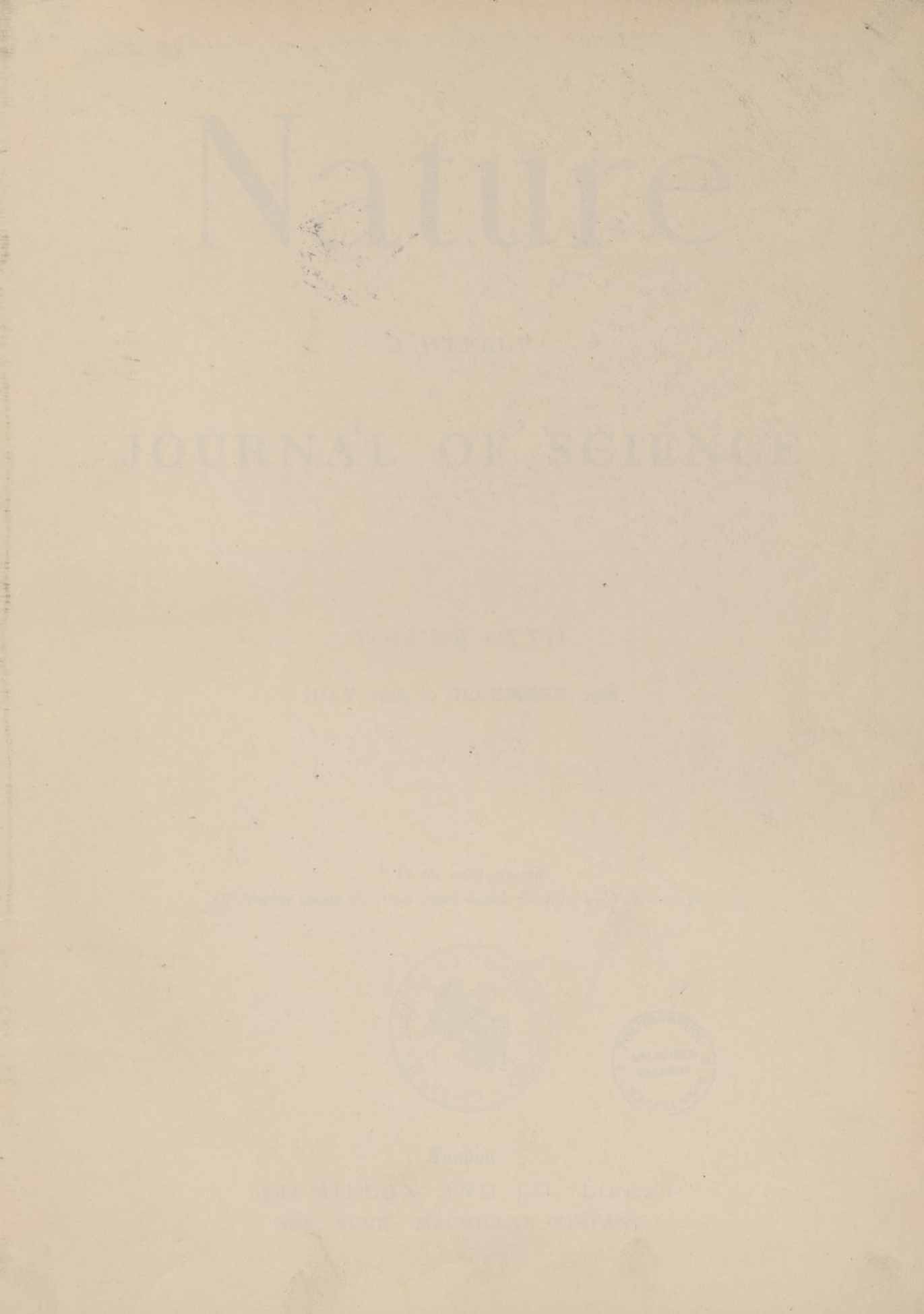

Nature

A WEEKLY

JOURNAL OF SCIENCE

VOLUME CXXII

JULY, 1928, to DECEMBER, 1928

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

London
MACMILLAN AND CO., LIMITED
NEW YORK: MACMILLAN COMPANY

INDEX

NAME INDEX

TITLE INDEX

ASTRONOMICAL NOTES.

CORRESPONDENCE.

DEATHS.

REVIEWS AND OUR BOOKSHELF.

Agriculture, Forestry, and Horticulture :

Anthropology and Archæology :

Biology:

Chemistry:

Engineering:

Geography and Travel:

Geology and Mineralogy:

Mathematical and Physical Science:

Medical Science:

Metallurgy:

Meteorology:

Miscellaneous:

Philosophy and Psychology:

Technology :

The various Supplements should be collated and bound with the numbers with which they were issued.

Printed in Great Britain by R. & R. Clark, Limited, *Edinburgh.*

NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE

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

SATURDAY, JULY 7, 1928.

CONTENTS.

The Impact of the State on Scientific Research.

IN consequence of a recommendation of the Select Committee of the House of Commons on Estimates, the Prime Minister, in October 1926, constituted a Sub-Committee of the Committee of Civil Research "to consider the co-ordination of research work carried on by or under Government, to report whether any further measures be taken to prevent overlapping, to increase economy and efficiency, and to promote the application of the results obtained." Mr. Ormsby-Gore was appointed chairman of the Sub-Committee, Major Walter Elliot was the other parliamentarian, the other members being permanent officials of the various departments concerned in the inquiry. The inquiry was spread over a year, the Sub-Committee reported on Dec. 14 1927, and the results of its deliberations were made public on June 14 last.[1]

With such terms of reference, it might reasonably have been expected that the Sub-Committee would consider it its duty to present a critical survey of the present organisation of the State-maintained or -assisted research services of Great Britain, to present broad details of the expenditure involved, to express its own views on the relative merits of the varying types of organisation which came under its purview, and to have given some indication of the directions in which the results of research might be applied with advantage to the community, and the new researches that were necessary. In these respects the report of the Sub-Committee is disappointing. It is critical of the attitude of indifference to research of former generations, but

[1] Committee of Civil Research. Report of the Research Co-ordination Sub-Committee. (London: H.M. Stationery Office, 1928.) 2*s*. 6*d*. net.

it is difficult to detect in its complacent generalisations on the present organisation of research whether it considers any changes desirable or that it is satisfied that the existing machinery works to the best advantage.

The report is evasive and apologetic in turn. It gives the impression that expenditure on research has to be defended against possible attacks by the ignorant, rather than justified to those who understand the real purpose of research and whose aim it is, in the interests of scientific research generally, to exact the greatest degree of efficiency from the instruments by which it is conducted.

Scant attention is given to the industrial research associations. No opinion is expressed regarding their future, although the Sub-Committee could not have been ignorant of the difficulties with which most of them have had to contend since their inauguration, and the fact that the Million Fund, out of which they have hitherto derived about half their yearly income, will be exhausted in a very short time. What is to happen to them if, for a variety of reasons, the industries they are intended to serve fail to make them self-supporting within the time limit stipulated by the Department of Scientific and Industrial Research? Has the policy laid down for those associations been sufficiently well defined? Is the present organisation of industrial research on a sound basis? Is the machinery for its co-ordination adequate? Is it considered the experiment has been sufficiently successful to justify the State providing ample guarantees for its continuance? It has been left to Lord Balfour to answer this last question. He informed a deputation representing nineteen of the associations which he received on June 29, that the Government is satisfied that the research associations have proved of real utility to the industries they represent. Accordingly, in order to help them to expand the scope of their work and to stabilise the position of the scientific workers attached to the associations, it has been decided to extend the period over which financial assistance is to be given.

Many other queries also come to mind. Which system of research for the fighting services is the better, that adopted by the Board of the Admiralty and the Air Ministry, or that in force at the War Department? Does the committee consider that it is desirable that the responsibility for the arrangement of any research undertaken at the Research Department, Woolwich, should be vested even nominally in a "Chief Superintendent directly under a Director in the Department of the Master-General of the Ordnance," particularly when the office of chief superintendent is held alternately by naval and military officers? This alternate succession must constitute a disturbing factor unless this and the other subordinate administrative posts in the Department held by officers of the fighting services are sinecures.

As regards meteorological research, the Sub-Committee refers to the impact of the work of the Meteorological Office on that of a number of different departments, to the recommendation made after the War to transfer it to the Committee of the Privy Council for Scientific and Industrial Research, and to its attachment to the Air Ministry in 1919. But no opinion is expressed regarding the desirability of this arrangement, which the Sub-Committee must have been aware has been the subject of a good deal of informed criticism. There is no reference to the present unsatisfactory state of the Geological Museum, although this matter was the subject of strong comment in the last report of the Advisory Council for Scientific and Industrial Research. We fail to find any reference to the need for research in the social sciences as distinct from medical research, or for anthropological and geographical research in connexion with Colonial administration. There is a further omission to express any opinion regarding the present state of veterinary research in spite of the fact that this is a matter which has for some time past engaged the earnest attention of the chairman of the Sub-Committee.

On only one subject of importance has the Sub-Committee expressed definite views. These occur in the last three paragraphs of the report and deal with the publication of scientific knowledge. The Sub-Committee rightly considers that the present variety of means adopted by different Government departments for the publication of results of scientific value is not an advantage. Each department has been a guide to itself in the matter, and sufficient account has not been taken either of the need for co-ordination and uniformity of presentation of results obtained by men of science in the Government service, or of the importance of regarding their contributions to knowledge as contributions to the common stock, inseparable from those of scientific workers outside the Government service. "It is," says the Sub-Committee, "incumbent on the Government to avoid adding to the mass of publications that must be searched by scientific workers if there already exist adequate means for the purpose in the scientific world." It considers that the most effective publicity for results is

obtained by means of the *Proceedings* and *Transactions* of the various learned societies and technical journals, hitherto "undertaken at the charge of individual workers banded together for the purpose." It therefore envisages the possibility of more extended use being made by Government departments of these agencies and of direct State contributions towards the cost of such publications. Evidently it considers that the increase, made in 1925, of the Treasury grant to the Royal Society in aid of publications, has been thoroughly justified, and it is permissible to assume that an application for a further increase would be received favourably.

This is the only bright spot in an otherwise dull summary of the methods by which the State fosters research, either in Government laboratories staffed by professional Civil Servants or in State-maintained or -assisted research institutions. It is conceded that such a summary will serve a useful purpose; it might, for example, stimulate more parliamentarians to take an active interest in a matter of vital importance to the nation by enabling them to appreciate the influence of scientific research on our social and economic life, but it was scarcely necessary to have called together so eminent a body to compile what appears to be a digest of various departmental memoranda, the only excursion into matters of policy being that noted above.

The composition of the Sub-Committee possibly accounts to a certain extent for the nature of its report. It is surprising, however, that its members did not realise that the following passage, taken from paragraph 236 of the report, dealing with the Research Council of the Ministry of Agriculture and Fisheries, needs only the substitution of "Departments" for "Institutes" to explain their own failure to deal fully with their terms of reference:

"A body consisting mainly of the heads of Institutes engaged for the most part on research in different fields is not, however, well adapted for the consideration of research policy. Directors of Institutes not immediately concerned can hardly be expected to offer opinions on subjects outside their own sphere or to criticise the work of Institutes for which their colleagues on the Council are immediately responsible."

Possibly if this Research Council consisted *solely* of directors of institutes its effectiveness might increase, and possibly if the directors of the various research departments had been entrusted with the task of preparing a preliminary report for the guidance and consideration of the two Ministers who served on the Research Co-ordination Sub-Committee, the final report might have been a more satisfactory document.

The Way the World might go.

The Way the World is Going: Guesses and Forecasts of the Years Ahead. 26 Articles and a Lecture by H. G. Wells. Pp. xi + 301. (London: Ernest Benn, Ltd., 1928.) 7*s.* 6*d.* net.

The Open Conspiracy: Blue Prints for a World Revolution. By H. G. Wells. Pp. 156. (London: Victor Gollancz, Ltd., 1928.) 5*s.* net.

MEN of science owe a debt of gratitude to Mr. H. G. Wells. He was born with a passion to make things better, and there is implicit in all his writings the view that the advancement of science and the application of scientific knowledge is the indispensable method whereby this end may be achieved. This passion has lost none of its intensity as the years have passed. No trace of cynicism has crept in. He remains as eager, as impatient, and as youthful as ever. He has not accumulated a series of tricks which he performs for the public amusement or "pour épater les bourgeois." He argues, debates, and pleads like the young man just becoming aware of all the absurdities, complexities, and possibilities of life.

Not to have grown old, weary, formalised, or pontifical is an achievement. Exuberance and vitality, a passion for the better ordering of society, a belief in science, are with Mr. Wells as they have always been. Add to that a sixth sense of understanding how ideas and experiences react upon different types of men and women brought up in different social strata, of sensing and expressing social relationships with their economic background: remember that to religious and æsthetic experience Mr. Wells is almost wholly insensitive, and we have some explanation of his positive achievements. His main achievement lies in his novels. In them is displayed an understanding of social as distinguished from individual relationships and experiences, which cannot be paralleled. The existence of Mr. Wells's novels relating to the War will make it possible in the future to understand how men and women were affected by that crisis in human affairs better than we can grasp how any crisis in the past affected those who lived through it.

This achievement, however, is incidental to Mr. Wells's main purpose. He wrote because he had lessons to teach. Every now and then he has tried to convey his lessons in some other form. Thus he has given us utopias, histories, newspaper articles. No matter what form he selects, his vitality carries us along. Nevertheless, as he departs from the form of the novel, we become

conscious of a certain thinness and a certain dryness. The further Mr. Wells gets from men and women, though his powers may be limited to portraying types rather than personalities, some virtue seems to depart, some cunning to leave him. It appears that it is only contact with the flesh and the hot breath of struggling men and women that moves him to his best work. When he contemplates men in abstraction his temperature falls. When he visualises *A*, *B*, and *C* as types of social classes *a*, *b*, and *c*, and brings them together, his imagination is fully exerted, his humour is at work. He flashes out remarks which illuminate our social problems. But when he begins with classes *a*, *b*, and *c*, his powers are not stimulated in the same fashion, and the illumination is correspondingly reduced.

(1) It is a bold thing to collect and publish in book form articles from newspapers on topics of the day. But these articles stand the test. They have vitality and width of vision. The topics discussed are viewed in relation to a broad background, and thus stand in contrast to the common run of journalism in which the attitude of the day alone is represented. The thought common to all these discussions is expressed in the following sentence. "While we are representing life in melodramatic colours as a struggle between the 'Haves' and the 'Have-nots,' the less romantic and interesting reality of a struggle between scientific organisation on the one hand and the alliance of personal greed with chaotic stupidity on the other may be undermining all the grounds of our melodrama."

It is on account of this emphasis on a scientific ordering of our affairs that we should be grateful to Mr. Wells. Men of science are only too apt to content themselves with the application of scientific method to their particular sphere, and to watch without protest the unsystematic, short-sighted, and blundering attempts to mend our social and economic organisation. It may seldom fall to men of science to go themselves outside their spheres, but they are untrue to their guiding principles if they do not urge that those who move in the political arena should attempt to plan and organise in what is essentially the spirit of science.

Mr. Wells admirably fulfils this task of appearing as the prophet of the scientific method in the social field. He is at his best when he is in contact with a concrete problem. In this book is included a lecture given in Paris, which is, as he tells us, "much more closely written than the rest of the book." It is not so alive as the rest of the book. Mr. Wells moves awkwardly in the world of abstractions. He seems to be wanting to get out of the study again and hear what people are saying and watch the expressions on their faces. His literary style, which is not unsuited to convey the jumble and flow of life and contact of man with man, is an uncouth weapon for dealing with academic niceties.

(2) What has just been said applies to "The Open Conspiracy." Mr. Wells has attempted to set down his programme. The book states "the essential ideas of my life, the perspective of my world. . . . This is my religion. Here are my directive aims and the criteria of all I do." Readers of "William Clissold" will remember hearing of the "open conspiracy." In that vivid work is conveyed the idea of the co-operation of men and women of good will and wide outlook in the task of producing world order and harmony. The programme as suggested in "William Clissold" is just definite enough to be real. It is not formalised or presented in an orderly fashion, but it comes through the incidental discussions and descriptions, and comes, moreover, with freshness. The book vibrates. It is exciting. It is concrete. Here Mr. Wells attempts a fuller treatment, more logical and more abstract. It has not the same compelling force.

Interesting and conspicuously sincere as the book is, Mr. Wells's genius is not well suited to this kind of presentation. In the novel form he can suggest the case for the control of population or the stabilisation of prices so as to make them overwhelming. He can show how absurdly some character fears the one and another character misunderstands the other. But when he tries to state the case in essay form, the result is somewhat commonplace and even jejune. The nature of the programme must already be familiar to readers of the novels: the organisation of world peace, the world organisation of credit, transport, and staple production, population control. He looks to its fulfillment coming through informal groups of people in substantial agreement with the main points in the programme who will work for it. It would appear that Mr. Wells has been impressed by the success of Bolshevism and Fascism in capturing the imagination and in focusing the energies of young people, and hopes that his very different programme may do as much.

Surely there is all the difference in the world between the ideals and dogmas of the Fascists and the Bolshevists, which demand from the mass of their adherents mere blind adherence, and Mr. Wells's programme, which is that of following

the light of science as an aid to social betterment and of accepting only that of which the informed intelligence approves. The "open conspiracy" is not likely to achieve its peaceful revolution in that way. The best hope lies, perhaps, in the joint approach to these problems by teachers and students in our universities, of which Mr. Wells speaks somewhat slightingly, and in the hope that some day the great body of men trained in science will refuse to remain content with the restriction of their methods to narrow fields, and will insist that they be applied to the wide and difficult problems of social organisation. A. M. C.-S.

The Cutaneous Circulation.

The Blood-vessels of the Human Skin and their Responses. By Sir Thomas Lewis. Pp. xv + 322. (London: Shaw and Sons, Ltd., 1927.) 37*s.* 6*d.* net.

SOME time ago a paper was sent to a certain society for publication; the comment made upon it was: "Whoever undertakes to act as referee will have to do a year's solid work before he sends in a report." The author of the present review feels much in the same position as the prospective referee. Sir Thomas Lewis has struck right out into new country and very important country. Moreover, it is a matter of great interest that the country is not very far away. There are few parts of the human frame which the doctor can see; with regard to most he has to go on inference. Of the few which he can see, the skin is one.

The step forward with regard to the skin is that it is now beginning to be regarded as an organ. Although, of course, it has long been a commonplace that the principal regulation of heat loss is carried out in the skin, thought has unconsciously settled too much round this word 'integument' as being synonymous with 'skin.' Whilst the importance of the skin as a covering cannot be over-estimated, its importance as an organ of the body which undergoes physiological changes in unison with other organs can be, and has been, very much under-estimated.

The significance which the skin has acquired in the eyes of those concerned with the *modus operandi* of the human body has arisen from several circumstances; of these, one is the recent expansion of knowledge with regard to the capillary circulation; another is the action of radiation, ultra-violet and otherwise; and a third, though in a more restricted way, the action of certain poisonous substances used in the War.

Some such considerations as the above will make many readers welcome, and welcome in no small measure, "The Blood-vessels of the Human Skin and their Responses." Moreover, Sir Thomas Lewis tells us in the preface, his original object in commencing the book was, to state in a consecutive and orderly way the observations which he had made on the cutaneous vessels. But this was not his only reason for writing the book. Regarding education from the point of view of a teacher of medicine, he was prompted by "a desire to stimulate a wider study and teaching of human physiology; for knowledge of healthy man forms the most manifest and abiding bond between physiology and medicine."

Chapter i. is introductory; it has to do largely with the anatomy of the vessels in the skin, but in the second, third, and fourth chapters an account is given of basal reactions on which the conceptions in the subsequent chapters are founded. These reactions are four in number:

	Reaction.	Cause.	Mechanism.
1	White reaction.	Gentle stroking.	Contraction of small vessels.
2	Red reaction.	Vigorous stroke with blunt point.	Relaxation of small cutaneous vessels due to the local production of a chemical dilator.
3	Flare of red area surrounding the stroke.	Abusive or repeated strokes with blunt point.	Axon nervous reflex from the abused area causing *arterial* dilation in the vicinity.
4	Wheal.	Still more drastic stimulation except in the case of sensitive skins, where the stimulation which ordinarily produces a red reaction and flare may produce a wheal.	Due to increased permeability of the walls of the small cutaneous vessels.

Of the four reactions named above, the white reaction appears to be a physiological response, possibly to stretching of the skin. The significance of the whole reaction is somewhat uncertain; indeed it may be permissible to raise the philosophic point with the author. Does it follow that an observed phenomenon necessarily has a significance? If he could definitely answer that question in the affirmative, biological science would be easier for those who pursue it.

To return from this digression, there remain the other three phenomena, the red reaction, the flare, and the wheal. These are the result of a lesion, be it ever so slight. The burden of the succeeding

chapters is to show that they are the result of the same lesion; whether only the red reaction occurs, or the red reaction plus the flare, or the whole three depends upon the extent of the lesion. The complete response, however, embraces the whole three, and for that reason the author includes the whole three in the term the *triple response*. The triple response thus consists of: (1) a strictly localised chemical stimulation; (2) an axon reflex; (3) an increased permeability of the vessels.

Some great man has defined the mission of science as being the reduction of numerous phenomena to a few simple underlying principles. If that be a true definition, Sir Thomas Lewis has furnished an excellent example of the scientific method: for the three individual components of the triple response are all, according to him, traceable to a single cause, namely, the liberation of some product of tissue disintegration at the seat of the lesion. This product, which he regards either as histamine or as something closely akin to it, and which he terms a histamine-like substance, apparently does three things: (1) it dilates the vessels at the immediate site of its production; (2) it stimulates nerve endings there, which, as the result of axon reflexes, dilate the arterioles over the area immediately surrounding (the flare); and (3) increases the permeability of the vessels so that exudation takes place through their walls (the weal).

In a certain number of persons, Chapter ix. will awaken considerable interest. In it Sir Thomas Lewis reduces burns of long-latent period, *i.e.* burns caused by radiations, $\beta\beta$ dichlordiethyl sulphide ('mustard gas'), etc., to the same general type as the more immediate injuries to the skin produced by freezing, stroking, etc. The sympathetic reader will want to know much more from Sir Thomas than he tells. That perhaps is the label of all great work.

Two questions arise at once.

(1) It is the general opinion of persons who deal with such burns, that, given a burn of a certain initial gravity, the time taken for healing differs greatly according to the cause of the burn. A burn caused by hot water will heal rapidly, an X-ray burn slowly, and a mustard burn neither so rapidly as a scald nor so slowly as an X-ray burn. Is this belief well or ill founded? And if well founded, what is the explanation? (2) It is the belief of those who see much of mustard burns—I think it is the universal belief of such—that one mustard burn sensitises the subject and that a series renders him almost incredibly sensitive to the gas. Is this belief well founded? And if so, what is the explanation? I am speaking now of definite burns in which the epidermis comes away at an early stage. If the epidermis, while still *in statu quo*, merely expelled a certain amount of histamine into the underlying tissues, why the difference in the time taken for healing as compared with the gravity of the initial lesion? When the body is rendered sensitive to mustard, is it really rendered sensitive to mustard or merely to histamine? If the latter, does a scald render the body (not at the site of the scald) sensitive to subsequent scalds?

The consideration of these more extensive lesions forms a natural transition to the later half of the book. This deals largely with the general regulation of the blood flow over extensive areas. Such topics are treated as the colour of the skin, the relation of blood supply to the metabolic processes not only of the skin but also elsewhere, the degree of tone maintained in the various vessels of the skin, and so forth. These subjects are discussed along the general lines indicated in the earlier chapters. A certain amount of this portion of the book is not outside the region of controversy, which fact does not detract from the necessity of reading this work. Indeed, anyone who reads it will close it with the fixed idea that to leave it unread is to be uninformed on the colour and appearance which the skin presents both in health and in disease.

The book is produced with the meticulous care to which all Sir Thomas Lewis's readers are accustomed. This applies not only to the form of expression and the type, but also eminently to the illustrations. J. B.

An Encyclopædia of Agriculture.

Handbuch der Landwirtschaft. Herausgegeben von Fr. Aereboe, J. Hansen und Th. Roemer. In fünf Bänden. Band 2, Lieferung 1. Pp. 128. 5·80 gold marks. Band 3, Lieferung 2. Pp. 128. 5·80 gold marks. (Berlin: Paul Parey, 1928.)

FOR some reason not altogether easy to understand, German publishers have not taken kindly to the idea of publishing encyclopædias of agriculture. It is forty years since the well-known "Handbuch der Landwirtschaft" of Freiherr von der Goltz was issued, and during the intervening time there have not only been great changes in agriculture itself, but also large encyclopædias have been published in England, America, and Denmark,

and an encyclopædic series of volumes has been issued in France. Now Messrs. Paul Parey are issuing a new 'Handbuch,' of which the first two sections have reached us.

The book is written for the agriculturist, especially for the student and lecturer in agriculture. It gives a concise account of the various branches of the subject brought well up-to-date and embodying modern ideas and results.

It differs in plan from the ordinary encyclopædia, being a collection of short treatises and not articles arranged alphabetically. The five volumes are to deal respectively with: (1) General agriculture, including its history and economics, organisation, finance and marketing; (2) soil and soil management; (3) crops; (4) general animal husbandry; (5) special animal husbandry.

The soil section is written by Dr. F. Schucht, the well-known authority in Berlin, who has managed to condense into forty pages an excellent summary of the present position of our knowledge of the origin, the chemical and physical properties of soils. Thanks to the work of the Russian investigators, soil classification is now on a broad basis, but this necessitates that the student and, above all, the teacher, should know something about the properties of other types of soil, such as the steppe, black earth, alkali soils, in order that he may appreciate properly the properties of the brown soils which predominate in Germany and other parts of Europe. The necessary information is clearly set out without unnecessary detail. At the end of the section there is a small list of German books in which the subject is pursued further, but in neither of the two books before us are references given to original papers. Perhaps, in view of the general nature of the 'Handbuch,' this was deemed unnecessary.

Dr. F. Löhnis, of Leipzig, deals with the microbiology of the soil, discussing the part played by micro-organisms in bringing about changes of importance to the plant, and the influence of natural and artificial conditions. This section is somewhat in the style of his lectures published some years ago, and it shows that he has the capacity for reducing the enormous mass of material collected in his "Handbuch der landwirtschaftlichen Bakteriologie" to a simplicity of statement that can be followed by the ordinary student.

Dr. Münzinger, of Hohenheim, follows with an account of meteorology in its relation to agriculture, discussing the influence of various climatic factors on the yield and quality of agricultural crops, and devoting a section to hail, a very serious trouble in some parts of Germany. The damage seems to be considerably greater in Baden than in Prussia, and generally worse in South Germany than in the north. There is also a useful summary of climatic conditions in the various regions of Germany.

The volume dealing with crops is on the same general lines. Each section is by a well-known authority on the subject, and written in a general way, giving the broad outlines with not too much detail, and in particular no detailed references to papers, but always a list of German books where full information can be obtained. Dr. F. Berkner deals with the cereals, rye, wheat, barley, oats and maize, giving an account of the varieties, phenomena of growth, and the cultural requirements of each crop. It is interesting to note that some winter barley is grown in Germany although its cultivation is difficult in Great Britain. In the description of the manuring of barley, great stress is laid on the need for supplying all three nutrients, nitrogen, phosphate, and potash, except where the crop is taken after one that has been itself heavily manured. Dr. Opitz' account of potato culture, of which the first part is published, promises to be one of the most interesting accounts of German practice.

It is difficult to judge entirely from two sections what the book is going to be like, and we hope that in succeeding parts the problems of plant disease will be adequately dealt with, these being among the most difficult in crop production. In the soil volume also, when it is complete, we shall hope to find an adequate treatment of cultivation implements, and especially of power for working them.

This idea of bringing together a group of experts, each to present his general experience without too much detail, has attractive features, and the result is, so far as we can tell from the sections published, a summary that will help the agricultural lecturer to keep up-to-date. It has long been a reproach that the lectures on agriculture have usually lagged behind the times and have not been modified by progress made either in research institutes or by the body of workers who are studying cost accounts. In extenuation it must be recognised that the lecturer would have an almost impossible task if he tried to keep pace with the great output of agricultural literature. Summaries are therefore essential, and these two sections indicate that the German lecturer, at any rate, will be well catered for by the new 'Handbuch.'

Modern Applications of the Kinetic Theory.

Kinetic Theory of Gases : being a Text and Reference Book whose Purpose is to Combine the Classical Deductions with Recent Experimental Advances in a Convenient Form for Student and Investigator. By Prof. Leonard B. Loeb. Pp. xvi+555. (New York : McGraw-Hill Book Co., Inc. ; London : McGraw-Hill Publishing Co., Ltd., 1927.) 27*s.* 6*d.* net.

PROF. LOEB'S book is very similar in appearance to the well-known Monograph Series of the American Chemical Society ; but, although the kinetic theory of gases has always occupied a very important place in physical chemistry, the book is from first to last a 'text and reference book' of pure physics.

The author claims with justice that the kinetic theory of gases "is to-day perhaps the only field in which the mechanical picture has not been dimmed by the breakdown of our mechanical concepts" ; but it is a surprise to find how the scope of the theory has widened since the outlines of the picture were drawn by Joule, Clausius, Maxwell, and Boltzmann. New developments began in 1908, when the brilliant experiments of Perrin brought to an abrupt end the Ostwald system of energetics, which professed to reduce the atom and molecule to the position of superfluous hypotheses. The proof given by Perrin of the real existence of molecules, and of their incessant jostling with one another, has been accompanied by a second line of development, in which ions and electrons play the part of molecules and atoms. These charged particles provide new opportunities for studying the kinetic phenomena of gases by electrical methods, as in Millikan's determination of the Avogadro number from the movement of electrified oil-drops in an electrical and gravitational field. In the same way, Blackett's study of forked α-particle trails is cited, with Aston's experiments on the mass-spectrograph, as confirmatory evidence of the atomic and molecular weights deduced in the first instance by means of Avogadro's hypothesis. An account is also given of measurements of the mean free path of *electrons*, projected with a wide range of velocities through gases at very varied pressures, and of the application of these electrical methods (as alternatives to observations of gaseous viscosities) for determining molecular areas.

Another unexpected but very welcome feature of the book is an account (covering about twenty pages) of Debye's work on molecular moments. The inclusion of Debye's "beautiful explanation of the paradoxical situation, . . . where the second equation held whilst the one from which it was derived failed," is justified by the author by reason of its relation to the kinetic theory, and of the desirability of making it familiar to American students, to whom it might otherwise be inaccessible on account of language difficulties and its omission from the usual reference books ; but English readers will be equally glad to read so clear an account of a rather complex problem in optics.

The eleven chapters of the book are followed by half-a-dozen appendices. Most of these are tables giving the numerical values of various constants and functions, but there is also a very valuable summary of the methods that have been used to determine the diameters of molecules, together with the data obtained for nineteen of the simpler gases. T. M. L.

Our Bookshelf.

Annual Survey of American Chemistry. Vol. 2 : July 1, 1926, to July 1, 1927. Edited by Clarence J. West. (Published for National Research Council.) Pp. 415. (New York : The Chemical Catalog Co., Inc., 1927.) 3 dollars.

THE series of annual volumes constituting this survey was inaugurated in order that chemists in the United States of America might be given a perspective view of the advance made in their various fields of research (subject, of course, to the very limited horizon defined in the title), and in order that the importance of certain prospective researches might be adequately emphasised. The first volume, covering the fiscal year July 1925–July 1926 of the National Research Council, evidently proved acceptable, since the second volume, that for 1926–27, has undergone (together with its price) an expansion of 50 per cent.

In addition to recording achievement, many of the fifty-one contributors offer suggestions for research in various directions. The omission of an author index from vol. i. is now repaired by the provision of separate author indexes for both volumes ; in addition, a brief résumé is given of the researches actually undertaken under the plan outlined in the former issue for promoting co-operative researches between industries and universities. It is, however, somewhat surprising to learn that "the laboratory facilities for chemical studies in colleges and universities, outside of the leading institutions, are abominable and a disgrace to learning. Among the leading institutions . . . the great majority are not keeping abreast of the times." The present volume contains 44 chapters, and deals with an extensive range of subjects in pure and applied chemistry. A. A. E.

Organic Syntheses: an Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Frank C. Whitmore, Editor-in-Chief. Vol. 7. Pp. vii + 105. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1927.) 7*s.* 6*d.* net.

THIS series has attained a recognised position as a useful adjunct to research workers and others who are engaged in the practice of organic chemistry. The latest issue contains precise directions, which have been independently checked in each instance, for carrying out thirty organic preparations. Although the contributors to this volume are mainly American, the international character of the undertaking is indicated by the fact that the list of authors includes the names of Holleman (Amsterdam), Lapworth (Manchester), Reverdin (Geneva), and Ziegler (Marburg). Among interesting substances the preparation of which is described are chloroacetamide, *p*-chloromercuribenzoic acid, diphenic acid, furan, furfuralacetone, guanidine nitrate, nitroguanidine, α-methyl mannoside, pentene-2, triphenyl stibine, xanthone, and anhydrous hydrogen cyanide. In the last-named preparation mention is made of Gattermann's interesting recommendation "that the operator smoke during the preparation, for he found that a trace of hydrogen cyanide is sufficient to give the tobacco smoke a highly characteristic flavour. This preliminary warning is useful in case of leaky apparatus or a faulty hood." Most of the methods given are based on known reactions, but considerable alterations in the published conditions have often been found necessary in order to secure satisfactory yields. In the case of anhydro-2-hydroxymercuri-3-nitrobenzoic acid, here described by Whitmore, Culhane, and Neher, no method of preparation has hitherto appeared in the literature.

Venereal Disease: its Prevention, Symptoms, and Treatment. By Hugh Wansey Bayly. Third edition. Pp. xv + 242 + 3 plates. (London: Faber and Gwyer, Ltd., 1927.) 10*s.* 6*d.* net.

THE third edition of this book does not differ in general arrangement from the second. Dr. Wansey Bayly continues to emphasise the need for more drastic steps in the campaign to prevent venereal disease, particularly urging the encouragement of self-disinfection and a scheme for notification and segregation under State control. While the latter suggestion may not meet with unanimous approval, it will be generally regretted that the recommendations of the Trevethin Committee should be completely ignored. The chapters on treatment have been extended to include references to scabies, pediculosis, diathermy, and the modern methods of dealing with dementia paralytica. The quoted results of induced malaria treatment recorded at one hospital are not encouraging, but they are not representative of general experience; Dr. Bayly cautiously refrains from dogmatic statements, but indicates two extreme views on the subject. The number of illustrations in the book has been considerably increased.

(1) *The Weather: an Introduction to Climatology.* By Dr. C. E. P. Brooks. (Benn's Sixpenny Library, No. 145.) Pp. 79. (London: Ernest Benn, Ltd., 1927.) 6*d.*

(2) *Börnsteins Leitfaden der Wetterkunde.* In vierter Auflage neu bearbeitet von Walter Brückmann. Pp. vi + 284 + 22 Tafeln. (Braunschweig: Friedr. Vieweg und Sohn A.-G., 1927.) 15 gold marks.

(1) DR. BROOKS'S little book is worthy of a wide public, and is an admirable example of popular exposition of science. Readers in whom it arouses a wider interest in meteorology and climatology are guided to further sources of knowledge in English books.

(2) Those who can read German can benefit also by Börnstein's well-known treatise, which has been largely revised by W. Brückmann in the fourth edition. It covers a wide field in great detail (considering the size of the book); the forms of clouds are indicated in a set of sixteen beautiful photographic plates which form a very attractive feature of the book.

Die heimische Pflanzenwelt in ihren Beziehungen zu Landschaft, Klima und Boden. Von Prof. Dr. Felix Rawitscher. Pp. ix + 238 + 12 Tafeln. (Freiburg im Breisgau: Herder und Co. G.m.b.H., 1927.) 6·80 gold marks.

THIS small book deals in a most interesting manner with the plant life of central Europe, and gives an extremely good idea of the modern tendencies of geographical botany. The environmental factors are concisely analysed, and their effects on the vegetation and flora are adequately illustrated by specific examples. The vegetation is described under the three main headings: forest, forest-free areas, and waters (fresh and sea). The geological history of the flora is summarised with special reference to the Glacial and post-Glacial periods. Eleven plates, of 21 excellently selected photographs, accompany the text, which is further illustrated by 64 black-and-white figures. These last include many outline distributional maps of very clear design. References to literature are given at the ends of the chapters and as foot-notes, and an index is provided. The work has a wider scope and a more general interest than is indicated by its title. W. B. T.

The Light of Experience: a Review of some Men and Events in my Time. By Sir Francis Younghusband. Pp. x + 305. (London: Constable and Co., Ltd., 1927.) 15*s.* net.

SIR FRANCIS YOUNGHUSBAND'S latest book begins with a short sketch of his life, and ends with a philosophical judgment on his experiences. The book, in fact, is partly an autobiography and partly a philosophical treatise. A man's philosophy is generally founded on his personal experiences, but it is not often that the two are set down together. If the practice were more common, we might obtain some interesting glimpses of the origins of various philosophies.

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.*]

The Absorption Spectrum of Vitamin A.

THE study of the oil-soluble vitamins has supplied overwhelming proof that both provitamin D and the antirachitic vitamin itself exhibit photochemical properties. As regards the action of light on vitamin A, the balance of opinion has, we believe, hitherto been in favour of an indirect oxidation process rather than a purely photochemical mechanism. Although the evidence for the former has been somewhat ill-founded, its adoption has led to the neglect of the latter view, which we are now able definitely to prove is the correct one.

As photochemical changes imply absorption, and presumably selective absorption, of light, we adopted some time ago the following working hypotheses:

(*a*) that provitamin D should exhibit selective absorption in the ultra-violet, and

(*b*) that vitamin A should exhibit selective absorption in the visible or near ultra-violet, since it has been demonstrated by many workers (for example, Peacock, *Lancet*, ii., 328; 1926) that this vitamin is destroyed either by sunlight or the light from an incandescent lamp.

The first hypothesis was confirmed by a spectrographic study of cholesterol from cod-liver oil, when three absorption bands at 293·5 $\mu\mu$, 281·5 $\mu\mu$, and 270 $\mu\mu$ were observed and shown to be criteria of provitamin D. This discovery paved the way to the recognition of ergosterol as the photochemical precursor of vitamin D.

As regards the second hypothesis, work on this has in the past been hindered by the difficulty of obtaining really rich sources of vitamin A. Since cod-liver oil is the best known source of this vitamin, it is clear that we should start from this material. The absorption spectrum of cod-liver oil had previously been examined by Schlutz and Morse (*Amer. J. Dis. Child.*, **30**, 199; 1925) and Schlutz and Ziegler (*J. Biol. Chem.*, **69**, 415; 1926), who found two absorption bands at about 328 $\mu\mu$ and 279 $\mu\mu$ in thin films of the oil. Heilbron, Kamm, and Morton (*Biochem. J.*, **21**, 78, 1279; 1927) also observed marked inflections in the regions 320 $\mu\mu$ and 270-290 $\mu\mu$, whilst Woodrow (*Phil. Mag.*, 943; 1928) has recently recorded both the band in the neighbourhood of 320 $\mu\mu$ and the fine structure associated with ergosterol. From these observations it is clearly reasonable to test the hypothesis that the 328 $\mu\mu$ band is connected with vitamin A, since no other constituent of cod-liver oil is known to show a band in this region of the spectrum.

A large and varied assortment of fish liver oils and vitamin A concentrates has now been collected and a detailed spectrographic examination made of the samples. The outstanding result of this work has been the recording of a prominent absorption band at 328·5 $\mu\mu$, the intensity of which, moreover, runs closely parallel with the vitamin A potencies of the various oils as measured by the well-known antimony trichloride colour test. Irradiation results in the disappearance of the chromogenic substance. Biological experiments have proved that aeration or oxidation also causes the destruction of the vitamin, and we have now found that the spectrographic tests indicate the same result.

In order to define the active wave-lengths more closely, a rich vitamin A containing oil was irradiated for forty-eight hours in a small silvered quartz test-tube. The advantage of the silvering lies in the fact that the thin film of metal transmits only a narrow band of the spectrum, the absorption of the oil being almost exactly the same as the transmission of the filter. Not only was the vitamin potency as determined by the colour test reduced to very small dimensions, but the selective absorption almost wholly disappeared.

It seems likely, from evidence which will be communicated in full elsewhere, that the first decomposition products of vitamin A include a substance possessing an absorption band in the region 275-285 $\mu\mu$.

Examination of 'non-saponifiable' extracts prepared in Prof. Drummond's laboratories indicates, as shown in the following table, that not only is the 328 $\mu\mu$ band present, but also that the dilution used is in good agreement with the high concentration of the vitamin present.

Material.	Prof. Drummond's Estimates ($SbCl_3$ Test).	Values from the 328 $\mu\mu$ Band.
Cod liver 1 . . .	1	1
Cod liver 2 . . .	2	1·6
Cod liver 3 . . .	3	3·2
Cod-liver oil extract *	500	200-300
Sheep-liver fat extract *	775	800-1000

* Non-saponifiable material from which all sterols have been removed by crystallisation and precipitation with digitonin.

The adoption of the 328 $\mu\mu$ band as a criterion of vitamin A will, we hope, assist in the elucidation of the chemical nature of the substance. Whilst the test may not always be as delicate as the antimony trichloride reaction, it is less empirical and in all probability more trustworthy.

R. A. MORTON.
I. M. HEILBRON.

The University, Liverpool.

Earthquake Warnings.

IN continuation of my letters to NATURE on earthquake warnings in 1923 (vol. 112, p. 538) and 1927 (vol. 120, p. 619), I should like to direct attention to an important paper by Prof. Ishimoto (*Bull. Earthquake Research Inst.*, vol. 4, pp. 203-222). Most of it is in the Japanese language and character, but there is a brief abstract in French on pp. 203-206, and the figures, plates, and tables are easily understood. These show the tilting of the ground preceding earthquakes in the Tango (Tahano) peninsula on the north coast of Japan, indicated by the 'tiltometer' (or 'klinograph') set up at Miyadu (Miyasu), 35° 27′ N. and 135° 13′ E.). The observations were carried out immediately after the great Tango earthquake of Mar. 7, 1927, and graphs are given showing the tilting during two periods from Mar. 15 to April 1, and from April 22 to Sept. 10 in the same year.

During this time there were nine earthquakes which were recorded either at Miyadu, or at Toyooka, 32 km. to the west, and had an intensity not below that indicated by II. on the Japanese scale (IV. on the Mercalli scale). All except two were immediately preceded by a marked tilting of the instrument, superposed on the minor diurnal tilts, due mainly to variations of temperature. The amount of the tilts preceding earthquakes varied from 6·5 to 19·8, and 26·2 seconds of arc, but the last took place in three stages

interrupted by contrary movements. The two exceptions were only three hours apart; one was not observed at Miyadu and the other had there an intensity of only I. on the Japanese scale, but even these were preceded by a feeble tilt. On the other hand, two earthquakes which had an intensity of only I. on the same scale were anticipated by tilts of 8·4 and 6·5 seconds of arc respectively. The diurnal tilts were usually about 2·5 seconds of arc.

The interval between the commencement of the tilt and the earthquake varied from six to thirteen days, except in one of the earthquakes with intensity I., in which it was only four days. At Kawabe, 10 kilometres to the north-west, the tilting was much feebler.

It is gratifying to find that the seemingly rash suggestion I made nearly five years ago has been so remarkably fulfilled. It is true that the results obtained by Ishimoto relate only to minor earthquakes; but the considerable change of level on the coast at Mitu and Sunakata, 5 km. and 8 km. east of the Gomura fault, two and a half hours before the Tango earthquake, indicate that on that occasion there must have been much greater tilting, and it no doubt had begun long before it was observed.

There is evidently much work to be done in ascertaining the relations between the secular movements that are always in progress, the intensity and direction of the anticipatory tilts, and the intensity and character of the earthquakes, as well as the changes of the topography that accompany them; but it has been abundantly shown that we have now at our disposal a means of saving the inhabitants of countries subject to earthquakes from the probability of bodily injury and loss of life, and even of giving them time to diminish to some extent material damages as well.

JOHN W. EVANS.

Athenæum Club, S.W.1,
June 21.

Reproductive Rhythm in Birds.

IN the issues of NATURE for April 4, 1925, and Mar. 5, 1927, were given brief accounts of the effects of subjecting juncos (*Junco hyemalis*) during the autumn to artificially increasing days in place of the normally decreasing days of that time of year. It was shown that in spite of extremely low temperatures, recrudescence of the gonads could thus be induced in mid-winter. Ordinary electric light bulbs were used as the source of illumination. This indicated that the changes could probably not be attributed to radiation. During the past winter, through a renewed grant from the Royal Society, it was possible to repeat these experiments and to introduce variations. A full account of these is shortly going to press. Considered together, they suggested that the development of the gonads was due directly to increasing activity made possible through daily extension of the waking hours.

To test this a cage was designed in which the birds could be compelled to keep moving, with only sufficient light to enable them to find the perches and prevent accidents. The cage consisted of a box 3 ft. by 2 ft. by 1 ft., with a wire front, a single perch running from end to end (Fig. 1, *A*), and food and water tins (*B*) on a level with the perch. At each end of the cage immediately above the perch and on the floor was a slit in the walls too small to permit the escape of the inmates. Outside the cage, at each end, and the width of the cage apart, were two large pulley wheels. Over them ran endless belts, passing through the cage, one at the front, the other at the back, and connected together at one point by a transverse wooden bar (*C*). The pair of wheels at one end was driven by an electric motor, the gearing being such that the bar took 40 seconds to complete a circuit, sweeping the perch and food troughs on the outward trip and the floor on the return. After the birds were deemed to

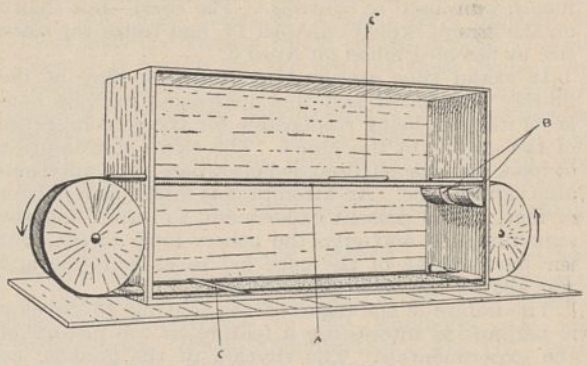

FIG. 1.—Experimental cage.

have got accustomed to the device, a second transverse bar was attached at the opposite point on the belt (*C'*). Wherever the birds might happen to be, they thus had to get out of the way of the advancing bar every 20 seconds. Nor could they go to roost on it, since it went out through the slit at the end at every turn. As they soon developed a system of merely hopping over it, the exercise could scarcely be described as strenuous.

Controls were kept in the same room and in a cage of similar dimensions, the two-candle-power bulb suspended from the ceiling bearing the same relation to each. No direct light entered either cage. As the movement of the machinery and the birds in the experimental cage tended to keep the controls awake, the latter's cage was covered with a thin sheet of translucent silk while the motor was running. The only window in the room was shuttered nightly at six and the motor started, continuing for 7½ minutes the first night, 15 the next, and so on until going for four hours. Beyond this the time was not increased. The shutter was removed again at 9 A.M. the next day. Controls and experimentals thus had daylight for nine hours, the equivalent of a mid-November day. But while the controls could go to sleep at dark, or at least sit motionless, the experimentals were forced nightly to increasing periods of activity.

The experiment commenced on Mar. 17 and terminated on April 28. Only nine birds were available. They came in from the aviaries, and their gonads were already in the first stages of spring development, measuring about 1 mm. in length as against 0·5 mm.

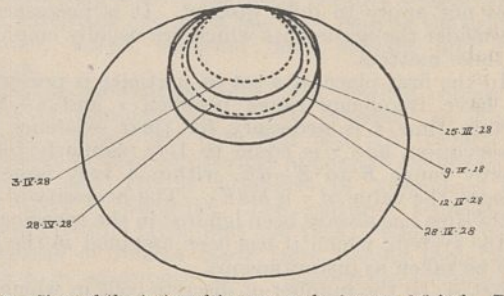

FIG. 2.—Sizes of the testes of juncos: scale, 1 mm. = 0·5 inch. Dates on the left refer to controls; those on the right to experimental birds.

of the minimal winter condition. In Fig. 2 the results of the experiment are shown diagrammatically, each ellipse representing the average measurements of the two testes of single birds killed on the days indicated,

controls by broken lines, experimentals by solid. The testes of the control killed on the last day (April 28) were somewhat flattened in extraction and the size shown is consequently too large. Three birds, all males, were used as controls.[1] The third—not shown on the figure—killed on April 11, had testes the same size as the bird killed on April 3.

It would thus appear that radiation may be definitely eliminated and that increasing exercise suggests itself as being responsible for the recrudescence of the organs in the junco. The extra consumption of food, for reasons discussed elsewhere, is of questionable significance. An attempt was made, as a matter of fact, in the present experiment, to ration half the experimentals and give the others food *ad lib.*, but the partitioning of the cage led to catastrophe and was abandoned after three weeks.

The failure of the testes of the controls to develop is perhaps as interesting a feature as the history of the experimentals. The rhythm of the gonads, no doubt countless centuries old, is evidently not inherited in the junco, and yet it has apparently become inherent in other species such as the trans-equatorial migrants.

WM. ROWAN.

University of Alberta,
Edmonton, Canada.

[1] While the small number of controls is admittedly unsatisfactory, the failure of the gonads to develop may be considered conclusive in the light of other experiments, *e.g.* one in which the gonads, after having been brought almost to breeding condition in early January, were reduced again, by light reduction, to the winter condition in March. Thirty birds were involved in this experiment, and reaction was uniform.

Statistical Methods in Quantum Theory.

IN the application of statistical methods in the quantum theory of the ideal gas (Fermi), electron gas (Sommerfeld), and light quantum gas (Bose), a duality of treatment has been introduced. The essential difference between the two methods of determining the number of micro-canonical states of the system is that in one case (Fermi-Dirac statistics) the Pauli 'verbot' is fundamental, while in the other (Bose-Einstein statistics) this restriction is assumed invalid. There can be no doubt that the application of the Fermi-Dirac statistics has resulted in a great advance in the solution of all atomic statistical problems, while the only experimental result which appears to support the Bose-Einstein statistics is Planck's radiation formula.

It is a matter of direct logical deduction that the existence of individual particles in a system implies Pauli's principle that no two particles can have the same 'co-ordinate' or quantum number description. It is impossible, then, to understand why Pauli's principle should be applicable to molecules, atoms, protons, and electrons, but not to light quanta, and in fact it is not necessary to assume that the principle does not apply to light quanta. It is necessary to reconsider the arguments which are usually employed in these matters.

In the first place, if a set of particles is prescribed to have frequency range between ν and $\nu+d\nu$, a certain time τ is necessary for their existence and observation, and τ is equal to $1/d\nu$ (similarly for an energy range E to $E+dE$, within a very large enclosure, the value of τ is h/dE). The necessity of this finite time has always been ignored in the specification of the system, which it has been assumed in the past can be taken as instantaneous.

Let A_s be the number of discrete cells in which the N_s particles of energy between E_s and E_s+dE are distributed. A_s is calculated in the usual way by the formula

$$\frac{1}{h^3}\int dx\,dy\,dz\,dp_x\,dp_y\,dp_z$$

over all possible values of the co-ordinates subject to the above-mentioned restriction on the energy. Following the argument used by Fermi, the most probable distribution which satisfies the Pauli 'verbot' is given by

$$N_s=\frac{A_s}{e^{\alpha+\beta E}+1}.$$

In an experiment to examine the distribution of energy among the particles, a stream of particles in a narrow beam must be allowed to pass out of the box containing the gas for a time T, say, and we must take into account, in the outward flow of the particles, the fact that the time T is divided into $\mu=\frac{T}{\tau}$ cells. Now μ, the number of time cells, is large, so that, considering the A_s places of energy E_s, we can have any number of quanta 0, 1, 2, 3 . . . etc., in one cell if regard is not paid to the time, and thus the Bose-Einstein statistics follows. But nevertheless, there will not be more than one quantum in the same cell if regard is paid to the time, and this corresponds to the physical facts. It is clear that we have now

$$N_s=\frac{A_s}{e^{\alpha+\beta E}-1}$$

for the distribution actually observed.

In the absence of fields of force, α is proportional to the rest mass of the particles, so for light quantum gas this reduces to Planck's radiation law.

In general, for any particles (all of the same kind) in statistical equilibrium, the Fermi-Dirac result will be observed if the particles are counted as individuals, but for any method in which the energy is determined by integration over a finite time, the Fermi-Dirac formula will not apply unless the time is equal to τ. Instead, a distribution law of the same form as Planck's law will be observed. It must be remembered, of course, that the difference between the Fermi, Maxwell, and Bose-Einstein distribution laws will only be detectable experimentally in the case of particles of small energy.

We cannot give, in the scope of a letter, full details of the consequences of the consideration of the time in statistics. We shall only mention that the 'continuity of path' theorem has to be reconsidered. We shall present an account elsewhere in the near future.

R. J. CLARK.
W. H. WATSON.

Physical Laboratory,
The University, Edinburgh.

The Negative Absorption of Radiation.

IN Einstein's celebrated derivation of the Planck radiation formula, an equilibrium is considered to exist between three elementary processes: (1) a spontaneous emission from the atoms, (2) an absorption of energy by the atoms proportional to the energy density in the field, and (3) an induced emission of energy from the atoms, also proportional to the energy density. The third process can be described as a negative absorption of radiation, and is quite characteristic for Einstein's theory, as the omission of it from the equations leads to Wien's radiation formula instead of to Planck's. The negative absorption of radiation also figures prominently in the Kramers-Heisenberg theory of dispersion. The physical existence of such absorption has been up to now an article

of faith rather than a proved experimental fact, and indeed some writers (Ornstein and Burger, S. N. Bose) have been tempted to question its reality.

A definite experimental proof is now forthcoming of the reality of negative absorption. We have discovered (NATURE, April 21, 1928, p. 619) that when a liquid, for example, benzene, is irradiated by monochromatic light, the radiation scattered by the molecules contains several spectral lines of modified frequencies. Careful measurements have shown that the difference between the incident and scattered frequencies is exactly equal to an infra-red frequency of the molecule, so that the process of modified scattering involves the absorption of radiation by the molecule. As the molecule has several characteristic infra-red frequencies, we have an equal number of modified scattered lines. This is seen in the photograph reproduced in Fig. 1, which is from a

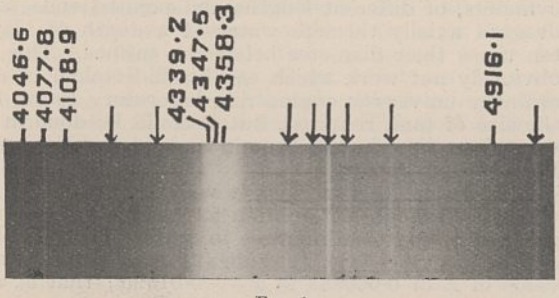

FIG. 1.

spectrogram of the scattering by liquid benzene, of the light of the mercury arc from which practically everything except the 4358 A. group of lines had been filtered out. In the spectrogram, the wave-lengths in the incident radiation are marked in A., and the modified scattered lines are indicated by arrowheads. (It may be mentioned in passing that the benzene had not been completely purified, hence a marked continuous spectrum is also present in the modified scattering.) The brightest modified lines are of longer wave-length than 4358 A., and their frequencies are determined by the infra-red absorption lines at 16·55 μ, 11·78 μ, 10·10 μ, 8·51 μ, 6·27 μ, and 3·267 μ. (These wave-lengths can be determined more accurately in this way than with an infra-red spectrometer.)

An inspection of the actual spectrogram, however, shows two modified lines of shorter wave-length than the exciting 4358·3 line, and the measurements show that their frequencies *exceed* that of the latter by the infra-red frequencies of the molecule, namely, those corresponding to 16·55 μ and 10·10 μ respectively. The presence of these lines proves simultaneously the existence in the liquid of molecules at levels of energy correspondingly higher than the normal, and the fact that the incident radiation induces a return to a lower state of energy ; in other words, that there is a negative absorption of the radiation. The feebleness of the modified line of enhanced frequency, in relation to the modified line of degraded frequency, is consistent with the supposition that the transitions in either direction are equally probable, if we take into account the fact that the proportion of molecules in the liquid in a higher level of energy than the normal is small at the ordinary temperatures.

C. V. RAMAN.
K. S. KRISHNAN.

210 Bowbazar Street,
Calcutta,
May 15.

The Connexion between Dry-rot of Swedes in New Zealand and British Seed.

A RECENT paper by Cunningham ("Dry-rot of Swedes and Turnips : Its Cause and Control," Bull. No. 133, N.Z. Dept. of Agric., 1927) appears to show that the fungus which causes dry-rot (*Phoma lingam*) is carried by the seed of these crops. An examination of some of Cunningham's cultures, purporting to represent various strains of *Phoma lingam*, shows, however, that all his conclusions are not valid. These cultures were received through the good offices of Dr. Pethybridge, and were said to be transfers from cultures received direct from Cunningham.

Critical study of these 'strains' during the last month has yielded very surprising results, for several of them show no Phoma-stage at all, but produce spore-forms referable to the Moniliales and the Ascomycetes. Thus, Cunningham's 473 (IA) contains a fungus which, as judged by its conidia and conidiophores, is a species of *Macrosporium*. It differs obviously from the typical *Alternaria*, which, as Cunningham mentions, is an exceedingly common inhabitant of swede seed-coats. In addition to the Macrosporium conidia, this fungus produces very freely sterile enclosed fruit bodies, which an examination of the same fungus isolated from Irish sources has shown to be perithecia and not pycnidia.

The fungus (473—IA), as studied in comparative culture in repeated experiments on six different media, is identical in growth and colour reactions (including saltation), in its conidia and conidiophores, and in its other fruiting bodies, with a fungus isolated a number of times from swede seed in Ireland. The latter fungus produces (in addition to the conidia of a *Macrosporium*) numerous enclosed fruit bodies, which were found in a few cases to contain asci and muriform ascospores, of the type of *Pleospora*. Although hundreds have been examined, none has been found to function as a pycnidium. It has been grown from a single conidium, a single ascospore, and a single ascus, and the results in all cases are identical ; in particular, the conidia and the fruit bodies have developed in each culture. Incidentally, it has been proved to be parasitic on swedes.

Similarly, Cunningham's 473 (IA) has been isolated from a single conidium in a number of cases, and on critical examination all the resulting cultures have proved to be identical with the original, both in their conidia and fruit bodies. Ascopores have not yet been found in 473 (IA), but we believe they will undoubtedly crop up there. This result appeared so surprising that it has been verified several times, and particular attention has been paid to the original culture, which contains both conidia and fruit bodies.

Similar conclusions have been reached concerning some of Cunningham's other 'strains' of *Phoma lingam*. While 503 (IA) and 533 (IA) (which are regarded as aberrant forms) appear to be species of *Phoma*, 488 (IB) is a species of *Alternaria*, and 505 (IB) is doubtful. The cultures representing Group II, 491B (IIA) and 596 (IIA), resemble closely isolations of *Phoma* made from rotting roots here. This is in agreement with Cunningham's conclusion that this group is chiefly responsible for dry-rot in New Zealand.

The net result of all this is that two of the five fungi sent by Cunningham to represent his Group I have been found to be species of *Macrosporium* and *Alternaria*, respectively ; one is doubtful ; and two are apparently species of *Phoma*. It is impossible to discuss here the question whether a Phoma-stage

ever occurs in *Macrosporium* or *Alternaria*, or the possibility that these latter stages have cropped up here in cultures which showed the Phoma-stage in New Zealand. It is safe to say, however, that *Phoma lingam* can have no other conidial stage unknown to all those who have worked on it, and that, therefore, the fungi in question have no connexion with this parasite.

The results now announced are particularly important to the British seed trade, which supplies swede seed to New Zealand. Their full import lies in the fact that, so far as one can gather from Cunningham's paper (p. 25), the parasite which is characteristic of English seed belongs to his group IA, and is apparently represented by his 473 (IA). Now this fungus is almost certainly not a *Phoma*, and without any qualification is not *Phoma lingam*. It is also, according to Cunningham, only weakly parasitic; and putting all the evidence together, it is obvious that it can have no possible connexion with the common dry-rot caused by *Phoma lingam*. Our own limited experience confirms the last two points; for a fungus identical with 473 (IA) is not uncommon on seed of Irish and English origin, while no true *Phoma* has been found on the 3500 seeds so far examined, which were drawn from seven different samples. It would be premature to suggest that *Phoma* never occurs there, but it appears to us likely that further study of the hibernation of this parasite, otherwise than on the seed, would be profitable.

I wish to acknowledge the great help received from the Imperial Bureau of Mycology in looking up the rather inaccessible literature of this subject.

PAUL A. MURPHY.

Albert Agricultural College,
Glasnevin, Dublin, June 12.

The Resistance of Pipes of 'Negative' Diameters.

IT is well known, from the results obtained by Stanton and Pannell, that the resistance, R, in dynes per square centimetre at the surface of a pipe of diameter d, carrying *any* fluid of density ρ, and viscosity μ, at a mean velocity v, is given by $R/\rho v^2 = f(\rho vd/\mu) \equiv L$, say. Prof. Lees has given a well-known formula for L, namely, $L = 0{\cdot}0763(\mu/\rho vd)^{0{\cdot}35} + 0{\cdot}0009$, and this function is accordingly sometimes known as Lees' function.

Considering this function recently for large values of $\rho vd/\mu$, which of course may be obtained when d only is large, it seemed evident that there could be no discontinuity in $R/\rho v^2$ when the curvature of the surface—which is $2/d$—passed through zero and became negative; that is, when the fluid changed from being on the concave side of the surface to being on the convex side.

Now $(\mu/\rho vd)^{0{\cdot}35}$ has no relevant analytic value for negative values of $\mu/\rho vd$; but it is quite different if the index, which was only empirically determined, was not 0·35 but exactly one-third. This led to the idea that probably the correct way of expressing L is as a rational function of $(\mu/\rho vd)^{\frac{1}{3}}$; and that the function found in this manner would be true for negative values of $\mu/\rho vd$ as well as for positive values.

Carefully measuring the ordinates of the middle of the band on Stanton and Pannell's well-known diagram, I found that the following simple equations represented the results with remarkable accuracy:

$$L = 0{\cdot}000635 + 0{\cdot}0725x \quad . \quad . \quad . \quad (1)$$

where $x \equiv (\mu/\rho vd)^{\frac{1}{3}}$, from $x = 0{\cdot}023$ to $x = 0{\cdot}052$; that is, from $\rho vd/\mu = 82{,}000$ to 7000 about; and

$$L = 0{\cdot}000635 + 0{\cdot}0725x + (0{\cdot}023 - x)^2 \quad . \quad (2)$$

from $x = 0{\cdot}023$ to $x = 0{\cdot}012$; that is, from $\rho vd/\mu =$ 82,000 to 600,000.

For values of $\rho vd/\mu$ less than 7000, formula (1) begins to deviate owing to approaching the critical velocity. For viscous flow we have $L = 8x^3$ exactly.

Formulæ (1) and (2) agreed with the readings to within only slightly more than 0·00001, whereas the errors of Prof. Lees' formula varied systematically from 0·00006 positive, at $\rho vd/\mu = 160{,}000$, to 0·00006 negative, at $\rho vd/\mu = 10{,}000$. These divergences are of course small enough to be negligible for ordinary purposes. Formulæ (1) and (2) are much easier to use in practice than Prof. Lees' formula, as the cube root of $\mu/\rho vd$ can very readily be found on *any* slide rule, while the 0·35 power cannot.

The reason for putting forth new formulæ for L is not that a better fit is obtained, but because I believe L will pass through $x = 0$ into negative values of x without any discontinuity in either magnitude or slope; and I want to appeal for the experimental determination of L for negative values of x. This will entail finding the resistance to motion when long cylinders, of different lengths and pointed ends, are dragged axially through water at a depth of (say) ten times their diameter below the surface. This is obviously not work which can be undertaken in an ordinary university engineering laboratory owing to the size of tank required, but it could be done in a very short time in the Froude tank at the National Physical Laboratory.

It is almost certain that it will be found that L will pass through a minimum for a certain negative value of x, and then increase to a large value (probably ∞) as $x \to -\infty$. Formula (2) gives a minimum value of L of 0·000988 at $x = -0{\cdot}01325$; that is, at $\rho vd/\mu = -429{,}000$. In water at 50° F., at a speed of 10 ft./sec., this would give the diameter as just over seven inches.

The values of L, for what I have called negative values of $\rho vd/\mu$, may, for all I know, have been determined: if so, I should be grateful to have my attention directed to them. If not, I hope they will be determined owing to their scientific interest and the intimate connexion which exists between L and the transfer of heat from the surface to the fluid.

ALBERT EAGLE.

The University, Manchester.

X-radiation from Gases.

IN the years 1924–25 attempts were made by me at the Norman Bridge Laboratory of Physics, Pasadena, California, to get X-rays from gases by means of hot sparks, but without positive results (*Proc. Nat. Acad.*, **11**, 413; 1925). Since then I have been investigating some different methods of solving this problem. The method first used was the following:

A crucible with a 1 mm. hole at the top and containing a small piece of metallic sodium was placed in a vacuum and bombarded from above with an electron stream concentrated towards the hole in the crucible—that is, the top of the crucible corresponded to the target in an ordinary X-ray tube. In this way the crucible was heated; the sodium evaporated; and the vapour escaped through the hole and was hit by the electrons. The X-rays radiated from the vapour were revealed in the following way. Beside the crucible I fixed a screen of brass with a small hole covered with thin aluminium foil. On the other side of the screen I put a photographic plate, and in this way I obtained a picture of the crucible and of the space above it as through a pinhole camera. Exposures were taken when the crucible contained sodium as well as when it was empty. On the part of the plate corresponding to the vapour-beam, I

obtained an apparent blackening in the first case, which did not appear when the crucible was empty. This first experiment showed definitely that it is possible to get X-rays from a gas.

Later, I started to work with sulphur instead of sodium, and then I placed the crucible in front of the slit of a vacuum spectrograph in order to get a spectrum of the X-radiation. Using a gypsum crystal as a grating, and a strong electron current (about 60 milliamperes), I obtained a very weak line on the part of the plate corresponding to the $K\alpha$-line for sulphur. So far as I know, this is the first time an X-ray spectrum has been obtained with a gas as radiator. In order to be able to control the conditions better, I rearranged the apparatus. A small electric heater was fixed round the upper part of the crucible, and in this way the beam of vapour could be regulated independently of the electron current. The latter one was coming from the side at right angles to the stream of vapour. Using an electron current of 90 ma., a tension of about 6000 volts, and a slit 0·6 mm. wide, I obtained 5 lines on the plate after 2 hours exposure. The strongest two correspond to the $k\alpha$ and $k\beta$ lines. The three others, which are the most interesting, are so weak, though, that it is impossible to determine their wave-lengths. The work is being continued, and by some improvements of the apparatus I hope very soon to be able to increase the intensity so that the weaker lines as well will be measureable.

ALBERT BJÖRKESON.

Physical Institute,
University of Upsala, June 8.

Animal Diseases in Elizabethan Times.

WHILE looking up certain references for a paper now in course of preparation, I recently came upon some interesting data in Prof. E. A. Lewis's "The Welsh Port Books" (London, 1927), with regard to live-stock epizoöties in Ireland in the time of Queen Elizabeth.

As is to be expected, the Welsh Port Books record numerous importations of animals and animal produce from Ireland—plough-horses, cattle, wool, hides, etc., and of course considerable quantities of fish. But the most interesting items are those relating to the import of "murrain sheep skins." Totalling up these items for the period Michaelmas 1593 to Michaelmas 1594 (Port Book K.R. 1299/5), we find that no less than 15,100 "morkins" or "murren sheepskins" were imported from Ireland to the port of Milford. Again, we have a single cargo containing "2000 morkins being murren sheep skins"—that of the *Rioll Defence* of Milford, trading to that port from Ireland in May 1599. In March 1601 there were imported from Waterford to Milford 300 murrain sheep skins, and in July 1602, from Wexford to Milford, "100 murrain sheep skins and 250 murrain lambfell and kidfell." Altogether, therefore, during the ten years 1593–1602 there are records of the import of 17,750 "murrain skins" from Ireland.

The term 'murrain' has always covered a variety of epizoöties, including probably anthrax, foot-and-mouth disease, etc., and if in the present instance it includes cases of microbic diseases, the above figures throw an interesting light on possible means of dissemination. But from the heavy incidence on sheep, and the absence of any reference to diseased cattle or other livestock, one may perhaps suggest that *Fasciola hepatica*, the sheep liver-fluke, was the main source of the damage. This parasite would of course always tend to flourish in such a wet country as Ireland, and especially in such a marshy and undrained Ireland as that of the sixteenth century. One of the earliest epidemics mentioned in history is that which appeared in Holland in 1552, and which Gemma called "lues infanda pecoris."

The matter is being investigated further, as it would seem to be of some importance in the history of animal diseases in Great Britain.

COLIN MATHESON.

Department of Zoology,
National Museum of Wales,
Cardiff, June 16.

Square Roots and the Decimal System.

IN NATURE of June 9, a correspondent, A. R., gives a method of James Thomson's for obtaining a series of convergents to a square root in the form of vulgar fractions.

A much more rapidly convergent set of values can be found by making use of the principle that if n is an approximation to the value of $\sqrt{N}$, then the expression

$$\tfrac{1}{2}\left(n+\frac{N}{n}\right)$$

is a much closer approximation. Thus we should find

$$\sqrt{6}=\tfrac{1}{2}(2+\tfrac{6}{2})=\tfrac{5}{2}\text{ approx.}$$
$$=\tfrac{1}{2}(\tfrac{5}{2}+\tfrac{6}{5}\,.\,6)=\tfrac{49}{20}\text{ approx.}$$
$$=\tfrac{1}{2}(\tfrac{49}{20}+\tfrac{20}{49}\,.\,6)=\tfrac{4801}{1960}\text{ approx.}$$

We thus get the series of convergents

$$2,\ \tfrac{5}{2},\ \tfrac{49}{20},\ \tfrac{4801}{1960},\ \ldots$$

as compared to the series

$$2,\ \tfrac{5}{2},\ \tfrac{22}{9},\ \tfrac{49}{20},\ \tfrac{218}{89},\ \tfrac{485}{198}\ \ldots$$

given by A. R.

The error in the value $\frac{4801}{1960}$ is less than *1 part in 18 million*, and this is obtained direct from the mere slide rule approximation of $\frac{49}{20}$ or 2·45. I have in practice found this to be much the most convenient way of finding a square root when the accuracy given by a slide rule is insufficient.

For cube roots the form

$$\tfrac{1}{3}\left(2n+\frac{N}{n^2}\right)$$

can be used in a similar manner.

From its simplicity one would have imagined that this method would have occurred to everybody who had often to extract roots, but except in Egypt (where I taught it myself) I have never met anybody who made use of it.

C. E. WOLFF.

The Gables, Hall Lane,
Mobberley, Cheshire,
June 10.

Can Crocodiles swallow their Food under Water?

RECENTLY I was touring the east coast of Lake Albert. At sunset one evening I saw a crocodile of medium size about 100 yards from the shore, very quietly and stealthily making its way toward the sandy beach. Having a telescope, I watched attentively, but to my surprise, when it grounded about 100 yards from me, it did not crawl out. It opened its mouth, disclosing a fish which I judged would weigh some 5 or 6 pounds, and proceeded to give it several vigorous bites before swallowing it head-first. This observation seems to suggest that the crocodile could not swallow the fish when submerged, else why did it take the trouble to swim to the shore with it?

G. D. HALE CARPENTER.

Entebbe, Uganda,
May 14.

Carriers of Electricity in the Atmosphere.[1]

By Prof. A. M. TYNDALL.

THE nature of ions in air has been a subject of study for more than thirty years, but our information is still incomplete and a variety of phenomena still require elucidation. A certain amount of information on the nature of ions in the lower atmosphere may be gained from a study of their motion in an electric field. Except in special cases which rarely arise at ordinary pressures, the motion of an air ion through the air is analogous to the motion of a sphere falling through a viscous liquid. This motion is one of uniform velocity the value of which depends upon the radius of the sphere, the force acting upon it, and the viscosity of the liquid. For a given force and medium, the larger the sphere the slower it moves. This may readily be demonstrated in a syrupy liquid by dropping into it two balls, one of lead and the other of aluminium, their relative sizes having been selected so that they have equal weights in the liquid.

Similarly, ions in air possessing the same electric charge but having different sizes, will move in an electric field at different rates, the larger one travelling slower. There are theoretical grounds for supposing that this factor of size, though not the only one, is of great importance in determining the motion of the ion.

Some interesting effects may be obtained by adding small quantities of an organic vapour to the air. Let us take, for example, the series of normal alcohols of chemical composition $CH_3(CH_2)_nOH$, where n may be zero or an integer. The molecules of these substances are known to be rod-like in shape, the length of the rod increasing with increase in the carbon content, *i.e.* with the value of n. They are also known to be polar, a property presumably mainly due to the OH group made up of a positive hydrogen nucleus and a negative atom of oxygen. For the purposes of a rough static model, these molecules may therefore be thought of as having an active head and a more or less inert tail, and they will be attracted to a negative ion with their heads inwards towards the ion and their tails spread out radially. The effective size of the ion will thereby be increased by an amount which depends on the length of the molecules of the particular alcohol added.

Experiments by L. R. Phillips and myself have shown that for a given vapour pressure of alcohol the reduction in mobility of an ion increases rapidly with increase in length of alcohol chain. Thus the highest alcohol (amyl) used in this work, though present as only 1 part in 300 of air, reduced the mobility of the ordinary negative air ion to about 40 per cent of its normal value. The effect on positive ions is nothing like so marked, though it is observable. This may be attributed to a weaker bond between the dipole and a positive ion, because the positive end of the dipole cannot approach it so closely.

By adding water vapour as well as alcohol vapour to the air, there is now a competition for places at the ion surface, so that short water molecules replace some of the longer alcohol molecules. We should on this view expect a rise in mobility of the ion, and this is observed.

If the molecules are made non-polar by removing the OH group and making them symmetrical in structure, the tendency to cluster on the ion should be almost entirely removed. This has also been confirmed by experiment, since it has been found that the hydrocarbon, decane, with ten carbon atoms and therefore roughly twice the length of the amyl alcohol molecule, has practically no effect on the motion of the ion in air.

New methods for measuring mobility have been devised with the special purpose of deciding whether all the ions move with the same speed. Considerable resolving power has been achieved. The negative ions appear to be of a single kind in air containing appreciable quantities of vapour. The positive ions over the same range and the negative ions in the presence of small traces of vapour appear to be complex. Certain features present themselves which are still the subject of investigation.

A lecture demonstration of the loading effect of alcohol may be conveniently made by applying a small voltage to an ionisation chamber so that the ionisation current is well below saturation. By blowing alcohol vapour into the chamber the current is reduced to about a half, due to the reduction in mobility of the ions conveying it. The ionisation current may be amplified by a valve method so that it is recorded on a galvanometer.

In the ordinary atmosphere, complicating factors are introduced by the presence of particles of dust, smoke, mist, and other nuclei. A number of small ions will attach themselves to these and will then move so slowly that their contribution to an ionisation current is practically negligible. In the demonstration referred to above, this may be readily shown by blowing tobacco smoke into the chamber, when the ionisation current to all intents ceases. In addition to the production of large ions by the union of small ions with nuclei, large ions may also be produced by the splashing and breaking up of water drops by frictional effects in dust storms and so forth. The presence of these large ions has marked local effects on the potential gradient at the earth's surface and the value of the air–earth current at a given place. Certain fluctuations in these values have been correlated with variations in the number of nuclei present.

When ions of a given sign are dragged through a gas by an electric field, they set the air in motion. With the relatively intense ionisation current from an electrified point this gives rise to the well-known phenomenon of the electric wind. One of the earliest methods of measuring the mobility of ions was based upon a study of this phenomenon.

[1] Substance of a Friday evening discourse delivered at the Royal Institution on April 27.

Again, if a discharge of this type takes place in a smoky atmosphere, the electric wind assists in carrying the charged smoke particles towards the surrounding surfaces, where the particles stick on impact. In other words, it acts as a smoke precipitator.

To sum up, it may therefore be said that the subject of atmospheric ions has a bearing on at least two important problems at the present time. First, there is the problem of the mode and mechanism of attachment of molecules and ions, linking up with allied problems in the structure of bodies in general; and secondly, there is the wide field of meteorology and the problem of atmospheric electricity in particular.

Natural Steam Power in California.

By Dr. E. T. ALLEN and ARTHUR L. DAY,
Geophysical Laboratory, Carnegie Institution of Washington.

OF Prince Ginori Conti's remarkable experiments in utilising the potential power in natural steam, the readers of NATURE have been kept informed (**121**, 59–62; Jan. 14, 1928). The novelty of his conception and the patience and ingenuity with which it has been pursued to full realisation have attracted much attention among engineers and the public, and people have already begun to consider the possibility of similar projects elsewhere.

FIG. 1.—Sulphur Creek canyon looking east.

The locality in Tuscany which is the scene of these experiments has long been known as a centre of the boric acid industry, but few have had any definite conception of its character. It is, or rather was before industrial exploitation had modified its appearance, a barren tract covered here and there with very hot steaming springs and vents from which natural steam gushed out in jets of varying size—not infrequently with impressive noise and velocity. Exploration has since brought to light similar regions in other parts of the world, but the Tuscan field still appears to be unusual in the high proportion of its steam output.

Preliminary prospecting for natural steam with the drill in Bolivia and in Oregon has proved unpromising; the flow of steam was too feeble. In the Dutch East Indies one well, bored to a depth of 66 m., showed a pressure (closed) of 4½ atmospheres and a potential power development of 900 kw. Other borings are contemplated in a number of fumarole areas in Java and Sumatra. The Valley of Ten Thousand Smokes, which has been mentioned in this connexion, is much too remote to claim consideration from a commercial viewpoint; besides, the most recent exploration in that region (1923) has proved that a great drop in the surface temperatures has occurred there in less than five years. The Italians have considered, and are perhaps still considering, the sinking of steam wells at Pozzuoli, near Naples, though we have not learned that actual borings have been made there. Recent advices from California inform us that a test hole drilled in Imperial Valley to a depth of 725 feet yielded steam at 175 lb. pressure; but the only development known to us that approaches the achievement in Tuscany has been carried out at The Geysers, a place 75 miles north of San Francisco and about 30 miles from the Pacific coast. It lies near the bottom of a deep V-shaped valley enclosed by steep mountain slopes, and reveals its presence to the approaching traveller as a barren stretch of ground from which on cold or damp

days great columns and clouds of steam are seen rising.

The hot ground which has been actually explored covers an area of only 35 acres. Where the surface is hottest the ground is absolutely barren, its desolate appearance being intensified in dry summer weather by salt encrustations—chiefly sulphates of magnesium and ammonium—which partially cover it. In less active spots a very sparse growth of grass and weeds may be seen, and in a few cooler places taller bushes and trees. Shallow hot springs, usually only a foot or two in diameter, yielding turbid water close to boiling temperature (which at this elevation is near 98° C.), are scattered over the surface, along the bottom and east side of the ravine. There are natural vents, never more than an inch or two in diameter, to be found here and there, but the steam that escapes from them, though frequently audible, is scarcely visible in the hot dry summers of California, save at morning and evening, when the observer finds to his surprise that it is not only pouring from the vents but is also seeping through the porous ground and enshrouding the mountain slope. A little below the surface the ground quickly reaches the temperature of boiling water, and in the two most active vents a surface temperature of 102° C. was measured.

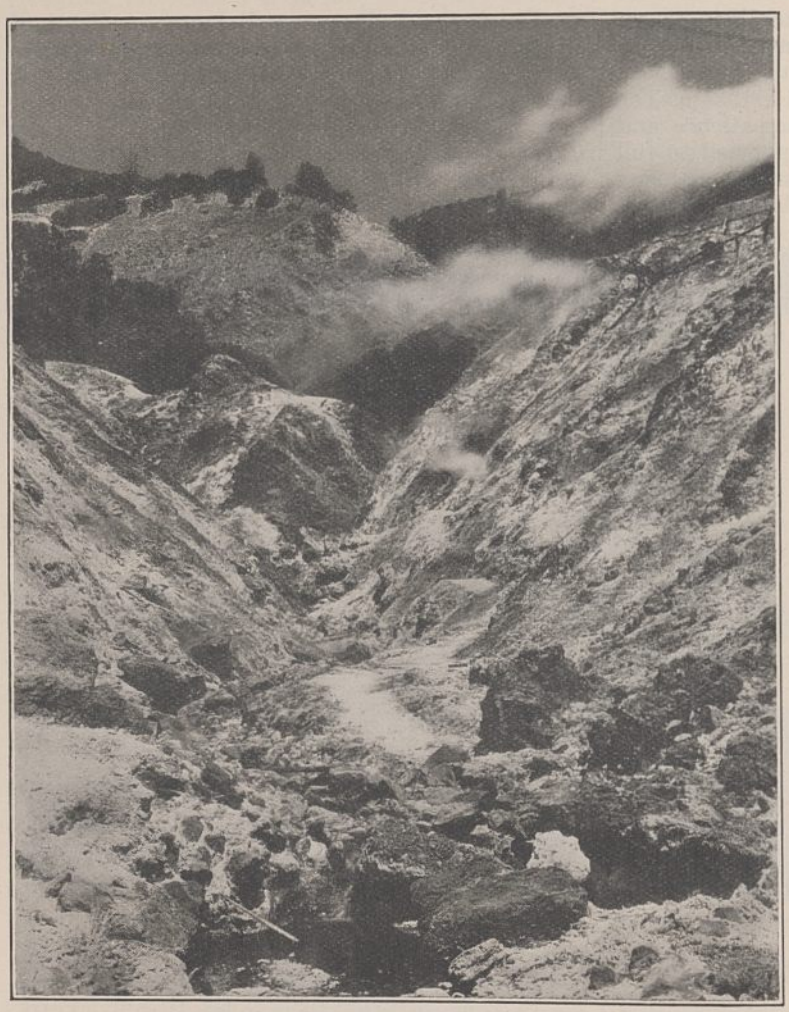

FIG. 2.—Geyser Creek canyon looking north at midday.

The Geysers has been known to the white man for about seventy-five years—a considerable period of time for that locality—but until recently it had attracted attention only as an unusual manifestation of Nature or for the reputed medicinal virtues of its hot-spring waters. About six years ago Mr. J. D. Grant, who has had considerable mining and prospecting experience, became interested in the constant escape of hot steam from the ground and, without any knowledge of the successful boring in Tuscany, conceived the idea of utilising it. Beginning in a small way with the help of a few men and an ordinary churn drill, he succeeded in drilling through the surface clay and into the underlying sandstone, keeping the steam condensed so far as possible by running in cold water from a tank on the mountain side. At intervals the rapidly heated water would shoot out like a geyser, after which more cold water would be let in. As soon as the hole had reached a suitable depth, an 8-inch steel casing was lowered into it and 'anchored' to the rock by the ingenious device of pouring around the pipe several hundred pounds of molten zinc, which congealed to form a tight joint.

It was about this time (midsummer of 1922) that we first visited the spot. Mr. Grant demonstrated the force of the steam by shutting off the cold condensing water and lowering the drill and tackle—representing a combined weight of about a ton—so as to cover the top of the pipe, when the whole mass was lifted several inches and the hot steam rushed out with a deafening roar. When the well had reached a depth of 200 feet the top was closed by a heavy gate valve. A second well was afterward drilled to a depth of 300 feet with power derived from the steam of the first well. Each of these two wells, when closed, developed a pressure of about 60 lb. per square inch. The practicability of utilising the steam was demonstrated by piping it to a small turbine and dynamo used for lighting the inn and cottages, the only buildings nearby.

Experimenting with the wells, Mr. Grant discovered that they would discharge continuously for a month, apparently without the least abatement of vigour, and, when closed again, would return to

(*Continued on p. 27.*)

Supplement to NATURE

No. 3062 JULY 7, 1928

Modern Views on Combustion.

THE study of the combustion of gaseous mixtures and vapours of fuels in air has recently received considerable attention from physicists, chemists, and engineers, with special regard to the subject of detonation or knocking in the internal combustion engine. Two years ago, an important discussion on the subject of gaseous explosions, under the chairmanship of Prof. H. B. Dixon, was held in London under the auspices of the Faraday Society, when several valuable papers were read by eminent workers in this branch of science. Since that time, however, discoveries have been reported which throw new light on the mechanism of combustion and on the function of traces of water, lead tetra-ethyl, etc., on ignitibility.

Hexane burns in air or oxygen with the formation of carbon dioxide and water in accordance with the chemical equation

$2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O$ + heat of reaction;

but little was known of the mechanism whereby the atoms are rearranged to form new molecules. The isolation of aldehydes from the products of combustion of hydrocarbons led Profs. Armstrong and Bone to the well-known hydroxylation theory of the combustion of hydrocarbons, by which the oxygen atoms are assumed to become interposed between the carbon and hydrogen, forming dihydroxyl compounds which lose water and form aldehydes.

Recently, new ideas have been advanced with regard to the intermediate and initial steps of combustion, and these arose from extensive investigations on the cause of detonation. Thus, in papers by Prof. H. L. Callendar and the staff of the Air Ministry Laboratory, Imperial College of Science, evidence was given that the first step in the combustion of gaseous systems was the development of nuclei, either of ionised molecular aggregates or of small liquid particles condensed in the engine cylinder charge during adiabatic compression. These nuclei sensitise the gas mixture to self-ignition on heating by acting as centres of oxidation. The significance of ionisation on gaseous reactions has been shown by the interesting results of Prof. Bone and his co-workers, obtained during researches on the influence of the energy of the electric spark on ignitibility of dried gaseous systems. Still more recently, the work of Finch and Hodges, of the Imperial College of Science, has also shown that whereas moisture may accelerate combustion of carbon monoxide in a region of comparatively weak ionisation, it has little or no influence in a region of sufficiently intense ionisation.

The inhibitory action of traces of lead tetraethyl, iron carbonyl, thallium vapour, etc., is better understood by the explanation involving the provision of nuclei which are rendered innocuous by the attachment of molecules of the inhibiting substances. It is interesting in this connexion to recall the similar conclusions of Prof. Dixon and Lord Rayleigh with regard to the inhibition of phosphorescence by traces of ethylene and other organic vapours.

On the chemical side, Prof. Callendar and his co-workers concluded that the nuclear particles became centres of peroxidation, the collision of a fuel molecule with one of oxygen resulting in the formation of a highly reactive and explosive organic peroxide, for example, an alkyl hydrogen peroxide, by the direct incorporation of the oxygen molecule, rather than in the formation of hydroxyl compounds, which involves a separation of the oxygen molecules into atoms. The primary formation of peroxides accounts at once for autoxidation and detonation.

Autocatalytic action during the combustion of gaseous mixtures has also recently been reported by White (carbon disulphide), Hinshelwood (hydrogen), and others. The peroxidation in gaseous mixtures affords a link with the interesting work by Moureu and Dufraisse and others on the mechanism of inhibitors on the oxidation and polymerisation of liquid substances such as acrolein.

The careful studies by Egerton and Gates, an outline of which is given by Mr. Egerton in the following pages of our Supplement, of the action of a large number of organic substances and metallic vapours on the self-igniting temperatures of fuel–air mixtures, shed further light on the difficult problem of detonation and indicate the complexity of gaseous reactions.

Engine Knock and Related Problems.[1]

By Alfred C. Egerton, F.R.S., Reader in Thermodynamics, University of Oxford.

ONE hundred and thirteen years ago Sir Humphry Davy commenced his magnificent researches on flame, which paved the way for all subsequent work on combustion. It is interesting to remember that Davy specifically thanked Michael Faraday, then twenty-four years old, for "his able assistance" during that work. It was the practical aim to combat the dangers of firedamp in mines that supplied the incentive to Davy's work on combustion. To-day practical ends still supply the main incentive to research on combustion. In one way or another improvement of the internal combustion engine is the source of much of the work that is done.

Whether we like or like not the advent of the internal combustion engine and the changes it has wrought, no one can deny the human achievement it represents. It is only necessary to recall the nature of the cycle of operations, the high temperatures involved, the exact timing of each function, and the speed with which those functions have to be carried out.

Amongst the noises which this product of human enlightenment has bequeathed to us, we have what is called engine 'knock' or 'pinking.' 'Knocking' is a sound which comes from the cylinder during the abnormal explosion of the charge. It is to be distinguished from 'pre-ignition'—usually a duller sound—which is caused by explosion of the charge prior to ignition by the spark, and may in certain circumstances also arise. 'Knocking' limits the compression of the charge. The following figures will make clear the effect of compression of the charge on the efficiency of the engine :

Compression Ratio.	Theoretical Efficiency.	Gain of Efficiency.
4 : 1	42·6	—
5 : 1	47·5	11·0 per cent.
6 : 1	51·2	8·0 ,,
7 : 1	54·0	5·5 ,,
8 : 1	56·5	4·5 ,,

If the compression ratio were raised from 4 to 6 there would be a gain in efficiency of nearly 20 per cent. The efficiencies of actual engines are considerably less, something of the order of 30 per cent at 4 : 1, and 35 per cent at 6 : 1, or a gain of about 16 per cent in efficiency. Mr. Ricardo, whose work has so greatly influenced engine design, is of opinion that for engines of, say, 3 inches to 4 inches cylinder diameter the maximum practical efficiency would be given by a compression ratio of about 7 : 1, taking into account the mechanical forces developed, and the means adopted to withstand them. It is not possible to reach such pressures, because the behaviour of the petrol fuel limits the pressure. In an ordinary automobile engine, compression beyond about 4-5 : 1 leads to 'knocking,' and consequent loss of power and damage. By careful design it is possible to arrive at compression ratios of 5 or even 6 : 1, but only at the sacrifice to some extent of other convenience. This forced limitation of the efficiency of the engine is unfortunate as applying to the automobile, but still more so to the aeroplane.

The world's production of petrol is of the order of 12,000 million gallons per year. A gain of 20 per cent on the efficiency might save more than 2000 million gallons of petrol. Any opinion as to the reserves of petroleum is not to be hazarded, but it is sufficient to say that any factor which could save such vast quantities of valuable raw material must be very potent economically. ('Cracking' and recovery of light fractions has increased the quantity and improved the quality of the petrol obtainable from petroleum, but the improvement as to compression attained is insufficient.)

It has long been known that benzene, toluene, xylene, etc., added to petrol improve its qualities as regards 'knocking'—but to raise the compression ratio from 4-5 to 6 : 1 would require the mixture to contain about 50 per cent benzene by volume. The world's production of benzene, limited as it is by the production of coke, is only a fraction of that which would be necessary to add to petrol to make it possible to use, universally, high-compression engines. In an effort to find something more effective than benzene, Messrs. Midgley and Boyd, of the Research Department, General Motors, Ltd., tried many thousands of different chemicals and came across lead tetra-ethyl. Since, in a detonating explosion, the luminous and ultra-violet radiation is more intense, they thought that a substance absorbing radiation might possibly affect knocking. They were led, therefore, to test iodine ; it was found to be effective, but not for the reason which suggested its trial, for bromine was found ineffective and chlorine even to induce knocking. They tried another neighbouring group of elements—tellurium, selenium, and sulphur—finding a similar relationship. Then, proceeding to try compounds in other

[1] Discourse delivered at the Royal Institution on Friday, May 25, 1928.

groups of elements which were soluble in petrol, such as tin and lead ethyls, they discovered the remarkable potency as an 'anti-knock' of the latter compound.

Many other substances, like diethyl telluride, or the unstable metallic carbonyls, behave similarly to a more or less marked extent. There are also organic products, such as the aromatic amines, which are effective, but about forty times as much would need to be added for the same effect as would be obtained with lead ethyl. It is not really satisfactory to give figures of effectiveness, as that seems to vary according to the circumstances of the test. The curve (Fig. 1) gives figures for the effect of small volume percentages of lead ethyl on the highest compression reached before knocking

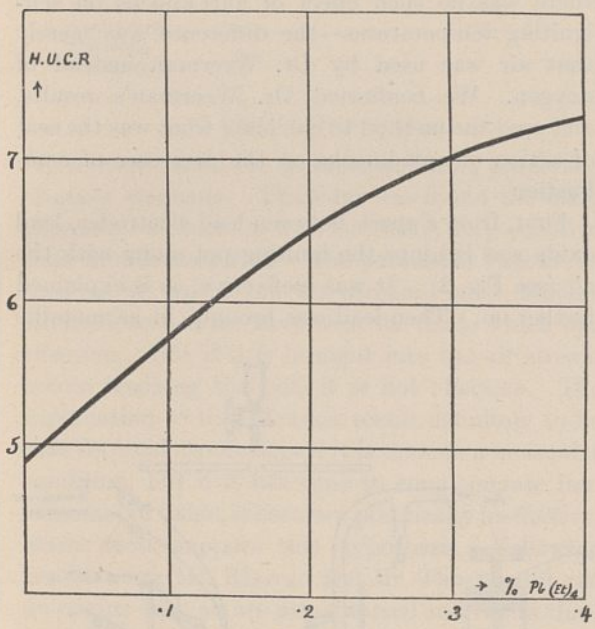

FIG. 1.

becomes audible, using a Ricardo variable compression engine. In Ricardo's engine the compression is varied by raising or lowering the whole cylinder, carburettor, camshaft and valve gear, the movement being measured by a micrometer screw. The engine is coupled direct to a balanced swinging field electric dynamometer. Another method of estimating the knocking characteristics of a fuel is provided by the fixed compression Delco engine, made by General Motors, Ltd. The extent of knocking is measured by a bouncing pin arrangement, the amount which it is bounced being measured by the volume of hydrogen generated during the time the pin closes an electrical circuit. The knocking character of a fuel can be compared against a standard fuel containing a definite quantity of anti-knock.

About one part of lead tetra-ethyl in 1500 parts of petrol (about 5 c.c. of ethyl fluid per gallon) will permit of the use of a compression ratio up to 6 : 1, and give an increase of at least 10 per cent in the power thereby. Furthermore, if all petrol were to be treated with such a 'dope,' it would be quite feasible from the point of view of supply, because it would entail about 40,000 tons of lead per annum, which is not more than 2 per cent of the world's production of that metal.

It is not the purpose of this discourse to enter into any controversial matters as to the poisonous character of ethyl lead or its effect on the engine. It is more interesting to consider 'why anti-knocks anti-knock?' Why should it be particularly interesting? The two remarkable points are the highly inflammable nature of the compounds which act as 'anti-knocks,' and the extraordinary small quantities required to be effective; 1 molecule of lead in 200,000 molecules of fuel–air mixture is definitely effective.

The Asiatic Petroleum Company afforded me facilities for investigating the problem, and I propose to outline the work as it developed from one stage to another. Discussion with Mr. H. T. Tizard led to the first line of attack. It was assumed that knocking in an engine—engine detonation—was akin to the setting-up of detonation in a gaseous mixture in a tube—a supposition later abandoned. The plan was to get an explosive mixture to detonate in a tube at a definite place, and then to find how the position would be altered by the presence of anti-knock. If the anti-knock delayed combustion, then the position of detonation ought to be further along the tube. Le Chatelier pointed out long ago the various ways in which flame can be propagated in an explosive mixture of gases. Depending on the conditions and the constitution of the mixture, flame may either be propagated with a uniform velocity by conduction of heat from layer to layer, or a vibratory type of combustion may be set up, or the flame may accelerate uniformly and finally detonate, if the strength of the mixture is above a certain limiting concentration. For the development of a detonation wave the gas in front of the explosion front must be heated by compression at least to its ignition temperature, and the rate of reaction must be so great that the fuel molecules are burnt before ever the compression wave has passed; combustion and compression then proceed simultaneously and with constant velocity. For example, the rate of travel of the detonation wave in an acetylene 1·5 oxygen mixture at normal pressure is about

2700 metres/sec. The photographic method, as developed by Prof. H. B. Dixon, was used in the investigations which Mr. Gates and I carried out on acetylene, pentane and hydrogen mixtures with various diluent gases.[2]

If the mixture is fired at the open end of a tube, the record of the travel of the explosion is very wobbly and detonation may occur at almost any place, but if the mixture is fired near the closed end of the tube, the explosion will be uniformly accelerated until detonation sets in, and it was found possible for given conditions (as to size of tube, etc.) to obtain detonation at a definite distance from the spark, and to study the effects of different diluent gases on the position of detonation.

Mixture + Diluent.	Position of Detonation.	Mixture + Diluent.	Position of Detonation.
C_2H_2 2·5O_2	cm.	C_2H_{12} 8O_2	cm.
$3O_2$	30	$2O_2$	12
3A	35	2A	34
$3N_2$	48	$2N_2$	50
$3CO_2$	98	$2CO_2$	62
$3C_2H_2$	53	$2C_5H_{12}$	80

Tube 0·9 cm. diameter. Pressure 760 mm.

It was found that anti-knocks did not influence the position of detonation (except in one or two cases, when the influence was to render the position earlier rather than later). These results have been confirmed by Lafitte working in Paris. At this stage a rather surprising negative result was all that had been reaped. It was necessary to go to conditions a little more like those in the engine—higher initial temperatures and higher initial pressures. For that purpose a long tube with a number of small glass windows was constructed ; it could be heated electrically, and could withstand considerable pressures. It was found that, for a given mixture, increase of pressure diminished the distance from the spark at which detonation is set up, up to a certain limiting pressure, further increase having then very little effect.[3] (A similar effect of pressure on the *velocity* of the detonation wave is known from Prof. Dixon's work, and was confirmed.) Again, it was found that although initial pressures up to seven atmospheres and initial temperatures of 230° were reached, there was no effect of anti-knocks (such as lead ethyl or nickel carbonyl) on the combustion of such detonating mixtures.

[2] *Proc. Roy. Soc.*, **114**, 137 and 157; 1927; and **116**, 516; 1927.
[3] *Proc. Roy. Soc.*, **114**, 152; 1927.

Fortunately, another line of attack was now open. Dr. Weerman[4] found that the igniting temperature of petrol, when dropped into a heated iron pot through which air was gently blown, was very considerably raised by the presence of anti-knocks. It was a curious result, for others had stated that

	Rise of Igniting Temperature.
	° C.
Selenium Diethyl	140
Iron Carbonyl	130
(Bismuth Triethyl	120)
Lead Ethyl	90
Nickel Carbonyl	40
Tellurium Diethyl	55
Bismuth Triphenyl . . .	42

there was no such effect of anti-knocks on self-igniting temperatures—the difference was merely that air was used by Dr. Weerman instead of oxygen. We confirmed Dr. Weerman's results, and used the method to elucidate what was the seat of action of anti-knocks on the processes of combustion.

First, from a spark between lead electrodes, lead oxide was led into the igniting pot along with the air (see Fig. 2). It was ineffective, as is explained farther on. Then lead was brought in as metallic

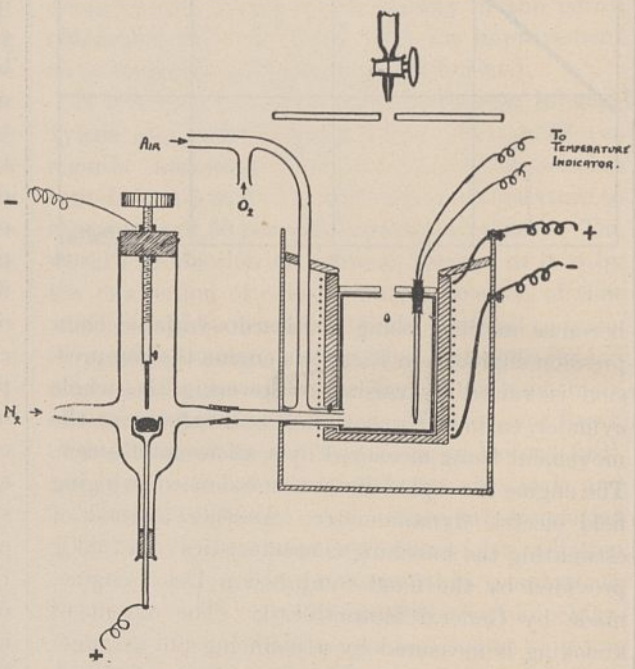

Fig. 2.

vapour from an arc in an argon stream, with immediate success—the igniting temperature was considerably raised, and to much the same extent

[4] *Jour. Inst. Petroleum Tech.*, **13**, 61; 1927.

for a given amount of lead so introduced as when introduced as lead tetra-ethyl in solution in petrol. So the lead part of the molecule dissociated from the ethyl molecule was essentially the active constituent. This being possible with lead, other volatile metals could be tested (see table below),

TABLE 1.

Effective.	Ineffective.	Doubtful.
Thallium	Aluminium	Tin*
Potassium	Magnesium	Cerium*
Lead	Mercury	Vanadium*
(Iron)*	Iodine	Titanium*
(Nickel)*	Phosphorus	Zirconium
Manganese	Gold	Thorium*
Bismuth	Zinc	Tantalum
Selenium		Tungsten*
Tellurium		Chromium*
Sodium		Cobalt*
Cadmium		Uranium*
Calcium		
Antimony		

* Tested by other methods.

and so were traced the ignition inhibiting properties of many elements. Thallium was found the most effective. Potassium was, curiously, very effective —an illuminating fact. The potassium vapour, as soon as it meets the air stream, must become oxidised, so it must have been the oxide which was effective. But if it is brought into the air stream before reaching the pot, it is not effective. The explanation to this paradox seems definitely to be that the oxide is effective if it is there in a molecular condition, but if it has time to conglomerate into 'chunks' of oxide, it becomes practically ineffective. Many facts support this hypothesis. Following on this work Mr. Ricardo and Mr. Thornycroft ran an engine with an arc attachment, and found that, even if air instead of nitrogen was passed over the lead arc, it was still quite effective. In that case there was, no doubt, plenty of lead oxide in molecular condition, whereas in the preliminary experiment which we described with the spark in air which failed to give an effect, the lead oxide was probably already conglomerated.

Summarising results up to this stage, it is found :

(1) That anti-knocks do not affect a rapidly accelerating explosion in a tube.

(2) That anti-knocks influence igniting temperatures of petrol (in a current of air).

(3) That in every case an anti-knock effective in the engine influences igniting temperatures, though in some cases the reverse is not found.

(4) That it is the metal part of an organo-metallic anti-knock which is mainly instrumental in the action.

(5) That this metal atom must be in an incipient state of oxidation.

Although there are now some experimental facts to which to appeal, there are many questions to answer. Is there any property in common between the substances which have effect ? What is the function of the anti-knock when it raises the temperature of ignition in the igniting vessel ? In what stage of affairs in the engine does the anti-knock have effect, and why, if it does not influence the rate of a detonating explosion, does it influence combustion in the engine cylinder ?

As to the first question, those substances which act as anti-knocks have, it seems, the common property that a state of equilibrium exists at the temperature at which they operate between certain products of the anti-knock. Thus, in the case of potassium, the oxides K_2O_3 and K_2O_4 have been shown to exist in a state of equilibrium in favour of the higher oxide at 400°. If the higher oxide is reduced to the lower, it can be regenerated by the next suitable impact with an oxygen molecule. It seems to be this property which renders such a small amount of metal effective ; as soon as some has had effect it is regenerated in an active condition.

Similarly with thallium, lead, bismuth, and manganese, such figures as there are for the oxide equilibria support the hypothesis. The metals zinc, magnesium, etc., are ineffective, for no such transformation is possible. The case of selenium is interesting ; the same sort of change may take place perhaps as occurs with sulphur compounds such as glutathiones in physiological oxidations. Some organic substances such as aromatic amines act as anti-knocks, though to a feeble extent compared with metallic compounds ; their behaviour also agrees with the suggestion that their activity is due to the formation of fairly stable oxidation products. In support of this we find quinone to be effective. These organic anti-knocks were shown to undergo combustion themselves at the temperature they are required to operate, so that the chance of their effective action is very much reduced.

The next question was, What do the anti-knocks do to the vapours which would ignite ? A study of the behaviour of a large number of inflammable substances in the igniting pot and the effect of anti-knocks of various kinds upon them has been made.[5] Anti-knocks definitely slow down the rate of reaction prior to ignition, as curves showing the temperature rise indicate. This result was con-

[5] *J. Inst. Petroleum Tech.*, **13**, 61, 251; 1927.

firmed by measurements of carbon dioxide produced, and, by Dr. Weerman, of oxygen absorbed. In the language of the chemist, the anti-knock is an 'inhibitor of oxidation.' Then comes the question, Is it in the body of the gas or on the surface of the vessel that the anti-knock has its effect? Davy demonstrated that surface combustion occurs in circumstances where flame cannot be set up. From a variety of observations we have come to the conclusion that ignition starts, not at the surface, but in centres of high energy in the body of the gas. The anti-knock delays combustion not specially at the surface, but by inhibiting the rate of oxidation prevents the setting up of these centres. If the surface-volume ratio of the ignition vessel is increased, the effect is to raise ignition temperature. If the anti-knock were to increase the activity of the surface, the effect indeed might be to raise igniting temperature; but it was not found that the effect of the anti-knock was proportional to the extent of surface.

If the effect of an anti-knock on a range of compounds is studied (see table below), it may be

TABLE 2.

Substance.	I.T.	Rise with $PbEt_4$.
Benzene	690° C.	18° C.
Cyclohexane	535	27
Methylcyclohexane	470	92
Pentane	515	75
Isohexane	525	46
Heptane	430	83
Petrol (Shell)	460	82
Ether	440	65
Alcohol	515	(9)
Acetaldehyde (iron vessel)	395	110
,, (silica vessel)	350	170
Pentane	540	87
Amylacohol	490	Nil
Amylenehydrate	640	35
Valericaldehyde	320	380
Dimethylaniline	445	Nil
Carbon Disulphide	120	Nil

noted that the combustion of normal paraffin hydrocarbons (which are those constituents of petrol that are most prone to knocking), is more inhibited than that of naphthenes, for example, such as cyclohexane. Further, there is a very remarkable inhibition of the combustion of aldehydes. Prof. Bone showed long ago that aldehydes are intermediate products in the combustion of hydrocarbons. One would be led to suppose that this is the seat of the action of anti-knocks, the further oxidation of the aldehyde being delayed. That must be so, but it is not the whole story. Let us assume that it is so, that the anti-knock or inhibitor acts only on the aldehydes in the course of the hydrocarbon oxidation and delays their oxidation. The amount of the aldehyde will then increase in the products of combustion. That is the opposite to what is found. Therefore to retain our hypothesis it could be suggested that the products of oxidation of the aldehydes hasten the initial hydrocarbon oxidation—a process of autoxidation. The consequence of such an addition to the hypothesis would be that considerably enhanced combustion should occur on addition of aldehydes to hydrocarbons. That is also not found to be the case to any marked extent. We have then to discard the hypothesis.[6] The inhibitor must be acting elsewhere besides. Suppose, then, that it also inhibits the initial oxidation of the hydrocarbon. Here, again, there is a difficulty. The quantity of inhibitor is insufficient to control the simple interaction of oxygen and hydrocarbon molecules. It must then be concluded that it acts on certain products of the primary oxidation of the hydrocarbon which tend to hasten (autocatalyse) that initial oxidation. Such is the argument by which we are guided to a general view of the process of combustion of a hydrocarbon.

Suppose some fuel molecules are amongst oxygen and nitrogen molecules in a vessel the temperature of which is gradually rising. The molecules primarily pick up their energy from the walls. It is the walls that control affairs at first, and reaction only occurs at the walls at first. Sufficient of the fuel molecules in the body of the gas may, however, gain momentarily sufficient energy to unite with an energetic oxygen molecule with which they happen to encounter. Prof. Callendar and his associates have investigated this temperature of initial combustion. It means essentially that a temporary peroxide is formed—a peroxide in a high energy state possessing the energy of activation of the fuel and oxygen and also potentially the reaction energy.

Several things may happen to this active addition compound of fuel and oxygen. (*a*) It may revert to a normal state and radiate energy in so doing, and form a stable peroxide. Peroxides are indeed found amongst products of combustion and of oxidation of organic compounds (as Wartenburg, Staudinger, Callendar, and Mardles and others have shown). (*b*) The compound may break up again, the parts being less active by the energy radiated. (*c*) The compound may reorganise and give highly active products, thus for ethane:

$$CH_3 - CH_3 + O_2 \rightarrow CH_3 - CH_3 . O_2$$
$$\rightarrow CH_3 . CHO + H_2O$$

[6] The reason for this lack of effect is probably that the concentration of the aldehyde is not great enough to transmit the reaction chain.

(Dihydroxyethane may possibly also be formed to some extent as an intermediate stage in the production of the aldehyde and water.) (*d*) Collision may occur. Encounter with inactive nitrogen molecules may result merely in frittering down the energy of the active product, but encounter with a fairly active fuel molecule, or product thereof, or oxygen molecule, will raise its energy so that it will react and produce active products. These products in turn may collide and activate other fuel molecules, and so on, a reaction chain mechanism being set up ; in the above case of ethane,

$$CH_3 - CH_3 + O_2 \longrightarrow CH_3CHO + H_2O,$$

the active aldehyde and/or water molecules being able to communicate their energy to activate other ethane molecules, and so on.

A rare occurrence thus becomes a frequent occurrence locally. This explains the setting up of centres of high energy in the body of the gas, indicated as necessary for ignition to occur. Any influence that tends to decrease the local concentration either of fuel or oxygen molecules or to dissipate the energy may break the chain of reaction, and so enormously affect the rate of oxidation. Once a chain mechanism is established, local free energy increases, and molecules can be excited into higher energy states, and in returning from those states can give out light. So it is that luminescence can be observed during combustion of hydrocarbons many degrees below their igniting temperatures. Further, as the mean temperature approaches the igniting temperature, the state of excitation becomes sufficiently intense to ionise a proportion of the molecules, actual inflammation being attended with more or less intense ionisation. Some sort of solidity is derived in support of the view put forward in that Dr. Bäckström,[7] working in Sweden, has found that the thermal oxidation of liquid aldehydes is essentially a chain reaction. More important still, Mr. Hinshelwood[8] can best explain his recent measurements of the rate of reaction of oxygen and hydrogen in terms of a reaction chain mechanism. The effect of the surface of the vessel in breaking the chains is indicated, and seems to be in accord with the observation before mentioned that increase of surface raises igniting temperature.

Returning now to the anti-knocks, it is established that they inhibit oxidation. They evidently act by breaking the chains. That, together with the chance of regeneration already mentioned, is sufficient to account for the small quantity of the 'dope' required. Perhaps they break the chain because reaction between metal peroxide in a molecular condition and active fuel peroxide occurs with mutual destruction and rearrangement, the resulting products having much less energy than they would possess had the fuel peroxide encountered another active molecule—the reaction, for example,

$$H_2 + H_2O_2 \longrightarrow 2H_2O$$

liberates much more energy than the reaction

$$H_2O_2 + PbO_2 \longrightarrow PbO + H_2O + O_2,$$

so that the water produced would be on the average less active in the latter case, and could not communicate sufficient energy to continue the reaction chain. Anti-knocks are not so effective in presence of high concentration of oxygen, for then the reaction chains are too easily propagated for their inhibition. Catalysts such as nitrogen or chlorine peroxides promote autoxidation by providing highly active products on reaction.

This question of the behaviour of anti-knocks has led deep into the processes of combustion ; enough has been said to indicate that much more work must be done before the detail is known to any degree of certainty.

Finally, we come to the third question, In what stage of affairs in the engine do the anti-knocks have effect, and why, if they do not influence the rate of a detonating explosion, do they influence combustion in the engine cylinder ?

When it had been shown that anti-knocks delay oxidation, Mr. Ricardo ingeniously arranged a test whereby it was found that preliminary oxidation during the compression stroke was much less when inhibitors were present than when they were not present. (This conclusion was likewise arrived at by Prof. Callendar and the Air Ministry Staff.) It was clear that anti-knocks act on the gaseous charge in the stage prior to ignition (and prior to inflammation at the flame front), and delay the initial stages of reaction in the manner already discussed.

Now, in front of a flame travelling along a tube there is a narrow region—a fraction of a millimetre in thickness—in which the gas is becoming heated to such a temperature that reaction is rapid enough for inflammation to be set up. Such a temperature is the ignition point in the circumstances in which the gaseous mixture there finds itself. There is a further rapid rise of temperature within the flame front due to the combustion of the mixture. If one knew all about the reaction velocity, the thermal conductivities, specific heats, and ignition

[7] Cf. the important experiments of Moureu and Dufraisse on autoxidants.
[8] *Proc. Roy. Soc.*, **118**, 170; 1928.

point, under given conditions of loss of heat, it ought to be possible to calculate the flame velocity. Such data are not complete, but it can be realised at once that any influence which delays matters in the 'heating up' zone will influence the rate. Furthermore, since the zone is exceedingly narrow, it is clear that any inhibitor 'will have to be quick about it' if it is going to have any effect, particularly if it has first to be decomposed and rendered in an active condition. When once in the zone of combustion, there is so much heat available that the inhibitor can have very little effect—in fact, the organic radicals which form part of the molecule go to add to the heat developed by their own combustion, and tend even to hasten matters; so it is that one can explain the negative results obtained in the detonation experiments, and the absence of effect when gases are suddenly ignited from the cold by adiabatic compression.

Some experiments have been made to test this conception. Comparatively slow flames in pentane mixtures of concentration similar to that used in engines, when photographed in a bomb, were shown to be slower when lead ethyl was present.[9] The uniform speed of flames in tubes could also be modified to some extent with pentane mixtures. These effects were particularly marked for vibratory flames, for then as the flame moves forward it decomposes and oxidises the lead compound, and on its return conditions are more favourable for the lead to be effective as an inhibitor. Using carbon monoxide or methane flames, no effect was observed with lead ethyl, but with the more easily decomposed iron carbonyl the rate is considerably modified. A 50 : 50 air–carbon monoxide (wet) mixture will burn with a blue flame at a rate of about a yard a second; exactly the same mixture containing $\frac{1}{1000}$th part by volume of iron carbonyl burns with a brightly luminous flame very much more slowly.

Photographs have been taken of explosions in acetylene and in pentane mixtures at about engine strength in a cylindrical bomb (19 cm. × 10 cm.) fitted with three windows, ignition being started in the centre of one of the endplates. When audible knock occurred, the photographs showed a check in the rate of combustion after the second window. Prof. Wheeler points out that this is probably due to cooling of the flame front as it meets the walls.[10] Vibrations in the flame are also visible. Dr. Fenning, at the National Physical Laboratory, has recorded the pressure effects in explosions of a knocking character in various mixtures at various temperatures in a similar bomb. Prof. Wheeler and Dr. Maxwell have also taken a number of beautiful photographs of this kind.[11] Their results indicate that in a knocking type of explosion a sudden vibratory and enhanced combustion occurs in the neighbourhood of the walls, which may lead to a compression or shock wave passing back through the products of combustion. It is not a 'detonation wave.' It is more "like a great flame which creates noises within the air" (Leonardo da Vinci).

Knocking appears to be due to inequality in the condition of the charge set up, particularly in regions of high pressure and temperature, as in the neighbourhood of hot exhaust valves. This inequality provides regions of high energy, containing molecules in high energy states, where reaction can spread more quickly. Unequal burning gives rise to a vibratory condition of flame. Any influences, such as a higher state of turbulence or cooler surfaces, or more even and longer combustion space, which tend to prevent sudden and local rise of pressure, and the setting up of centres of high energy, tend to prevent knocking. Anti-knocks, such as lead ethyl, by inhibiting the processes of combustion which we have seen to occur in those centres, are therefore effective in preventing knocking. Furthermore, they have been rendered effective by the temperature and oxidation to which they and the charge are exposed during the compression stroke; the charge in the engine cylinder is so affected by its previous exposure to oxidation during compression that the opportunity for the flame to meet regions in a high state of energy is greater than when those previous oxidations have been appreciably inhibited by anti-knocks or other factors.

Prof. Callendar has directed attention to the importance of the presence of nuclei—small droplets of unevaporated fuel—in the charge in the engine cylinder. A discussion of this aspect of the subject cannot be entered upon here. The concentration and energy of the molecules of vapour at the surface of an evaporating droplet, and the rate of oxidation at the surface of the droplet, are such as greatly reduce the temperature of ignition. The tendency to knock would likewise be enhanced. But it is also certain that knocking is possible in completely vaporised mixtures, and that anti-knocks will affect the temperature of ignition of completely gaseous fuels. A more general viewpoint is adopted in this discussion of engine-knock and the problems that relate thereto.

We have come now to the end of our story—not, though, to the end of an investigation. Thinking again of Davy's researches on flame—of the questions, How does a flame start? What prevents it starting? What occurs at the surfaces exposed to the ignitable gases? we see the horizon of the unknown ever widening. We will quote from the opening remarks of Faraday's lectures on the Chemical History of a Candle, "So abundant is the interest that attaches to the subject, so wonderful are the varieties of outlet which it offers into the various departments of philosophy. There is no more open door by which you can enter to the study of natural philosophy than by considering the physical phenomena of a candle."

[9] *Proc. Roy. Soc.*, **116**, 516; 1927.
[10] *Proc. Roy. Soc.*, **116**, 516; 1927.
[11] *J. Inst. Petroleum Tech.*, Feb. 1928. See also Duchesne, *C.R.*, **186**, 220; 1928.

Printed in Great Britain by R. & R. Clark, Limited, *Edinburgh.*

the same pressure as at first. With the aid of outside capital the work was continued under a competent engineer, Mr. J. D. Galloway, of San Francisco, who completed five new wells ranging from about 400 to 650 feet in depth and developing pressures (when closed) from 95 lb. to 276 lb. per square inch. Further measurements showed a steam output for the individual wells of 7500 to 52,000 lb. per hour (average above 30,000 lb.), corresponding to a switch-board delivery (average) of about 1000 kilowatts per well at a pressure of 75 lb. The wells are separated by distances varying from 50 feet to 175 feet, and none of them appeared to show any diminution in pressure or flow of steam due to the output of its neighbours.

The figures show that the steam wells here are fully equal to those in Tuscany in point of power developed, and that they contain a somewhat smaller percentage of fixed gases to diminish the effectiveness of the application of the steam to power development. On the other hand, the chances for extension of the power development appear much more limited. While the hot ground in Tuscany is said to cover an area of about 100 square miles, thermal activity in the Californian locality is confined to a narrow belt less than a quarter of a mile in width and not more than six miles in length, and even within this area hot water and steam appear at the surface only in places. In Tuscany, too, there is an added commercial advantage in the boric acid supply; in California the percentage of boric acid in the gas is small. But the industrial outlook is not unpromising; the operating company has under consideration at the present moment a plan for the appropriate utilisation of the power. Of the scientific interest of what has already been accomplished there can be no doubt whatever.

In the summers of 1924 and 1925 we were permitted to make quite a large number of tests on five of the seven wells—all that were completed at the time. Analyses showed that the steam was accompanied by other gases varying in amount from three-quarters of one per cent to a maximum of two per cent by volume. These gases are mixtures of carbon dioxide—always the chief constituent—and smaller amounts of hydrogen, methane, hydrogen sulphide, nitrogen, argon, and traces of boric acid and ammonia (about 0·03 per cent). A series of temperature and corresponding pressure measurements in the closed wells showed that the former ranged from about 154° C. to 190° C. at the top, while pressures varied from 62 lb. to 180 lb. per square inch. The most powerful well, as a matter of safety, was kept partially open during the time of these experiments, discharging at a pressure of about 120 lb. per square inch. Without taking time to analyse the figures,[1] it may be said that they prove conclusively the superheated character of the steam. Nasini had already reached the same conclusion regarding the natural steam of Tuscany. A wider experience has proved that this is not a sporadic occurrence in thermally active ground; we have found vents in the Yellowstone Park, in the Lassen National Park, and many in Alaska, where the temperature of the escaping steam was so high as to leave no doubt of superheat.

The facts would probably convince any competent observer that the source of the steam in the wells under discussion could not be derived from a reservoir of water, either above or below ground. The high temperature, high pressure, enormous output, and superheated character of the steam point to hot magma below the surface, of such extent that the steam may be drawn off in quantity for an indefinite time without materially diminishing its pressure. Only a hot magma, probably still near its crystallisation temperature, could answer these requirements. We know that water is an invariable constituent of all types of igneous rocks and that there is more of it in the glassy rocks which approach in character nearer to the liquid state. We know also that the gases associated with the steam both in the wells and in natural vents correspond in character to those found in igneous rocks, varying only in their relative proportions from place to place as other rock constituents do.

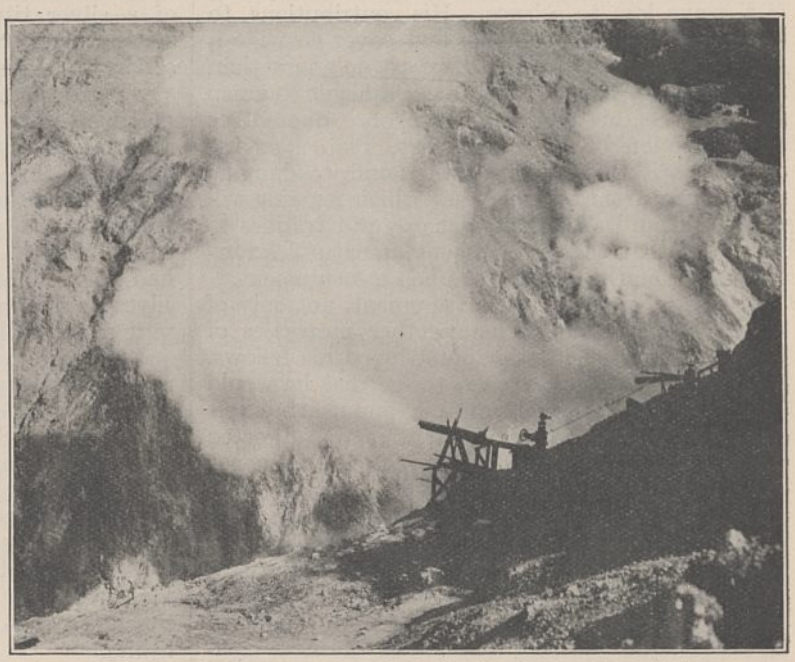

FIG. 3.—Wells No. 1 and No. 2 discharging into the atmosphere, 1924.

The area where these steam wells are located is superficially covered with sediments and meta-

[1] For details see "Steam Wells and Other Thermal Activity at 'The Geysers,' California." E. T. Allen and Arthur L. Day, Carnegie Institution Publication No. 378 (Washington, D.C.: Carnegie Institution), pp. 55 seq.

morphics, but a core of gabbro was brought up from a depth of 230 feet in drilling one of the wells, while andesite outcrops on the higher peaks of the mountain range. With the incomplete evidence at hand it would appear that the rock from which the steam issues is not recent, for the sediments are apparently of Cretaceous or Jurassic age. The view here presented concerning the source of the steam assumes the existence of a fault—a means of egress for the imprisoned steam. Of that we have interesting evidence in the fact that within a narrow belt, more than 25 miles in length, many quicksilver mines as well as all the hot areas are found. However, every theory of hot springs assumes the existence of faults to account for their appearance at the surface, and the association has been proved to be true in so many instances as to inspire some degree of confidence in its general validity.

Obituary.

PROF. T. W. RICHARDS, FOR. MEM. R.S.

THE death of Prof. T. W. Richards on April 2, at the comparatively early age of sixty years, is a grave loss to science. His contributions to knowledge were so valuable and cover so wide a field that it is impossible here to do more than indicate their scope: yet it is not difficult to grasp the secret of his greatness. He once quoted, as an expression of his own views, Plato's saying that "if arithmetic, mensuration, and weighing be taken away from any art, that which remains will not be much." All that Richards did testifies to his belief that the development of natural knowledge is primarily dependent upon measurement.

It was in precision of measurement, not only of atomic weights but of many other properties of matter, that Richards far outstripped his fellows. To read any of his papers is to see that he would spare no effort to ensure the maximum attainable accuracy in his data. His attention was directed to work on atomic weights through the influence of J. P. Cooke (himself a pupil of Regnault), who worked on the ratio of oxygen to hydrogen and undoubtedly did much to inspire Richards' interest in chemistry. Shortly after graduating at Harvard in 1886, Richards began work on the atomic weight of copper, and in the next few years he developed the essential features of the new technique for the determination of halide ratios upon which many of his subsequent researches depended. Successively assistant, instructor, and assistant professor in the Department of Chemistry at Harvard, he was appointed professor of chemistry in 1901, and chairman of the Department in 1903.

During this period, with the frequent collaboration of his colleague, Prof. G. P. Baxter, he was actively at work, and when, in 1912, he became director of the Gibbs Memorial Laboratory at Harvard, he had already redetermined the atomic weights of more than thirty important elements. By a critical survey of the researches of Stas, and especially by the continual criticism and development of his own methods, Richards, at tremendous cost in thought and labour, achieved that essential simplicity which is the mark of genius. The obvious importance and interest of his work attracted many able research students, by whom his methods and ideas have been widely disseminated; and, more significant still, it inspired and guided not a few who had never seen him.

Richards investigated the balance and developed improved methods of weighing; he invented the nephelometer and ascertained the conditions in which it can be used to determine precisely traces of dissolved salts and to indicate the end-point of a silver titration. He demonstrated the insidious effect of occluded moisture and gases in solids, to avoid which he invented the so-called 'Harvard bottling apparatus,' with which it is possible to fuse and resolidify a salt in any desired atmosphere and then transfer it in a dry, inert gas to the closed vessel in which it can be weighed. It was Richards who first applied the centrifuge to facilitate the purification of salts by fractional crystallisation, and he showed how Stas' results had been vitiated by the solubility of oxygen in silver and developed a procedure by which really pure silver could be prepared.

Richards' methods are well exemplified in his monumental work with Willard on the ratios of silver and silver chloride to lithium chloride and perchlorate. By taking advantage of the high proportion of oxygen in the perchlorate of a metal of low atomic weight, a very accurate ratio of silver to oxygen was obtained, and this served to establish, in relation to the fundamental value $O = 16{\cdot}000$, really precise and trustworthy values for the atomic weights of silver and chlorine, and the best available value for the atomic weight of lithium.

In later years Richards played his part in the development of modern views of the atom, and we owe to him some of the most accurate determinations of the atomic weight of lead from radio-active sources, and also the only precise evidence yet available that the molecular volumes and the molecular solubilities of isotopes are identical.

Though it is by his work on atomic weights that Richards is best known to chemists, he made many other valuable contributions to knowledge. A study of atomic and molecular volumes led him to formulate the theory of the compressible atom. He observed that the same atom might occupy different volumes according to its state of combination, and concluded that atoms were compressible, and that in compounds they were, in fact, compressed by the forces of chemical affinity. Though this conception seems to us to-day to be simple, natural, and readily intelligible, it was, when propounded, a revolutionary notion which was quite generally discredited. By it, however, Richards was led to carry out a most valuable series of measurements of compressibilities of

elements and compounds, in which again he had to develop, test, and apply entirely new experimental methods. The results, of value in many ways, afforded strong confirmation of his basic hypothesis. In later years, Richards's interest centred chiefly upon these problems of atomic and molecular volumes and compressibilities, and, though he was active in many other fields, he undoubtedly regarded this as his most important work.

These are but a few examples of the methods and data by which he enriched the physical sciences. He made most valuable contributions to precise thermometry and calorimetry. We owe to him the proposal to use the transition points of pure compounds as fixed points in thermometry, and it was at Harvard that the methods of adiabatic calorimetry were first developed and applied. He also greatly increased the precision of determinations of surface tension and obtained the standard data for many important liquids.

This recital of Richards's achievements should be greatly extended and amplified, but enough has perhaps been said to indicate how fundamental and extensive they were. Their value was generally recognised, and the honours that fell to him are, like his works, too numerous to detail. Many American and foreign universities honoured him and themselves by the award of degrees. He was a foreign member of the Royal Society, an honorary fellow of the Chemical Society, before whom he delivered the Faraday Lecture in 1911, and he received in turn the Davy Medal, the Franklin Medal, and the Le Blanc Medal. Many other American, British, and foreign scientific societies similarly honoured him, and in 1914 he was awarded the Nobel prize for chemistry. He was an active member of numerous societies and committees, and served as president of the American Chemical Society, of the American Association for the Advancement of Science, and the American Academy of Arts and Sciences.

We mourn in Richards a great and kindly man who was a great chemist: his place is marked by the cairn of exact data he raised with his own hands.

H. V. A. BRISCOE.

DR. W. A. YOUNG.

DR. W. A. YOUNG, Director of the Medical Research Institute, Gold Coast, while engaged on investigations connected with yellow fever, contracted the disease and died on May 30 at Accra. His death is peculiarly tragic in view of his early age, and of the fact that two other investigators have died in West Africa in like circumstances within a period of a few months. It is believed that he became infected while making a post-mortem examination on his colleague, Dr. Noguchi, whose death was referred to in our issue of June 9 (p. 914).

William Alexander Young was born in 1889, graduated M.B., Ch.B. (St. Andrews) in 1911, and after holding the office of house surgeon at the Halifax Royal Infirmary and studying tropical medicine at the Liverpool School, joined the West African Medical Service in 1913. He was first stationed in Sierra Leone, and during the War served with the Cameroon Expeditionary Force (1915–16). In 1920 he was transferred to Nigeria and appointed assistant bacteriologist. From June to December 1923 he was attached to the Nigerian Tse-tse Fly Investigation staff, and was part author of the second report prepared by that body. He was then transferred to the Gold Coast on appointment as pathologist, and in September 1924 was promoted to the directorship of the Medical Research Institute.

Young's interests in the field of tropical medicine were wide, and the subjects of his publications remarkably diverse. His papers, most of which appeared in the *Transactions of the Royal Society of Tropical Medicine and Hygiene*, the *Journal of Tropical Medicine and Hygiene*, and the *West African Medical Journal*, deal with blackwater fever, leprosy, trypanosomiasis, plague, dysentery, and yellow fever. He was equally at home in the laboratory and in the field, as instanced, on one hand, by an experimental work on the effects of emetine (carried out during a period of leave in collaboration with G. R. Tudhope), and, on the other, by a detailed survey of the tse-tse fly conditions in the Gold Coast. His aim, in view of his position as Director of Medical Research, was to maintain a good knowledge of many subjects, rather than to concentrate for a long period on one.

When it was suggested that Noguchi should come to Accra, Young, who was then giving most of his attention to yellow fever, accepted the suggestion with enthusiasm, and at once began preparations for work on a larger scale. Soon after Noguchi arrived, Young volunteered to assist him, and the two worked together until the end.

Young applied himself with zeal to administrative duties. On his initiative the staff of the Medical Research Institute at Accra was considerably increased, and an additional laboratory was opened at Sekondi. He also designed and had fitted locally a very efficient motor laboratory. In his dealing with his subordinates, both European and native, he was very considerate and tolerant, appreciative of achievement and forgetful of errors, and both European and native will miss him greatly.

WE regret to announce the following deaths:

Prof. A. A. Breneman, consulting chemist and chemical engineer, editor (1884–93) of the *Journal of the American Chemical Society*, who carried out work on explosives, water analysis, etc., aged eighty-one years.

Dr. W. M. L. Coplin, emeritus professor of pathology and bacteriology in the Jefferson Medical College, on May 29, aged sixty-three years.

Prof. E. M. Crookshank, emeritus professor of bacteriology at King's College, London, on July 1, aged sixty-nine years.

Dr. William H. Nichols, Jr., vice-president of the Allied Chemical and Dye Corporation and a past president of the American Chemical Society and of the American Society of Chemical Industry, known for his work on the metallurgy of copper, on May 28, aged seventy-six years.

Sir John Isaac Thornycroft, F.R.S., a pioneer in the design and construction of small high-speed vessels, on June 28, aged eighty-five years.

News and Views.

THIS week Lord Sydenham of Combe, soldier, administrator, and publicist, celebrated his eightieth birthday, and the occasion enabled many friends to proffer their congratulations. Born on July 4, 1848, Lord Sydenham (formerly Sir George Clarke) was educated at Haileybury and the Royal Military Academy, Woolwich. In 1868 he entered the Royal Engineers, afterwards seeing much active service, and earning a reputation as an authority on military matters. He had also made a special study of fortification, in regard to which he wrote (1910) a well-known treatise. From 1894 until 1901 he was superintendent of the Royal Carriage Factory, Woolwich, vacating this post on becoming Governor of Victoria. He was raised to the peerage in 1913; and further, in 1917, designated G.B.E. Taking a keen interest in public affairs, Lord Sydenham became chairman of the Royal Commission on Contagious Diseases, 1913–15; afterwards president of the National Council for Combating Venereal Diseases. He was president of the British Science Guild from 1917 until 1920. He had been elected a fellow of the Royal Society in 1896. Last year Lord Sydenham published an interesting reminiscent book, entitled "My Working Life."

RECENT events indicate that the movement for calendar reform is making progress, and that not in regard to Easter only, but in the direction of some of the more far-reaching proposals which were included in the report of the late Committee of Inquiry of the League of Nations as calling for careful consideration, though without any definite expression of opinion on the part of the Committee as to their respective merits. One event of great importance is the passing of a resolution at the meeting of the U.S. National Academy of Sciences at Washington on April 23 last, favouring "a change in the present calendar, looking to the establishment of 13 months per year, grouped so that the last 13 days of June and the first 15 days of July form the proposed new month, the odd 365th day being designated as 'Year day,' and the extra day in leap year being designated as 'Leap Day,' and permitting among other things the establishment of a fixed date for Easter Sunday." Another significant circumstance is the adoption by Standing Committee No. 3 of a resolution for submission to the annual plenary Congress of the League of Nations Societies being held at The Hague during the past week, which, though not specifying any particular proposals, directs attention to the defects and inconveniences of the existing calendar, and "invites the League of Nations Societies to urge the Governments of their respective countries to take immediate steps to expedite the convening by the League of Nations of an International Conference entrusted with proposing specific measures for the reform of the calendar."

IT is evident that the work of exploration already done under the ægis of the League of Nations is being vigorously followed up by those eager for reform, but it seems likely that much resistance will be offered, especially perhaps in European countries, to the specific proposals approved by the U.S. National Academy of Sciences. The suggestions relating to 'Year Day' and 'Leap Day' have been opposed by certain powerful religious communities, and it will probably be long before chronologists and the majority of people can be reconciled to the substitution of a 13-months for the time-honoured 12-months year. It is always open to any business organisation to arrange its affairs on whatever system it finds convenient, without the general disturbance in so many departments of social life which the suggested radical change would involve. It is, however, of great importance that the questions at issue should be thrashed out by competent bodies in all countries, in order that objections raised may be met and, if possible, removed. The activity displayed by those anxious to reform the calendar is accordingly to be welcomed, but it is necessary to guard against hasty and insufficiently considered action.

As radio receiving sets are now often connected with public or private supply mains so as to obviate the trouble and expense of the charging and maintenance of accumulators, it is advisable that there should be some supervision of the apparatus supplied by radio manufacturers for this purpose. Without this supervision there may be, in exceptional cases, risk of fire or even risk to life. Regulations for the design and installation of this class of apparatus have now been issued by the Institution of Electrical Engineers, with the approval of the Radio Manufacturers' Association. The cases containing them must be made of metal or non-ignitible material, or various kinds of specified woods. All holes for the passage of cables must be made so as to avoid abrasion of the cables. When a conducting material is used for the containing case it must be earthed. The temperature of the air inside the containing case must not exceed 120° F., and the apparatus must be adequately protected by fuses. A novel rule is that when radio apparatus is connected with direct current supply mains the aerial must have only inductive connexion with the apparatus through a transformer or condenser. With alternating current supply mains the capacity of the connecting condenser must not exceed 0·001 of a microfarad. Head telephones and loud speakers must be connected with the radio apparatus through a transformer or through a circuit which includes a condenser. Insulation resistance tests which the apparatus must pass are also specified. These regulations should render the new radio apparatus quite safe without appreciably increasing its cost. They do not apply to radio apparatus, such as a crystal set, which is not connected with the mains. Even in this case, care has to be exercised in installing the devices when the building is wired for the electric light. Shocks have been received when using headphones or when handling apparatus connected with the earth owing to the operator accidentally touching at the same time a portable metal lamp standard, an electric heating or cooking appliance, a metal switch

or similar device, owing to it having accidentally become 'alive' due to the development of a fault in the electric wiring.

SENATORE MARCONI and G. A. Mathieu have recently developed a multiplex system of radio communication, using short waves. We learn from Marconi's that experiments made at the Marconi beam station at Bridgwater have been completely successful. Music has been sent from Montreal, using the same apparatus and aerials as those through which two simultaneous Morse telegraph messages were being sent. The music was received at full strength and the quality was excellent, so that the Bridgwater party could dance to the strains from across the Atlantic. There was no hint of Morse interference, and it was impossible to tell that the music of the dance band was being transmitted from Canada on the same radio circuit as a high-speed 'dot and dash' service. The Bridgwater receiving station was built by the Marconi Company in 1926 for the General Post Office, which gave permission for the present experiments to be made. The new apparatus enables all the beam stations equipped with it to deal with three times the amount of work they can do at present. As some of the present simplex stations are working almost to their full capacity, this new invention is a very timely one. Instead of having only one channel of communication between each transmitter and receiver, it will be possible to use at least three. An appreciable economy in working will therefore be effected. Empire broadcasting at a comparatively low cost is also rendered possible. When equipped with multiplex apparatus the Empire beam stations can transmit broadcasting at the most suitable time for any part of the Empire without in any way interfering with the ordinary commercial services. It is claimed that with the new apparatus the effects of 'fading' are considerably diminished. At the present time the multiplex equipment at the Canadian beam station near Montreal and the receiver at Bridgwater are the only instruments in use. It is hoped, however, that in a few weeks' time multiplex working between England and Canada will have been achieved.

DURING the daytime many thoroughfares in London are choked with vehicles, and extensions or repairs of underground cables and pipes have become almost impossible. In addition, new services make it necessary to dig deeper and deeper in order to get an unobstructed passage, and the modern practice of laying wood blocks on a concrete foundation makes excavation very difficult. The loss also entailed on the public, and especially on shopkeepers, when excavations are in progress is serious. The London Traffic Act of 1924 has done good work by appointing a permanent committee as a co-ordinating authority. The only logical plan appears to be to construct subways or tunnels under the footways or roadways or both, which will accommodate in an orderly and readily accessible manner the plant at present laid in a haphazard manner over the whole of the roadway. This is the plan which E. S. Byng advocates in *World Power* for April. Although subways were constructed in London nearly sixty years ago, yet their development has been very slow. The Post Office, however, has made some useful subways. In Paris, the very extensive system of tunnels and galleries built under the main boulevards has proved of the greatest value to public utility companies. In Madrid there is a useful system of underground canals which is largely utilised. Twenty years ago, sixty miles of tunnels were constructed under the main thoroughfares of Chicago at considerable expense. They are 7½ feet high by 6 feet wide, and are lined with concrete. As a general rule, American cities have not adopted subways, but in Los Angeles and other places the engineers are being forced by the increase of traffic to consider their possibilities. It would be advisable to widen the powers of such bodies as the London Advisory Committee so as to enable them to provide for both present and future requirements.

THE centenary of the birth of Eduard Suess, the illustrious author of "Das Antlitz der Erde," is to be commemorated in Vienna, where for half a century he was professor of geology, by the erection of a public monument. British geologists will welcome an opportunity of celebrating the occasion, for throughout the world the brilliant work of Suess has been a source of inspiration to his admirers during at least two generations. Moreover, the name of Suess will always be intimately linked with England, since it was in London, at 4 Duncan Terrace, Islington, that he was born in 1831. The council of the Geological Society of London has had the happy thought of paying a fitting tribute to his great services to geology by placing a memorial tablet on the house in which he was born. The permission of the owner of the house and of the local authorities has already been obtained, and fellows who may wish to contribute to the cost, which will amount to about ten guineas, are invited to send a small subscription (not exceeding five shillings) to the Secretary of the Geological Society, Burlington House, W.1.

BEFORE and after the British Association meeting at Glasgow there are to be geological excursions, led by the president and local secretary of Section C (Geology). The numbers going on these excursions are necessarily limited, but there are still a few vacancies. One excursion (Aug. 30–Sept. 5) led by Mr. E. B. Bailey, is to Ballachulish and Fort William to see the cauldron subsidences of Glencoe and Ben Nevis, recumbent folds and slides of Ballachulish and Fort William, and the parallel roads of Glen Roy. This visit has been arranged to help the Discussion of "Highland Problems" which appears in the programme of the meeting. The other excursion is to Arran (Sept. 12–19), to see the schists, Highland border rocks, Old Red Sandstone, Carboniferous, New Red Sandstone, and the Tertiary igneous complex. It will be led by Dr. G. W. Tyrrell, whose Geological Survey Memoir on the district is expected to be published before the meeting. Applications to join these excursions should be made to

Dr. G. W. Tyrrell, Geological Department, University, Glasgow.

IN recent years the Royal Scottish Museum in Edinburgh has made great progress in the display of its valuable collections both from an educative and an artistic view-point. The Report of the Director for the year 1927, issued from the Scottish Education Department, recounts further advances, the most interesting being the opening, on the occasion of a visit paid by Her Majesty the Queen, of a British Bird Hall in a new block, mainly destined for the development of the natural history department. The early opening of three new galleries, devoted to comparative ethnology, technology, and mineralogy, is foreshadowed. Educational activities bulk largely in the report. Daily demonstrations were given on subjects pertaining to art and ethnography or to natural history; lantern lectures and gallery demonstrations arranged by the Education Authority of Edinburgh were given to 2456 school children; a series of loan cases of natural history specimens for the aid of nature study is circulating in primary and secondary schools; and on one occasion the Museum was specially opened at the request of a party of 1400 Nottingham miners on their way to a football match in Glasgow, so that they might visit the Mining Hall. Many interesting and valuable specimens were added to the various collections by gift and purchase throughout the year, and the scientific importance of the cabinet collections of natural history has been appreciated by many experts. It is regrettable that a Museum visited by 468,504 individuals in the course of the year should have to complain of the poor sale of its post cards and descriptive publications.

DR. J. B. ORR, of the Rowett Research Institute for Animal Nutrition, Aberdeen, and Sir Arnold Theiler, formerly of the Veterinary Research Institute, Onderstepoort, South Africa, have been making a careful study of pasture and stock problems in Australia. Unfortunately Dr. Orr's visit has been only a brief one, but Sir Arnold Theiler will spend six months in the Commonwealth. Problems of pasture improvement and animal nutrition generally are being taken up by the Council for Scientific and Industrial Research, and it is hoped as a result of Dr. Orr's presence to arrange for the utmost co-operation between workers there and in other parts of the British Empire, particularly at Aberdeen. The question of how best to organise tropical agricultural research work in Australia or adjoining territories has been under discussion between the Council and the Empire Marketing Board for some time, and Dr. Orr's observations will no doubt weigh considerably with the Board when a decision comes to be made. The policy of the Council towards veterinary research will be based largely upon the recommendations to be made by Sir Arnold Theiler.

SIR JOHN RUSSELL arrived in Australia towards the end of May and was met by a formidable programme, designed to enable him to see as much of agricultural development and research as was possible in a limited time. Between the lectures which he has delivered in the capital cities at the invitation of the universities, he has visited all readily accessible places of interest, particularly in the irrigation areas of South Australia, Victoria, and New South Wales. The progress of these areas is of much importance to Australia from the point of view of her immigration policy, and the scope and need for scientific work are immense. Sir John will endeavour to arrange for close association between the Council for Scientific and Industrial Research and the Imperial Soils Bureau, the institution of which at Rothamsted was recommended last October by the Imperial Agricultural Research Conference.

AT the annual meeting of the Royal Society of New South Wales, held on May 2, Prof. J. D. Stewart delivered his presidential address on "The Application of Science to the Sheep Industry." He pointed out that it is essential for the prosperity of Australia that the pre-eminence of this industry be maintained by further development. Many of the problems of the pastoral industry are primarily due to the physiographical characteristics of Australia, its topography, climate, and variability of rainfall. Increase in sheep population alone will not advance the industry very far, unless certain conditions retarding progress are better controlled and improved methods of production are more actively stimulated. Some of the more important problems and weaknesses of the industry, including the control of drought by fodder and water conservation, longer range weather forecasting, and increased facilities for transportation were then discussed. The wide field that exists for investigations in animal nutrition was mentioned; the Council for Scientific and Industrial Research is already taking action in this matter. Research in animal genetics and a more scientific study of wool are also necessary. Attention was also directed to the control of pests by biological methods, and to the suppression of animal diseases by further research, and the better organisation of veterinary effort. The proposal of the Wool-brokers and Wool-growers and the Pastures Protection Boards (N.S.W.) to raise funds for research in problems of the sheep industry, shows that the industry is willing to assist in the investigation of causes that retard its development.

THE eighth Annual Report of the Industrial Fatigue Research Board (to Dec. 31, 1927) again illustrates the value of systematic inquiry into problems of national importance. The variety of the problems investigated under the direction of the Board is as remarkable as the success which has attended them. Researches in progress, briefly described in the report, include the physiology of ventilation, accident causation, the relation of age to the acquisition of dexterity, the problems of vocational guidance, the design of machinery in relation to the operator, sickness among cotton weavers, card-room operatives, and printers, weight carrying by women and load carrying by men, atmospheric conditions in mines, telegraphist's cramp, and methods of vocational selection. The results obtained from investigations so far completed are broadly reviewed and the conclusion is stated that

"the increase in rate of output on short shifts, the beneficial influence of short rest pauses, the importance of high illumination in fine processes, the disadvantageous effects on work involving muscular effort at high temperatures, have been repeatedly indicated in so many investigations . . . that they can be accepted as established within a high degree of probability and *ripe for experimental application on a large scale under practical conditions*." Another interesting investigation mentioned is that in which the effects of menstruation were studied. The results showed that "this strictly physiological phenomenon has, as a rule, no appreciable effect on working capacity amongst normal healthy women." Glimpses of the methods of investigation employed, as well as a brief summary of the results obtained, are also to be found in this report.

SOME criticisms of the use of airships in the Arctic have been made by Dr. W. Bruns, secretary of the new International Society for the Exploration of the Polar Regions by airship, known as Aeroarctic, which, according to a recent *Daily News Bulletin* issued by Science Service of Washington, D.C., is organising a polar expedition for next year in LZ127, the giant airship now being completed at Friedrichshafen. The small size of General Nobile's airship not merely prevented the carriage of equipment requisite for a forced landing, but also seriously limited the cruising radius. This limitation of radius, with the low-speed of the *Italia* (about 53 miles per hour), necessitated a base in Arctic regions exposed to the vagaries of Spitsbergen weather. The German expedition proposes to have a base outside the Arctic at Leningrad, and others at Murmansk and Nome, away from the unsettled conditions of the North Atlantic, and hopes for a cruising radius of about 8000 miles for its airship.

AN exhibition of maps illustrating the cartography of the British Empire was opened at the Science Museum, South Kensington, on June 28, and will remain open until the end of October. The exhibition has been arranged in connexion with the International Geographical Congress which meets this month in London and Cambridge, and the conference of Directors of Survey in the Dominions and Colonies. Most of the maps selected are those in current use, but the Ordnance Survey is showing a series of sheets illustrating the successive editions of the one-inch map from 1801 to the present day, and the Hydrographical Department of the Admiralty is contributing a number of charts from the eighteenth century and a series of charts of the Downs from 1795 onwards. An exhibit has been arranged to illustrate from various parts of the world the stages through which map-making has passed. There are examples of the sailing chart of the Marshall Islanders, wooden relief maps of the Greenland Eskimo, a world map from about 700 B.C., and several reproductions of medieval maps. Sixteenth and seventeenth century maps are also represented. In an adjoining gallery there is an exhibition of modern surveying instruments. Catalogues of the exhibition are available.

ON Thursday, June 28, at a reception held at the Ross Institute and Hospital for Tropical Diseases, Putney Heath, the Harben Gold Medal of the Royal Institute of Public Health for 1928 was presented by the Viscount Leverhulme, honorary treasurer of the Institute, to Sir Ronald Ross, in recognition of his eminent services to the public health.

IT is announced in *Science* that Congress has adopted a resolution providing for the striking of a gold medal commemorative of the achievements of Thomas A. Edison, and the presentation of the medal to Mr. Edison by Congress.

BARON FERENCZ VON NOPCSA, of Vienna, and Prof. Frederico Sacco, the distinguished palæontologist of Turin, have been elected foreign members of the Geological Society of London. Dr. W. J. Jongmans, of Heerlen (Holland), and Señor Don César Rubio y Muñoz, of Madrid, have been elected foreign correspondents of the Society.

THE Eastman Kodak Research Laboratory at Rochester, N.Y., is recognised as one of the foremost in the world, and has been responsible for many important scientific and industrial developments in relation to photography. It is under the directorship of Dr. C. E. K. Mees. A research laboratory in London is to be developed on similar lines, as part of the Kodak factory organisation at Harrow, and will be under the direction of Dr. Walter Clark, of the Science Museum, South Kensington. Dr. Clark is a graduate of University College, London, and was for five years with the British Photographic Research Association. He is honorary secretary of the seventh International Congress of Photography being held this year.

THE Research Association of British Paint, Colour, and Varnish Manufacturers has issued the first number of a *Review of Current Literature relating to the Paint, Colour, and Varnish Industries*. The review is arranged in a convenient form and should prove to be of great service to all those connected with these industries.

A HANDBOOK to Tasmania was prepared for the members of the Australian Association for the Advancement of Science on the occasion of its meeting in Hobart in January this year. There are chapters on different aspects of natural science by various Tasmanian authors. Particular attention may be directed to those on geology, botany, and forestry. There are also useful chapters on hydro-electric development, manufactures, and education, and a candid and thoughtful economic survey of the past and present. A coloured geological map and some excellent photographic views are bound with the volume.

MESSRS. Watson and Sons, Ltd., 313 High Holborn, W.C.1, have issued a catalogue of photomicrographic and projection instruments, which includes some useful hints for the beginner on photomicrography.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A head of the engineering department of the Hull Municipal Technical College—The Director of Education,

Education Offices, Guildhall, Hull (July 11). A demonstrator in the physics laboratory of the Royal Naval Engineering College, Keyham, Plymouth—The Secretary of the Admiralty (C.E. Branch), Whitehall, S.W.1 (July 12). An assistant to the head of the Plant Disease Research Division of the Ministry of Agriculture for Northern Ireland, and an assistant to the head of the Ministry's Dairy Bacteriology Research Division—The Secretary, Civil Service Commission, 15 Donegall Square West, Belfast (July 14). Junior assistants at the National Physical Laboratory, Teddington—The Director, National Physical Laboratory, Teddington (July 14). Two geologists on the Geological Survey of Great Britain—The Director, Geological Survey and Museum, 28 Jermyn Street, S.W.1 (July 14). A mycologist at the Royal Horticultural Society's Gardens—The Director, Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey (July 16). An assistant professor of physics at the Military College of Science, Woolwich—The Assistant Commandant, Military College of Science, Red Barracks, Woolwich, S.E.18 (July 21). A fellowship for research work in connexion with aeronautics—The Clerk, The Company of Armourers and Brasiers, 81 Coleman Street, E.C.2 (July 28). A mechanic to take charge of the college workshop, and laboratory stewards for the chemistry and physics departments of the University College of Hull—The Secretary, University College, Hull (July 29). A second in command to the Chief of the Economic Botany Division of the Commonwealth Council for Scientific and Industrial Research—The Acting Secretary, Commonwealth Council for Scientific and Industrial Research, 314 Albert Street, East Melbourne, Victoria (Aug. 31). An investigator for work on the Flying Fox (*Pteropus spp.*) problem in Australia—F. L. McDougall, Australia House, Strand, W.C.2 (Aug. 1), or The Acting Secretary, Commonwealth Council for Scientific and Industrial Research, 314 Albert Street, East Melbourne, Victoria (Sept. 1). A part time professor of highway engineering at the City and Guilds Engineering College—The Academic Registrar, University of London, South Kensington, S.W. 7 (Sept. 4). Lecturers in applied chemistry and in economic entomology in the University of Queensland—The Secretary, Queensland Government Offices, 409 Strand, W.C.2. A lecturer in mining subjects at the Mansfield Technical College—The Principal, Technical College, Mansfield. A lecturer in chemical engineering at University College, London—The Secretary, University College, Gower Street, W.C.1. A woman laboratory assistant with knowledge of botany, physics, and chemistry, at Bedford High School—The Head Mistress, High School, Bedford.

Our Astronomical Column.

TELESCOPES OF THE FUTURE.—It seems very possible that certain innovations may be made in the construction of telescopes. Larger aperture seems required without much additional weight; the solid, thick disks for reflectors are difficult to cast, mount, and utilise in an efficient manner, and atmospheric disturbances affected their performance in no small degree. For general work, the really large instruments have been often discarded for smaller sizes by Herschel, Rosse, and Lassell, being found more serviceable and expeditious.

Prof. G. W. Ritchey, of Pasadena, California, who has worked for some time in Paris, had a considerable share in the making and mounting of the 100-inch reflector at Mount Wilson and has experimented with several instruments of large size. He concludes that "future optical mirrors will be made not of solid disks but built up of glass plates; light, cellular structures, cemented together and figured at high mountain sites" where they are intended to be employed. He says that he hopes to make a reflecting telescope with a practically perfect mirror 50 feet in diameter. He describes details of his project in the *Journal of the R.A.S. of Canada* for May-June 1928, and expresses himself with confidence in regard to the realisation of his plans.

Prof. Ritchey's experience gives great weight to his opinions, and it is to be hoped that his researches will ultimately place a greater and more efficient telescope in the hands of those dealing with some of the greater questions in astronomy which require the help of more instrumental power than that hitherto employed. The immediate future may therefore witness the dawn of a new astronomy, if combination disks of glass plates, light and easily manipulated, can be utilised. They may carry practical astronomers far beyond the limits reached by means of their previous equipment.

THE CURVE OF SUNSPOT ACTIVITY.—S. Oppenheim, in *Astr. Nach.*, No. 5566, discusses the sunspot activity of the last two centuries and obtains a curve with several periodicities, the longest period being 450 years, and the principal one 11¼ years. He conjectures that the long period is identical with that suspected in terrestrial magnetic phenomena, the duration of which is given as between 450 and 500 years. He notes that some variable stars have a second periodicity much longer than the principal one (Mira 218 years, R.V. Tauri 3·6 years). He gives a curve from his formula which is compared with that from Wolf's sunspot numbers. The agreement is close except for the present maximum. His curve gives a sharp maximum at 1928·5, higher than any since 1870; the observations up to the present point to a low flat maximum considerably below that of 1917. The high maximum of 1778 and the low one of 1816 are very well represented.

THE ORBIT OF COMET PELTIER-WILK.—This comet was independently found by Mr. Peltier in the United States and by Mr. Wilk of Cracow. Its definitive orbit has been deduced by Mr. F. Kepinski, also of Cracow. The observations ranged from Nov. 21 to Dec. 30, 1925. They are divided into six groups, which are all well represented by the adopted orbit, the largest deviation being 2″.

The following are the elements:

T	1925 Dec. 7.267395 U.T.	
ω	126° 7′ 13·46″	1925·0
Ω	140 34 35·59	
i	144 36 22·22	
e	1·0005047	
log q	9·8828482	

This adds another to the considerable list of comets the orbits of which appear to be hyperbolic; the deviation from a parabola in this case is so small that it can reasonably be ascribed to planetary perturbations.

Research Items.

PHYSIOLOGICAL COST OF MANUAL LABOUR.—The subject of Report No. 50 of the Industrial Fatigue Research Board (London : H.M. Stationery Office) is the physiological cost of the muscular movements involved in barrow work, by Dr. G. P. Crowden. Although labour-saving devices have gradually eliminated many heavy manual occupations, yet processes still remain which make heavy muscular demands on the worker. In many industries where continuous transport is involved, loads are usually conveyed by truck or barrow. The movements investigated were those demanded by heavy barrow work of the kind employed in the production of 'Fletton' bricks. A single barrow worker will move approximately 10,000 burnt or finished bricks, or 8000 unburnt or green bricks, in a working day of 9 hours. As a finished brick weighs about $5\frac{3}{4}$ lb., a worker may transport more than twenty-five tons of bricks through distances varying from 25 to 75 yards in a day. The physiological cost of part of the process was investigated in order to determine : (*a*) the relative importance of the factors involving oxygen consumption on the part of the worker ; (*b*) the optimum condition under which such work may be performed. By physiological cost is meant the amount of oxygen used during work and recovery in excess of the amount used during an equal period of time, the subject being in a resting state. The conditions for maximum efficiency on the part of the barrow worker were studied by experiment and observation, and various suggestions made for the improvement of barrow design so as to ensure for the worker the best posture. The appendix gives an interesting account of the application of the recommendations made to routine works' practice, and the report of the works' manager who supervised them.

THE ORIGINS OF BIRDS.—It has generally been considered that the fossil bird *Archæopteryx* was the forerunner of modern birds, and that from fully accomplished flying birds the ostriches and their relatives were derived by processes of degeneration. New light has been thrown on the question in an important paper by Dr. P. R. Lowe (*Proc. Zool. Soc.*, p. 185 ; 1928). The wide distribution of the struthious group in prehistoric times is suggestive of an early origin, and so far from insular restriction indicating potential degeneracy towards flightlessness, through lack of incentive to continued flight, it is probably no more than the expression of the survival of a stock the efficiency of which led to its disappearance elsewhere in the face of more stern competition. A detailed analysis of the distribution and structures of the feathers, and of the skeleton and musculature of the wing and other regions of the body, instead of pointing to degeneration from a flying type, indicates rather a true primitive condition, the wing itself being more closely related to a generalised non-volant sauropsidian fore-limb than to a volant carinate limb. The development of modern struthious birds is arrested at a stage not much more advanced than the downy stage of a fowl. *Archæopteryx*, the *Struthiones*, and the *Tinamous* are regarded as three side issues of the avian stem, which have arisen in the order named, the first being most closely related to the original reptilian ancestry. This arrangement of origins, however, would seem to imply that the perfected feathers of *Archæopteryx* and of modern flying birds had been attained independently, unless it be assumed that modern birds branched at some point from the *Archæopteryx* side-shoot.

A CONSTANT TETRAPLOID HYBRID.—*Digitalis purpurea* was originally crossed with *D. ambigua* by Gärtner in 1849. In a paper by Mr. B. H. Buxton and the late Mr. W. C. F. Newton (*Jour. of Genetics*, vol. 19, No. 3) the F_1 hybrid is compared with the parents. The leaf-shape of the two parents is very different, and the length-breadth ('phyllic') index of the F_1 is intermediate, the flower characters showing features from both parents. Contrary to earlier counts, the haploid chromosome number is 28. The F_1 hybrid is intermediate and the F_2 is similar but larger, and cytological examination showed that the plants are tetraploid ($2n = 112$). Very few of the F_1 plants produced seeds, the few viable pollen grains occurring as dyads following a division of all the chromosomes after failure to pair and undergo a reduction division. All plants resulting from open-pollination of the F_1 were triploid and sterile. This is an additional case of a new polyploid form arising from a cross and breeding true. The cytological examination makes it clear what has happened and why the hybrid must remain constant and be regarded as homozygous, although of heterozygous ancestry.

ORIGIN OF THE RAND GOLD.—An important investigation of the areal distribution of the pay streaks within the Main Reef group of gold-bearing conglomerates on the Rand has recently been carried out by Leopold Reinecke, and his results and conclusions appear in the *Trans. Geol. Soc. S. Africa*, vol. 30, pp. 89-119 ; 1928. New criteria bearing on the genesis of the gold and the location of payable ore-bodies in advance of mining operations have been successfully established. It is concluded that the arrangement in plan of the pay-streaks in relation to the folding, fracturing, and dyke-intrusion that has occurred since the banket was formed, definitely disproves the precipitation hypothesis and indicates that subsequent redistribution of the gold has been merely local. The origin of the gold as a stream-deposited placer is proved by the close relation between the highly payable belts and the lines of maximum currents deduced from the lenses of conglomerate. The current lines form a braided pattern spreading out to the east, thus supporting Mellor's deltaic hypothesis in its essential features, but tending to show that the reefs should perhaps be alternatively interpreted as flood-plain deposits laid down at some distance from the sea. The coarseness of the reefs points to very unusual conditions of flooding, and Reinecke considers that the most likely agency for causing the requisite floods would be an ice sheet or glacier which could pick up alluvial gravels in the foothills of a mountain range to the west and deposit a load of coarse debris far down the broad plain of a great valley.

GEOPHYSICAL METHODS OF PROSPECTING.—Prof. A. S. Eve and Dr. D. A. Keys (U.S. Bureau of Mines, Technical Paper 420, 1927) have presented in simple language a general survey of modern geophysical methods of prospecting. Such a survey in the English language has long been overdue, and it is to be hoped that it will assist in some degree to remove much of the scepticism with which geophysical methods are regarded at the present day. By virtue of the very simple treatment afforded, this paper is but an introduction to a rational and fundamental study of the subject, but the authors do not fail to indicate where necessary the difficulties of interpretation, and the need for the employment of experienced geophysicists and geologists in this work. Only the

principal methods are discussed, namely, the magnetic, gravitational, electrical, and seismic methods, while the secondary methods, which have as yet been inadequately tested, are enumerated, and the fundamental distinction between the purely scientific methods and the 'psychological' methods, such as the divining rod, is aptly emphasised. It is to be hoped that the U.S. Bureau of Mines will continue the issue of papers dealing with the different aspects of geophysical prospecting, and thus make available the vast amount of literature now widely scattered in places inaccessible to the average student of the subject.

THE TANGO (JAPAN) EARTHQUAKE OF 1927.—The fourth volume of the *Bulletin of the Earthquake Research Institute* (Tokyo, 1928) contains seven papers on this important earthquake, the strongest felt in Japan since 1923. Of one of the most detailed accounts (pp. 159-177) by Messrs. N. Yamasaki and F. Tada, a summary has already been published (NATURE, vol. 120, p. 967). Another account, by Prof. A. Imamura (pp. 179-202), adds several points of interest. In addition to the permanent displacements along the Gomura and Yamada faults, and for about ten miles westwards along the coast, a temporary elevation of about two or three feet seems to have occurred along the coast about 2½ hours before the earthquake. Small sea-waves were also observed at several places, the water being first lowered by about 4 feet and then raised by the same amount above the normal level. General H. Omura (p. 223) illustrates the results of the repeated triangulation of the district. Assuming that a pair of stations to the south were unchanged in position, it would seem that the horizontal dislocation is almost equally distributed on both sides of the Gomura fault. A slight counter-clockwise twist is also to be recognised over the whole seismic area. Precise levellings made in April (H. Omura, p. 225) indicate that the western side of the Gomura fault and the northern side of the Yamada fault were upheaved and the opposite sides lowered by amounts increasing towards the faults. The levellings were repeated after the lapse of forty days, and these show that the changes revealed by the first series were increased in the immediate neighbourhood of the Gomura fault but diminished elsewhere.

NEON LAMPS.—According to a recent *Daily Science News Bulletin*, issued by Science Service of Washington, D.C., a new neon lamp has been developed at Schenectady which employs an incandescent cathode in place of the cold cathode of the tubes used at present for illuminated signs. Elimination of the cathode dark space and cathode fall of potential in this way increases enormously the ratio of the light produced to the power supplied, and at the same time reduces the rate at which gas disappears under the influence of the discharge. No details of the design of the tube are given, and it will be particularly interesting to see how the problem of preventing rapid disintegration of the cathode by positive ion bombardment has been solved. The new light has been tested in fog on the Hudson River, and could be picked out from boats more readily than other lights in the vicinity.

PORRO PRISM FIELD GLASSES.—The first binoculars embodying a Porro prism system were made under the direction of Prof. Ernst Abbe at the Zeiss works at Jena in 1893, and the manufacture of prism binoculars has been carried on continuously by the firm since that date. Developments in recent years have been directed mainly towards obtaining an enlarged field of view and increased light transmission. The various models now being made by Messrs. Carl Zeiss are illustrated and described in catalogue T 380, which has been recently issued by the firm. In addition to the well-known models having object glasses of 24 mm. and 30 mm. respectively, and a magnification of 6 or of 8 and an apparent angular field of view of about 51°, there are wide angle instruments giving a magnification of 8 and a real field of view of 8·75°, or an apparent angular field of 70°. There are also larger binoculars magnifying 10, 12, 16, and 18 times, with high light-transmitting power, for use in sea and air navigation and for other special purposes. Corresponding to the majority of these glasses, monocular models are supplied for use with one eye and, for purposes in which an instrument of small size and weight is required, a miniature monocular (× 8) is included, the outside dimensions of which are 1 in. × 1½ in. × 2½ in.

THE MOLECULAR WEIGHT OF HÆMOCYANIN.—Hæmocyanin is a blue pigment which is the respiratory agent in the blood of certain lower animals (*e.g.* Mollusca, Crustacea, and Arachnida). In many ways it is analogous to hæmoglobin, the respiratory pigment in the blood of higher animals, but the metallic constituent of hæmocyanin is copper, while that of hæmoglobin is iron. Different kinds of hæmocyanin appear to exist, since specimens from different species differ in copper content. The *Journal of the American Chemical Society* for May contains an account of an investigation of the molecular weight of hæmocyanin carried out by T. Svedberg and E. Chirnoaga. The material used was prepared from the blood of the vineyard snail *Helix pomatia*, and the isoelectric point was found to be at *p*H 5·2. Both sedimentation velocity and sedimentation equilibrium methods gave a value of 5,000,000 ± 5 per cent for the molecular weight, while centrifugal experiments at a high speed of rotation indicated that all the molecules of hæmocyanin were of equal weight and practically spherical with a radius of $12{\cdot}1 \times 10^{-7}$ cm. The authors therefore consider this protein to be a chemical individual.

THE PREPARATION OF CHLORIDE-FREE COLLOIDAL FERRIC OXIDE.—The stability of colloidal ferric oxide is usually explained by assuming that the ferric oxide particle (micelle) consists of x molecules of insoluble Fe_2O_3 and y molecules of a soluble salt, known as the 'solution link.' If the ferric oxide sol is prepared from ferric chloride, some of the latter would act as the 'solution link' and the micelle would have the formula $xFe_2O_3 . yFeCl_3$. The removal of the chlorine by ionisation would account for the positive charge carried by the particle. In view of the widely differing values obtained for the iron–chlorine ratio of such colloidal solutions by numerous investigators, C. H. Sorum has attempted to obtain a constant ratio by carrying the dialysis to the extreme limit of completeness, and his results, which are described in the *Journal of the American Chemical Society* for May, are of considerable interest. It was found that stable ferric oxide hydrosols giving no reaction for chlorine could be prepared from ferric chloride. These sols remained uncoagulated even after dialysis at 90°–97° C. for five weeks, and were not precipitated after twelve months. In view of the fact that the amount of chlorine present was less than 0·0001692 gm. HCl per litre, and that great care was taken to exclude other electrolytes, the 'solution link' theory does not seem to account for their stability.

New Buildings at University College, Nottingham.

AS already announced in NATURE, the new buildings of University College, Nottingham, are being opened by their Majesties the King and Queen on July 10. They form a worthy monument to Sir Jesse Boot, by whose generosity they have been provided. They occupy a good position in the new University Park, and provide ample accommodation for a large Arts Department, for four of the main branches of science, and for the Department of Pharmacy; they also include a large assembly hall, a library, a refectory fitted with all modern requirements, and commodious common rooms for men and women students.

CHEMISTRY DEPARTMENT.

The Chemistry Department forms a 'T' shaped building and, with the exception of the basement stores and a room for large scale operations, comprises two floors. In planning it two very important considerations have been kept in mind: first, that the main laboratories should be amply supplied with daylight and means of ventilation; and secondly, that the service store-room should be centrally placed and easily accessible from all parts. In accordance with these requirements four of the main laboratories are lighted both from above and from side windows and their walls are of white glazed tiles; draught is provided for fume chambers and fume hoods on the working benches by means of numerous fans; with these arrangements it would seem that even at busy times the atmosphere of the laboratories will not be unpleasant. The service and supply stores are centrally situated on the main floor, the former opening directly into the largest laboratory and being very conveniently placed for all the other important rooms. The main laboratory will accommodate about 80 students at one time; opening out of it are two smaller rooms, one of which is for physical chemistry. On the same floor there is another large laboratory for inorganic work, a lecture theatre which seats about a hundred, and a class room with accommodation for about forty students; lecture experiments for the theatre and class room will be got ready in an adjoining preparation room. The professor's room and chemistry staff room are also on this floor.

The principal laboratory for organic chemistry, with working places for about thirty students, is on the floor above. Adjoining it are the professor's laboratory and other small laboratories, followed by the Chemistry Museum—for minerals and specimens, and ending with a joint departmental library for physics and chemistry. Each of the three larger laboratories has its own balance room leading out of it.

PHYSICS DEPARTMENT.

The Physics Department is compact, the most frequented rooms being connected by short passages or stairs. The rooms are arranged thus: Workshop on ground floor; lecture rooms, teaching laboratories, and store rooms on the first floor; research laboratories and professor's room and staff room on the second floor. The lecture theatre contains about one hundred seats, the steps of the seating rising from the lecture table on the isacoustic principle. The lecture lanterns are placed in front of the lecture tables and the screen is above the lecturer, so that lantern experiments and slides can be seen by the audience to the greatest advantage. The laboratory teaching is done in four large rooms, of which the largest has a floor space of 72 ft. by 36 ft. Steady tables are obtained by fixing them either on basement walls or on outer walls of the building. The circuit supplies to all laboratories and lecture rooms include direct and alternating high tension current, low tension current by bare copper rods, gas, water, steam, compressed air and exhaust. The research rooms are four in number, the largest having an area of 44 ft. by 28 ft. The workshop floor space, in two rooms, is 54 ft. by 25 ft. In order to protect the rooms above from vibration and noise from the machinery in the workshop, the shafting is carried, not on the ceiling of the workshop, but on a girder frame in the room, attached to the basement floor. The equipment includes four lathes, one of which is a Lorch-Schmidt, milling, shaping, and several drilling machines. A heavy lift connects the three floors of the department.

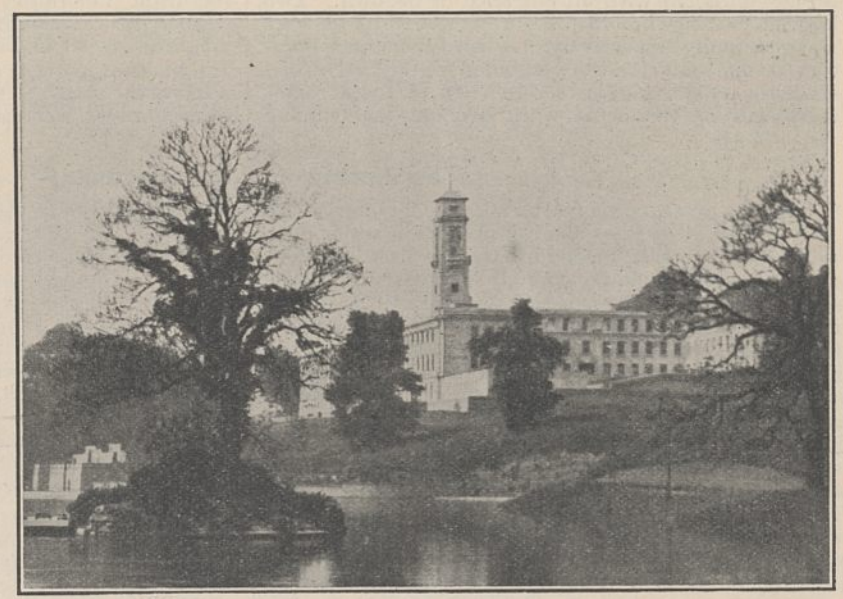

FIG. 1.—New buildings, University College, Nottingham, from the south-east.

The accommodation in this department should suffice comfortably for, say, 150 undergraduates and future post-graduate research students, as well as for research by members of the staff.

BIOLOGY DEPARTMENT.

The Department of Biology comprises a lecture room accommodating about eighty students and three main laboratories. Of these, the general laboratory, which will be used both by botany and zoology students, contains fifty-four working places, each fitted with a microscope cupboard and a drawer for books and instruments. The advanced laboratory will be used by senior botany students

(including post-graduates) and accommodates thirty workers. The third main laboratory is equipped for bacteriology, its fittings including a large culture-cabinet for the storage of stock cultures. A dark room and photomicrographic equipment is attached to this laboratory. Small research laboratories are provided for the head of the Department and members of the staff.

In addition to the laboratories there is a teaching museum, the long window case of which is convertible into a working bench. Senior zoology students will work here, and provision has also been made for the storage and study of medicinal plants and specimens. A plot of land has been set aside for experimental field studies and plant houses in the grounds behind the department.

DEPARTMENT OF GEOLOGY AND GEOGRAPHY.

The Department of Geology and Geography occupies the ground floor in the back western wing of the new buildings. It is compactly arranged and is self-contained with an entrance of its own. Two large elementary laboratories are provided for geology and geography respectively. A third spacious laboratory is set aside for the combined use by advanced students in both subjects. In each of these rooms there will be the usual work benches and tracing tables, together with adequate drawer accommodation for those geological collections which are in most frequent use and for maps of all kinds. There will also be glass-fronted wall cases for the exhibition of teaching series. The museum will be similarly equipped for the preservation and demonstration of more valuable exhibits. A room with seating accommodation for nearly forty students has been set aside for lecture purposes, whilst a suite of smaller rooms is being furnished for such purposes as staff research laboratories, classroom, preparation room, dark-room, and store room. A wide corridor, which connects all these rooms, will be fitted with additional show cases, and with cupboards for the storage of wall maps.

PHARMACY DEPARTMENT.

The Pharmacy Department consists of a large dispensary, a class room, and a model manufacturing laboratory, and shares with the Biology Department a laboratory-museum for pharmacognosy. The manufacturing laboratory is fitted with steam-heated copper pans, vacuum and fractionating stills, ovens, etc., and electrically-driven drug grinding machinery. An enclosed portion of this laboratory is devoted to apparatus used in testing, such as a polarimeter, refractometer, microscopes, and balances.

The Aurora and its Spectrum.[1]

THE two outstanding features that characterise the spectrum of the polar aurora are a set of four well-marked bands belonging to the first negative group of nitrogen, and a strongly defined very narrow spectral line in the green, the wave-length of which, measured by Babcock with a Fabry and Perot interferometer, was found to be $5577{\cdot}35 \pm 0{\cdot}005$ A. Less important features are a set of bands belonging to the second positive group of nitrogen and a miscellaneous, and as yet unidentified, set of sixteen lines or narrow bands. The auroral green line, the identity of which was for long unknown, was shown in 1925 by McLennan and Shrum to originate in gaseous atomic oxygen. This spectral line exhibits great variations in intensity with changing conditions of excitation. Helium and neon when mixed in excess with oxygen enhance the intensity of the line. Argon does the same thing, but to a much greater extent. In 1927, McLennan and McLeod established the identity of the oxygen green line with the auroral green line beyond question, through obtaining $5577{\cdot}341$ A. $\pm$ 0·004 A. for the wave-length of the former by the use of a Fabry and Perot interferometer.

The region in which auroræ generally occur in the upper atmosphere has for its lower boundary a height of approximately 80 km., and for its upper limit a height of more than 400 km. Auroræ occur with greatest frequency and brilliance at a height of 98 km., but they have been observed so high as 1000 km. It follows, then, that oxygen and nitrogen must be constituents of the earth's atmosphere up to these great heights. Through the work of Campbell, Lord Rayleigh, Slipher, and others, it is now known that on any clear night in any latitude, the whole sky is glowing with a faint green light, which is monochromatic and has the same wave-length as the 'green line' of the polar aurora. While the polar aurora appears to be excited by streams of electrons emitted by the sun from time to time, the green light of the non-polar aurora appears to originate through the action of some other agent.

The presence of the first negative bands of nitrogen in the spectrum of the aurora connotes an 'excitation potential' of 19·6 volts, while the absence of any nitrogen bands in the spectrum of the non-polar aurora imposes an upper limit of 12·6 volts for the 'excitation potential' of the oxygen-auroral green line. With such 'excitation potentials' applied to oxygen, the only wave-lengths, with two doubtful exceptions, other than $\lambda 5577{\cdot}341$, known to originate in atomic oxygen, that could be emitted, lie too far in the ultra-violet or in the infra-red to appear in spectrograms taken hitherto of the auroral light.

The theoretical spectral term scheme formulated for atomic oxygen provides for two low metastable states, namely, $^1S_0$ and $^1D_2$, in addition to the normal $^3P_{012}$ levels. The recent work by Bowen on spectra of nebulæ makes it clear that so-called 'metastable states' are but states of long mean life, and that provided the gases involved are at a sufficiently low density, one may expect emission of radiation, corresponding to transitions between levels ordinarily designated as metastable. In such transitions it will be noted that the electronic azimuthal quantum-number selection rules must necessarily be violated.

Under similar density conditions it is clear, from Bowen's work, that transitions are to be expected in which the inner quantum number selection rules also may be violated. In an investigation recently carried out by McLennan, McLeod, and Ruedy, photographs were obtained with a powerful echelon spectrograph of the magnetically resolved components of the auroral green line. The structure was shown to be that of a normal Zeeman triplet, and this result, combined with other evidence available, goes to show that the transition $^1S_0 \rightarrow {}^1D_2$ is the one that gives rise to the auroral green line.

In an attempt to learn something of the agent responsible for the emission of the auroral green light from clear night sky, several series of observations were recently made by McLennan, McLeod, and Ireton, on the intensity of light received from the zenith in the course of a single night. In this investigation two lines of procedure were followed. In the one case several spectrographs of high light power were constructed and used to photograph the green line at

[1] Abstract of the Bakerian Lecture delivered by Prof. J. C. McLennan, F.R.S., before the Royal Society on June 28.

intervals throughout the night; in the other case, a continuous record of the intensity was obtained by means of a filter and slit moving over a photographic plate. With the most efficient of the spectrographs used, it was found possible to obtain satisfactory spectrograms of the green-line radiation from the night sky with exposures so short as 30 minutes.

By co-ordinating all the results obtained during a period that included observations on nine consecutive nights, it appears that from sunset onwards there is a gradual increase in the intensity of the auroral light from clear night sky. The intensity reaches a maximum at about an hour after midnight, and from that time onwards until sunrise it gradually lessens.

Haddock Biology.

IN *Fisheries, Scotland, Sci. Invest.*, 1927, III. (January 1928), Dr. Harold Thompson continues his account of recent investigations into the economy of the haddock fisheries. In this paper he deals particularly with the haddock of the north-western North Sea, including the Moray Firth, the bight on the east Scottish coast (Buchanness-Fife Ness) and the Firth of Forth.

Two matters are of special interest. For the first time on record, living haddock marked and released were recaptured. The haddock is a delicate fish to handle, and efficient implements of capture, such as the trawl, damage the fish beyond hope of recovery. Thus it is necessary to employ the tedious method of hand-lining for securing the specimens to be marked. A total of 1112 fishes were marked and released at different times during the years 1923–27. Of these, only 57 were recaptured, mostly within three months from liberation. It is thus seen that large numbers of haddock would require to be marked to secure a fair number of returns, especially of fish absent more than three months.

In his extremely interesting study of the fluctuations in the annual recruitment of haddock stock by new brood, Dr. Thompson demonstrates that there are great differences in the number of surviving brood haddock during a series of years. In the extreme case in the North Sea, the numbers contributed in a specially good survival year may be twenty-five times more than those of an unusually poor year. Natural variations of this order, occurring at source, place the question of 'fishing out' or 'overfishing' in a new light.

The experience of recent years has been that, provided that a cycle of good to moderate brood years is experienced, the severe pruning effect of the fisheries is more than counterbalanced. On the other hand, a succession of poor to moderate years inevitably leads to an outcry on account of the scarcity of haddock, and at such times attacks are made on the present-day methods and intensity of fishing. Since the War there has been in the North Sea an example of both a poor and a good cycle of brood years. Thus, the years 1921 and 1922 produced a pair of broods almost negligible in numbers, and the years 1923 to 1926 good, or at least moderate, broods. In 1922, 1923, and the first part of 1924 the haddock catches in the North Sea dwindled away to an unprofitable point, but from the latter part of 1924, when the splendid 1923 brood had reached a marketable size, the average catch per unit of time kept mounting up until the winter of 1926. Since then, however, the average catches in the North Sea generally have tended steadily to fall to a more regular level, but to increase in the area north-west of Scotland. The main cause of this fluctuation was the gradual elimination of the prolific and widely distributed 1923 brood, together with its normal movement towards the north and west, which are the localities where the haddock makes its chief home in later life. The broods of the succeeding years 1924 to 1926 were not capable of maintaining the increased average catches occasioned by the 1923 brood.

The Public Library System of the United States.

IN the year 1926, with the assistance of the Carnegie United Kingdom Trustees, a visit was paid to the jubilee conference of the American Library Association by a representative body of British librarians. The observations of six of these were published by the trustees last year under the title "Some Impressions of the Public Library System of the United States of America." The value of this report induced the trustees to invite two other British librarians, Miss K. E. Overbury and Dr. E. E. Lowe, to attend last year's annual conference of the American Library Association, held in Toronto.

As the American public library system is probably more developed than that of any other country of the world, this account of a pilgrimage among American libraries cannot fail to be of interest to librarians in England. The publication is confined to aspects of the subject which were not treated at length in the earlier report.

In the United States, the public libraries are definitely considered as part of the educational machinery of the country. It is evident that a rapidly growing nation, with a large immigrant population of all nationalities, must use every means of educating its new citizens rapidly. The public library service is a ready and efficient means of accomplishing this object. Consequently, work with the schools and children is probably more developed in the United States than elsewhere; although, of course, this may be due in part to the preponderance of women librarians, and their natural regard for children. Collections of books for children are sent to schools by a large majority of the libraries. In many libraries there is a well-appointed children's room with a specially trained librarian. Children come to the library room in groups for a library hour under supervision. Stories are told and book-talks given. This story-hour has been the cause of considerable discussion, and librarians have been divided in opinion as to the value of the service. It continues, however, to be developed.

A particular feature of the progressive libraries in America is the number of the staff, which is very much greater than is provided in Great Britain. Excellent provision is made for their accommodation and comfort; one library has a luxurious lavatory with five baths and hot-air blasts for drying, instead of towels.

Another speciality are the numerous well-organised travelling libraries, like those of Samuel Brown in Scotland from 1817 to 1836. Book vans in the States serve isolated communities, which are too small to have a branch or deposit station. The vans have 'stops' in various sparsely populated districts and also visit houses. A valuable feature is the social side of the work. Miss Overbury recounts a humorous occasion when the librarian, who had left books on poultry for the farmer's wife, inquired after the chickens and whether the books had been useful; the farmer replied favourably, adding, "My wife reads the books and I look after the poultry."

S. C. B.

University and Educational Intelligence.

CAMBRIDGE.—Dr. H. S. Carslaw has been elected to a supernumerary fellowship and Dr. E. C. Stoner to a research fellowship at Emmanuel College. Dr. H. Godwin has been re-elected to a research fellowship at Clare College. Dr. P. I. Dee has been elected to a Taylor research fellowship at Sidney Sussex College. Mr. G. F. C. Gordon, Trinity College, and Mr. L. G. P. Thring, Trinity College, have been reappointed as superintendents of the engineering workshops and drawing office respectively.

J. D. Solomon, Trinity College, has been awarded the Harkness scholarship in geology, and K. M. N. Paterson, Newnham College, has been awarded the Wiltshire Prize in geology. The Frank Smart prizes in botany and zoology have been awarded to S. Clay, Emmanuel College, and J. B. Harman, St. John's College, respectively.

DURHAM.—The following appointments have been made in the Durham division of the University of Durham: Mr. J. A. Chalmers has been appointed lecturer in physics in succession to Dr. R. K. Schofield, who is joining the staff of the Rothamsted Experimental Station. Mr. Chalmers went from Highgate School with a Foundation Scholarship to Queens' College, Cambridge, where he obtained first class honours in physics in Part 2 of the Natural Sciences Tripos in 1926. He has since been a demonstrator in the Cavendish Laboratory. Miss E. Marion Higgins has been chosen to fill a lectureship in botany which was vacated by Dr. Elsie Phillips on her marriage. Miss Higgins is a graduate with first class honours in botany of the Royal Holloway College, London, and has for two years been a demonstrator and research student in the University of Liverpool. She has published papers dealing with marine algology.

A NEW Department of Geography has been created in the Faculties of Arts and Science. Mr. Gordon Manley, who has been made lecturer in geography, graduated from Caius College, Cambridge, with first class honours, and with distinction in climatology in Part 2 of the Geographical Tripos. At Cambridge he worked on geodetical problems under Sir G. Lenox-Conyngham. He was a member of the Cambridge Arctic Expedition to Greenland in 1926, and conducted pendulum observations there. Since 1926 he has been assistant lecturer in geography at the University of Birmingham.

EDINBURGH.—At the graduation ceremonial on Thursday, June 28, the Honorary Degree of Doctor of Laws was conferred on, among others, Sir John Rose Bradford, president of the Royal College of Physicians, London; Prof. F. G. Donnan, professor of general chemistry in the University of London; Prof. J. Cossar Ewart, professor-emeritus of natural history in the University of Edinburgh; Dr. R. A. Fleming, president of the Royal College of Physicians, Edinburgh; Dr. G. L. Gulland, professor-emeritus of medicine in the University of Edinburgh; Mr. J. A. Hood, founder of the James A. Hood chair of mining in the University of Edinburgh; Mr. H. S. Wellcome, founder of the Wellcome Research Laboratories at Gordon College, Khartoum, and of the Wellcome Bureau of Scientific Research, and the Historical Medical Museum, London; Prof. Niels Bohr, professor of theoretical physics at the University of Copenhagen.

The Degree of Doctor of Science was conferred on Mr. E. T. Copson, for a thesis entitled "(*a*) Some Problems in the Theory of the Partial Differential Equations of Mathematical Physics; (*b*) Some Applications of Holder's Inequality"; Mr. J. W. Donaldson, for a thesis entitled "The Heat Treatment, Volume Changes, and Thermal Conductivities of Grey Cast Iron between 15° and 600° C."; Dr. J. A. Hawkins, for a thesis entitled "A Gasometric Method for Determination of Reducing Sugars, and its Application to Analysis of Blood and Urine"; Mr. A. R. Urquhart, for a thesis entitled "The Adsorption of Water by Cotton."

OXFORD.—At the Encænia on June 27, the degree of D.Sc. was conferred on Lord Melchett of Landford. In his Latin speech introducing Lord Melchett, the Public Orator alluded to his advocacy, both theoretical and practical, of scientific research in its bearing on useful ends.

In a Convocation held on June 29, Viscount Grey of Fallodon was admitted and installed as Chancellor of the University, in succession to the late Viscount Cave. The speech of the Public Orator, in welcoming the new Chancellor, contained an apt reference to his skill in ornithology, and, with a glance at his literary and piscatorial pursuits, a classical play on the words "musæ" and "muscæ."

ST. ANDREWS.—In accepting the resignation of Prof. J. A. C. Kynoch from the chair of midwifery in the University, on his having reached the age limit as one of the visiting medical officers of the Dundee Royal Infirmary, the University Court records its high appreciation of the services rendered by him as the occupant of the chair for a period of thirty years, and as Dean of the Faculty of Medicine from 1909 until 1920.

Dr. George Forbes has presented to the University the books forming the library of his father, the late James David Forbes, for twenty-seven years professor of natural philosophy in the University of Edinburgh, and for nine years, until his death in 1868, Principal of the United College of St. Salvator and St. Leonard in the University of St. Andrews.

The degree of D.Sc. has been conferred upon the following: N. M. S. Langlands, for a thesis on experiments on binocular vision; W. Saddler, for a thesis on form theory with its associated geometry; R. F. Thomson, for a thesis on dyestuffs and optically active bases.

MR. F. W. ANDERSON, a graduate of Leeds, has been appointed assistant lecturer in zoology and geology at University College, Southampton.

OF the summer vacation courses for teachers in England, those arranged by the Education Committee of the West Riding of Yorkshire, to be held at Bingley on Aug. 1-15, are noteworthy for the wide range of choice of subjects offered. The programme comprises eleven courses in all, including one, conducted by Dr. H. W. T. Wager, on "The Teaching of Nature Study," intended to give guidance in the teaching of natural history in schools. Biological theory will be dealt with and the relation of biology to instruction in health will be discussed. The time-table is so arranged that students following this or any other of the special courses will be able to attend also a general course on matters of current interest in education, including, "The Library and the School," "The Modern or Central School," "Vocational Guidance," "School Journeys," "The Doctor and the Teacher," and "Drama and the School." Simultaneously, courses in physical training and swimming will be given in the neighbouring town of Ilkley.

Calendar of Customs and Festivals.

July 5.

ST. MODWEN, also known by many other names, such as Monynna, Moninia, Moduenna, Nodwenna: a saint probably of the ninth century. Of royal Irish birth, she is said to have ministered in Ireland, England, where she is associated particularly with Burton-on-Trent and the island of Andresey (otherwise the Isle of St. Andrew, to whom a shrine there was dedicated), and Scotland, especially at Stirling and Galloway, where she built three churches. She is also reputed to have made three pilgrimages to Rome, one when well over the age of one hundred years. The multiplicity of her names, and the peculiarities of the records of her missionary journeys and pilgrimages, have led to the suggestion that three saints, one for Ireland, one for Scotland, and one for England, have been confused. Her connexion with Saint Brigit and with a retinue of nuns who accompanied her wherever she went, suggests that, like that saint, her legend has grown by accretions reminiscent of a pagan deity, and that the cult of this goddess was localised at many places in the three countries, or that the acts of the saint incorporate three separate deities in a synthetic personality. She is sometimes identified with St. Etain, Edania, Etavin, or Heidin, of Tumba, Co. Roscommon, also venerated on this day. The grave of the latter lay near the ruins of her church, while near a church called Killoscoban was a well sacred to her, to which many resorted for spiritual comfort and the healing of disease.

July 7.

OUR LADY OF CHARTRES.—On this day is observed a festival in honour of the Virgin Mary at Chartres, the oldest and most important shrine of the Virgin in France. This is generally held to have been originally a pagan cult of the Gauls. A primitive wooden image of the deity and child, which was later identified with Our Lady, was an object of great veneration in the Cathedral until it was burned during the French Revolution. Another relic, however, still remains, the Veil of the Virgin, presented to the Cathedral by Charles the Bald in 876. It had been given to Charlemagne by the Empress Irene. The Veil is exposed at rare intervals only, the last occasion being in 1927, when the tenth centenary of the building of the crypt by Bishop Fulbert was celebrated. The last occasion previously was 1876, on the one thousandth anniversary of the gift of the relic.

July 9.

At Wolverhampton on this day, the eve of the great fair, which in the time when the wool trade flourished, was a great resort of wool merchants, a procession took place in which men in antique costume, musicians, peace officers, and many of the prominent inhabitants took part. The fair lasted eight days by the charter, but seems to have been prolonged to fourteen. It was finally discontinued by the Lord of the Manor. It is an interesting example of a local celebration which had, through commerce, grown to national or, owing to the relations of the wool trade with Flanders, even to international importance. Antiquarians have at different times suggested various explanations of the procession, some connecting it with the necessity of a town guard to keep order, which would make it an analogue of the setting of the watch in London and elsewhere; others have regarded it as a survival of the Corpus Christi celebration.

July 10.

ST. ETTO (seventh century).—An Irish missionary saint, known in French as Zé. He passed over to France and made pilgrimage to Rome, finally settling in the diocese of Cambrai. He is held in great veneration by the peasantry, and at Liesses a great festival with processions is held annually in his honour on July 10. Near Dompierre there is a fountain of Zé. Among the peasants he is invoked for the cure of diseases and the prolongation of life, as well as to avert distempers from the cattle and other animals.

July 13.

ST. ERNON or ARNEY of Enniskeen, partly in Co. Louth and partly in Co. Cavan, where his festival was celebrated on this day and stations performed at a holy well now dried up. There was also a large block of stone outside the church, on which, significantly, the Holy Mass used to be celebrated at times of persecution.

July 15.

ST. SWITHIN'S DAY, actually falling, according to calendrical reckoning, on July 2, is usually regarded as the fifteenth day of the month. Some parish accounts, which record expenditure by the churchwardens, indicate that on this day a form of celebration must have taken place, although no other record appears. According to widespread popular belief, rain on this day will be followed by rain for forty days. Reference to this belief as current among husbandmen is made by Ben Jonson in "Every Man in his Humour" and there are numerous other references in literature which show that it is a popular belief of long standing.

The traditional origin of the superstition is that St. Swithin, bishop of Winchester, who died in 865, was buried in the open churchyard at his own request. Many miracles were wrought at his tomb, and the monks, therefore, on his canonisation wished to honour him by moving his body to the choir of the church. The removal was to have taken place in a solemn procession on July 15, but it rained so violently on this and the succeeding forty days that the removal was abandoned, and instead a chapel was erected over the grave. The fact is, however, that the site of his grave was forgotten until the tenth century and his relics were translated to the Cathedral church in 971, and in 1093 removed to the present church, founded in 1079.

On several occasions in the year forecasts of the weather are based on its character on a particular day or a particular season. Some are traditional experience, such as the prognostication of the weather in the coming year from the direction of the wind on New Year's Eve, or the belief that a mild clear New Year's Day foretells hard weather up to May. In the Highlands of Scotland a fine Shrovetide is said to bring a foul Easter. On the other hand, some such prophecies suggest a magical or religious basis. The belief in the power of spirits in the twelve days preceding Epiphany, which in a more refined form becomes a conception of their peculiar sanctity, underlies the idea that each of these days foretells the weather in one month of the year. Other saints' days and festivals are associated with forecasts of weather, and usually for the period of forty days following, for example, the duration of the classical Halcyon Days, when the kingfisher sat on its nest, St. Vincent, Jan. 24; St. Paul, Jan. 25; Candlemas or the Purification of the Virgin; St. Processus and St. Martinian, July 2; St. Martin, July 4; as well as St. Swithun. The German custom of casting the image of the saint into a river, recorded on St. Paul's day (see under Jan. 25, NATURE, Jan. 21, p. 121), suggests that this association probably arose from some rain-bringing ceremony or invocation similar to those which take place at the tombs of Moslem saints (Westermarck, "Ritual and Belief in Morocco," pp. 244 *sqq.*).

Societies and Academies.

LONDON.

Royal Society,[1] June 21.—E. S. Semmens: The selective photo-chemical action of polarised light (Part 3). Well-washed potato starch grains, in distilled water, disintegrate under the influence of a Tyndall beam of light, polarised by the colloidal particles of diastase, contained in an outer vessel. The stages of hydrolysis bear a strong resemblance to those formed under ordinary diastatic action, suggesting that the polarisation of the incident radiation of heat or light is an important factor in the action of colloidal catalysts. As catalytic action takes place at surfaces, the possibility of some correlation between the constant plane of vibration of the radiation and the definitely orientated force fields or electron orbits of the molecular surface layers is indicated.

W. R. Brode and R. A. Morton: The absorption spectra of solutions of cobalt chloride, cobalt bromide, and cobalt iodide in concentrated hydrochloric, hydrobromic, and hydriodic acids. The principal absorption band of cobalt chloride in concentrated hydrochloric acid was shown previously to consist of six superimposed component bands. The frequencies of the maxima of these bands, and also of bands in the blue and green regions, are always, within the limits of error, integral multiples of 12·28 f. Cobalt bromide in concentrated hydrobromic acid gives similar bands. Corresponding bands of the chloride and bromide systems are given by the use of the same integers, but with fundamental frequencies of 12·28 and 11·70 respectively. Cobalt iodide in hydriodic acid also shows banded absorption, the frequencies of maximum absorption being integral multiples of a fundamental frequency of 10·79 f.

T. M. Lowry and G. G. Owen: The mechanism of chemical change. (1) Promotion and arrest of the mutarotation of tetra-acetylglucose in ethyl acetate. Solutions of tetra-acetylglucose in dry ethyl acetate have been prepared which were sufficiently pure to show no change of rotatory power during a period of several hours. The addition of a drop of water does not initiate mutarotation, but a rapid change is induced when a drop of dilute acid or alkali is added; the mutarotation curves are, however, inflected instead of unimolecular, as if the action had been resolved into two consecutive stages. Since the action of alkali was the same when the polarimeter tube was rinsed with the solvent and refilled with a second sample of the clean dry solution, it appears possible that these inflected mutarotation curves are characteristic of surface action, whereas the normal unimolecular curves are developed by homogeneous catalysis.

C. H. Gibson and C. N. Hinshelwood: The homogeneous reaction between hydrogen and oxygen. The combination of hydrogen and oxygen at temperatures between 500° and 600° C. has been studied by a static method. Above 500° a homogeneous reaction comes into play. The reaction is markedly accelerated by steam, but also by gases such as helium, nitrogen, and argon. The results can be interpreted by assuming reaction chains propagated through the gas. These chains are broken by de-activation of molecules in a heterogeneous reaction at the walls of the vessel, and lengthened by inert gases, which increase the time during which molecules escape contact with walls. The order of effectiveness of various inert gases can be correlated with diffusion coefficients.

H. Glauert: The characteristics of a Karman vortex street in a channel of finite breadth. The theory of the drag due to the formation of a vortex street behind a body has been developed by Karman, and is now extended to the case where the breadth of the vortex street is not more than one-sixth of the breadth of the channel. The formula obtained for the drag of the body is similar to that given by Karman and involves two parameters which must be determined experimentally. By means of certain assumptions it is possible to predict the constraint of the channel walls in terms of the flow in an unlimited fluid. These assumptions are valid for bodies of bluff form only.

K. R. Rao and A. L. Narayan: On series in the spark spectra of germanium. To aid in the identification of the important groups of different stages of ionisation, the spark spectrum of the element under different conditions of excitation has been photographed from λ6500 to λ2080, and measured with an accuracy of about 0·05 A. About eighty lines of germanium have been analysed. The spectrum of Ge II has been almost completely analysed. In the spectrum of Ge III, series of sharp and diffuse triplets have been detected, converging to a common limit. Series in the spectrum of Ge IV have been extended to the region of long wave-lengths, members of the secondary series being found.

N. K. Adam: The structure of thin films (Part 11). With the object of measuring the cross-section of the benzene ring, in the plane of the ring, the behaviour of various derivatives of resorcinol and phloroglucinol, with long chains in the ring, has been studied in the monomolecular surface films. The main object has not been attained, since no substances could be found which formed films in which the benzene ring was both lying flat on the water and packed closely against the rings of neighbouring molecules in a similar position. The hydroxyl groups in the ring seem to increase the attraction of one ring packed face to face on another, and this increase is more important for orientation than the increase in the attraction for the water, caused by the hydroxyl groups. In the case of compounds with a resorcinol group at each end of a long chain, which form gaseous films, cohesional corrections to the gas laws are diminished by acetylating the hydroxyl groups, and the area of the molecule is increased, confirming the view that the molecules lie flat in the gaseous films.

E. Newbery: Metal overvoltage measurements with the cathode ray oscillograph. Experiments on metal deposition with the aid of the cathode ray oscillograph show that overvoltage and transfer resistance do not occur unless a gas is being liberated at the electrode. Hydrogen is always deposited along with metal when the metals of the iron group are separated electrolytically from pure solutions of their respective salts, and this gives rise to hydrogen overvoltage at the cathode. This exceptional behaviour is probably due to hydration of the ions of these metals.

G. B. Bandopadhyaya: Photoelectric effect of soft X-rays. The number of photoelectrons liberated from twelve different elements under soft X-rays from a copper target has been measured with a special quartz tube. The relative photoelectric sensitiveness is of same order as observed under ultra-violet light. From the critical potentials it is inferred that under soft X-rays by far the greater number of photoelectrons come from the valency orbit, or from orbits very close to it, and have energies below 10 volts.

A. Caress and E. K. Rideal: On the chemical reactions of carbon monoxide and hydrogen after collision with electrons. The decomposition of carbon monoxide into carbon and carbon dioxide (also some suboxide), and its union with hydrogen to form

[1] Continued from Vol. 121, p. 1042.

formaldehyde (and polymers) under excitation by electron impact have been examined. Hydrogen atoms produced by thermal dissociation react directly with carbon monoxide molecules, and also react with enhanced efficiency with carbon monoxide positive ions. This increase in reactivity is attributed to either a chain or a cluster mechanism. Hydrogen molecules react with carbon monoxide positive ions, but more readily with ions excited to the $2\ ^2S$ level: the reaction products have been obtained in quantities sufficient for chemical tests.

F. P. Bowden and **E. K. Rideal**: The electromotive behaviour of thin films. (Part 1) Hydrogen. A quantitative investigation of the changes of electrode potential at the surfaces of metallic cathodes during the electrolytic deposition and removal of very small quantities of hydrogen show that the electrode potential is a linear function of the surface concentration of the hydrogen, and the potential of the polarised cathode depends only on the true surface concentration of the added hydrogen, and is independent of the nature of the underlying metal. Apparent differences observed are due to differences in real areas of cathodes. The amount of hydrogen deposited is small, sufficient to form 1/3000th of an atomic layer, causing a change of 100 millivolts in electrode potential. The results can be explained on the assumption that electrode potential is due to electric doublets on its surface, the electric moment of these doublets being that of a proton and electron separated by a distance equal to the diameter of the hydrogen atom. (Part 2) The areas of catalytically active surfaces. The real area of cathode surfaces has been evaluated by measurement of amount of deposited hydrogen required to raise the potential by a definite increment. The real area of metal sponge, such as platinum black, may easily attain a value two thousand times its apparent area. The real area of a sand-papered metal is about ten times its apparent area, and nickel activation by alternate oxidation and reduction causes an increase of nearly fivefold. Rolling reduces real area. Specific catalytic activity of various metals differs widely, but for any one metal specific activity of the surfaces only suffers small variations by chemical or thermal treatment. Violent mechanical treatment, such as sand-papering or rolling, causes marked increase in activity.

W. Payman: The detonation wave in gaseous mixtures and the pre-detonation period. An experimental method has been developed for photographing the invisible shock or compression waves sent out through a gas mixture on detonation of a solid or gaseous explosive in contact with it. The effect of position of point of ignition on initial movement of the flame in a closed tube has been examined; the observed retardation of the flame seems to occur simultaneously with the break-up of flame front into two separate portions moving in opposite directions. Visible evidence has been obtained of the movements of the hitherto invisible compression waves. These are not due to the spark, as has been previously supposed, the spark-wave being comparatively feeble. The compression waves travel at speeds much greater than that of sound in the gaseous medium through which they are passing, and appear to be due to renewed chemical activity of some kind behind the flame front. Similarly, the detonation wave appears to have its origin behind the flame front.

G. P. Thomson: Experiments on the diffraction of cathode rays. (2) Further experiments on the diffraction of cathode rays by films of aluminium, gold, and platinum show very close agreement with the de Broglie wave theory. Deflexion in a magnetic field shows that the diffracted rays have the same velocity as the undeflected rays within 1 per cent. A large number of diffraction rings can be seen when a magnetic field is used, which is analogous in its action to the achromatising effect of a prism on Newton's rings. The rings are all of the sizes predicted by the wave theory from the crystal structure. From the observed resolving power the minimum number of waves in a train is about 50 for the beam of cathode rays used.

R. Ironside: The diffraction of cathode rays by thin films of copper, silver, and tin. The patterns are like those got in X-ray powder analysis, consisting of a series of concentric rings, with modifications. These patterns may be interpreted on the de Broglie hypothesis by considering an electron as a group of waves, and only by this theory has an explanation of the phenomena been derived. There is a discrepancy of 1 per cent between the cathode ray and X-ray methods of determining the crystal spacing. According to theory, the product of the diameter of a given ring in the pattern due to a given metal and the square root of the voltage used in producing it should be constant (except for $\frac{1}{2}$ per cent relativity correction for each 10,000 volts); the data derived from the experiments satisfy this test.

A. Reid: The diffraction of cathode rays by thin celluloid films. A probable structure for the films is derived; the experimental results agree with those predicted by the de Broglie theory.

W. E. Curtis and **W. Jevons**: The Zeeman effect in the band spectrum of helium. The Zeeman effects in two regions of the helium band spectrum have been investigated in fields up to 20,000 gauss with an 8-ft. concave grating (third order) and a Fabry-Perot 1-cm. étalon. Resolution of the magnetic components has only been effected in one case, but a great many instances of broadening have been observed; some information as to the polarisation of the components has been obtained by means of a double-image prism. In the case of those bands which are due to transitions between S and P electronic states, the results are completely in accordance with theoretical predictions. In the case of another band, details of which have not been previously published, the effects are relatively large throughout both Q and R branches (the P branch being too weak to observe) and they show similar polarisations. The final state of this band is known to be the $2P$ electronic state of the ortho-He_2 molecule, but the relation of the initial electronic state to the known term sequences of He_2 is not clear.

B. F. J. Schonland: The scattering of cathode rays. The author's recent cathode-ray scattering experiments are not suitable as an adequate test of the relativity correction to the orbit of a β-particle deflected by an atomic nucleus, owing to the effect of radiation and of the spiral form the orbit may take. An estimate is made of the amount of scattering to be expected, which is in fair agreement with that observed.

VIENNA.

Academy of Sciences, Feb. 2.—**A. Müller**: A convenient preparation of 1, 4-dioxy-*n*-butane (tetramethylene-glycol) and 1, 4-dibrom-*n*-butane.—**E. Rona** and **E. A. W. Schmidt**: A method of producing highly concentrated polonium preparations. Distillation of a gaseous polonium compound in the presence of a collecting metal.—**E. Bussecker**: Volatility curves of radium-*C* and -*B* deposited on gold by single and double recoil. A possible alloy between the active deposit and the gold leaf substratum.—**H. P. Cornelius** and **M. Furlani-Cornelius**: Report on

geological investigations on the Insubric line between the Tessino and the Tonale pass.

Feb. 9.—**E. Gebauer-Fülnegg and E. Riess**: The course of oxidation in aryl-sulpho-arylides.—**E. Gebauer-Fülnegg, E. Riess, and S. Ilse**: Studies on aryl-sulpho-chloride (2).—**S. Oppenheim**: The periods of sunspots: Besides the 11-year period there seem to be many others including a longer period of some 450 years comparable with the earth's magnetic period. As a variable star the sun may be compared to Mira Ceti and R. V. Tauri.—**O. Abel**: A contribution to the phylogenesis of horses: the phylogenetic position of *Hipparion* and *Neohipparion*. *Hipparion* is confirmed as a form between the Miocene and Quaternary horses; *Pliohippus* and *Plesippus* are apparently not direct ancestors of recent horses.—**R. Girtler**: The calculation of indeterminate kinetic-static systems.—**R. Pöch** (the late) Anthropological publications, vol. I. West African negroes were studied in prisoner-of-war camps.

Official Publications Received.

BRITISH.

Catalogue of Indian Insects. Part 14: Palpicornia. By A. d'Orchymont. Pp. iv+146. 2.8 rupees; 4*s*. 6*d*. Part 16: Cosmopterygidae. By T. Bainbridge Fletcher. Pp. v+33. 10 annas; 1*s*. Part 17: Yponomentidae. By T. Bainbridge Fletcher. Pp. iv+26. 8 annas; 10*d*. (Calcutta: Government of India Central Publication Branch.)

Hampstead Garden Suburb. Programme of the Coming-of-Age Celebrations, June 23rd to 30th, 1928. Edited by W. Loftus Hare. Pp. 66. (London: F. Howard Doulton and Co., Ltd.) 6*d*.

FOREIGN.

Ministry of Public Works, Egypt: Physical Department. Helwan Observatory Bulletin No. 33: Time Determinations and Observations of Wireless Time Signals, 1926, October and November. By P. A. Curry. Pp. 20. (Cairo: Government Publications Office.)

Bulletin of the American Museum of Natural History. Vol. 57, Art. 5: An Ornithological Survey of the Serra Do Itatiaya, Brazil. By Ernest G. Holt. Pp. 251-326+plates 6-19. (New York City.)

CATALOGUES.

McGraw-Hill Books on Mathematics and Physics. (List 13.) Pp. 16. (London: McGraw-Hill Publishing Co., Ltd.)

A Catalogue of Important and Rare Books on Zoology and Geology: including the Entomological Library of G. T. Bethune-Baker and a Selection from the Library of W. de Selys Longchamps. (No. 417.) Pp. 130. (London: Bernard Quaritch, Ltd.)

Addenda List for General and Industrial Laboratory Apparatus Catalogue. Eighth edition. Pp. 40. (London: A. Gallenkamp and Co., Ltd.)

Catalogue of Microscopes. Part 5: Photomicrographic and Projection Instruments. Pp. 501-532. 32nd edition. Part 6: Petrological Microscopes. 32nd edition. Pp. 601-624. (London: W. Watson and Sons, Ltd.)

Catalogue de livres anciens et modernes rares ou curieux relatifs à l'Orient. (No. 7.) Pp. 62. (Paris: Librairie Adrien-Maisonneuve.)

Old and Modern Books: Bibliography, English and Foreign Literature, Voyages and Travels. (No. 21.) Pp. 66. (Newcastle-on-Tyne: William H. Robinson.)

The Taylor-Hobson Outlook. Vol. 3, No. 9, June. Pp. 81-92. (Leicester and London: Taylor, Taylor and Hobson, Ltd.)

Diary of Societies.

WEDNESDAY, JULY 11.

ROYAL MEDICO-PSYCHOLOGICAL ASSOCIATION (Annual Meeting) (at West Riding Mental Hospital, Wakefield) (continued on July 12 and 13).

PUBLIC LECTURE.

THURSDAY, JULY 12.

INSTITUTE OF PHYSICS (at Institution of Electrical Engineers, Savoy Place, W.C.2), at 8.—Dr. C. E. Kenneth Mees: Physics in Photography.

CONGRESSES.

JULY 9–14.

SEVENTH INTERNATIONAL CONGRESS OF PHOTOGRAPHY, 1928 (at the Imperial College of Science and Technology, South Kensington).—Dr. A. Steigmann: Theory of Photographic Sensitivity.—Dr. Lüppo-Cramer: The Herschel Effect as a Regression Phenomenon.—L. A. Jones and V. C. Hall: On the Relation between the Time and Intensity in Photographic Exposure.—Dr. S. E. Sheppard and A. P. H. Trivelli: A Comparison of some Developers for Sensitometric Standards.—Dr. S. E. Sheppard and Crouch: A Machine for the Automatic Development of Sensitometric Strips.—L. A. Jones: Systematic Nomenclature in Photographic Sensitometry.—L. A. Jones and Russell: The Expression of Plate Speed in Terms of Minimum Useful Gradient.—O. Sandvik: On the Measurement of Resolving Power of Photographic Materials.—L. A. Jones and Chambers: High-Intensity Time-Scale Sensitometer.—Dr. E. P. Wightman and Quirk: Intensification of the Photographic Latent Image.—Dr. A. Steigmann: Silver Iodide in the Full-Ammonia Emulsion.—Prof. Dr. Emil Baur: Sensitisation and Desensitisation.—Prof. Dr. A. Lottermoser: Observations and Measurements on the Light-Sensitivity of Silver Halide Sols.—Prof. Dr. Fritz Weigert: On the Light-Sensitivity of Photographic Layers.—T. Thorne Baker and Balmain: The Effect of Temperature on the Sensitivity of Selected Photographic Emulsions and the Influence of Wave-length on such Temperature Effect.—O. Bloch: The Interaction of the Silver Halides in Emulsion Form.—Dr. F. C. Toy, and others: On Turbidity.—Prof. Dr. J. Eggert: On Secondary Processes in the Exposure of Silver Halides.—Prof. Dr. R. Luther: Sensitometric Studies.—Dr. F. M. Hamer: A Chemical Study of Desensitisers. Part I. An Account of the known Desensitisers.—Dr. D. A. Spencer: The Ferro-Prussiate Process; The Ferro-Gallic Process; The Diazo-Type Process; A New Application of the Ferro-Gelatine Process; Printing in Colours with Diazo Compounds.—H. W. Lee: The Modern Super-Speed Lens.—S. Jasienski: The Stereoscopic Effect of High-Aperture, Long-Focus Objectives.—N. Fleming: The Photography of Sound Waves.—Dr. Anderson: The Testing of Photographic Shutters; Lens Interferometry.—Prof. Hartridge: The Focal-Plane Shutter.—Capt. C. J. P. Cave: The Photography of Inaccessible Interior Architectural Details with a Spot-Light.—G. Auborne Clarke: The Photography of Clouds.—Prof. E. G. Coker: Photography as an Aid to the Study of Mechanical Stresses.—O. G. S. Crawford: Archæological Photography from the Air.—Capt. M. Hotine: On Photographic Surveying.—Prof. Namias: On Positives by Reversal.—A. R. Hinks: The Work of the Wild Phototheodolite in the Shaksgram—W. M. H. Greaves: Astronomical Spectrophotometry.—Dr. E. Viterbi: The Fine-grained Emulsion and its Application to Spectrography.—Mr. Elwell: Paper on and Demonstration of Talking Film.—A. J. Bull: Tone Rendering by Half-Tone Processes.—H. M. Cartwright: (1) The Progress of Photogravure Etching; (2) A Method of Colour Correction.—A. A. K. Tallent: Latest Applications of Pyro-Tanning Processes.—E. L. Turner: Modern Photo-Engraving Screens.—William Gamble: The Present Position and Future Possibilities of Photo-Engraving.—H. N. Durham: Mercury Printing Processes.—F. J. Tritton: The Uses of Colour Photography in the Printing Trade.—Prof. Dr. E. Lehmann: On his Two-Colour Process.—Dr. R. von Arx: Dye-transfer Process from Dye Mordant Images.—F. G. Tutton: The Value of the Chromoscope in Commercial Colour Photography.—Commander H. E. Rendall: A Paper on Tri-colour Cameras.—Dr. R. A. Houston: A Paper on the Colour Mechanism of the Eye.—Julius Rheinberg: Demonstration of Micro-Spectra Method of Colour Photography.—F. C. Tilney: Pictorial Photography: the Relation of Technical Advance.—H. Garnet and G. H. Oakden: The Original Binocular Stereoscopic Camera of John Benjamin Dancer.—Dr. E. Kuchinka: W. Fr. Voigtländer's Eight-inch Double-Objective, and other Large Objectives.

JULY 13, 14, AND 15.

MIND ASSOCIATION: ANNUAL MEETING AND JOINT SESSION WITH THE ARISTOTELIAN SOCIETY.

July 13.

At 5.—Mind Association (Annual Meeting) (at Clifton Hill House, Bristol), followed by a Joint Session with the Aristotelian Society, for which the following arrangements have been made:—

Friday, July 13.

At 8.—Chairman: Prof. J. A. Smith.—Address by Prof. G. C. Field.

Saturday, July 14.

At 10.—Chairman: Prof. Beatrice Edgell.—Symposium: The Nature of the Self and of Self-consciousness. Prof. G. Dawes Hicks, Prof. J. Laird, A. Dorward.

At 2.—Chairman: Prof. J. H. Muirhead.—Symposium: Bosanquet's Account of the General Will. A. D. Lindsay, Prof. H. J. Laski.

At 8.—Chairman: Prof. H. Wildon Carr.—Symposium: Time and Change. J. MacMurray, R. B. Braithwaite, Dr. C. D. Broad.

Sunday, July 15.

At 2.—Chairman: Prof. G. E. Moore.—Symposium: Is there a Moral End? Prof. J. L. Stocks, Prof. W. G. De Burgh, W. D. Ross.

At 8.—Chairman: Prof. T. P. Nunn.—Symposium: Materialism in the Light of Modern Scientific Thought. Prof. L. J. Russell, Miss L. S. Stebbing, Prof. A. E. Heath.

EXHIBITION.

MONDAY, JULY 9–SATURDAY, JULY 21.

ROYAL ANTHROPOLOGICAL INSTITUTE.—Exhibition of the Archæological Objects found by Miss G. Caton-Thompson in her Excavations in the Fayum, 1927–1928.

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.