious, but it is more extraordinary to learn that ever since then the parrot has placed the tin can on its head every night. " He places the tin on his head before falling asleep, and keeps it on like a night-cap until the first streak of dawn awakens him." When by day he had to be transported by rail, he clapped the tin over his head whenever he encountered the strange sights and sounds of the railway station. During his quarter of a century he has worn out at least four tins. We fear to speculate as to the thought which originated and continued this curious action, but remembering the imitativeness of parrots (this one talks and calls the children by name, as well as mimicking dogs and fowls), we wonder if his master ever wore a night-cap.

A striking example of human concern for the well-being of wild fauna, apart from mere prevention of cruelty, has recently been set by the Viennese Society for the Protection of Birds. Owing to the very inclement weather in Austria at present, thousands of swallows have been stranded on their migration southwards. The Society has taken the problem into its hands and has collected the stranded birds, giving them sanctuary and food. The birds are then being sent over the Alps either by specially heated coaches attached to the night express train or in cases, which each hold 1000 birds, by aeroplane. The first consignment of 2000 birds was sent to Venice on Sept. 25, and, landing in a suitable climate, took to their wings, finally making their way south. On Sept. 26, 25,000 birds were sent by aeroplane. The weather was unsettled on Sept. 27, so 35,000 were sent to Venice by train. Thousands more are being dealt with, and after resting in Vienna will in due course be sent to Venice.

A large number of visitors availed themselves of the invitation of Sir Joseph Petavel to attend a reception at the National Physical Laboratory on Sept. 24, arranged in connexion with the Faraday celebrations and the centenary meeting of the British Association. Each visitor was provided with a programme of exhibits, members of the staff were present to explain the various investigations being made, and by an excellent system of signs and numbers it was a simple matter to find any particular exhibit. Tea was served in the great building housing the new duplex wind tunnel. This tunnel is 14 ft. by 7 ft. in section, and in it models up to 7 ft. or 8 ft. span can be tested with air speeds up to 75 miles an hour. Another notable aeronautical exhibit was the compressed air tunnel, now nearing completion, in which models will be tested under an air pressure of 300 lb.

per sq. in., the air jet being 6 ft. in diameter. Whereas the other wind tunnels are built of wood, this tunnel has a steel shell $2\frac{1}{2}$ in. thick and weighs 250 tons. It has been tested hydraulically to 500 lb. per sq. in. By the use of this tunnel, scale effect is eliminated, and the results of experiments are immediately applicable to the full-scale machine or component. In the William Froude Laboratory visitors were shown a model ship under test, and the methods of making the models. The demonstrations of flashover tests at 350 kv. on a porcelain insulator string in the High Voltage Laboratory also attracted many visitors. Throughout the laboratory every facility was afforded for learning what was being done, and the efforts of the members of the staff were much appreciated.

The extensive new laboratories of the Lancashire and Cheshire Coal Research Association were opened on Sept. 22 by Mr. R. A. Burrows, the first president of the Association. The Association was formed in 1918, the funds being provided voluntarily by eight of the large colliery firms in Lancashire. The organisation is now supported by the Lancashire and Cheshire Coal Owners' Association, which includes substantially all the collieries in the coalfield. The programme of work of the Research Association embraces the physical and chemical survey of the seams of the coalfield, the investigation of problems connected with safety in mines, and the study of coal mining. The coal survey work forms part of the National Coal Survey, and in 1922 the fuel research organisation of the Department of Scientific and Industrial Research provided grants to enable the work on the survey aspects of the Association's work to be expedited.

Dr. F. S. Sinnatt, of the Department of Scientific and Industrial Research, who was the first director of research to the Lancashire and Cheshire Coal Research Association, outlined its early history and development, and said that the staff has been favoured by the enthusiastic support of the coal owners of the district, and has been helped by the fact that there has been continuity of direction by the Council. Originallv the Association was largely concerned with the problems of the utilisation of coal, but now its investigations embrace questions of safety and coal winning. Prof. J. S. Haldane, who is especially interested in the investigations connected with the Safety in Mines Research Board, welcomed the establishment of the new laboratories, and said that he regretted it had not been possible for him to come to Lancashire more frequently to help them in the work they were doing. A very large number of coal owners from the Lancashire coalfield and fuel technologists from every part of the country inspected the laboratory, the details of which were explained by the director of research, Mr. Simpkin.

The report presented by the Seismological Committee to the British Association contains, besides references to the death of the late chairman, Prof. H. H. Turner, the revision of the seismological tables, and work on deep-focus earthquakes, an interesting note on recent earthquakes by Messrs. A. W. Lee, R. Stoneley, and F. J. W. Whipple. A map of the North Sea earthquake of June 7, depending on about 400 observations, has been prepared by Dr. H. C. Versey and Mr. Stoneley. The shock was felt at Waterford, in the Channel Islands, the north of France, in Belgium, Holland, and Denmark, and so far east as Hamburg and Brunswick. The epicentre indicated by the map agrees closely with the position assigned to it by the Rev. J. P. Rowland, *S.J.* (see Nature, vol. 128, p. 147, July 25, 1931). It lies under the North Sea, near the Dogger Bank, and about 60 miles from the coasts of Yorkshire and Norfolk. The spacing of the isoseismal lines suggests that the focus was decidedly deeper than in most British earthquakes. The seismograph records show, however, that it was not below the granitic layer.

A representative party of twenty members of the University of St. Andrews, officially accredited by the Un versity Court and travelling under the auspices of the Overseas Education League (see Nature, Aug. 1, p. 196), returned to Southampton on Sept. 26 from an enjoyable and highly successful visit to the provinces of Quebec and Ontario. Throughout their tour the visitors were cordially welcomed by civic and educational authorities and in private homes, and special facilities were placed at their disposal so as to enable them to see as much as possible, in a limited time, of Canadian life, institutions, activities, and resources. The group was officially entertained by the cities of Montreal, Toronto, and Hamilton, by McGill, McMaster, and Queen's Universities, and by the Universities of Toronto and Western Ontario. In Quebec, the members were received by the Lieutenant-Governor at 'Spencer Wood', and were the guests of the Provincial Department of Public Instruction at Kent House, Montmorency Falls. At Montreal, visits were also made to Macdonald College and the Université de Montréal; at Toronto, to the Canadian National Exhibition and Lake Simcoe; at Ottawa, to the National Research Laboratories and the Gatineau district; at Hamilton, to Queenston and Niagara Falls; and at Kingston, to the Royal Military College and the Thousand Islands.

At a farewell dinner, given to the visitors from St. Andrews, at the Chateau Frontenac, Quebec, by Mr. E. W. Beatty, president of the Canadian Pacific Railway and Chancellor of McGill University, Prof. John Read, leader of the party, stressed the importance of such tours as a factor in education and in promoting understanding between Great Britain and the overseas Dominions. He expressed the hope that similar tours will follow this initial venture, and commented on the value of an interchange of teachers, as well as of an increasing number of post-graduate students, between Canadian and British universities. As one means to this end, he advocated the gradual establishment of non-resident lectureships in universities throughout the Empire. The Rev. Father Cannon, of Laval University, in giving the young Scots a glimpse of educational history in Quebec, explained the main factors which have enabled the French- and English-speaking Canadians to live together in harmony. At the conclusion of the evening, according to the *Chronicle-Telegraph*, Quebec, "the score of braw lads and lasses frae the auld grey toun, rose and sang 'Ygorra, Beatty', a version of their University song, in honour of the C.P. president".

THE *Polar Record* (Scott Polar Research Institute, Cambridge), in its July issue, maintains the high standard of usefulness shown in its first issue. There is again a full record of the activities of all exploring expeditions in both north and south polar regions and a great deal of material that is otherwise difficult of access. It is of interest to note that the Russian Academy of Sciences has been exploring the Indigirka region in eastern Siberia and has established several meteorological stations: also that a new research station is functioning in the little-known New Siberian Islands in lat. 73° 11′ N., long. 143° 15′ E. Stations have also been started in Franz Josef Land and, to the east, in the newly discovered Kamenev Islands. In an article on the Second Polar Expedition, 1932–33, Dr. G. C. Simpson gives a list of the many stations which various States propose to establish as their contribution to that international project.

IN discussing, in the issue of *Scientiarum Nuncius Radiophonicus* for July 30, the hypothesis that the penetrating rays originate in the 'annihilation of matter', Prof. Gianfranceschi points out that this expression is not readily acceptable by all. Annihilation of matter, in the sense applied to this process by Jeans and others, would give rise to energy in the form of photons, these being nuclei of radiant energy, which is a state of matter. It seems, therefore, preferable to say that the positive or negative corpuscles are transformed into primigenic matter, with liberation of a certain quantity of radiant energy, of which photons are composed. In this form the hypothesis is capable of wide extension. Electrons and protons are a special form of the universal primigenic matter, and both the formation of corpuscles within this matter and their dissolution to re-form the primigenic matter are possible. This universal primigenic matter is what constitutes space-ether, since, even in the hypotheses of the most advanced relativists, real space has physical properties and is hence a primigenic form of matter.

THE annual Henry Herbert Wills Memorial Lecture in physics at the University of Bristol will be given in the Wills Physical Laboratory by Prof. Niels Bohr on Oct. 5, at 5.15 P.M. Prof. Bohr will speak on "Space-Time Continuity in Atomic Physics".

THE 1931 award of the Ferranti Scholarship of the Institution of Electrical Engineers (annual value £250, tenable for two years) has been awarded to W. G. Thompson, of Armstrong College, Newcastle-on-Tyne.

THE inaugural sessional address of the Pharmaceutical Society of Great Britain will be delivered by Prof. G. E. Gask, dean of the Faculty of Medicine in the University of London, on Oct. 7. The presentation will also be made of the Pereira Medal of the Society.

THE Foreign Work Committee of Leplay House is arranging to take a group to Italy during the coming Christmas vacation. Rome and Naples will be the centres from which Oetia, Tusculum, Herculaneum, Pompeii, Paestum and other places of interest from the archæological, historical, and sociological point of view will be visited. For full particulars application should be made to Miss Tatton, Director, Foreign Work Committee, Leplay House, 65 Belgrave Road, Westminster, S.W.1.

MESSRS. Ernst Leitz, of Wetzlar (London Branch, 20 Mortimer Street, W.1), have recently completed their 300,000th microscope, which, in accordance with their usual custom of dedicating each 50,000th microscope to a well-known scientific worker or institution, has in this instance been presented to Prof. Ludwig Aschoff, of the Pathological Department of the University of Freiburg. This microscope, in addition to having valuable apochromatic objectives, is equipped with the new Ultropaque illuminator (working in incident light) and the complete set of fifteen new objectives specially constructed for this illuminator. The Ultropaque arrangement, which is a recent innovation, has already proved of value in cancer research and in the investigation of living tissues in general. Previous gifts of Leitz microscopes, each marking the completion of 50,000 instruments, have been made to the German Sanatorium for Consumptives, Davos, Switzerland; Robert Koch; Paul Ehrlich; Prof. M. Heidenheim; and the Institut für Schiffs- und Tropenkrankheiten, Hamburg.

MESSRS. W. and G. Foyle, Ltd., 119 Charing Cross Road, W.C.2, have just circulated a comprehensive catalogue (Dept. 7) of second-hand and new books on technical subjects and applied science. In many cases both the published price and that asked for second-hand copies is given—a useful feature.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned :—A chemist-bacteriologist in a margarine factory in St. John's, Newfoundland—The Trade Commissioner, Newfoundland Government Offices, 58 Victoria Street, S.W.1 (Oct. 8). An honours graduate in chemistry at the Wolverhampton Municipal Secondary School—The Director of Education, Wolverhampton (Oct. 10). A London representative of the New Zealand Fruit-Export Control Board—The Secretary, New Zealand Fruit-Export Control Board, Box 882, Wellington, New Zealand (Nov. 30). A lecturer in chemistry at the Handsworth Technical College—The Principal, Handsworth Technical College, Handsworth, Birmingham. A lecturer in the building trades department of the Cape Technical College—Chalmers and Guthrie (Merchants), Ltd., 9 Idol Lane, E.C.3. A chief mathematical master at the Swansea Grammar School—The Director of Education, Dynevor Place, Swansea.

ERRATUM.—In the announcement of Messrs. G Bell and Sons' standard and new science books in last week's issue of NATURE, the title of Prof. E. N. da C. Andrade's "The Structure of the Atom" was incorrectly printed as "The Mechanics of the Atom", and that of his "The Mechanism of Nature" as "The Mechanics of Nature".

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.*]

Isolated Quantised Magnetic Poles.

IN the last number of the *Proceedings of the Royal Society*, Dirac has come to the conclusion that the quantum theory requires the existence of discrete magnetic poles of a strength equal to 137÷2 times the electronic charge. If such objects were common one might expect the universe to be a good deal different from what experimenters have found it to be, so far.

There seems no a priori reason why the whole theory of atom building which has been built up for electrons and nuclei—an electrostatic problem apart from details—should not be carried over bodily into the corresponding magneto-static problem of the attractions of the oppositely charged poles. In this way we might, at first, expect to get a set of 'magnetic' atoms, similar to the electric atoms of which matter is generally supposed to be built up. These atoms would be a good deal different from those we think we are familiar with. How much different depends to some extent on what the mass of a magnetic pole is. The quantum theory does not tell this, but I think its value, if it exists, can be fixed by an argument based on classical ideas at about 500 times that of the corresponding electronic object. Following this general line of argument, the dimensions of these magnetic atoms come out at 10^{-14} cm. to 10^{-15} cm. compared with 10^{-7} cm. to 10^{-8} cm. for the atoms of the periodic table. The frequencies of the 'spectral' lines emitted by these magnetically constructed atoms would run about 10^{10} times those of the corresponding lines of the electronic spectra; for example, the first line of the Lyman series would be raised from $\nu = 2{\cdot}5 \times 10^{15}$ to $\nu = 3{\cdot}1 \times 10^{25}$ sec.$^{-1}$ if the corresponding states are capable of existence. Even if quite large changes are made in the mass of the magnetic poles, which is the doubtful element, the corresponding numbers will still remain quite wide apart.

Dirac has suggested that the reason these magnetic poles have not been observed may be that the forces between them are so much larger than those between electrons and protons that they cannot be separated. There is reason for believing they could not get together to the extent indicated by the preceding numbers. The number of kinds of atoms with azimuthal quantum number 1 which can be formed from these magnetic units is much less than unity. This follows from Dirac's formula for the spectral terms for hydrogen, or alternatively, from the principle of minimum time. This may be forcing the required atoms too much into the pattern of those with which we are familiar. In any event, no atom with azimuthal quantum number less than 34½ can be made out of these elements. Otherwise the time factors in the wave functions involve real exponentials and become infinite with lapse of time. However, even with such high quantum numbers the forces would still be enormous compared with those in corresponding electronic structures and the frequencies would still be quite high.

There may be an application of these products of the quantum theory in the field of 'ultra-penetrating' radiations. I have no first-hand knowledge of the process of creation, but I should suspect it would be relatively difficult to create objects with the intrinsic energy of these magnetic poles. It seems likely, therefore, that their abundance would be very small compared with that of electrons and protons, but there might be enough in the universe to account for such ultra-penetrating radiations as are not capable of being accounted for otherwise. The possible existence of such isolated magnetic poles, with properties so very different from those of electrons and protons, obviously changes the basis for discussion of a good many cosmological questions.

O. W. RICHARDSON.

King's College,
London, W.C.2,
Sept. 18.

Similarity between Cosmic Rays and Gamma Rays.

As heretofore indicated,[1] it was in the fall of 1926 that Millikan and Cameron began to use high pressure electroscopes in order to increase the sensibility of their cosmic ray measurements. They built at first two such electroscopes and filled them to pressures of 8 atmospheres and 30 atmospheres respectively. Their first published results [1] were obtained with the 8-atmosphere filling, and they then assumed that for these hard rays the observed ionisation would be proportional to pressure. By directly comparing, however, a little later, similar spherical electroscopes of 1600 c.c. capacity filled to 1 atmosphere and to 8 and 30 atmospheres respectively, they were surprised to find that the ionisation shown in the 8-atmosphere electroscope was but about five times, and that in the 30-atmosphere electroscope was but 13·8 times that in the 1-atmosphere electroscope. These facts were published in one of their 1930 publications,[2] but since the authors were then interested merely in the *variation* in the ionisation in a given electroscope with depth beneath the top of the atmosphere, they made no attempt to discuss the reasons for these low factors. They did, however, *by direct comparisons find that these factors were the same for the gamma rays of radium and thorium as for the cosmic rays, thus bringing to light another significant similarity in behaviour of these two types of radiations.*[3]

Since Broxon [4] and Hoffmann [5] have both, in recent publications, commented upon these pressure-ionisation relations as measured by them, in entire agreement too with our own measurements, but without directing attention to what we consider to be the correct explanation of the phenomena, we have decided to present it herewith in this brief note. There are two causes of this failure, even for very hard rays, of the expected linear relation between pressure and ionisation. The first and the less important of the two is that mentioned by Hoffmann, namely, the mixture with the hardest beta rays which are formed by Compton-encounters with the original cosmic ray photons, of soft secondary beta rays which may be fully absorbed even within the air of the electroscope at 1 atmosphere, and can contribute no more to the ionisation when the pressure is high than when it is low. We have reasons which, merely for brevity's sake, we omit from this brief note, for thinking this cause of departure from linearity in the pressure-ionisation curve to be relatively small. The main cause of divergence from this relation is the following.

The low energy electrons shaken loose by the original ionising beta ray, if thrown an appreciable distance from the parent positive atom at 1 atmosphere, could be thrown but a small fraction of this distance at 8 atmospheres or at 30 atmospheres. The tendency to recombine then increases very rapidly with pressure. This lack of saturation effect will scarcely be noticed at all when the impressed field is varied from, say, 100 volts to 300 volts as in our own experiments. In other words, for such fields the ionisation currents will give all the usual indications of being saturated, though very strong variations of field rising up to thousands of volts, should bring to light the fact that they are not. *This lack of saturation is then, in our judgment—and we have experimental evidence for it—the real cause of the pressure-ionisation effects discussed otherwise by Hoffmann and Broxon.*

R. A. Millikan.
I. S. Bowen.
Norman Bridge Laboratory,
California Institute, Pasadena, California,
Aug. 15.

[1] Millikan and Cameron, *Phys. Rev.*, **31**, 922; 1928.
[2] Millikan and Cameron, *Phys. Rev.*, **37**, 237; 1930.
[3] Hoffmann in (5) below comments upon having also observed this relation in his own earlier work.
[4] Broxon, *Phys. Rev.*, **37**, 1320; 1931.
[5] Hoffmann, *Zeit. für Phys.*, **69**, 704; 1931.

Graphical Indication of Humidity in the Upper Air.

Sir Napier Shaw's representation of upper air temperatures by the method of the T-ϕ or tephigram is, from the thermodynamical aspect, the best that has yet been proposed. The depegram (or graph of dew-point temperatures), which ordinarily accompanies it, is a practical means of representing humidity, yet most meteorologists will agree that it is not as wholly satisfying a method for humidity as the tephigram is for temperature. A thermodynamic indication of humidity along with the tephigram is of importance, especially in the tropics, and further consideration of the mode of representing humidity is therefore desirable.

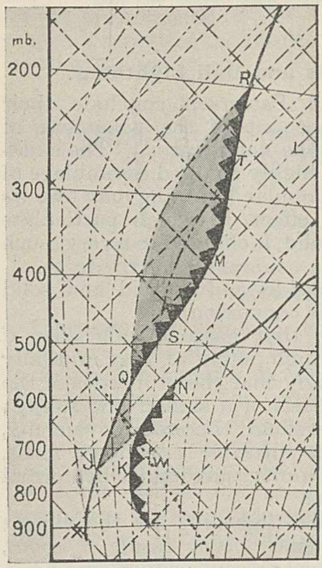

Fig. 1.—Tephigram and estegram: ——, isobars; – – – –, isentropics; —·—, isothermals; ......, isohygric; —·–·—, saturation adiabatics.

In the accompanying diagram (Fig. 1), X the dry bulb and Y the dew-point temperatures at the 900 mb. level, are plotted on tephi-paper. The isentropic XW and the isohygric (or line of constant specific humidity) YW are drawn and intersect at W. Through W is drawn the saturation adiabatic WZ, cutting the 900 isobar at Z. We may call Z the 'saturation' temperature or *S.T.*, and direct attention to the following important properties: The *S.T.* is so nearly the same as the ventilated wet bulb temperature that in practice they may be substituted for one another.[1] If a sample of the air at the 900 mb. level is raised adiabatically, the dry bulb temperature of that sample moves along the isentropic XW, the dew-point temperature along the isohygric YW, and the saturation temperature along the saturation adiabatic ZW. The air becomes saturated at W, all the three temperatures coincide there, and further upward displacement causes them to follow the saturation adiabatic WST. Beyond T the saturation adiabatic runs parallel to a dry isentropic; that is, it is associated with, and can be identified by, a definite value on the potential temperature scale. That potential value of the *S.T.* (or wet bulb) is allied to the equivalent potential temperature; it remains an invariant in all adiabatic processes whether the air is saturated or not.

If the saturation temperatures or the wet-bulb temperatures of the upper air be plotted on the appropriate isobars or tephigram paper, the resulting graph of *S.T.*'s, or estegram, proves to be of greater importance thermodynamically than the depegram. We may note the following points:

(1) From any two of the three graphs, tephigram, estegram, and depegram, the third may be readily constructed on tephi-paper without reference to tables.

(2) If we define air of latent instability to be air which, when raised adiabatically, finds at some level above the condensation level an environment in which it is unstable, then all air samples of latent instability are indicated by the points on the estegram that lie to the left of the lowest saturation adiabat tangential to the tephigram. For example, LMN is the lowest saturation adiabat tangential to the tephigram $XQMR$, and to the left of it lies the portion ZN of the estegram; hence the layers of air between the heights represented by Z and N are those which on adiabatic ascent will develop instability in another higher layer.

(3) Superadiabatic gradients being excepted, all layers which form a latent unstable environment for samples of air displaced adiabatically upwards from one or more of the lower layers are indicated by points on the tephigram which lie to the right of the highest saturation adiabat tangential to the estegram. For example, KQR is the highest saturation adiabat that touches the estegram, and to the right of it lies the portion QMR of the tephigram; Q and R therefore represent the limiting heights between which instability may arise on account of the adiabatic ascent of a lower layer.

(4) If the lowest saturation adiabatic tangential to the tephigram lies wholly to the left of the estegram, then no layer possesses latent instability. This is frequently the condition of continental air in India. On the other hand, oceanic equatorial air seems frequently to possess so marked a latent instability that samples of the lower air when raised adiabatically will release more energy during the higher unstable portion of their ascent than is needed to be supplied in the lower stable portion. The point J on the diagram (with *S.T.* at K) represents such an air sample, because the area QRM represents a much greater release of energy than needs to be supplied to raise the sample from J to Q.

A classification of Indian tephigrams, suggested by the above considerations, is being undertaken by a research student.

C. W. B. Normand.
Poona, India, July 20.

[1] Cf. *Ind. Met. Mem.*, **23**, part 1.

Activated Adsorption.

The transition from van der Waal's adsorption to activated adsorption is shown by a minimum on the adsorption isobar,[1] and a similar minimum occurs on the isobar representing the transition from activated adsorption to chemisorption.[2] There is thus a region of temperature over which the amount of adsorption increases with rise in temperature. The experimental work so far published shows that, at least in the case of the first type of transition, the processes are reversible. The positive temperature coefficient must therefore be associated with an increase in the heat of adsorption.

If ϕ be the activation energy of the surface atoms and Q the heat liberated on adsorption, then at constant pressure the number of surface atoms which are covered by gas molecules will be given by $N' = N.e^{(Q-\phi)/RT}.k$, where k is a constant but slightly affected by temperature. In the above transitional regions, $Q - \phi$ must possess at first a negative value, ultimately becoming zero and then positive. It is unlikely that ϕ will decrease with increase in temperature, therefore Q must become larger as the temperature is raised. There are but few experimental data bearing on this point. The heat of adsorption of oxygen on charcoal, for the same amount of gas adsorbed, increases from 70 to 110 k.cal. as the temperature increases from 20° to 110° C.[3] From 100° to 200° C. the heat is practically constant. These values probably refer to a transitional region between van der Waals and chemisorption, but this is somewhat uncertain. The figures, however, lend support to the above view, that the heat of adsorption in the transitional regions increases with rise in temperature. More experimental work is needed on the effect of temperature on the heat of adsorption.

The activated surface atoms will undoubtedly be mainly singlets at low temperatures, but doublets will increase in number as the temperature is raised. The increase in the heat of adsorption may be due to this fact, for the energy liberated on adsorption will probably be the greater the more activated the group of surface atoms by which the adsorbed molecule is held.

W. E. GARNER.

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[1] Cf. Benton and White, *Jour. Amer. Chem. Soc.*, **52**, 2332; 1930; and Taylor and Williamson, *Jour. Amer. Chem. Soc.*, **53**, 2178; 1931.
[2] Garner and Kingman, NATURE, **126**, 352; 1930. *Trans. Far. Soc.*, **27**, 322; 1931.
[3] Garner and McKie, *Jour. Chem. Soc.*, 2455; 1927.

Change of Dielectric Polarisation of Nitrobenzene with Temperature.

RECENTLY one of us (J. M.) has determined the changes of density D and dielectric constant E of

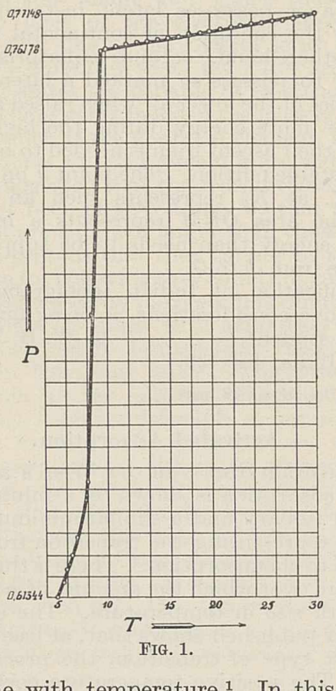

FIG. 1.

nitrobenzene with temperature.[1] In this connexion we would like to repeat here that the freezing point of nitrobenzene lies at 5·5° C. and not at 9° as given in the Landolt-Börnstein tables.

On the basis of these data, we have computed the dielectric polarisation P of nitrobenzene, according to the formula of Clausius-Mossotti,

$$P = \frac{E-1}{E+2}\frac{1}{D}$$

The results of this computation for the temperatures between 5·5° C. and 30° C. are represented on the accompanying curve (Fig. 1).

The value of P changes linearly with temperature, varying from 30° down to 9·6°. At 9·6° there appears a sudden drop in the value of P. This suggests that at the point 9·6° (which, as our former studies have shown, is a transition point from one liquid modification of nitrobenzene into another one, also liquid) the structure of the molecule undergoes a change. We have therefore to do here with a phenomenon somewhat different from that appearing in liquid helium, where the structure of the molecule does not undergo a change.[2]

The summary of the results we have obtained with nitrobenzene can be stated as follows: at the point 9·6° there appears to be a jump of the value of dielectric constant, a distinct change of slope in the density curve, and a very distinct change in the value of the refractive index.

M. WOLFKE.
J. MAZUR.

Physical Laboratory, Technical Institute,
Warsaw, July 20.

[1] J. Mazur, NATURE, **127**, 741, 893; 1931.
[2] M. Wolfke and W. H. Keesom, *Comm. Leiden*, No. 192*a*.

Charged Aerosols and Ball Lightning.

MESSRS. Cawood and Patterson conclude their extremely interesting account of the behaviour of electrified aerosols with the comment:[1] "The existence of such a spherical highly charged assemblage of particles suggests that globular lightning may owe its origin to an analogous effect, in which particulate matter, either liquid or solid, is charged to a very much higher potential".

Is it advisable to consider only liquid and solid particulate matter in this connexion?

Is it not conceivable that gaseous molecules, if charged to a sufficiently high potential, may mutually repel each other so strongly that the properties of the assemblage cease to be that of a similar one subject only to ordinary Maxwellian thermal movements, forming temporarily an unstable expanded mass, perhaps of considerable tenuity, surrounded by normal gas at ordinary pressure?

Puzzling features of ball lightning are the violent explosions which sometimes occur inside a room, without damage to persons present or furniture.[2,3]

If an attenuated electrified mass of gas can suddenly collapse, like an evacuated electric light bulb, it would afford an explanation of this mysterious behaviour.

During the explosion of certain gaseous mixtures, charged molecules which are not subject entirely to Maxwellian thermal movements, temporarily, may complicate the phenomena.

Exceptionally high voltages can now be developed in a few research stations; further research may reveal the conditions under which the charged aerosol behaviour can be extended to gases.

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[1] NATURE, July 25, 1931, p. 150.
[2] Marchant, NATURE, Jan. 25, 1930, p. 128.
[3] Reynolds, NATURE, March 15, 1930, p. 413.

Resonance Spectrum of Hydrogen.

WHILE we were attempting to photograph the spectrum of arsenic by the Paschen hollow cathode discharge in helium, plates were obtained which revealed with remarkable intensity the Lyman series of hydrogen extending down to the 15th member. The most interesting feature of the series, however, is the peculiar distribution of intensity among its members. Instead of the intensity diminishing steadily to the very last member, it diminishes rather slowly to the 10th member; there is a definite increase in intensity of the 11th and then an abrupt fall, so that the remaining members are only just observable.

Further experiments under varying conditions of pressure of helium and arsenic in the discharge have definitely indicated that the phenomenon must be interpreted as a case of resonance occurring only in the presence of arsenic. With a high pressure of arsenic and a low pressure of helium, the 10th and the 11th members of the Lyman series appear with considerable intensity (the 11th being stronger), while the others show a rapid diminution in intensity, the 8th and 9th being very faint.

It is considered that the energy of excitation of this resonance spectrum is to be sought for in a transfer, by collisions of the second kind, from the excited arsenic atoms. Further investigations are in progress to determine the exact value, from series data, of the first ionisation potential of arsenic, a knowledge of which throws considerable light on the correct interpretation of the phenomenon.

A full report of the results will be published as soon as they are ready.

K. R. RAO.
J. S. BADAMI.

Physikalisch-Technische Reichsanstalt,
Charlottenburg, Berlin,
Aug. 25.

Contraction Constants of Enzyme-Substrate Reactions.

CHANGES of volume accompanying enzyme hydrolysis have been utilised by Sreenivasaya and Sastry [1] to follow the kinetics of enzyme action by means of the dilatometer. The procedure employed in the above investigation does not bring into consideration the substantial volume change occurring in the initial stages of the reaction, and therefore gives no idea of the total contraction resulting from the complete hydrolysis of the substrates. The total contraction given by an enzyme-substrate system depends only on the absolute amount of the substrate in the reaction mixture, and is proportional to it.

The contraction of a few systems has now been investigated by a specially designed dilatometer; the contraction per gram-molecule of the substrate has been calculated, and found to be a constant for each enzyme-substrate system. For urea-urease the constant is 24, while sucrose-invertase has a constant of 6. These constants are of considerable value in the dilatometric estimation of substrates in physiological liquids and plant saps. Constants for other enzyme-substrate systems are being determined.

M. SREENIVASAYA.
H. B. SREERANGACHAR.

Department of Bio-chemistry,
Indian Institute of Science,
Bangalore, July 15.

[1] *Biochem. Jour.*, **23**, 975; 1929.

The Treatment of 'Gapes' in Chickens.

OUTBREAKS of 'gapes' among chickens usually lead to a very high mortality. The disease is due to the presence of the nematode worm *Syngamus trachealis* Lieb. in the windpipe. Treatment with turpentine in olive oil, applied with a feather, is often successful in skilful hands, but I have only saved one pullet thus. A severe outbreak occurred among my chickens in March 1930, and I treated a number with carbon tetrachloride dissolved in medicinal paraffin, probably about a two per cent solution. Fewer died than I expected, but being otherwise occupied, no records were kept.

In January this year four chickens were hatched out, and all developed gapes when about a month old. Two died, and I started to treat the remaining two cockerels by giving, on three successive nights, about 2 c.c. of carbon tetrachloride solution, administered by means of a pipette with teat. Though one appeared to be very ill at the start, both recovered. Successive outbreaks were similarly treated, fourteen birds in all, with only one death up to about the end of May. The birds were usually a month or six weeks old when attacked. Late in May, however, gapes appeared in two broods, of eight and six, when about a fortnight old. The treatment failed completely, and thirteen died, even though the amount of carbon tetrachloride was increased up to probably about five per cent. One pullet, however, never contracted gapes, though she must have been as heavily infected as the others. This bird is still alive, and might form the starting point of an immune race.

Though unsuccessful among chickens a fortnight old, the treatment has undoubtedly been successful among older birds, and appears to be worth the attention of those engaged in work on poultry. My own trials were rather rough and ready, a cure rather than a definite research being the object. The breeds were Light Sussex and White Wyandotte, including crosses.

W. R. G. ATKINS.

Antony, Torpoint, Cornwall.

A Spark Method of Measuring High Resistance.

A CONDENSER of capacity $c\mu f$ charged through a resistance r megohm by a battery of e volts, has at any instant a charge $q = ec(1 - \epsilon^{-t/cr})$. After a time, t sec., the charge is approximately equal to $2/3\ ec$. The attainment of this stage in the charging process may be determined by inserting a spark gap in parallel with the condenser, of which the sparking potential is $2/3\ e$, the spark passing when $t = cr$.

This suggests a method of measuring resistances of a high order (or capacities of a low order), and some preliminary experiments have been made with standard megohms and xylol alcohol resistances of the order of 10^8 ohm. The spark gap consisted of two platinum wires about 1 mm. apart fused into a highly evacuated glass tube, the sparking potential being about 410 volts. The values obtained for the resistances in this manner were about 10–15 per cent too great, but consistent results were obtained in all cases. The large results (that is, large values of t) obtained are probably due to leakage through the condenser insulation or across the glass of the spark tube. The elimination of these defects is under investigation, and it is hoped shortly to publish elsewhere the results of further work.

J. A. C. TEEGAN.

London, Aug. 17.

Research Items.

A Late La Tène Spear-head from the Thames.—In *Man* for September, Mr. T. D. Kendrick describes and figures a remarkable ornamented iron spear-head found in the Thames at London and now in the possession of Captain Ball. It is 11·8 inches long and has a broad triangular blade with rounded base angles. The wings are flat; but the blade itself is bisected on each face by a raised mid-rib, sharp-edged and triangular in section. This extends from tip to base, where it merges into the socket, which is faceted for a short length and then runs on round-sectioned. The forging is excellent and shows no trace of the annealed joint. Bronze plates are affixed to the lower part of the wings on each face—thin strips of metal with bevelled edges about $3\frac{1}{2}$ inches long. They are applied as four separate pieces, being fastened in position by a number of neat little pins, of which two have the heads traversed by the ornament on the plates. No two of the plates are alike, but each is cut into a sinuous form with eccentric leaf-shaped protuberances, and each is ornamented with an incised design in which a disc-ended S-shaped scroll, set off against a basket-work background, is the principal element. The pattern is not in the best tradition of this sort of work. The form of the spear-head would suffice to date it to the La Tène period. A large number of decorated spear-heads have been found abroad and some in Ireland. Yet this single English specimen is unique among all decorated La Tène spear-heads because of the manner of its ornament. Other spear-heads are decorated by inlay or by incised or openwork devices in the iron blade, but here it is in the form of applied plates of a different metal. In richness of decoration it is surpassed by a specimen from Hungary and one from Switzerland; but it is much later than either. It belongs to the middle of the first century A.D., and must be regarded as an important document for the study of 'Celtic' art in Britain, marking the complete disappearance of the fluid elegance of the earlier foliate design.

Speed of Flight of Birds.—An important contribution to our knowledge of the speed of flying birds is made by T. H. Harrisson in *British Birds* (Sept., p. 86). The data were obtained by well-designed methods of using a motor-car and motor-cycle; they cover 103 records for thirty-six species, and they refer only to normal daily flight. Comparison of the figures here with those which have been published by other observers suggests that in some species at least (for example, rook, swallow, and lapwing) there may be a difference between the speed of migratory and of normal daily flight. But it is evident also that speed for a species is not a constant: ten sets of records for the starling give speeds ranging from 48 to 24 miles an hour, the non-migratory speeds ranging from 32 to 24 m.p.h.; and eight readings gave the ring-dove a range from 51 to 27 m.p.h. The speeds of different species show striking differences: the fastest speed recorded by the author was 59 m.p.h. for a stock-dove, the slowest 17 m.p.h. for a herring-gull, and the seemingly slow tawny owl gave speeds of 45 and 41 m.p.h., while the swallow (eleven observations) yielded no better than a range from 23 to 32 and an average of 27·3 m.p.h.

Japanese Nematodes.—Dr. Shigemoto Imamura in his paper "Nematodes in the Paddy Field" (*Journal of the College of Agriculture*, Imperial University of Tokyo, vol. 11, No. 2; 1931) investigates the nematodes of the rice fields and their numbers before and after irrigation. This is an exceedingly interesting and important subject. Forty-eight species belonging to twenty-five genera are described and figured. The Anguillulidæ are by far the most numerous, amounting to more than seventy-five per cent of all those found in the fields before irrigation. The worms belonging to this family are more or less injurious to the higher plants, and it is found that after irrigation their numbers are reduced to less than one-third. The whole nematode population after irrigation was reduced to about half as many as before, but whereas before irrigation they were chiefly those which were injurious to the crops, after irrigation they were chiefly those which fed on other animals, including the Anguillulidæ, the predatory genus *Mononchus* being much to the fore. The results of these investigations suggest that the irrigation either causes the injurious nematodes to be drowned or to be devoured by other nematodes such as *Mononchus*. Most of the nematodes both before and after irrigation occurred in the layer of soil in which were the roots of the rice plants.

Duration of the Pleistocene Period.—An address to the American Association for the Advancement of Science by G. F. Kay on the classification and duration of the Pleistocene is published in the *Bull. Geol. Soc. Amer.*, **42**, pp. 425-466, 1931. Reasons are given for the interpretation that Pleistocene history involves four cycles from the time of advance of the first ice-sheet, the Nebraskan, to the retreat of the last, the Wisconsin, each being recorded in the deposits laid down during the early glacial stage and in the changes which those deposits underwent during the interglacial stage. New names have been chosen for the four epochs so defined: *Grandian* (Nebraskan and Aftonian), *Ottumwan* (Kansan and Yarmouth), *Centralian* (Illinoian and Sangamon), and *Eldoran* (Iowan, Peorian, and Wisconsin). The evidence used in estimating the durations of the interglacial stages was gained from field studies in Iowa of the relative depths of the leaching of calcium carbonate in similar materials which throughout their times of leaching were similarly situated topographically and climatically. The results in years are: post-late Wisconsin, 25,000; post-Iowan, 55,000; Sangamon, 120,000; Yarmouth, 300,000; and Aftonian, 200,000. The *minimum* duration of the times of actual glaciation is estimated at 30,000 years. The combined estimates give for the whole of the Pleistocene in Iowa a minimum of about 700,000 years. In so far as the rate of downward leaching may well have decreased as the depth increased, it is judged that the Pleistocene deposits may actually represent a much longer time, possibly up to two million years.

A Connexion between Electricity and Magnetism.—It is invariably found in experimental investigations that magnetic poles have to be dealt with in quantities equal in amount and opposite in sign. With the usual method of formulation, this fact is taken over into quantum mechanics, which is thus applicable only when there are no isolated magnetic poles. In a paper in the September number of the *Proceedings of the Royal Society*, Dr. P. A. M. Dirac shows that this restriction can be removed by a natural development of quantum mechanics. The new theory leads to a simple formula $hc/2\pi e\mu_0 = 2$, where μ_0 is a quantum of magnetic pole strength and the other symbols have their conventional significance. Comparing this with the well-known relation $hc/2\pi e^2 = 137$, which is known to be closely true from experiment independently of any theory, shows that $\mu_0/e = 137/2$. In other words, the attractive forces between two one-quantum poles of opposite sign is almost 5000 times that between electron and proton, a result which may explain why a separation of poles of opposite sign has never been effected.

Estimation of Dissolved Metals.—In the September number of the *Proceedings of the Royal Society*, F. Twyman and C. S. Hitchen describe an improved spectrophotometric method for the estimation of metals in solutions. It consists in principle in the measurement of the intensity of a line from its length in the spectrum photograph obtained when a disc of special contour is rotated in front of the slit of the spectrograph during the exposure. Much attention has to be paid to details of procedure, such as the operation of the spark source of light and the development of the plate, but it appears that the necessary operations, which are described in full detail, are neither unduly laborious nor intrinsically difficult. The method, as given for minor constituents in solutions of metals, seems to have as great advantages as the corresponding method for the analysis of alloys; it is rapid, sufficiently accurate, and often superior in many respects to a chemical analysis, whilst the spectrogram gives a permanent record of the analysis.

Constitution of Cyanidin Chloride.—In a communication to the *Journal of the Indian Chemical Society*, vol. 8, p. 329, Dr. M. Nierenstein discusses the constitution of cyanidin chloride, a substance which is of interest both to chemists and to botanists on account of its relationship to the anthocyanidin pigments of flowers. Since cyanidin chloride breaks down on hydrolysis to phloroglucinol and protocatechuic acid, it is necessary to ascertain the mode in which the two nuclei of these products are linked in cyanidin. Willstätter ventured in 1914 to assign a definite structure to the latter compound, since it was supposed that it could be produced from the anthoxanthone quercetin by reduction. The fact that this reduction theory, though strongly favoured by Everest, Willstätter, and other chemists, appears to conflict with botanical evidence led Malkin and Nierenstein to reinvestigate the matter. These authors (*Jour. Amer. Chem. Soc.*, 52, 2864; 1930) were able to show that reduction of quercetin leads to a dimolecular product, quercetylene chloride, and not to the monomolecular pentahydroxyflavylium chloride, which has the structure assigned by Willstätter to cyanidin chloride. It appears that both quercetylene chloride and pentahydroxyflavylium chloride have been identified with natural cyanidin chloride, but the evidence on which identity of composition is based is stated to be inconclusive. Furthermore, X-ray analyses of the natural cyanidin chloride and the synthetic product have revealed their dissimilarity. Thus there appears to be some doubt about the actual structure of cyanidin chloride. A possible solution of the problem, based on the fact that Freudenberg has reduced the compound to epicatechin, is tentatively suggested in the paper.

Astronomical Topics.

Detection of Neujmin's Comet, 1913 III.—Search for this comet has been going on for some months. A telegram from the U.A.I. Bureau, Copenhagen, on Sept. 26 announced that Dr. Nicholson, at Mount Wilson, had found it in the following position:

Sept. $17^d\ 12^h\ 18{\cdot}0^m$ U.T., R.A. $4^h\ 43^m\ 48^s$,
N. Decl. 38° 29′, Mag. 15. Daily motion $+40^s$, N. 9′.

It was stated that there was no nebulosity; this was frequently the case in 1913.

This position and the motion are satisfied within 1′ by the following elements, which are from the B.A.A. Handbook for 1931, with adjustments to period, eccentricity, and date of perihelion:

T	1931 April 29·98 U.T.			
ω	346°	57′	48″	} 1931·0
Ω	347	18	10	
i	15	9	3	
ϕ	50	47	54	
log q	0·18415			
Period	17·689 years.			

Ephemeris for 0^h U.T.

	R.A.	N. Decl.	log r.	log Δ.
Oct. 2.	$4^h\ 49^m\ 43^s$	40°40′	0·3712	0·2566
10.	4 49 32	41 45	0·3828	0·2514
18.	4 46 31	42 42	0·3942	0·2475
26.	4 40 58	43 27	0·4054	0·2460

This comet must be ranked as belonging to Saturn's family; its orbit makes a close approach to that of Saturn in the region passed by the comet after aphelion. It is the second member of the family to be observed at a second apparition. Tuttle's comet has been observed at seven apparitions.

Collapsed Stars and Novæ.—Prof. E. A. Milne suggested, in the *Observatory* for May, that novæ are the result of the collapse of a star of ordinary density. This collapse may produce rotational instability and cause the star to split into two portions. These may then re-expand, which would give an ordinary binary star. A system like that of Sirius might result if the larger star re-expanded, while the smaller one retained its high density. The very great disparity in state of the components of Sirius, both presumably of the same age, might thus be explained.

Incidentally, Milne concludes, from the observed frequency of novæ, that every star is a nova at least once in its history. This suggests the question: Has the sun had the disease yet? The appulse of another star, which is the current explanation of the birth of the planetary system, would produce conditions in the sun that would bear some resemblance to an outburst of a nova. Milne ranks the nuclei of planetary nebulæ, also ex-novæ, and possibly the ordinary Wolf-Rayet stars, as collapsed stars that have a high density and a high temperature.

Velocity of Light from the Spiral Nebulæ.—Some months ago Prof. Perrine made the suggestion that the positions of the distant spirals with reference to stars in their vicinity should be observed at different times of the year, as a test whether they indicated the same velocity of light as that from bodies in our own galaxy. It was not anticipated that any difference would be shown, as ever since the Michelson-Morley experiment it has been generally accepted that light from any source gives the same measured velocity. It was, however, of considerable interest to make the experiment. This has been done by Mr. Gustaf Strömberg, using plates obtained with the 60-inch reflector at Mt. Wilson; the results are given in *Pubs. Astr. Soc. Pacific*, August 1931. They give the same aberration constant for the stars and the nebulæ within 0·006″, which is far below the limits of probable error. Hence the velocity of light from the nebulæ is not influenced by the large recessional speed (11,000 km./sec.) which Humason found for the nebulæ that were observed by Strömberg.

The International Illumination Congress.

THE International Illumination Congress, which took place on Sept. 1–19, was the first conference of this kind to be held in Great Britain. Something like twenty different countries were represented and the number of names on the official membership list exceeded 500. It may be recalled that the Congress consisted of two distinct sections: the initial period during which members visited in succession London, Glasgow, Edinburgh, Buxton, Sheffield, and Birmingham; and the subsequent stage, on Sept. 13–19, which took place at Cambridge and was devoted to the proceedings of the International Commission on Illumination. During the first period more than a hundred different papers on varied subjects were presented and discussed; at Cambridge, reports from the various national committees surveying progress in different fields or making suggestions for international action were presented, and in some cases effect was given to these suggestions by suitable resolutions.

The programme in London (Sept. 1–3) was mainly social. Such institutions as the National Physical Laboratory, the E.L.M.A. Lighting Service Bureau, the G.E.C. Research Laboratories at Wembley, and the training centre for gas engineers at Watson House were visited. At a luncheon given by the Gas Light and Coke Co. and the leading London electric supply undertakings on Sept. 2, the toast of the Congress was proposed by the Rt. Hon. George Lansbury, M.P., who, on behalf of H.M. Office of Works, had taken a keen interest in the floodlighting arrangements. On the evening of the following day there was also a dinner at the Dorchester Hotel, at which the president (Mr. C. C. Paterson) presided. There were also motor trips round the streets of London by night and a visit to the Croydon aerodrome, where night-flying by artificial light could be witnessed. But the most interesting event of the London programme was undoubtedly the steamboat trip from Westminster to the Port of London, the return journey of which was designed to enable visitors to inspect the floodlighting.

Much has been written regarding the floodlighting, which aroused extraordinary popular interest. It is stated that the crowds on the evening of Sept. 2, the opening day, were the greatest in London since Armistice night. It is impossible to describe this lighting in detail, but there were several features of exceptional interest. The most brilliant illumination (estimated at 20 foot-candles) was attained on Buckingham Palace, which received light from 183 projectors, each rated at 1500 watts; but the treatment of other buildings was artistic and successful, such as the floodlighting, by rose-coloured light, of Somerset House and the pleasing 'local lighting' of Thames House, which enabled its architectural features to be 'picked out' and the roof to be revealed by special strip reflectors. Considerable enterprise was shown in two examples of gas-lighting, the special treatment of Whitehall (bringing the illumination up to Class "A" standard, that is, a minimum of 2 foot-candles, which is attained in no other street in Great Britain) and the floodlighting with gas of St. James's Park. The latter, whilst very effective pictorially, is of considerable technical interest because of the novel gas-lighting projectors designed specially for this scheme. During September there were, however, more than fifty towns throughout the country where floodlighting installations were arranged; Edinburgh Castle may be mentioned as a most noteworthy and effective example of floodlighting.

The party left for Glasgow on Sept. 3. On the following morning, a civic welcome was extended to them by the Lord Provost at the Royal Technical College, where the sessions took place. At Glasgow there were three simultaneous sessions, devoted respectively to lighting developments, photometric precision, and daylight. The papers grouped under lighting developments were mainly descriptive. Miss C. Haslett and Miss Nora E. Millar put in a plea for better domestic lighting. Mr. C. W. Sully emphasised the importance of good lighting to electric supply undertakings, which should set up well-staffed 'lighting service' departments. Sig. C. Clerici reviewed recent progress in illuminating engineering in Italy. Mr. C. A. Atherton presented an informative paper surveying educational methods throughout the world and illustrating (by reproductions of posters, etc.) the effect of national characteristics.

In these three sessions twenty-seven papers were presented, so that one cannot do more than briefly indicate a few salient points. The chief item in Section 2 (Photometric Precision) was a comprehensive survey of photometry by the National Dutch Committee, in which reference was made to the unsatisfactory nature of the various existing photometric standards. There appear to be two alternative possibilities, either a standard based on physical photometry or one based on the use of tungsten lamps of known dimensions. The latter seems the more practical method. Other papers were designed to show the degree of precision possible in laboratory and commercial photometry. Thus R. Kovesligethy and P. Selenyi and also L. Simek (Czechoslovakia) indicated the possibility of confining errors to within 0·25 per cent. A useful contribution by B. P. Dudding and G. T. Winch led to the interesting conclusion that the error in visual photometry consists of two approximately equal portions, arising respectively from imperfect visual judgment and inaccuracies in establishing the standard electrical pressure at which lamps operate. A further inference may be made that, if suitable precautions are taken, laboratory photometry based on the use of photoelectric cells gives greater consistency than is attainable by visual methods. Of special interest was the analysis by A. K. Taylor (G.B.) and by J. Wetzel and A. Gouffé (France) of errors in portable photometers. In the discussion, the importance of accurate control of the current taken by the lamps in such photometers was emphasised; it is regarded as doubtful whether adequate precision can be obtained from customary types of ammeters or voltmeters, and more sensitive methods (based on the use of null-points and bridges, etc.) have been suggested by J. T. MacGregor Morris.

There were no less than ten papers included in the Section on Daylight Illumination, the authors of which were drawn from seven different countries. Of the three British papers, that by P. J. Waldram contained an informative survey of the development of legal aspects of access of natural light, and the corresponding photometric methods that have been evolved in Great Britain. There appears to be good basis for the suggestion that in buildings a minimum daylight factor of at least 0·2 per cent should be adopted. With the normal sky-brightness of 500 lux already approved by the International Commission on Illumination, this factor would correspond to a minimum of 1 foot-candle.

On the evening of Sept. 4 there was a civic reception in the City Chambers by the Lord Provost, followed by a tour of inspection of the lighting of streets in

Glasgow and its environs. The following day was devoted to a pleasant excursion on the Firth of Clyde, and on Sept. 6 the party travelled on to Edinburgh, breaking the journey at Gleneagles. It had been remarked that in Glasgow there was little or no floodlighting, whilst at Edinburgh attention had been concentrated on the illumination of the Castle, which on account of its commanding site is an ideal subject. Although the degree of brightness in this case was less than in some London installations, the effect was very fine, the inequalities in the illumination of the extensive surface of the walls operating as a positive advantage.

At Edinburgh also there was a very full programme of papers, no less than 34 being presented in the four sections dealing with public lighting, diffusing materials, aviation lighting, and physiological problems. The outstanding session, however, was that devoted to public lighting. This was undertaken jointly with the Association of Public Lighting Engineers, the eighth annual conference of which was being held simultaneously. The morning papers were mainly statistical. Contributions reviewing progress in gas and electric street lighting were presented by Sir Francis Goodenough and Mr. W. J. Jeffery. Of considerable scientific interest was the account by Mr. W. S. Stiles ("Mass Experiments in Street Lighting") of impressions of degree of glare, visibility, etc., gathered in Sheffield and Leicester by an appeal to a considerable number of observers.

The afternoon session resolved itself largely into a discussion of the British Standard Specification for Street Lighting, which was ably dealt with by the president (Mr. C. C. Paterson) and others. Modifications in the original specification were explained and the difference between 'methods of grouping' and 'criteria of excellence' illustrated. These papers gave rise to a good 'international' discussion, and the chairman (Dr. N. A. Halbertsma, of Holland) excited general admiration by his interpretations in three languages and his skilful guidance of the discussion. An informative contribution was that of C. Clerici (Italy), who described the lighting of the arterial road from Rome to Ostia, by means of 60 watt fittings 'staggered' at intervals of only 25 ft.—an example of remarkably close spacing. In the section on aviation lighting, the papers by H. N. Green ("The Light Distribution from Navigation Lamps") and the British National Committee ("Ground Lighting Equipment for Aviation") were of special merit. In Section 2, J. W. Ryde and B. C. Cooper were responsible for two papers dealing with the theory of opal glasses. Japan was responsible for three papers in this section. On Sept. 8, visitors left for Buxton, where the next sessions were held.

(*To be continued.*)

Photographic Analysis of Explosion Flames.*

IN principle the method usually employed for the photographic analysis of explosion flames is the same as that originally designed by Mallard and Le Chatelier fifty years ago. It consists in photographing the movements of the flame along a horizontal glass tube on a sensitised plate or film moving vertically at a suitable known velocity, thus obtaining (*inter alia*) a graph compounded of the two velocities, from which that of the flame at any point can be deduced. Mallard and Le Chatelier employed horizontal tubes of diameter between 1 and 3 centimetres in sections, each 1 metre long, connected in series by means of caoutchouc rings. The whole was focused, by means of a wide aperture lens, on a plate moving vertically with a known uniform velocity of about 1 metre per second.

As the plates used by Mallard and Le Chatelier were not sufficiently sensitive to give satisfactory records with feebly luminous flames, such as those of hydrogen-oxygen explosions, they employed explosive mixtures of carbon disulphide with either oxygen or nitric oxide, the flames of which are much more actinic, believing them to be typical of all explosive 'oxygen' or 'air' mixtures respectively. The behaviour of these mixtures on explosion was found to differ according as they were ignited at or near (*a*) the open, or (*b*) the closed end of a tube. In the former case the flame always proceeded for a certain distance along the tube at a practically uniform slow velocity, which was regarded as the true rate of propagation 'by conduction'. This initial 'uniform movement' was usually succeeded by an 'oscillatory period', the flame swinging backwards and forwards with increasing amplitude, and finally *either* dying out altogether *or* giving rise to 'detonation', according to circumstances. With some 'oxygen'-mixtures the initial period of uniform velocity was short, and appeared to be succeeded abruptly by 'detonation', without passing through any intermediate oscillatory period. When, however, the mixtures were ignited near the *closed* end of the tube, the forward movement of the flame was continuously accelerated until finally 'detonation' was set up. In 'detonation', where the explosion is propagated from layer to layer by 'adiabatic compression', the flame velocities are both uniform and high, usually of the order 2000 to 3000 metres per second.

The experimental method was developed and improved by the late Prof. H. B. Dixon and his collaborators in Manchester during the nineties of last century. They used a highly sensitive film rotating vertically on the periphery of a drum with a constant velocity (which, however, varied between 25 and 50 metres per second in different experiments), the explosion tube being placed at such a distance from the camera that the size of the image was about one-thirtieth of the flame. In this way they analysed the progress of an explosion from its origin up to the final attainment of its maximum force and velocity in 'detonation'. They also discovered (i) the wave of 'retonation', which is thrown back through the still burning or chemically active medium from the point where detonation starts (a phenomenon also independently discovered by Le Chatelier in 1900), (ii) the effects of collisions between two explosion waves, as well as of the passage of 'reflected waves' through the hot products of combustion behind the flame front.

Within recent years the experimental method has been further developed and improved in the laboratories at the Imperial College, South Kensington, chiefly by means of the new high-speed photographic machines designed by Mr. R. P. Fraser, which have so increased its analysing power that it is now possible to photograph and measure movements in explosive flames occurring periodically with frequencies up to 250,000 per second. With a new type of camera embodying the principle of a mirror revolving *in vacuo* at high constant velocity (16,000 r.p.m.) and projecting the image of the explosion flame on to a stationary film, we hope soon further to increase the analysing power four- or five-fold. So that in the near future we hope to be able to photograph and measure periodic flame-movements occurring with frequencies of a million per second.

* Substance of an evening discourse delivered before the British Association on Sept. 24 by Prof. William A. Bone, F.R.S.

The results already obtained have modified and corrected many of our former ideas concerning the nature of the initial phase of slow uniform flame-movement in gaseous explosions, and (*inter alia*) completely disproved the supposed 'law of flame speeds'. Indeed, it now seems probable that what Mallard and Le Chatelier visualised as flame propagation 'by conduction' is an ideal condition perhaps realisable only when a stagnant explosive mixture is ignited without impulse at the centre of a spherical vessel of infinite radius.

Important new information has been obtained regarding the influences of 'compression' and 'shock' waves upon the speeding up of combustion and flame movements during explosions; and it is now proved that the speed can be abruptly raised from a lower to a higher uniform value when a flame is overtaken by a 'shock' wave travelling in the same direction. Indeed, it has been shown that in such manner the flame-speed can be successively raised *per saltum* many times, and that it may assume any uniform value between the limits of that theoretically corresponding with propagation by 'conduction' and that due to propagation 'by adiabatic compression'.

Much new light has been thrown on what may be termed the 'pre-detonation' phase of explosion, when the flame is advancing at a speed greater than that of any 'shock' wave through the unburnt medium, and is therefore overtaking any such shock waves which are ahead of it. 'Detonation' is ultimately set up when a rapidly moving flame on the verge thereof is just about to overtake a shock wave immediately in front of it. Thereupon an 'ignition ahead' of the flame-front occurs, and immediately afterwards 'detonation' is set up. Indeed, during the 'pre-detonation' phase a series of successive such 'ignitions ahead' may occur, detonation being set up immediately after the last one.

We have obtained photographs analysing the phenomenon of 'spin' in detonation, which was first observed five years ago in detonations of moist $2CO + O_2$ mixtures by C. Campbell and D. W. Woodhead, working in the late H. B. Dixon's laboratory, and later confirmed in our laboratories at South Kensington. 'Spin' has also been observed in detonations of methane-oxygen, pentane-oxygen, undiluted acetylene, and other media, and apparently is caused by the helical rotation of a luminous 'head' of detonation in the flame front together with a long luminous 'tail' behind it. The pitch (L) and frequency (f) of such rotation in detonations of a given medium varies with the internal diameter (D) of the tube, so that, while the ratio L/D for diameters up to about 1 inch is constant, and nearly equal to 3·0, the helical velocity of the rotating 'head' of detonation is approximately of the same order, irrespective of the medium or of the tube diameter. Thus, in the case of a moist $2CO + O_2$ medium, which exhibits the phenomenon most markedly, $f = 44{,}000$ per sec., and $L = 3{\cdot}95$ cm. in a tube of 1·3 cm. internal diameter, the velocity of the 'head' of detonation along its helical path being 2500 metres per second.

These discoveries have necessitated revision of the old classic conception of 'detonation' and opened up new lines of inquiry concerning it.

Within recent years the photographic method has also been used for the purpose of analysing (i) ignition phenomena, including the 'induction' period of explosions, (ii) the influence of moisture upon explosions of carbonic oxide-oxygen mixtures, and (iii) the influence of strong electrical fields upon gaseous explosions.

The Construction of Man's Family Tree.*

SOMEWHERE about the year 1865 Ernest Haeckel drew a family tree to represent man's relationship to the rest of the animal kingdom. Neither Darwin nor Huxley were so daring. In 1871 Darwin went no further in his "Descent of Man" than to infer that "a member of the anthropomorphous subgroup gave birth to man". In 1863 the utmost Huxley adventured was the opinion that man had arisen by "the gradual modification of a man-like ape or from the same stem". Haeckel saw life as a great tree rooted deeply in the geological past with only the end-twigs peering through the surface of the earth into the present as living forms. The terminal twig on the extreme right of his tree represents humanity (*Homo sapiens*). Man, the gorilla, and the chimpanzee are made to emerge from the same terminal stem. Following this human-gorilla stem to the left downwards, we find shooting from it the orang twig, then at a still longer interval, the gibbon branch, then the old world monkeys, then those of the new world, and ultimately this primate stem merges with the stem of the prosimiæ or lemurs.

The facts which guided Haeckel were the multitude of structural points in common which could be explained only as an inheritance from a common ancestor. To convert his hypothesis into true history it was necessary to find the fossilised remains of his missing links; but very few of these were known in his day—Neanderthal man and Dryopithecus and Pliopithecus from the Miocene deposits of Europe. Haeckel depicted the human stem as breaking away from that leading on to the gorilla and the chimpanzee rather more than half-way through the Tertiary period. On Osborn's estimation in years, Haeckel thus gives man's antiquity at 20 or 25 millions of years.

In 1895 Dr. Eugen Dubois, in order to incorporate his newly discovered Pithecanthropus, showed the central stem as represented at first by a proceropithecus, the ancestor of the old world monkeys, then the prothylobates, the ancestor of the gibbons, then the prototype of the great anthropoid apes, followed by the Pithecanthropus type and finally the stem ending in the human form.

Some years previously Sir Arthur Keith was engaged with the dissection of some 300 specimens, gorillas, chimpanzees, etc., and the collection of records of human dissections, in the hope of arriving at a clear-cut explanation of the distribution of anatomical characters. In 1900 he drafted a chart to show the mass of data thus collected. He arrived at the conclusion that the evolution of posture gives the clue not only to the evolution of man but also to that of all the higher primates. There are only two main ways in which an animal can climb a tree—either with the body horizontal (pronograde) or upright (orthograde). Sir Arthur Keith concluded that an arboreal orthograde anthropoid had first diverged in a humanward direction in specialisation of spine, leg, and foot. It was on the trees and not on the ground that man first came by the initial stages of his posture and carriage.

What has happened in the last thirty years confirms the conviction that in the study of the gibbon is the key to the evolution of the great anthropoids and man. In 1910 the discovery of Propliopithecus in the older

* Substance of an evening discourse delivered before the British Association on Sept. 26 by Sir Arthur Keith, F.R.S.

oligocene of Egypt extended the antiquity of what is apparently an ancestor of the gibbons, and presumably orthograde, for a good many million years. It affords a fixed point for speculation concerning the evolution of the orthograde posture. Prof. Osborn and Prof. Wood Jones, who exclude the other anthropoids from the ancestry of man, are prepared to accept Propliopithecus as an ancestor from which both man and the chimpanzee may have arisen.

Sir Arthur Keith's census showed so many anatomical characters in common in the big-bodied group, gorilla, chimpanzee, and orang, that he postulated a common ancestor for the big-bodied group. The discoveries of Dr. Foutan in the lower Miocene of Egypt (1920) of two orthograde primates, one the size of a gibbon, the other half-way between the gibbon and man, support his contention that the great orthograde primates evolved at the beginning of the Miocene. It was at this period, evidently one of great plasticity, that Sir Arthur Keith supposes the human line to have separated from the great anthropoids. Dr. W. K. Gregory also brings the human stem from the anthropoids at the beginning of the Miocene. They both give the human stem an antiquity of about 20 million years.

The human posture was completely evolved before the end of the pliocene period. Allowing two geological periods, the Miocene and the Pliocene, this represents about 18 million years for the evolution of the human characteristics of foot, leg, thigh, and pelvis. Beside Pithecanthropus we now know two other forms of early Pleistocene man, Eoanthropus and Sinanthropus. By the end of the Pleistocene, then, the human stem had been in existence long enough to have broken up into many divergent branches; but we are uncertain whether they represent the ancestors of any race now living. Hence in our tree we trace the living races to an early pleistocene ancestor not yet discovered.

It is not claimed that this formula explains all the facts. Prof. Wood Jones points out that the human body preserves many primitive features which have disappeared from those of anthropoids and of monkeys—features which Sir Arthur Keith thinks are to be explained not by modifying the family tree but by a fuller understanding of the laws of inheritance. In the United States, Dr. W. K. Gregory assigns a place to Australopithecus, the Taungs skull, nearest to man. Dr. A. H. Schultz, of Johns Hopkins University, has drafted a tree in which the gibbon and man are opposed as contrasted forms, while Prof. H. Fairfield Osborn excludes the anthropoidal stage from human ancestry.

Sir Arthur Keith concludes by giving his support to the form of man's family tree which was drafted by Haeckel sixty-five years ago. All are agreed that anthropoid and man have a common ancestry; it is merely the degree of relationship which is in dispute.

A Retrospect of Wireless Communication.*

SIR OLIVER LODGE said that, looking back over his connexion with wireless telegraphy, the first paper which had attracted his attention was one by Lord Kelvin in 1853 on "Transient Currents", which gave the theory of electric oscillations in a masterly manner considering that the idea of self-induction was not then born. Kelvin knew that electric energy could be stored in and released by a condenser in a manner analogous to that in which energy could be stored and released by a coiled spring, and, moreover, that the current resulting from the condenser discharge possessed properties akin to inertia or momentum. The discharge would consequently be of an oscillating character unless the circuit resistance exceeded a certain critical value, and the resulting spark a beaded band instead of a continuous band.

With a large enough condenser, oscillations should be slow enough to give a musical note. The frequency of the note depends on the capacity of the circuit and on its self-induction, which Kelvin spoke of as the "electrodynamic capacity of the discharging circuit". Such a musical note was exhibited by Sir Oliver at the Royal Institution in what was called a 'whistling spark', the pitch of which could be brought down to reach the tones of the human voice.

One factor the theory did not take into consideration was possible loss of energy by radiation, in the same way as a tuning-fork mounted on a sounding-board loses energy to the surrounding air, thus diminishing the time during which the charge would oscillate. At the time, such radiation was unsuspected, and in any case there were no means of detecting it.

The first to show that an electric discharge would generate radiation was Fitzgerald, who discussed the problem mathematically in a paper read before the British Association in 1880. In a further paper in 1883, he calculated the actual energy lost per second by a given condenser and self-induction and showed that it was proportional to the fourth power of the frequency. To obtain an efficient radiator it was necessary to work with a frequency of not less than one million cycles. Fitzgerald took as the basis of his research the results of Maxwell's investigations on electromagnetic theory

In 1865, Clerk Maxwell had attempted to treat mathematically what Faraday had long brooded over as the 'electric field', regarding it as distinct from matter and existing in the ether of space round the charged body. Maxwell evolved two sets of equations, one for the electrostatic field and another for the magnetic field surrounding a current. These he combined in an endeavour to discover the nature of the electromagnetic field. His result, which is now familiar to scientific workers, was the differential equation expressing wave motion. Fortunately, the separate electric and magnetic constants of the ether, which are immeasurable, did not enter into the expression except as a product, which experiments in Germany had shown to be capable of determination.

Maxwell set to work to determine experimentally the rate of propagation of the electromagnetic waves predicted by his theory, and obtained the surprising result that it was equal to the velocity of light.

Theories of light up to this time had treated the ether as an elastic solid capable of transmitting vibrations at a tremendous speed. No single theory had been able to account for all the phenomena of light, and Maxwell's theory, published in 1873 and representing a complete departure from accepted ideas, came as a revelation. His equations have formed the basis of all subsequent work on electromagnetic waves.

Attempts were soon made to verify Maxwell's theory experimentally by the production of ether waves by electro-magnetic means. In 1887 or 1888, Sir Oliver Lodge, working with closed condensers, obtained evidence of their existence in the form of nodes or loops characteristic of ether waves reflected back on themselves at the end of a wire attached to such condensers.

* Substance of an evening discourse delivered before the British Association on Sept. 26 by Sir Oliver Lodge.

At the same time, Hertz in Germany was making experiments on the way in which electric forces streamed out from a discharging conductor. Using an oscillatory circuit consisting of two widely separated plates joined by a wire, he was able to generate waves as Fitzgerald had predicted. These waves were generated in space and had such energy that they caused little sparks to be emitted by a conductor on which they fell. Hertz showed that Maxwell's theory would account for his radiation in every detail, and he made maps of the lines of force during each phase of the oscillation. These maps were published in NATURE in 1889, in a translation of Hertz's paper by Sir Oliver Lodge.

Other means of detecting the waves than by the scintillæ they produced were soon developed. Sir Oliver Lodge discovered the principle of the coherer which was afterwards improved by Branly, and in 1894 he showed that Hertz's waves combined with a Branly detector could be used for the sending and receiving of messages in Morse code.

At the same time, Marconi in Italy was studying the application of Hertzian waves to telegraphy, and in 1896 he came to England and was able to interest Sir William Preece, chief engineer to the Post Office, and to secure his co-operation. Marconi persevered with his experiments, and to him must be attributed the great success of wireless telegraphy.

About the same time Sir Oliver Lodge had realised the importance of selectivity and had taken out a patent for a receiver incorporating capacity and self-induction and capable of being tuned.

The next step, also to be attributed to Marconi, marked the beginning of trans-Atlantic wireless communication. Marconi made use of an elevated aerial connected through a spark gap to earth. The waves generated were consequently in a vertical plane and could travel great distances before becoming attenuated by the earth's resistance. He arranged for a powerful series of signals to be sent out from a station in Cornwall and he himself went to Newfoundland to try to detect them. The experiment was a complete success, and demonstrated that the waves would follow the contour of the earth, a fact which was afterwards explained by the theory of the Heaviside layer. This acts as a kind of whispering gallery and reflects the waves impinging on it.

So far, signalling had been confined to discontinuous trains of waves generated by spark transmitters, but it was realised that there would be a distinct improvement if the signals could be made to consist of modulations in amplitude of a continuous wave of definite frequency, the modulations recurring with a frequency of their own.

The first experimenter to achieve this was Duddell, using an electric arc as part of a circuit containing capacity and inductance. So long as the circuit was not interfered with, the note emitted by the circuit was of uniform tone, but it could be varied by alteration of the self-induction or capacity by means of a key. Duddell's arc responded only to low frequency vibrations and was not applicable to the extremely high frequency vibrations needed for effective transmission. Poulsen improved the arc by immersing it in hydrogen under various pressures, and finally obtained an arc of really high frequency, which he patented in 1903.

There still remained the problem of detecting such waves. In 1904, Fleming perceived that the rectifying action of the two electrode valve could be adapted for the detection of ether waves, and he patented the vacuum valve as a detector. At first the valve was only used for the discontinuous system of spark signalling. Later, Fessenden devised the heterodyne system of reception, in which he superimposed on the received wave another of nearly the same frequency, producing low frequency beats which could be detected by the valve and made to operate a telephone. It was now possible to superimpose on a continuous wave the modulation of the human voice, applied by a microphone, and to detect the resulting vibrations at a distant station. This was the beginning of wireless telephony.

The amount of energy received at a station was small and the signals therefore feeble. De Forest conceived the idea of introducing the grid into a valve and supplying the latter with energy from a local high-tension battery. The pulsations of the received wave were applied to the grid, which therefore acted as a regulator, sometimes assisting the flow of current in the valve and sometimes retarding it. The energy of the signals received was supplied by the local battery, the grid merely acting as a relay, putting energy into the disturbance, but not otherwise interfering with it. It was soon found that the three electrode valve could be used for generating continuous waves, at the same time enhancing their power enormously. Thus in 1913 it became feasible to transmit speech and music to great distances.

In 1917 there was further development when the remarkable property of quartz was utilised to control the frequency of transmitted waves. If a crystal of quartz is compressed it becomes polarised, while on the other hand if it is electrified it constricts. This reversible action renders quartz a natural intermediary between mechanical and electrical vibrations. Eccles uses the vibrations of quartz as a transmitter for electrical waves of steady frequency. This frequency is regulated by a tuning-fork adjusted to the frequency desired and operating on a piece of quartz so as to generate waves of the same frequency. After amplification, signals of enormous power can be sent out with a precision of tuning hitherto unequalled. Broadcasting on a large scale was thus made possible. It was initiated in the United States in 1920 and in Great Britain in October 1922.

Beyond the Milky Way.*

THE star-system best known to us is the Galactic system, which is bounded by the Milky Way. About two million such systems of stars can now be observed; they are known as extra-galactic nebulæ. A random collection of extra-galactic nebulæ seems at first to show a bewildering variety of size, shape, brightness, and constitution, but a scientific study soon reduces them to law and order. Rejecting all those which are not seen edge on, we find that by far the greater number of the remainder can be arranged in a single continuous sequence, beginning with spheres and ending with flat discs. Since the speed of rotation of a body increases as it shrinks, it seems likely that we may interpret this sequence of nebulæ as one of different stages of development or evolution. If this conjecture is sound, a nebula starting with little rotation at first and shrinking in size would gradually increase its speed of rotation as it shrank, and would move steadily along the sequence as it did so.

The way to test this conjecture is to calculate for ourselves how a mass of rotating gas would change

* Substance of an evening discourse delivered before the British Association, London, on Sept. 29 by Sir James Jeans, F.R.S.

in shape as it condensed and shrank. Although the mathematical analysis is not simple, and cannot be absolutely precise, it is fairly conclusive; we find that the evolution of a mass of rotating and shrinking gas would be represented exactly by passage along the sequence.

How did the nebulæ themselves come into being? The conjecture which at once jumps to the mind is that the nebulæ may have been formed by the same process as the stars; just as the stars came into being as condensations in a tenuous uniformly spread gas —the outer fringes of the nebulæ—so the nebulæ may themselves have previously come into being as condensations in an earlier mass of uniformly spread tenuous gas. This can never be more than a conjecture, but there are strong arguments in its favour.

Differences in size and brightness between nebulæ of the same shape are almost entirely due to a distance effect. This makes it possible to estimate the distances of all nebulæ, even the very faintest, with fair accuracy. The faintest which can be observed photographically in the 100-inch telescope prove to be at the amazing distance of about 140,000,000 light-years. Dr. Hubble finds that the two million nebulæ which lie within this distance are fairly uniformly spaced at about 1,800,000 light-years apart. We can construct a model, by taking apples and spacing them at about 10 yards apart, until we have filled a sphere a mile in diameter. This will use about 300 tons of apples. This sphere is the part of space we can see in the 100-inch telescope; each apple is a nebula containing matter enough for the creation of several thousand million stars like our sun: each atom in each apple is as big as Betelgeux, with a diameter equal to, or slightly larger than, that of the earth's orbit.

The circumstance that the nebulæ are fairly uniformly distributed through space certainly supports the conjecture that they may have originated out of a primeval gas spread uniformly through space. Moreover, it can be proved that such a gas would not stay uniformly spread through space but would break up into condensations; and that each condensation would have something like the same mass as the observed nebulæ.

The general breaking-up process of which this is the beginning is in operation throughout the universe. It might be thought that the attractive forces of gravitation would continually draw all the broken pieces together again. The exact reverse appears to be the case. Not only is the substance of the universe for ever being broken into smaller pieces, but these pieces for ever tend to scatter farther and farther apart. Every ray of sunlight that enters our eye carries mass with it; eight minutes previously this mass was part of the mass of the sun. Every second the sun loses more than four million tons of mass in the form of sunlight and sun-heat. As the result of this continual loss of mass the sun's gravitational hold on its family of planets for ever weakens, and these are driven further off into space. The earth's orbit round the sun is not so much like a circle or ellipse as like a coiled watch-spring—a spiral for ever receding into the cold and dark of space.

The same tendency affects the galactic system as a whole. Throughout the universe, all the smaller broken pieces, satellites, planets, stars, are scattering away from one another in apparent opposition to the laws of gravitation.

Still more surprising and sensational is the recent discovery that the largest pieces of the universe—the great extra-galactic nebulæ we have been discussing—are to all appearances engaged in a similar scattering. They, too, appear to be running away from us and from one another. Until recently it was thought that on the whole the nearer nebulæ were approaching the galactic system, while the more remote were receding. We now know that the nearer nebulæ appeared to be approaching merely because they happen to lie mostly in the direction towards which the sun is being carried by the rotation of the galaxy; actually we are approaching them. After the sun's motion in the galaxy has been taken into account, all, or nearly all, of the nebulæ appear to be receding from the galaxy. The nearer nebulæ have small speeds, and the more remote nebulæ have greater speeds; in general, speed is approximately proportional to distance. This simple law seems to hold to the very farthest of the nebulæ—Hubble finds that for every million light-years of distance there is a speed of recession of about 105 miles a second. The last nebula to be investigated at Mount Wilson shows a speed of recession of 12,300 miles a second; its distance, as estimated from its faintness, being about 105 million light-years.

On the face of it, this looks as though the whole universe were uniformly expanding, like the surface of a balloon while it is being inflated, with a speed such that it doubles its size every 1400 million years.

There is one strong theoretical argument in favour of regarding the apparent speeds as real. Einstein's original cosmology regarded the universe as being as full of matter as a universe of its size could possibly be without violating the theory of relativity. Recently, Lemaître, of Louvain, has shown that a universe of this type would not be static—there would be an unstable quality about it. The condensation of the primeval gas into distinct nebulæ, and the imprisonment of a large part of the free energy of the universe in these nebulæ, would cause it to start expanding, in which case it would continue to expand, its radius finally increasing exponentially with the time, until it ended up as an empty universe—finite matter spread through infinite space. Throughout the motion the relative speed of recession of any two nebulæ would be exactly proportional to their distance apart, so that, at first glance at least, this theory seems exactly to fit the observed facts. It not only provides a suggestion as to why the nebulæ may be receding. It goes much further, and predicts that they must be receding; if Einstein's relativity cosmology is sound, the nebulæ have no alternative—the properties of the space in which they exist compel them to scatter.

Yet various circumstances suggest a need for caution. For one, the speeds of the nebulæ are not strictly proportional to their distances. Again, the very magnitude of the apparent speeds casts doubt on their reality; they would reduce the whole existence of the universe to a mere flash—at any rate in comparison with what we have recently believed. If they are real, Eddington has calculated that the universe must have started from a radius of about 1200 million light-years, and that its total mass must be about $2{\cdot}3 \times 10^{55}$ gm. which is the mass of $1{\cdot}4 \times 10^{79}$ protons and an equal number of electrons. So far as we can tell from the masses of the extra-galactic nebulæ, the present average density of matter in space appears to be not less than 10^{-30} gm. per c.c., which, with the same amount of matter, would assign a radius of 13,200 million light-years to the universe—only eleven times its initial value. If the motions are real, the universe is only at the beginning of its career; as it appears at present to be doubling in size every 1400 million years, the few doublings which these figures permit cannot have occupied more than 10,000 million years at most.

General calculations on the ages of astronomical bodies point to far longer periods of time than this. The mere act of condensation of the nebulæ was probably a matter of hundreds of thousands of millions of years. Perhaps there is no real difficulty here; it might well take this long to get the doubling process really going. The real difficulty is that the stars carry intrinsic evidence of having lived through far longer periods than this.

Spectroscopic binaries provide further evidence. Observation reveals a complete sequence; it begins with systems which appear to have just broken into two as the result of rotation—pairs of stars describing circular orbits, and almost in contact—and ends with systems in which the two stars are far apart and describing elliptical orbits. Theory suggests that this observational sequence exactly depicts the evolution of a star which has broken into two as the result of excessive rotation. The outstanding importance of this sequence to our present discussion lies in the fact that the stars at the beginning of the sequence are undoubtedly many times more massive than those at the end. It seems likely that those which are now at the end must have begun at the beginning and lost the greater part of their mass in the form of radiation, and to do this would take millions of millions of years.

Considerations such as these make it very difficult to believe that the universe can be such an ephemeral concern as the apparent speeds of recession of the nebulæ would suggest.

Birthdays and Research Centres.

Oct. 5, 1861.—Sir Thomas Heath, K.C.B., K.C.V.O., F.R.S., honorary fellow of Trinity College, Cambridge, Joint Permanent Secretary to the Treasury, 1913–19, and Comptroller-General of the National Debt Office, 1919–26.

Having published my "Manual of Greek Mathematics" in the early part of this year, I am continuing my life-study of Greek mathematics and astronomy, with the view of keeping pace with the new discoveries in that and allied fields which are continually being made. Thus it is that I was able to include in the "Manual" some interesting things that have come to light since the publication in 1921 of the "History of Greek Mathematics"; for example, an investigation by Archimedes of the problem of inscribing a regular heptagon in a circle (preserved in an Arabic treatise) and some very remarkable results of the study of Babylonian cuneiform inscriptions of 2000–1800 B.C.

I have long wished to write upon the mathematical passages of Aristotle, and hope to proceed with that work if circumstances permit.

Oct. 9, 1863.—Prof. A. C. Seward, F.R.S., professor of botany in the University of Cambridge.

Since the publication in 1925 of two papers on Cretaceous plants collected in Greenland by Mr. Holttum and me ten years ago, I have been working through a large consignment of fossils sent to me through the courtesy of colleagues from the museums of Copenhagen and Stockholm. With the help of the additional data thus obtained, I hope to complete in the near future a supplementary account of the rich Cretaceous floras of western Greenland. In this work much assistance has been received from junior co-workers.

Other lines of work are: a more systematic consideration of the bearing of palæobotanical data on the general problem of evolution; and a more critical study of the geographical distribution of plants during the several geological periods.

One of the subjects which I would recommend for treatment is a careful revision of European collections of Tertiary plants.

Oct. 10, 1893.—Prof. M. Saha, F.R.S., University professor of physics, Allahabad.

The Physical Laboratory of the University of Allahabad is one of the oldest and smallest laboratories in India, having been established about thirty years ago, but little research work was done before I took charge in October 1923. Since then, my colleagues and I have been trying our best to organise the laboratory for research work, but I must confess that I am not satisfied with the progress so far made. Research work is being carried on chiefly in spectroscopy and X-rays. At present we are engaged in studying the absorption spectrum of saturated halides of multivalent elements, and on the modification of quanta by photo-ionisation. The work on thermal ionisation has been temporarily suspended owing to lack of space and time. Research students are engaged in the classification of spectral lines. There is a wireless section, with a good broadcasting station, and it is planned to undertake work on propagation of radio in India, but nothing has been achieved, in so far as the co-operation of other universities could not be secured. The staff (total strength, nine) is heavily overworked, as there are about 200 undergraduate and 25 advanced students, and the laboratory is too much congested, for there has been practically no extension since its foundation.

Societies and Academies.

London.

Institute of Metals, Sept. 15 * (Annual Autumn Meeting, Zurich).—W. E. Alkins: Experiments in wire-drawing. (2) Notes on the relation between reduction of area by cold-drawing and tensile strength of H.-C. copper. Annealed copper rod 0·435 in. diameter was drawn through straight-sided tapering dies at single drafts of slowly increasing amount. The resulting 'primary' tensile strength reduction of area curve consists of an approximately rectilinear portion up to about 15 per cent reduction and of a smooth curve concave to the reduction axis from 15 per cent upwards. Below 15 per cent, results are consistent with the view that drawing takes place by simple elongation under tensile stress; above 15 per cent the curve has the form of a rectangular hyperbola, and one asymptote appears to lie suggestively near the limiting tensile strength to which copper can be cold-drawn.—Clement Blazey: Brittleness in copper. The experiments described are a continuation of those described in two other papers already published under the title of "Brittleness in Arsenical-Copper". It has been found that the brittleness is not restricted to arsenical-copper, but may be produced in copper free from arsenic.—Edward J. Daniels: The attack on mild steel in hot-galvanising. Experiments have been carried out in the laboratory to determine the rates of attack on mild steel strip when immersed in different brands of zinc at various temperatures between 432° C. and 540° C. The influence of the addition of small percentages of aluminium, antimony, and tin has been investigated, and the action of alloys of zinc and cadmium has also been studied.—J. S. Dunn: The oxidation of some copper alloys. The zinc-copper alloys fall, so far as their behaviour under oxidation is concerned, into two classes, fairly sharply separated. Those with copper contents below about 80 per cent all oxidise at essentially the same rate, and all give rise to an oxide which is almost pure zinc oxide.

* Continued from p. 554.

Those with copper above about 86 per cent oxidise at approximately the same rate as copper, and the oxide contains the metal in the same proportion as the original metal. The rate of oxidation increases exponentially with temperature, doubling itself approximately for every 75° C. rise in temperature.—W. R. D. Jones: The copper-magnesium alloys. (4) The equilibrium diagram. Magnesium and copper form solid solutions to a limited extent. At the ordinary temperature 0·02 per cent copper is soluble in magnesium and 2–2·2 per cent magnesium in copper. Two compounds, Mg_2Cu and $MgCu_2$, exist which do not form solid solutions, but form eutectic series with each other and with the solid solutions of copper with magnesium, and of magnesium in copper. The compound MgCu is not formed in the solid state.—Hugh O'Neill: Note on the diameter measurement of certain Brinell indentations in cold-rolled metal. Diameter measurements of the indent may differ by 3-4 per cent according to whether vertical or oblique illumination is used with the measuring microscope.—Hugh O'Neill and J. W. Cuthbertson: The work-hardening capacity and elongation properties of copper. So far as they go, the results indicate that (*a*) the Tetmajer 'uniform elongation' value, and (*b*) the 'extensibility', that is $(1 + a)$, where a is the index in the Bertella-Oliver elongation equation, are reliable measures of the work-hardening capacity of a metal.—C. J. Smithells, S. V. Williams, and E. J. Grimwood: Melting nickel-chromium alloys in hydrogen. Sound ingots can be produced by this method, provided that all the oxides present in the melt are reduced by hydrogen before casting. Alloys prepared from commercial materials give better resistance to oxidation than those prepared from pure materials. The probability that the presence of certain impurities has a beneficial effect was confirmed by making deliberate additions of elements known to be present as impurities in the raw materials. The process of hydrogen melting of nickel-chromium alloys is being applied on a commercial scale. The process has also been used with success for the preparation of other metals and alloys in a ductile state without the use of the usual deoxidisers.

ROME.

Royal National Academy of the Lincei, Feb. 15.—U. Cisotti: Circulations about regions of dead water limited by a polygonal wall and by a free surface.—L. Cambi and A. Cagnasso: A new series of nitroso-sulpho-salts of iron: nitrosodithiocarbamates. Treatment of a solution containing $Fe(NO)SO_4$ with the aqueous solution of a dithiocarbamate results in the immediate formation of an emerald-green nitroso-salt of the general formula $(R_2N.CS.S)_2Fe.NO$. These compounds, several of which have been prepared and analysed, appear to be ferric nitrosodithiocarbamates, but their constitution has not yet been definitely established.—G. Dantoni: The definition of integrals.—R. Caccioppoli: Linear functionals in the field of analytic functions.—R. Calapso: A theorem on Green's angle.—E. Gugino: The behaviour of the forces of reaction in the motion of any material system acted on by positional forces.—G. B. Bonino and L. Brüll: Raman spectrum and chemical constitution of certain chloroethylenes. In a recent study of the ultra-red molecular spectrum of ethylene, Mecke classified the frequencies of the oscillations characteristic for the molecule of this hydrocarbon into valency and deformation oscillations. For tetrachloroethylene, the symmetry of which is similar to that of ethylene, the ratios between these frequencies are calculated to be

$$\sqrt{\frac{2}{C+2Cl}} : \sqrt{\frac{1}{2}\left(\frac{1}{2\,Cl}+\frac{1}{C}\right)} : \sqrt{\frac{11}{2\,Cl}} = 1{\cdot}31 : 1{\cdot}85 : 1,$$

the values obtained by Pringsheim and Rosen being 1·45 : 1·91 : 1. The cis- and trans-isomerides of 1 : 2-dichloroethylene are also considered.—A. Quilico and M. Freri: Azopyrrole blacks (3). For certain of the black products formed from pyrrole and diazo-compounds as the result of a complicated process of oxidation and coupling, attempts are made to establish the number of pyrrole and phenyl nuclei taking part in the condensation, and a hypothesis concerning the general lines of their structure is advanced.—A. Debenedetti: Determination of the optic axial angle of biaxial minerals by means of Fedorow's plate.—G. Tallarico: The biological value of the products of manured or artificially fertilised soil. Experiments with turkeys show that the birds given a vegetable diet grown on manured land are more resistant to disease than those fed on material grown on soil artificially fertilised.—Ada Bolaffi: Certain lipoidal fractions of the adenocarcinoma of the rat.—G Armellini: Memorial notice of P. G. Hagen.

SIDNEY.

Linnean Society of New South Wales, July 29.—W. J. Dakin: On a new bopyrid parasite from the coast of New South Wales. Description of a new genus allied to the group *Orbione*, *Parapenæon*, and *Epipenæon*, the type species being an ectoparasitic branchial parasite under the branchiostegites of a penæid prawn, *Aristeus foliaceus*.—J. R. Malloch: Notes on Australian Diptera (28). Data on the occurrence of the family Rhagionidæ in Australia. A key is given to the genera of the family.—G. H. Cunningham: The Gasteromycetes of Australasia (12). The genus *Scleroderma*. The genus is represented in this biological region by five species, of which *S. australe* and *S. radicans* are confined to Australia, *S. flavidum* extends to Africa and North America; and the other two species, *S. Bovista* and *S. verrucosum*, have a general distribution. A general account is given of the morphology and development of the genus, as well as an artificial key to the species.

Official Publications Received.

BRITISH.

New Zealand: State Forest Service. Annual Report of the Director of Forestry for the Year ended 31st March 1931. Pp. 14. (Wellington, N.Z.: W. A. G. Skinner.)

The Technique of Field Experiments: being the Report of a Conference held at Rothamsted on May 7, 1931, under the Chairmanship of Sir A. D. Hall. Pp. 64. (Harpenden: Rothamsted Experimental Station.) 1*s*. 6*d*. net.

Mines Department. Ninth Annual Report of the Safety in Mines Research Board, including a Report of Matters dealt with by the Health Advisory Committee, 1930. Pp. 86+12 plates. (London: H.M. Stationery Office.) 2*s*. net.

Department of Scientific and Industrial Research. Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1930. Part 2. Pp. v+90+4 plates. (London: H.M. Stationery Office.) 2*s*. net.

Transactions of the Institute of Marine Engineers, Incorporated. Session 1931. Vol. 43, No. 7, August. Pp. 305-344+xxxviii. (London.)

Observations made at the Royal Observatory, Greenwich, in the Year 1929 in Astronomy, Magnetism and Meteorology, under the Direction of Sir Frank Dyson. Pp. vii + A110 + B2 + Cix + C131 + D65 + E46 + 19. (London: H.M. Stationery Office.) 37*s*. 6*d*. net.

Photographic Magnitudes of Stars brighter than $14^{m}.0$ in 40 of Kapteyn's Selected Areas, determined at the Royal Observatory, Greenwich, under the Direction of Sir Frank Dyson. Pp. 69. (London: H.M. Stationery Office.) 6*s*. 6*d*. net.

East London College (University of London.) Calendar, Session 1931–1932. Pp. 206. (London.) 1*s*.

Battersea Polytechnic. Technical College for Day Students, and Day School of Art and Crafts. Calendar, Session 1931-1932. Pp. 50+16 plates. 3*d*. Domestic Science Department and Training College. Full-time Day Instruction, Afternoon and Evening Classes, Session 1931-1932. Pp. 35+9 plates. 3*d*. Department of Hygiene and Public Health, Session 1931-1932. Pp. 24+6 plates. 3*d*. Calendar of Evening and Afternoon Courses and Classes for Session 1931-1932. Pp. 32+14 plates. Free. (London.)

The Botanical Society and Exchange Club of the British Isles. Report for 1930 (with Balance-Sheet for 1929). By Dr. G. C. Druce. Vol. 9, Part 3. Pp. 247-504+30. 10*s*. Report for 1930 of the Botanical Exchange Club. By C. E. Britton. Vol. 9, Part 4. Pp. 505-534. 4*s*. (Arbroath: T. Buncle and Co.)

Report of the Progress of the Ordnance Survey for the Financial Year 1st April 1930 to 31st March 1931. Pp. 29+6 plates. (London: H.M. Stationery Office.) 4s. net.

The Hundred and Ninth Report of the Commissioners of Crown Lands. Pp. 38. (London: H.M. Stationery Office.) 2s. net.

Ceylon. Part 4: Education, Science and Art (F). Administration Report of the Director of the Colombo Museum for the Year 1930. By Dr. Joseph Pearson. Pp. F9. (Colombo: Government Record Office.) 10 cents.

Journal of the Chemical Society. August. Pp. vi+1877-2228+xii. (London.)

Supplement to the Journal of the Indian Mathematical Society, Vol. 18: Report of the Seventh Conference of the Indian Mathematical Society held at Trivandrum in April 1931. Pp. iv+54. (Madras.)

FOREIGN.

Smithsonian Institution: United States National Museum. Bulletin 104: The Foraminifera of the Atlantic Ocean. Part 8: Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planarbulinidae, Rupertiidae and Homotremidae. By Joseph Augustine Cushman. Pp. ix+179+26 plates. (Washington, D.C.: Government Printing Office.) 65 cents.

Smithsonian Miscellaneous Collections. Vol. 85, No. 5: Infra-Red Absorption Bands of Hydrogen Cyanide in Gas and Liquid. By F. S. Brackett and Urner Liddel. (Publication 3123.) Pp. 8. (Washington, D.C.: Smithsonian Institution.)

Proceedings of the United States National Museum. Vol. 79, Art. 1: Three New Species of Polychaetous Annelids from Chesapeake Bay. By Aaron L. Treadwell. (No. 2867.) Pp. 5. Vol. 79, Art. 2: Revision of the Species of Beetles of the Genus Trirhabda North of Mexico. By Doris Holmes Blake. (No. 2868.) Pp. 36+2 plates. Vol. 79, Art. 4: Four New Species of Trematode Worms from the Muskrat, *Ondatia zibethica*, with a Key to the Trematode Parasites of the Muskrat. By Emmett W. Price. (No. 2870.) Pp. 13. Vol. 79, Art. 6: Two New Species of Nematode Worms of the Genus Ostertagia from the Virginia Deer, with a Note on *Ostertagia lyrata*. By G. Dikmans. (No. 2872.) Pp. 6+2 plates. Vol. 79, Art. 11; The Two-winged Flies belonging to Siphosturmia and Allied Genera, with Descriptions of Two New Species. By H. J. Reinhard. (No. 2877.) Pp. 11. Vol. 79, Art. 14: Descriptions of Thirteen New American and Asiatic Ichneumon-Flies, with Taxonomic Notes. By R. A. Cushman. (No. 2880.) Pp. 16. Vol. 79, Art. 15: Descriptions of New Marine Mollusks from Panama, with a Figure of the Genotype of Engina. By Paul Bartsch. (No. 2881). Pp. 10+1 plate. (Washington, D.C.: Government Printing Office.)

Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. 83. Fishes obtained by the Barber Asphalt Company in Trinidad and Venezuela in 1930. By Henry W. Fowler. Pp. 391-410. (Philadelphia.)

Instituts scientifiques de Buitenzorg: "'s Lands Plantentuin". Treubia: recueil de travaux zoologiques, hydrobiologiques et océanographiques. Vol. 12, Livraison 1. Pp. 168. (Buitenzorg: Archipel Drukkerij.) 2.50 f.

Report of the National Committee on Calendar Simplification for the United States, submitted to the Secretary of State, Washington, August 1929. Pp. 119. Supplementary Report of the National Committee on Calendar Simplification for the United States, submitted to the Secretary of State, Washington, May 1931. Pp. 112. Religious Aspects of Calendar Reform. Second edition. Pp. 37. (Rochester, N.Y.)

League of Nations. Fourth General Conference on Communications and Transit. Preparatory Documents, Vol. 1: Calendar Reform. (Official No. C.G.C.T.1.) Pp. 28. (Geneva.) 1s. 3d.

U.S. Department of Agriculture. Technical Bulletin No. 252: Two Citrus Leaf Miners of the Far East. By C. P. Clausen. Pp. 14. (Washington, D.C.: Government Printing Office.) 5 cents.

Journal of the Faculty of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Vol. 26, Part 2: Flora of Hokkaido and Saghalien. II. Monocotyledoneae. Typhaceae to Cyperaceae. By Kingo Miyabe and Yushun Kudo. Pp. 81-277. (Tokyo: Maruzen Co. Ltd.)

CATALOGUES.

A Complete Catalogue of Heffers Publications, 1931-1932. Pp. 62. (Cambridge: W. Heffer and Sons, Ltd.)

Catalogue of Books on Natural History. (No. 65.) Pp. 24. (London: R. S. Frampton.)

Carotene B.D.H. Pp. 6. (London: The British Drug Houses, Ltd.)

Catalogue of Chemical and Industrial Laboratory Apparatus. Ninth edition. Pp. 1471. (London: A. Gallenkamp and Co., Ltd.)

Diary of Societies.

FRIDAY, OCTOBER 2.

INSTITUTION OF CHEMICAL ENGINEERS (at Chemical Society), at 6.—N. E. Rambush and F. F. Rixon: The Gas Generator as a Direct Producer of Metallurgical Products.

SOCIETY OF CHEMICAL INDUSTRY (Manchester Section) (at Engineers' Club, Manchester), at 7.—Dr. T. Callan: Selected Chapters in Organic Analysis (Lecture).

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—R. P. Mears: Submersible Bridges on Indian Roads.

SATURDAY, OCTOBER 3.

GILBERT WHITE FELLOWSHIP (at 6 Queen Square, W.C.1), at 3.—Dr. P. Flemming: Harley Street, Historical and Topographical Notes (Lecture).

INSTITUTE OF BRITISH FOUNDRYMEN (Lancashire Branch) (at College of Technology, Manchester), at 4.—W. West: Low Total Carbon Cast Irons and their Service to the Foundryman.

MONDAY, OCTOBER 5.

SOCIETY OF ENGINEERS (at Geological Society), at 6.—Major C. K. Cochran-Patrick: Present Practice in Aerial Survey.

BRITISH PSYCHOLOGICAL SOCIETY (Education Section) (at London Day Training College), at 6.—H. A. Simmonds: Vocational Guidance and Education.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Queen's Hotel, Birmingham), at 7.30.—W. A. Tookey: The Internal Combustion Engine and its Performances (Presidential Address).

BRITISH KINEMATOGRAPH SOCIETY (in Gaumont British Theatre, Wardour Street), at 7.45.—T. Thorne-Baker: The Spicer-Dufay Colour Process.

SOCIETY OF CHEMICAL INDUSTRY (London Section) (at Chemical Society), at 8.—Sir Daniel Hall: Recent Applications of Science to Agriculture.

TUESDAY, OCTOBER 6.

LONDON NATURAL HISTORY SOCIETY (at London School of Hygiene and Tropical Medicine), at 6.30.—C. S. Bayne: Humbug in Ornithology and Entomology.

IRON AND STEEL INSTITUTE (jointly with Lincolnshire Iron and Steel Institute) (in Modern Schools, Scunthorpe), at 7.—B. Matuschka: Solidification and Crystallisation of Steel Ingots: the Influence of the Casting Temperature and the Undercooling Capacity of the Steel.—A. Robinson: Melting Shop of the Appleby Iron Co., Ltd.—Dr. W. Rosenhain and A. J. Murphy: Accelerated Cracking of Mild Steel (Boiler Plate) under Repeated Bending.

WEDNESDAY, OCTOBER 7.

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN, at 3.—Prof. G. E. Gask: Inaugural Address and Presentation of the Pereira Medal.

INSTITUTE OF FUEL (jointly with other Societies) (at Institution of Electrical Engineers), at 7.—Dr. W. R. Ormandy: Coal: Smokeless Fuel and Oil from the National Standpoint.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at Chemical Society), at 8.—J. C. Maby: The Identification of Wood and Wood Charcoal Fragments.—Dr. T. Callan and N. Strafford: The Examination of Dyed Leathers in Cases of Alleged Dermatitis.—Dr. W. L. Davies: The Determination of Chlorides in Dairy Products and Biological Material.

THURSDAY, OCTOBER 8.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Merchant Venturers' Technical College, Bristol), at 7.—W. A. Tookey: The Internal Combustion Engine and its Performances (Presidential Address).

INSTITUTE OF MARINE ENGINEERS (Junior Section), at 7.—J. R. Douglas: The Running and Maintenance of Marine Turbines.

INSTITUTE OF METALS (London Local Section) (at 83 Pall Mall), at 7.30.—W. T. Griffiths: Chairman's Address.

ROYAL AERONAUTICAL SOCIETY.—Prof. Piccard: Experiences in his Balloon Ascent.

FRIDAY, OCTOBER 9.

INSTITUTE OF METALS (Sheffield Local Section) (jointly with Sheffield Society of Engineers and Metallurgists) (in Applied Science Department, Sheffield University), at 7.30.—Dr. W. Rosenhain: Gases in Metals.

INSTITUTION OF PRODUCTION ENGINEERS (at Society of Motor Manufacturers and Traders, 83 Pall Mall), at 7.30.—Annual General Meeting.

SOCIETY OF CHEMICAL INDUSTRY (Chemical Engineering Group) (at Chemical Society), at 8.—D. M. Wilson: The Manufacture and Testing of Asphalt Paving Material.

PUBLIC LECTURES.

MONDAY, OCTOBER 5.

ROYAL INSTITUTE OF PUBLIC HEALTH, at 4.—Dame Louise McIlroy: Recent Researches in the Prevention of Maternal, Fœtal, and Neo-natal Mortality (Harben Lectures). (Succeeding Lectures on Oct. 6 and 7.)

UNIVERSITY OF BRISTOL (in Wills Physical Laboratory), at 5.15.—Prof. Niels Bohr: Space-Time Continuity in Atomic Physics (Henry Herbert Wills Memorial Lecture).

TUESDAY, OCTOBER 6.

KING'S COLLEGE, LONDON, at 5.—Dr. J. W. Pickering: Blood Plasma and Platelets. (Succeeding Lectures on Oct. 13, 20, and 27.)

GRESHAM COLLEGE, at 6.—Sir George Newman: Physic. (Succeeding Lectures on Oct. 7, 8, and 9.)

SATURDAY, OCTOBER 10.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 3.—C. Williams-Ellis: Architecture? What's the Use?

HORNIMAN MUSEUM (Forest Hill), at 3.—Miss M. A. Murray: Egyptian Beliefs in the Hereafter.

MATHEMATICAL ASSOCIATION (London Branch) (at Bedford College for Women), at 3.—B. C. Wallis: Arithmetic from the Examiner's Point of View.

CENTENARIES.

FRIDAY, OCTOBER 2.

JAMES CLERK MAXWELL CENTENARY CELEBRATION (at Cambridge).

Friday, Oct. 2 (*morning*).—Addresses by Prof. Max Planck, Sir Joseph Larmor, and Prof. Niels Bohr.

(*Afternoon*).—Addresses by Dr. William Garnett, Sir Ambrose Fleming, and Sir Oliver Lodge.

FRIDAY, OCTOBER 9.

MICHAEL FARADAY CENTENARY CELEBRATION (in City Hall, Newcastle-upon-Tyne), at 7.—Dr. W. M. Thornton: Faraday and his Successors—the Growth of an Idea.

CONGRESS.

OCTOBER 5 TO 10.

CONGRESS ON TUBERCULOSIS (at Davos).—*Principal Subjects for Discussion*:—Development and Course of Tuberculosis of the Lungs; Extra-Pulmonary Tuberculosis; Collapse Therapy.