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Cotton Research and Industry.

IN a recent issue (Mar. 10, p. 362) we directed attention to the scientific work being carried on in the cotton fields by the Empire Cotton Growing Corporation, and the possibility of this work being checked, if not discontinued, because of the difficult position in which the Lancashire industry finds itself. The publication of the reports of the experiment stations founded by the Corporation for the year 1926–27, comes therefore at an opportune moment ; as they throw a considerable light on the character of the research instituted —probably in the long run the most important of its many activities. A sound scientific basis appears to have been laid for the success of its effort to increase the quantity and improve the quality of the cotton being produced within the British Empire. These reports are collected in a handy volume of about 250 pages, interspersed with tables, diagrams, plates and maps, and placed before the public at the low figure of half a crown.

The founding of an experiment station concerned with any particular crop is by no means so simple a matter as it might appear, and usually follows years of local study. Even when the need for it has been demonstrated and the problem to be solved has been clearly defined, a thorough survey of the country has to be made in order to determine the most suitable site, special attention being paid to such economic factors as communications, transport facilities, supplies, as well as climate and soil. It is often found advisable to take up a small area of land for a couple of years to make sure that no adverse factors have escaped notice. This preliminary survey work of the Corporation, made at a time when no staff was available for the running of the stations, deserves a passing reference. Experienced officers were deputed to travel over practically all of the cotton-growing tracts in the Colonies ; and in this work the Corporation was specially fortunate in securing the co-operation of a number of senior members of the Indian agricultural service, who were permitted to retire on proportional pensions under the Reforms Scheme. A series of valuable reports has been sent in and published, and some idea was thus formed as to where research was most likely to be profitable.

As to the staffing of the stations, a wide net was spread over the scientific and agricultural schools in Great Britain, and selected students were encouraged by scholarships to undergo post-graduate training to fit them for cotton research.

The response was on the whole good, and many of these students are already at work. The stations reported on this year are naturally in all stages of development, varying from a few acres tentatively acquired, to large ones with full equipment and buildings, and the reports are in consequence of very different interest and value. It is evident, however, that the Corporation has within a remarkably short period succeeded, in spite of great difficulties in obtaining suitably trained officers, in building up an agricultural department of an entirely novel character, namely, one devoted to the study of one crop scattered over the whole range of British Colonies in the warmer tracts. There are in the present volume reports from Queensland, the Transvaal, Natal, Swaziland, Southern Rhodesia, the Anglo-Egyptian Sudan, Uganda, Nyasaland, Nigeria, and Fiji, prepared by plant breeders, entomologists, and agriculturists in charge of separate areas.

It must be remembered that the research work recorded in the pages of the reports is only a portion of that being conducted by the officers of the Corporation. The Cotton Research Station in Trinidad is not included; and it is somewhat difficult to draw the line between the Corporation's work and that of the existing agricultural departments of the various Colonies, because there seems to have been a gradual drafting of men sent out by the former into the expanding Colonial service, whenever it has been found possible to allocate funds for the purpose. The unity of aims and the perfectly amicable relations existing between the officers under these two controlling bodies is a marked characteristic of the work of the Corporation.

Before proceeding, however, to more detailed reference to the character of the scientific work embodied in these reports, it is natural to inquire why the local agricultural departments cannot deal with the work undertaken by the Corporation; and also why this particular crop—cotton—needs financial assistance from Great Britain, as against such staples as rubber, tea, and sugar, for which research is provided for locally. The answer to the first question is fairly simple. The agricultural department in any colony has charge of the whole of the crops grown within its limits; and it can rarely afford to depute an officer entirely to the study of one crop, however important.

The second question is not capable of quite so simple an answer, because it depends on the distribution of capital. The capital connected with the cotton industry is located in Lancashire, while that in tea, sugar, and rubber lies chiefly in the places where these crops are grown. The cause for this is to be found in the character of the raw material yielded by the plant in either case. The cotton plant produces, naturally, in the fields, a raw material in its finished state; and all that is required is for this to be collected, kept dry and clean, and sold to the local buyer for pressing and forwarding to the mills at home. But in tea and sugar, and at present in rubber, the produce of the plant is in such a condition that it has to undergo complicated treatment before it can be sent across the ocean. Taking sugar as an example, the canes are full of sweet juice which has to be expressed, and which is then liable to rapid deterioration in the air; and the more stable sugar has to be extracted from it on the spot as expeditiously as possible. Furthermore, the canes grown on an acre of land will vary in weight from, say, 20 to 50 tons or more, and the transport of this mass of material to the crushing mill is an important item of expenditure. For both of these reasons the sugar factory must be placed as near to the cane fields as possible; and the capital for the erection of an efficient, up-to-date sugar factory will run to some £200,000. A similar location of factory on the plantation is also necessary for tea and rubber; and in all three cases a large tract of land must be acquired and put permanently under one crop—which, in effect, adds considerably to the capital to be sunk on the spot. Moreover, whether the selling price be high or low, cultivation must proceed and the factory be kept going: in sugar, at any rate, closing down the factory in lean years would spell ruin.

The growing of cotton is under entirely different conditions. There is no local capital involved, and anyone who owns a bit of land can either grow it or not at will; when prices are high the area increases, and when low other crops are grown instead. Rotation of crops, practically impossible in the other staples mentioned, is a prime necessity, and is everywhere practised in native cultivation; therefore a change of crop is easily effected. To attempt to collect a levy on the growers for the prosecution of research would immediately curtail the area sown, and thus defeat the object in view. It is obvious then that, with cotton, the capital required to finance research must come from the mills; and the Cotton Corporation, as representing them, takes the part of the fairy godmother to the cotton growers. It acts on the principle that improving the quality is the surest way to increase the quantity, in that

it enhances the price received by the cultivator; and thus the two aims of the Corporation are inseparably connected. The most encouraging features in the project are that the class of cotton raised in British Colonies is, as a rule, distinctly better than that grown in the United States, which it is designed to replace; and also that land and labour cost less, and therefore it can be more cheaply produced.

One glance through the reports will convince anyone that each tract has its own set of problems, and in most cases may have its own limiting factors; and the idea of one central experiment station devoted to cotton growing can at once be abandoned. In the Union of South Africa the annual rainfall is the basal factor, and has been found to be distinctly unreliable; and, in addition, a minute insect attacks the leaves to such an extent that it is essential to breed types resistant to this pest. In Nigeria the limiting factor seems rather to be competition with other crops, coupled with transport difficulties, and a cotton fetching a high price is needed. Nyasaland is chiefly concerned at present with working out the most suitable rotations for three sets of conditions: European plantations, and native cultivation for high and low areas. Fiji is devoted to the finer counts, and can grow Sea Island cotton, but, owing to the practical disappearance of the market for this during recent years, is concentrating on obtaining a long-stapled type which is more marketable. Queensland, however well she may grow cotton, will sooner or later have to face competition between that raised by white labour and native grown from elsewhere. The Anglo-Egyptian Sudan, with its varying conditions of moisture—obtained solely by irrigation, by rainfall, and by the two together—practically covers the whole field of cotton breeding and cultivation. Speaking generally, these tracts appear to be able to grow perfectly good cotton, but all require the services of (1) plant-breeders to evolve the most suitable type of cotton to be grown, (2) entomologists to preserve it from the local insect pests, and (3) agriculturists to grow healthy crops at the least possible cost.

Probably the most promising direction for a permanent increase in cotton growing in the British Empire is at the moment in India, but that country has its own problems and its own well-developed scheme of cotton research. There are vast possibilities in the Sudan, and great hopes are entertained in the Union of South Africa.

It will be sufficient here briefly to refer to the work being carried out in these two places. The outstanding factor in South African research is the Jassid infestation, which has practically wiped out the standard varieties hitherto relied upon. It has been observed that hairiness in the leaves is a distinct hindrance to the development of this insect; and the plant-breeder at Barberton has succeeded in evolving hairy forms strongly resistant to the Jassid, and at the same time with the good qualities of those forms it is necessary to replace. This result is being hailed with satisfaction by the planters everywhere, and the strains obtained will apparently also be required in Southern Rhodesia. This piece of research is particularly creditable, in that it has been conducted under most disheartening conditions; a record drought has visited South Africa during the last three years, again and again spoiling the experimental plots.

The report from the Sudan covers more than forty pages; but considering the large tract of country dealt with and its greatly varying conditions, this is not at all excessive. Special attention is now being paid to the southern, more tropical section, where a good deal of native cultivation has been inspected during the year. Although there is plenty of work still to be done in the northern, irrigated areas, it is perhaps to this southern rain-fed tract that we may look for the greatest permanent increase in cotton growing. A good deal of exploratory work is thus included in the report, and this portion is extremely interesting. Observations are recorded on the gradually changing vegetative covering of the country, with the increasing rainfall on going south; and studies are mentioned of root range and the character of the different layers of soil in various place—always a matter of interest in the Sudan—as indicating likely areas for expansion. Variety plots have been laid down and a certain amount of selection has been begun among the native-grown crops.

It is obvious that a great deal of important scientific work is being done on the Corporation's experiment stations, all tending towards the ideal of making the Lancashire mills less dependent on the vagaries of the United States cotton supply; and it would be little short of a disaster if the work were checked at the present stage.

When a new disease broke out in the Java canefields and swept through the island from end to end, the planters, although smarting from a loss of £200,000 in one year, came together and agreed to tax themselves in support of a scientific department to fight the disease. The amount of

the levy was at first small, but it paid so well that it has been gradually increased, until the annual amount spent on scientific work is at present £100,000. Again, when the trade slump in 1921 threatened the Hawaiian sugar industry, the attitude of the heavily hit planters was expressed by the director of the experiment station in the following motto: "More investigation, more experimentation, more research, leading to higher yields per acre and lower costs per ton of sugar"; and there was no suggestion of the planters cavilling at this increase in their levy.

One result of the action in these two instances appears to-day in the fact that Java and Hawaii are producing more than five tons of sugar per acre, against round about two tons in all the other chief cane-growing countries [1]—a matter of some significance now that the sugar industry is in low water. The tea and rubber planters have within the last few years started their own research stations; at any rate one sugar concern, the Colonial Sugar Refining Company, runs its own agricultural, entomological, and mycological research; and a perception of the losses incurred by disease has in one case caused this company to multiply its mycological staff, so that every field on every estate can be thoroughly surveyed, and appropriate cultivation and scientific remedies applied. It is to be hoped that such will be the feeling inspiring the action of the Lancashire cotton trade, in the present deplorable condition of the larger section of this industry.

Botanical Records in the Rocks.

Handbuch der Paläobotanik. Von Prof. Dr. Max Hirmer. Mit Beiträgen von Dr. Julius Pia und Dr. Wilhelm Troll. Band 1: *Thallophyta, Bryophyta, Pteridophyta.* Pp. xvi + 708. (München und Berlin: R. Oldenbourg, 1927.) 48 gold marks.

IN a 'handbook' of palæobotany, botanists, geologists, and others interested in the story of plant-life in the past expect to find a summary of the labours of students who have made it their business to collect and interpret the botanical records of the rocks. Prof. Hirmer's volume in the main satisfies this requirement. Among the many questions which experts are expected to answer we may include the following: What light is thrown upon the evolution of plants by the samples of vegetation preserved in sedimentary strata? Does a comparison of the successive floras which have flourished on the earth's surface afford evidence of a continuous progressive development from simple to more complex types? Or is there reason to believe that a comparison of extinct and recent plants demonstrates a marked tendency towards recurrent cycles—a rapid rise to power and the successful colonisation of wide spaces on the part of certain groups, followed by their decline and by the apparently sudden appearance of new dynasties destined for a time to play the leading rôle in the world's vegetation?

In the second volume the author will no doubt deal with some or all of these general questions. The volume before us is mainly descriptive and carries us to the end of the Pteridophyta. Dr. Julius Pia contributes an introductory section on the preservation of plants as fossils, and to him have also been entrusted the Algæ and Fungi. No text-book of palæobotany is considered to be complete without a chapter on the various methods of fossilisation: there is, however, one aspect of the subject which is generally overlooked or inadequately treated. The present is in many respects the key to the past: geologists are accustomed to speak of the imperfection of the record, and it needs but little imagination to realise that the emphasis placed by Darwin on this imperfection was not exaggerated. On the other hand, we should be in a better position to form a just estimate of the proportion borne by fossils to the mass of contemporary vegetation if we had a fuller knowledge of what is now happening in different areas inhabited by trees or by herbaceous plants. We should like to know more about the conditions under which rivers are now accumulating in the sediments of deltas representative samples of the vegetation on their banks and on the higher ground watered by the parent streams; the relation of woody to herbaceous plants; the capacities of different kinds of vegetable debris to resist wear and tear; and so on. One suspects that many of the older floras are represented in the rocks almost exclusively by plants that were confined to certain habitats. By a closer study of the processes of rock-building at the present day, it might be possible to estimate with greater precision the chances of preservation of material derived from different geographical regions. Hints on the preparation of unpromising specimens for microscopical examination would have been a useful addition to the chapter on fossilisation.

The account of calcareous Algæ is on the whole very satisfactory; it directs attention to the wealth of form of such Algæ as the Dasycladaceæ in Mesozoic and Tertiary seas as compared with

[1] Maxwell, "Economic Aspects of Cane-Sugar Production," p. 57.

the relatively small number in the seas of to-day. The treatment of fossil Bacteria, of the problematical genera Pila and Reinschia, and of some of the other supposed Thallophyta, might with advantage have been more critical. Dr. Pia unfortunately reverts to the old name Prototaxites for the Silurian and Devonian plant which is usually known as Nematophyton, and he assigns it to the Brown Algæ. The systematic position of this genus is still very uncertain, but it is almost certainly not in the Phæophyceæ. At the end of each section is appended a bibliography, which is usually adequate. Dr. Troll gives a useful survey of the Bryophyta and directs attention to the important discovery by Mr. J. Walton of specimens of very modern-looking Liverworts in the English Coal Measures.

The greater part of the volume is written by Prof. Hirmer, who compresses much into his well-illustrated descriptions of the Palæozoic representatives of the several groups of Pteridophyta. Most of the figures are taken from previously published books and papers: diagrammatic drawings illustrating morphological features are a welcome addition, and restorations of Lepidodendra, Sigillariæ, and Calamites are in many respects an advance upon previous attempts. Students will be grateful to the author for having collected much information from widely scattered sources and for making it available to the botanical reader. In his summaries of the morphological characters at the end of the descriptive accounts, he makes many suggestive comparisons of extinct and living types, but he tends to over-emphasise points of detail, and does not sufficiently consider readers who desire to know in what respects such plants as Lepidodendron, Calamites, and other Palæozoic forest trees differed from their modern descendants.

In the account of Psilophytales, Rhynia and Psilophyton are placed in different families, a separation which it would be difficult to justify. The lack of secondary phloem in stems of Lepidodendron well provided with secondary wood is an interesting fact worthy of greater prominence. No evidence is furnished in support of the statement that Asterocalamites was widely distributed in Upper Devonian floras. The account of Mesozoic ferns compares unfavourably with that of the Palæozoic genera; it fails to bring out the contrasts in geographical range between extinct and recent species, and it does not sufficiently illustrate the relative antiquity of the several families. There is no reference to an important paper by Prof. Halle on the schizæaceous fern Ruffordia, and Dr. Bommer's description of Weichselia, a fern assigned on insufficient data to the Cyatheaceæ, is overlooked.

Such criticisms as have been made are not intended to be an expression of disapproval of the volume as a whole: on the contrary, the reviewer heartily welcomes the publication of a work which in some respects differs from all earlier books on palæobotany. The author undertook a very laborious and difficult piece of work; the first volume is by no means free from errors and its descriptive summaries are very unequal in value. We look forward with interest to the appearance of the second volume. A. C. S.

Lucretius.

T. Lucreti Cari de Rerum Natura libri sex. With Notes and a Translation by H. A. J. Munro. Fourth edition, finally revised. Vol. 2: Explanatory Notes. With an Introductory Essay on the Scientific Significance of Lucretius, by Dr. E. N. da C. Andrade. Pp. xxii+424. (London: G. Bell and Sons, Ltd.; Cambridge: Deighton Bell and Co., 1928.) 12*s.* 6*d.* net.

MUNRO was the chief scholar in Cambridge fifty years ago, and his study of Lucretius gave him a prestige such as pure scholarship confers no longer upon any man. He was a perfect editor in his own scholarly way; yet he brought little sympathy and less knowledge to bear on the scientific doctrines taught in the great scientific poem which he edited. He admits that Lucretius has produced "a very complete and systematical account of the natures and properties which belong to the two great constituents of the universe, matter and void"; but Munro says bluntly that "We of course care not for the scientific value or truth of the poem, but for its poetical grandeur and efficacy upon our imaginations."

Indeed it is full of fine things which charm our ears and stir our imagination. Phrases like 'mors immortalis' or 'flammantia moenia mundi' cling to the memory; the whole parable of the Talents is wrapped up close in 'vitaque mancipio nulli, datur omnibus usu'; and after two thousand years 'tantum religio potuit suadere malorum' has not lost its sting. But after all, scientific doctrine and not literary beauty is the main thing in this, the one great scientific poem of the world: so scientific men have prized this great epic for 'its scientific value or truth' ever since it was written. Celsus and his brother physicians (the scientific men of Rome) were all Epicureans, and doubtless

knew the poem by heart; Giordano Bruno and Gassendi preached its doctrines and impressed them on seventeenth century philosophy just when physical science was awaking to its first golden age; Boyle quotes the poem repeatedly; and later on Tyndall, Clifford, Kelvin and Clerk Maxwell himself, in their several ways and degrees, admired and praised it. Newton found in it (among other important things) a clear statement of the Galilean principle of the falling body: "Et quamvis res leviores, quæ æris vel aquæ resistentiam difficilius vincunt, in his fluidis descendant tardius, tamen in spatio vacuo ubi nulla est resistentia atomos omnes tam graviores quam minus graves propter gravitatem sibi proportionalem æquali celeritate descendere, *sic docet Lucretius*."

Lucretius attributes the phenomena of the world to necessity, or as we should say, to physical law: 'nam certe neque consilio,' for verily not by design, was the world made. He holds just as Bacon did, that teleological explanation should be left severely alone by the natural philosopher; he understands as well as did Lagrange, that (to borrow a phrase from Larmor) the great desideratum of a science is its reduction to the smallest number of dominating principles; and the greatest of all these dominating principles he found in the atomic theory. Within our own lifetimes the atom was but an hypothesis, first a useful, then an indispensable hypothesis—one of the most potent of scientific *Denkmittel*, or modes of economising thought. Then Maxwell, Clifford and Kelvin began to show that atoms *must* exist, and nowadays we know at last that they *do*. They are no longer hypothetical, but as real as any other objective things; and we wonder more than ever before at the marvellous insight and prescience of the ancient founders of the atomic theory.

Less than a twelvemonth ago I paid my last visit to Arrhenius. As we walked past the Museum hard by his house, and looked up at the great names inscribed upon its walls, Arrhenius said, "Surely Democritus was the greatest of them all." It was the mantle of Democritus which Epicurus wore, and it was at Epicurus's feet that Lucretius sat to learn the story of the atoms; but who it was that had told it to Democritus we do not know. Democritus was a rich man's son in a provincial town, about the time when Xerxes drew his broken fleet and army home from Salamis; he has left nothing of his very own, save a few hearsay fragments and broken sentences out of his many books. Yet at this day a great physicist looks on him with something like awe, and speaks of him with reverent admiration; for he was the father, so far as all our pedigrees can go, of the most fundamental postulate of all physical science.

The shadows which surround the person of Democritus are but part and parcel of the mystery which hides the origin of the Greeks and the sources of their wisdom. Pythagoras, Thales, Heraclitus, and others besides Democritus are shadowy and all but legendary figures; we trace our science and learning back to them almost as the Japanese trace their empire to the sun and moon. But even Greek wisdom did not come straight from heaven; there were brave men before Agamemnon and wise men before Democritus. The world had rung with the clash of armies and the fall of ruined empires before the day of Greece began; time and again an old order passed away, giving place to new; but doubtless when almost everything was lost, a few seeds of ancient learning, Hittite, Chaldean, Cretan, Egyptian and what not, fell upon good Greek soil and multiplied an hundredfold. Our ignorance of what did happen, and how and when, is the deepest puzzle and the greatest romance of history.

While Democritus's own words are all but vanished, and very few of Epicurus's remain, Lucretius's poem gives us the completest, plainest account we have of any ancient system of philosophy; we read it without effort, and reading it we feel at home. Though we translate Plato and Aristotle into our own tongue, the language they speak is not yet our own; nor do they think and reason in our modern, western way. But any of us may read Lucretius, and under all his splendid diction find nothing hard to follow, nothing anomalous or strange. The present re-issue of Munro's "Lucretius" is vastly the better of a short preface (of some twenty pages) on the scientific significance of Lucretius, by Prof. E. N. da C. Andrade; who not only gives us a singularly clear epitome of the Epicurean philosophy, but also manages to illustrate it by modern instances in a wonderfully happy way. For example, Prof. Andrade not only reminds us of Le Sage's corpuscular, or atomic, theory of gravitation, but also tells us that Le Sage entitled his treatise "Lucrèce Neutonien"; that in short, he got it from Lucretius, and acknowledged the debt. Prof. Andrade shows us how Sir Isaac Newton and Sir William Bragg went straight to Lucretius for the phrase "the Nature of things,"—as before them no less a person than Paracelsus had also done. Again, he shows how Lucretius supposed the atoms of a solid (unlike the smooth round atoms of a liquid) to be

hooked and so to cling together; and how these hooked atoms were used in the seventeenth century, even by John Bernoulli himself, and how they have served their turn again with modern chemists to explain chemical combination and valency. Only yesterday (I mean fifty years ago) Crum Brown used to describe to us beginners the carbon atom, with its four little hooks or 'hands,'—as Kekulé's flash of insight had conceived it a few years before, in that Annus Mirabilis when the "Origin of Species" appeared. As for the smooth round atoms to which Lucretius attributed the fluidity of a fluid, they come pretty near to Dr. Harold Jeffreys' brand-new concept of the structure of a liquid, as formed of 'units' (each an aggregate of molecules), 'perhaps roughly spherical,' and mobile on one another.

Each generation may study Lucretius in the light of its own knowledge. Gassendi compared his teaching with that of Copernicus and Kepler and Gilbert; we think of him in the light of J. J. Thomson's work, and Rutherford's and Bragg's. Prof. Andrade even shows how Dr. G. C. Simpson's newest theory of thunderstorms, with the raindrops borne up on rising air-currents, has its counterpart in the 'seeds of fire' which, according to Lucretius, are carried up into the 'hollow clouds.' I am inclined to think that the sixth book, in which this and other meteorological passages occur, is mostly derived from another source; and, interesting as it is, is less profound than the more strictly Epicurean portions of the poem.

The whole epic is but a short one, of some seven or eight thousand lines; but there is scarcely a passage in it which has not some close and peculiar interest for ourselves. The hereditary germplasm of Weismann, and Darwin's 'pangenesis,' are no other than the Lucretian doctrine of 'primordia,' which, variously combined, lurk hid within the parent's body and are handed on from father to son—'quae patribus patres tradunt a stirpe profecta.' The conservation of matter is proclaimed more than once, and with the utmost clearness: 'res . . . non posse creari | de nilo neque item genitas ad nil revocari'; or again, 'nam neque adaugescit quicquam neque deperit inde.' The conservation of energy is almost as clearly laid down. The very atom itself is declared not to be in ultimate analysis; but itself to consist of certain *minima*, which never did and never will subsist of themselves, for of their very nature they are primary and minimal constituents of the other—'alterius quoniam est ipsum pars primaque et ima.'

On one strange point of the Lucretian doctrine (the kernel of the whole thing, according to some) Prof. Andrade says very little; though what he does say is very much to the point. This is that *exiguum clinamen*, by which the atoms swerve ever so little, and only now and then, from their straight determined path: and so are brought into collision, which collisions are the starting-point of a new order of things. Thus a certain freedom of action is possessed even by the atom, and is the first faint adumbration of our own soul's free-will —'unde haec est nobis innata potestas.' Here Lucretius tries, as did Epicurus, to get behind the more unqualified and more relentless materialism of Democritus. It reminds us of that 'something more' which many a physiologist is constrained to postulate when physical science fails him to explain the humblest of his vital phenomena. It reminds us in a more apt and more important way (without our pressing the analogy too far) of Newton's famous scholium: "a cæca necessitate, quæ eadem est semper et ubique, nulla oritur rerum variatio."

D'ARCY W. THOMPSON.

Early Man and Civilisation.

(1) *Ancient Civilisations: from the Earliest Times to the Birth of Christ.* By Donald A. Mackenzie. Pp. xix + 283 + 12 plates. 12*s.* 6*d.* net. (2) *Footprints of Early Man.* By Donald A. Mackenzie. Pp. xviii + 190 + 16 plates. 5*s.* net. (London and Glasgow: Blackie and Son, Ltd., 1927.)

WITHIN recent years the evidence relating to the extinct members of the human family and the cultural achievements of the pioneers among our own species has increased at such a rapid rate that the intelligent public, and not a few of the professional archæologists themselves, are apt to be bewildered in the face of all this new information. Few of those actually engaged in the work of recovering this new evidence have the time or the wider knowledge successfully to undertake the task of interpretation and exposition. A legion of writers has rushed in to supply this widely felt need; but, unfortunately, most of them have not exercised their own judgment, but have simply followed one or other of the professional authorities. Hence, Mr. Donald Mackenzie, a writer of great literary ability, who has read widely and critically, and with independent judgment has interpreted what he has learned in the light of his knowledge of the folk-lore of the Scottish Highlands, has come to occupy the unique position of an independent and lucid expositor of the progress in this difficult department of anthropology.

In the larger of his two new books he discusses in a fresh and interesting way the origin of civilisation and the history of its development in Egypt, Crete, Sumer, and Mesopotamia, with brief but illuminating sketches of the origins in Persia, India, and China, and many apt illustrations, culled from other places, of the factors involved in the process of invention of arts and customs.

The smaller book is concerned mainly with the remains of extinct types of man—a subject with which Mr. Mackenzie is not so familiar—but it also presents a clear sketch of the field covered by the larger work.

Both books include accounts of the most recent discoveries, and reveal a nicely balanced perspective in the view they present of the whole field of inquiry. What lends a particular charm to Mr. Mackenzie's work is the series of scraps of apt corroborative evidence which he collects from unexpected places and weaves into his lucid and entertaining narrative. For example, he has been able to discover several important references, ancient and modern, to that too much neglected region, the Wadi Alaqi in Nubia, which in all probability was the first place in the world's history where metals were worked. The ancient mines of gold and copper ore are said in one of Mr. Mackenzie's quotations to cover an area of one hundred square miles.

These books are so excellent and useful that they are sure to run into new editions. Hence it seems to be worth while to direct attention to some of the statements that need modification. Rhodesian man did not have "a more highly developed brain" than Neanderthal man ("Footprints," p. 51); nor is it accurate to say that Piltdown man had a head such as is described on p. 14, or is "nearer to the modern man species than was the Neanderthal" (p. 168); it was Dr. Lawrence Balls, and not Mr. Lucas (p. 177), who identified the botanical material from mummies; the late Prof. Montelius was a Swede, and not a Frenchman (p. xviii), and Mr. Charles R. Knight did not visit the Rancho-la-Brea pits or see the material collected there (p. 24). In the larger book the statement that "the maximum date for the dawn of the Palæolithic Age is 125,000 B.C." calls for correction; and in both works a source of confusion would be avoided if the word "neolithic" were omitted altogether.

In spite of these lapses, the books are perhaps the best introductions to their respective subjects at present available.

Our Bookshelf.

A Handbook of the Birds of Eastern China (Chihli, Shantung, Kiangsu, Anhwei, Kiangsi, Chekiang, Fohkien and Kwangtung Provinces). By J. D. D. La Touche. Part 4 (containing Families Ploceidæ, Fringillidæ, Bombycillidæ, and Hirundinidæ). Pp. 293-398 + plates 10-13. (London: Taylor and Francis, 1927.) 7*s.* 6*d.* net.

THE present part of Mr. La Touche's "Birds of Eastern China" contains the Families Ploceidæ, Fringillidæ, Bombycillidæ, and Hirundinidæ, the sequence adopted by the author being the same as that in the new edition of "The Avifauna of India." The present part nearly concludes the true passerine birds, and we understand that Part V. will include the remaining Passeres and, we hope, the Pico-Passeres, containing the Woodpeckers, Barbets, and other forms very richly represented in China.

Of the true finches, the author includes twenty-six species and sub-species, whilst of buntings there are no fewer than thirty. We must note that in the centre of the genus Emberiza, the author has evidently, by mistake, interpolated the two genera, Passerina and Calcarius. It is true that many systematists lump all three genera under Emberiza; even those who do, however, usually place these two genera either at the end or at the beginning of the group. In dealing with the Fringillidæ, we are struck by the remarkable knowledge displayed by the author of the habits and nidification of so many of its members, a fact that adds very greatly to the interest of the work. We notice that Mr. La Touche still includes the sparrows with the finches, and we are inclined to agree with him that, so far as our present knowledge goes, it is impossible to divide them, although, as Sushkin has pointed out, the sparrows have many characters which seem to ally them to the Ploceidæ or Weaver-birds.

The present part is fully up to the standard set by the author in the first three parts, and we anticipate with pleasure an early issue of the fifth part. The photographs at the end of the book are not only beautiful in themselves but also undoubtedly are a great help in assisting one to understand the country on which the book is written. The map included is merely the previous map issued, in which certain corrections have been made.

Synthetische und isolierte Riechstoffe und ihre Herstellung. Von Dr. Rudolf Knoll. (Monographien über chemisch-technische Fabrikationsmethoden, herausgegeben von L. Max Wohlgemuth, Band 10.) Zweite, vollständig neu bearbeitete und erweiterte Auflage, von Alfred Wagner. Pp. viii + 257. (Halle a. Saale: Wilhelm Knapp, 1928.) 14·50 gold marks.

IN the new edition of this book the author has maintained the general plan of the original, but the process of revision has necessarily entailed a considerable expansion of certain sections. The descriptions of apparatus and plant used in iso-

lating and synthesising perfumes and their components form a particularly useful feature of the work; the general treatment is here supplemented by particular references to the manufacture of important specific substances, such as phenylethyl alcohol, cinnamic acid, salicylaldehyde, piperonal, and synthetic musk. The descriptions of quantitative determinations and of individual substances, although brief, are on the whole adequate for the purpose in view. This section of the book, however, cannot be exonerated from sins both of omission and commission: for example, the account of synthetic menthol is restricted to a mention of the reduction of menthone and pulegone with an excess of nascent hydrogen; and it is incorrectly stated (p. 82) that *d*-menthone, like *l*-menthone, yields a mixture of *l*-menthol and *d-iso*menthol when treated in this way. It need scarcely be pointed out, moreover, that *l*-menthone is not converted to *d*-menthone when treated with sulphuric acid, "nach der Inversionsmethode von Beckmann" (p. 164).

The references to natural sources could be augmented with advantage, and some of the existing references need correction: thus, it is surprising to find in this revised work a repetition of the statement, long since proved to be without foundation, that *l*-menthone occurs in the essential oils of *Eucalyptus hæmastoma*, *E. dives*, and *E. radiata*. A useful feature of the book is a list of thirty-two continental perfumery firms, together with a summary of the products in which they specialise.

J. R.

(1) *The Industrial Arts: their History, Development, and Practice as Educational Factors.* By Frederick J. Glass. Pp. xxiii+311. (London: University of London Press, Ltd., 1927.) 12*s.* net.

(2) *Stencil Craft.* By Frederick J. Glass. (The Artistic Practical Handicraft Series.) Pp. vii+64. (London: University of London Press, Ltd., 1927.) 1*s.* 6*d.*

IT is easy to recognise in any book by Mr. Glass the work of one whose knowledge is only equalled by his power of expressing his thoughts, not merely with the force of the artist, but also with the literary finish of a master. It is true that he makes a lapse respecting a so-called 'quotation' from Kipling, and in "The Industrial Arts" he wrongfully describes as "plate tracery" the lancet windows of Fig. 16. In this book, as in others, he develops the lines upon which teachers should advance in the instruction of their pupils in craftsmanship. It is barely exaggerative to remark that he surveys the crafts "from China to Peru"; what does he *not* touch upon, indeed? Incidentally, it scarcely seems accurate to describe Boccaccio as of "the same age" as Savonarola and Macchiavelli; he died long before either of these two saw the light. A few notes upon stencilling merely supplement the special handbook (2) on this subject, which Mr. Glass has just produced in a series of manuals recently noticed in NATURE. His books perhaps err on the side of recommending too comprehensive a study in the schools; his enthusiasm carries him away—but then it is such a generous enthusiasm.

P. L. M.

Physics in Medical Radiology. By Prof. Sidney Russ, Dr. L. H. Clark, and B. D. H. Watters. Pp. xii+234. (London: Chapman and Hall, Ltd., 1928.) 12*s.* 6*d.* net.

THIS book has been written primarily for the use of candidates preparing for the examinations of various universities for a diploma in medical radiology and electrology. The information it provides is given in an exact and lucid manner, and the book is not only well adapted to meet the needs of the students it caters for, but should also appeal to other practising medical radiologists.

Some minor points call for comment. The data on p. 45 refer to the absorption of ultra-violet light by *dead* tissue. Some recent evidence has been obtained showing that the penetration through *living* tissue may be much greater. The half-life period of radium is given as 1680 years on p. 88, and 1760 years on p. 93, and certain of the constants quoted for other radioactive substances are not quite up-to-date.

We expected to find some reference in Chap. viii. to Duane's method of determining the 'effective' wave-length of a heterogeneous beam of X-rays, and also in a later chapter to the theory and use of an auto-transformer.

Two valuable appendices give the revised recommendations of the British X-ray and Radium Protection Committee, and a description of a hospital radium service. A misprint in the latter on p. 218 gives 'my' instead of 'our.'

The book can be recommended with confidence.

Apollonius: or The Present and Future of Psychical Research. By E. N. Bennett. (To-day and To-morrow Series.) Pp. 95. (London: Kegan Paul and Co., Ltd.; New York: E. P. Dutton and Co., n.d.) 2*s.* 6*d.* net.

THIS review of the achievements and hopes of psychical research appears to be written without bias and with an undiminished confidence in the future. It wisely concentrates on the psychological aspects of this kind of research, and does not claim any authenticity for the physical phenomena which have so largely figured in its records. "In view," we read, "of the more immediate results of real value which may be secured from a study of the subjective phenomena of psychical research it is obvious that, unless a physical medium is willing sooner or later to submit himself frankly and honestly to every reasonable test proposed by the best scientific minds, it is comparatively useless for a researcher to spend his limited time in inconclusive sittings for the alleged marvels of telekinesis or materialisation."

Whatever may be the eventual value of the investigations of thought transference and automatic writing, there is no doubt that psychical research has rendered a service in throwing light upon many dark corners of the past.

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 Specificity of Ergosterol as Parent Substance of Vitamin D.

AN interesting relationship between chemical structure and potential biological activity has become apparent during the course of the work which started from the observation that ordinary cholesterol is rendered antirachitic by ultra-violet irradiation. As is now well known, it is not cholesterol itself, but an impurity contained in it in minute amounts which enables it to be activated, and this impurity is most likely identical with ergosterol, the characteristic sterol of fungi (ergot, yeast, etc.). A consideration of the molecular structure of sterols in this connexion leads to the suggestion that not only the presence of the unsaturated carbon linkings, but also their number, is a deciding factor in the photo-chemical production of vitamin D from ergosterol. Thus the saturated sterols, coprosterol, di-hydrocholesterol and di-hydrositosterol remain inactive after irradiation. Further, neither cholesterol nor sitosterol with one double bond, nor stigmasterol, cholesterylene, oxycholesterylene, and di-hydroergosterol, with two such linkings, can be activated. Ergosterol with three double bonds, however, possesses this property to such a high degree that its calcifying action can be demonstrated even in daily doses of 1/100,000 mgm. in rats, whilst daily doses of 2-4 mgm. cure rickets in children.

It became, therefore, of considerable interest to investigate whether the photo-chemical change connected with vitamin formation was specific for ergosterol, depending on the position of the three double bonds in the molecule, or whether other substances with three or more double bonds would also yield the vitamin on radiation. We had already previously established that squalene, the open-chain di-hydrotriterpene with six double linkings occurring in the livers of elasmobranchs, cannot be activated, and the same holds for the oxygenated olefinic terpenes, nerolidol and pseudo-ionone. The tentative conclusion seems justified that unsaturated open-chain compounds cannot be activated.

A relatively mild chemical treatment, that is, removal of hydrochloric acid from its hydrochloride, leads from ergosterol to iso-ergosterol. Although this isomer contains three double bonds, differing in their position only from those contained in ergosterol, it cannot be activated. This also holds for a second isomer, neo-ergosterol, obtainable from ergo-pinacol by distillation. From all this evidence, which results from the work of several observers, including especially Windaus and his collaborators and ourselves, it would appear that not only a typical ring-structure, but also a specific position in the molecule of the three unsaturated bonds, is essential for photo-chemical conversion into vitamin D.

This generalisation, however, would seem to be invalidated by the statement of Windaus and Holtz (*Nachr. d. Ges. Wissensch.*, Göttingen, 1927) that digitaligenin, the aglycone of the digitalis glucoside, digitalinum verum, can be rendered antirachitic by irradiation. Since digitaligenin is a hydroxy-lactone containing three double bonds and is structurally related to cholic acid, another sterol derivative, its activation would not seem improbable. The statement has already been accepted in the literature and has led to the deduction of the existence of more than one vitamin D in Nature.

A detailed consideration of Windaus and Holtz's experimental technique, however, leaves their conclusions open to doubt, since a solution of digitaligenin in olive oil was used for irradiation. The obvious criticism arises that the choice of olive oil as a solvent for this type of experiment is an unfortunate one. It is well known that olive oil itself becomes antirachitic when irradiated, a property common to vegetable oils in general. We re-examined this question by irradiating for the biological tests an alcoholic solution of digitaligenin under the same conditions as an alcoholic ergosterol solution. The irradiated substances, freed from alcohol and dissolved in inactive olive oil, were tested by our usual technique on rats of the same litter. The irradiated digitaligenin was given in doses of 1/10,000, 1/5000, 1/250, and 1/100 mgm. and was found entirely inactive, whilst the control rats, receiving 1/10,000 mgm. irradiated ergosterol, were free from rickets. In view of the correlation existing between the ultra-violet absorption spectrum and the potential activity of ergosterol, it was of interest to examine digitaligenin in this respect. We found, as was to be expected, that this unsaturated substance showed a strong absorption in the ultra-violet, differing entirely in character and position, however, from that of ergosterol. Instead of three absorption bands, of which the one at 280$\mu\mu$ characterises ergosterol, digitaligenin shows only one band with a maximum at 340$\mu\mu$, extending from 270$\mu\mu$ to 390$\mu\mu$. In addition, there is general absorption, and possibly secondary bands, in the region below 250$\mu\mu$. Moreover, the broad absorption band of digitaligenin remains practically unchanged after two hours irradiation, whereas the ergosterol bands rapidly disappear under these conditions.

The fact that digitaligenin cannot be activated strengthens the assumption that only a molecular structure, such as that possessed by ergosterol, enables a sterol to be photo-chemically converted into vitamin D, and confirms the evidence already available for the view that ergosterol is the specific parent substance of vitamin D.

O. ROSENHEIM.
T. A. WEBSTER.
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Hampstead, N.W.3, Mar. 23.

Lead Tetraethyl in Internal Combustion Engines.

WHILE looking through the article by Dr. E. Mardles in NATURE of Mar. 17, my attention was arrested by Table V. This table, the origin of which is not stated, appeared in a Report of the U.S. Bureau of Mines, dated December 1924 (Serial No. 2661).

Dr. Mardles gives this table as a typical analysis of the deposits, but it should be emphasised, as I have endeavoured to do in another journal, that there is no such thing as a typical analysis of these deposits, because the deposits vary in quantity and kind according to the conditions of engine operation. With one engine, for example, it is possible to obtain 9 per cent. or 17 per cent. or 36 per cent. of the lead supplied in the petrol, in the deposits on the cylinder heads and pistons. The percentage can be fairly accurately controlled by varying the conditions of operation.

Just above Table IV. in Dr. Mardles' article, the statement is made that "The results of prolonged engine trials with fuel containing not more than 6 c.c./gal. confirm the claims made that ethyl petrol will not injure spark plugs, valves, or stems." As against this statement may be quoted the following from a very noteworthy paper on "Dopes and Detonation," by Prof. H. L. Callendar, Capt. R. O. King,

and Flight-Lieut. C. J. Sims (*Engineering*, April 9, 1926, p. 475): "The patentees recommend, however, that the mixed dope called 'Ethyl fluid' should not be used in a greater proportion than 5 c.c. per gallon, each 5 c.c. containing 3 c.c. of lead ethide, which, according to the A.M.L. tests, would permit an increase of compression ratio of about 10 per cent. The importance of this limitation has recently been confirmed by an endurance test of 100 hours on a Napier Lion engine of 450 h.p. at the Royal Aircraft Establishment. . . . Shell Aviation spirit was used for the first 50 hours with 5 c.c. per gallon of the normal ethyl fluid. For the second 50 hours B.P. Aviation spirit was employed with 5 c.c. per gallon of ethyl fluid, containing a larger proportion—namely, 2·5 c.c. of ethylene dibromide—the content of lead ethide being 3 c.c. in both cases. . . . After 50 hours, the spark-plugs showed heavy deposits of lead salts and high leakage of gas through the mica. After 100 hours these defects were intensified. All plugs showed signs of having been severely over-heated, and the deposits of salts formed an easy flash-over path. Three cases of punctured mica were noted, which would render the plugs useless in an engine."

These results have been confirmed in varying degrees in motor-car engines, but all engines do not show anything like the same susceptibility, and there is no doubt that the conditions of operation play an important part.

I am not free at present to discuss this subject here as fully as I might otherwise wish, but I feel justified in commenting on one further point in Dr. Mardles' article. Under the heading "Compression and Efficiency," it is stated that "considerable progress can be made with the use of higher compression ratios involving an annual saving in the aggregate of many million pounds sterling." This statement is amenable to simple arithmetical examination. Assuming a compression ratio of 5 to 1 for straight petrol and 5·5 to 1 for ethyl petrol—an increase of 10 per cent.—we find by interpolation from Table I. on page 424, that the indicated thermal efficiency would increase from 32·8 per cent. for straight petrol to 34·5 per cent. for ethyl petrol, an increase (theoretically) of 5·2 per cent. This increase is obtained at the expense of the added anti-detonants, and if these cost more than 5·2 per cent. of the fuel, there is 'in the aggregate' a loss. As a matter of fact, the present cost of doped fuel is 1*d.* per gallon more than the equivalent straight petrol, an increase of 1 in 14·5 in the London area, or 6·9 per cent. It is clear, therefore, that with existing prices, a motorist who raised his compression ratio by 10 per cent. in order to utilise the properties of the new fuel, would incur a loss in fuel costs alone of 1·7 per cent.

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THE observations made by Mr. Rowell that deposits in an engine after running on ethyl petrol are subject to considerable variation in quantity and kind are certainly true. This is indicated by the two analyses given in Tables IV. and V., the first made in Great Britain and the second in the United States. Naturally, the lead content would vary with engine conditions and would appear less, for example, with a high degree of carbonisation. There is also no significance between the amount of lead used and found respectively. Thus, the amount of final lead deposits from cars that have actually run 40,000 miles on ethyl petrol would bear only a small proportion to the 12 lb. of lead consumed, whilst with a car run for an hour on ethyl petrol the proportion would doubtless be higher.

The conclusion given in the article, that the results of prolonged engine trials confirm the claims made that ethyl petrol would not injure engine parts, was based in part on the extensive experience of motor-car manufacturers in the U.S.A. and of the U.S. Naval Air Service, which uses ethyl petrol almost exclusively for fuel.

The quotation made by Mr. Rowell from a paper by Prof. Callendar, Capt. R. O. King, and Flight-Lieut. Sims relates to early experiments on the behaviour of ethyl petrol in an aero engine, but subsequent research with lead tetraethyl in air-cooled aero engines can be summarised in the statement that after one hundred hours' run no ill effects on the engine were shown (*Jour. Roy. Aero. Soc.*, **30**, 731; 1926).

In spite of Mr. Rowell's calculations that the use of ethyl petrol is uneconomical, I still maintain that with the use of higher compression ratios there would be an annual saving in the aggregate of many million pounds sterling. This statement is independent of the increase in compression ratio obtainable with any particular petrol or engine, and it must be remembered that lead tetraethyl is but the first successful 'anti-knocker'; future research may yield others which it is hoped will enable the motor engineer, by removing restrictions due to fuel failings, to operate at a compression ratio in the neighbourhood of 7 : 1.

E. MARDLES.

The Non-Appearance of the Recombination Luminescence in the Reaction between Alkali and Halogen Atoms.

FROM the possibility of a direct dissociation of salt molecules of NaCl type in the non-charged normal atoms by the light action (Franck, Kuhn u. Rollefson, *Zs. f. Phys.*, **43**, 155; 1927) follows another possibility—*a direct recombination* of the alkali and of the halogen atoms in a salt molecule, followed by a continuous light emission. All attempts to find this recombination spectrum have been without result. The chemiluminescence spectra emitted in the reaction between alkali atoms and the halogens have nothing to do with the continuous bands known as the absorption bands of the salts in question.

These negative experimental results make it necessary to look for another mechanism of the building of the heteropolar molecules of this type instead of that of the inversion of dissociation. Some investigations on the chemiluminescence permit us to outline such a mechanism. From Polanyi's and his collaborators' investigations we can assume with considerable certainty that the reaction $Na + Cl_2$ in the gas phase follows the scheme:

$$\begin{aligned} Na + Cl_2 &= NaCl + Cl \\ Cl + Na &= NaCl^{\cdot} \\ NaCl^{\cdot} + Na &= NaCl^{\cdot} + Na' \\ Na' &= Na + h\nu. \end{aligned}$$

In this scheme the exciter of the chemiluminescence (in this reaction an intense line spectrum of sodium is observed) is a molecule $NaCl^{\cdot}$, which has an excess of energy. The great intensity of the chemiluminescence suggests that the exciter ($NaCl^{\cdot}$) must exist a sufficiently *long time* as an energy-rich molecule to meet a sodium atom. Such a long living molecule could be a *dipole* $\overset{+}{Na}\overset{-}{Cl}$, which is formed by the recombination of the sodium and chlorine atoms, and *gradually* loses its excessive energy of vibration by the emission of infra-red radiation quanta (Kondratjew, *Zs. f. Phys.*, **45**, 67; 1927).

We shall now see in what way such a recombination can occur. Plotting the potential energy E of the system atom-atom and then that of the system $\overset{+}{\text{ion}}$-$\overset{-}{\text{ion}}$ as a function of the distance r between two nuclei, we obtain two curves, which in the case of all heteropolar diatomic salt molecules *give an intersection* at a smaller or greater distance r_c. Such curves are represented in Fig. 1 (here J is the $\overset{+}{\text{ion}}$-$\overset{-}{\text{ion}}$ curve, A the atom-atom curve). At the intersection (r_c) the energies of the system (Me) (X) and of the system $(\overset{+}{Me})$ $(\overset{-}{X})$ are *equal*. At this point the valency electron of the metal can be 'adiabatically' transferred to the halogen atom, *i.e.* a transformation $(Me)\,(X) \rightarrow (\overset{+}{Me})\,(\overset{-}{X})$ can occur. This mechanism of the building up of NaCl was proposed by the author

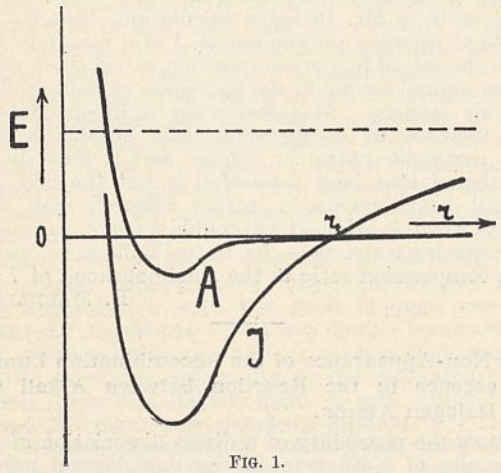

FIG. 1.

in the discussion on chemical kinetics in the first Physico-Chemical Conference in Leningrad in February 1927 (published in *Communications on the Scientific and Technical Works in the Republic*, vol. 23, Leningrad, 1927). The possibility of the transition $(A)\,(B) \rightarrow (\overset{+}{A})\,(\overset{-}{B})$ is also suggested by F. London (London, *Zs. f. Phys.*, **46**, 455; 1928).

The molecule $\overset{+}{Me}\,\overset{-}{X}$ $(Me\,X)$, formed in this way from the neutral atoms, can therefore exist for a comparatively long time in a high vibrational state. The energy of vibration of such a molecule can be increased by the absorption of the temperature radiation, to a quantity $Q + J - E$ (Q is the heat of reaction $Me + X = MeX$, J the ionising potential of the cation and E the electron affinity of the anion). It is quite possible that this circumstance explains the appearance in the chemiluminescence spectrum of lines the excitation energy of which considerably exceeds the reaction heat (Q).

As to the transitions $(A) \rightarrow (J)$ at the distances $r < r_c$ we can here expect *a priori* a spontaneous transition followed by emission of light. The wavelengths of this radiation should be determined by the probabilities of the corresponding transitions. The absence of visible radiation in the reactions in question evidently suggests that the probability of the transition $(A) \rightarrow (J)$ at r_c and in the neighbouring points is very considerable.

Then we can expect the radiation in the case of recombination of one normal and one excited atom, the curves (Me') (X) or (Me) (X') and $(\overset{+}{Me})$ $(\overset{-}{X})$ of which do not intersect. It is very interesting, that in the chemiluminescence spectrum of the reaction $K + I_2$, a large continuous band is observed, but it is not observed in the case of the reaction $Na + I_2$ (Ljalikoff u. Terenin, *Zs. f. Phys.*, **40**, 107; 1926). At the same time the curves (K) (I) and $(\overset{+}{K})$ $(\overset{-}{I})$ do not intersect ($J_K - E < A_I$, $A_I = 2^2p_2 - 2^2p_1$ is the excitation energy of the metastable level of the iodine atom) and the curves (Na) (I′) and $(\overset{+}{Na})$ $(\overset{-}{I})$ do intersect.

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Science Teaching in Schools.

I SHOULD like, if I may, to make a few observations, as briefly as possible, on the recent correspondence in NATURE on this subject.

If any discussion is to materialise, two things may safely be taken for granted, namely, that there is likely to be much diversity of opinion, and that the bulk of that opinion will be in favour of modification rather than revolution. 'The inevitability of gradualness' applies here; and it may reasonably be urged (*a*) that the present system is not altogether devoid of good qualities, and (*b*) that the scientific attitude, which is far more important than mere book knowledge, may be acquired in any branch of science, whether physics, chemistry, or biology. I think we may assume that at present the abolition of the 'subject' system is impracticable, even if it were desirable. There are some who fear, not without justification, that too extended a course of elementary science tends to degenerate into what the Rev. Dr. Folliott stigmatised some years ago as "everything for everybody, science for all, schools for all, rhetoric for all, law for all, physic for all, words for all, and sense for none."

Again, it would be unfortunate if by any means, democratic or despotic, too exact a syllabus were to be imposed upon schools. We all have our own ideas, and teach best those things in which we are most interested. My plea is for greater liberty in this respect, and for more time in which to deal with essential mental and manipulative processes; and these can only be gained if the university examiners agree to modify their demands. They could easily do this, if they chose, and could thereby succeed in distinguishing between boys of real ability and those who had merely crammed far more efficiently than at present.

I have reason to believe that the suggestion was made last year that some of the university examiners should meet the Science Masters' Association in London, and that the examiners themselves were willing, and even anxious, to do so. It would be interesting to know on what grounds so desirable a step was frustrated.

A. K. GOARD.

Marlborough College, Wilts, Mar. 25.

FROM the recent correspondence which has appeared in NATURE on the teaching of science in schools, the most striking impression I have obtained is that on a problem which one would expect to be perfectly straightforward, opinions differ enormously. In other words, it is evident that those people who are now engaged in teaching science do not themselves know, as a body, what their aims and objects are, and what are the best methods necessary to attain them. Controversy is always stimulating, but when it arises from such a wide range of opinion it tends to hamper progressive movement, and has a bad effect on those people who in perfect good faith listen to each expert in turn.

As one who has taught many branches of elementary science for some years, it seems to me that the relations

of school and university play at present a dominating rôle in the science taught at schools, and the influence is not all to the good. The main object of schools seems to be to produce scholarships, and the main objects of universities to produce research workers. Such objects have a cramping effect on the whole organisation of science teaching. In the first place, very many boys from public and secondary schools never go near a university; and secondly, only a relatively small proportion of students who do go there become first-class research workers. The really good research worker survives under almost repressive conditions, and is often hampered by the people whose job it is to teach him. When research is so badly paid it seems a pity that it should be held up as an ideal to any students but the very best, especially since progress in the applications of science only partly keep step with the rate at which discoveries are made, as the modern system of agriculture in England shows very clearly.

The great mass of boys and students do not possess the research mind, and no amount of training in method will give it to them. In their scientific edueation they slowly, and often painfully, acquire some technical knowledge, most of which is of no further value when the examination is over. Pushing them hard merely dulls their wits and gives them a bad taste for science. They lack the imagination required for research, and the technical ability to handle apparatus with real success. They do, however, make up the bulk of those people who control our complex industrial system, because they possess general ability and character for leadership.

My personal complaint is that, while science has now illuminated the western world for some hundred years, no bold attempt has yet been made to reorganise and direct our social system in keeping with it. It has been given no cultural value, although it has had a profound and disturbing effect on all previous types of culture and æsthetic ideals. As a new force it yet lacks 'official' recognition except in Central and Eastern Europe, where it is beginning to affect art, literature, and possibly music. The coming of science and industry has completely changed the world. It has given us social, economic, and international, problems which cry aloud for scientific solutions; but unless the mass of the people is trained in the atmosphere of science, it will persist in attempting to solve these problems on traditional medieval lines. In this respect there is an enormous field for our educational institutions, which still waste time teaching the difference between density and specific gravity, and the number of stamens in a flower, in jargon which has been invented to make the task difficult. At present science as taught, with exceptions of course, is in the 'date' stage of history or the 'capes and peaks' stage of geography. It will only gain respect as an educational medium when it has set up cultural ideals which are attractive to all types of thinkers. Of course, evolution in the right direction is inevitably taking place in spite of efforts to prevent it, but we could accelerate the change considerably if we really pulled together.

R. Weatherall.

Eton College, Windsor, Mar. 28.

Beats by High-Frequency Interruption of Light.

For some time past we have been engaged in developing a compact laboratory method of measuring the velocity of light by utilising the Kerr electro-optic effect in nitrobenzene for obtaining very rapid intermittence in a light beam. The restoration of light by nitrobenzene (put between crossed Nicols) under electric stimulus is comparatively large and is almost instantaneous—the lag being of the order of 10^{-10} sec.

The Kerr cell employed was of the type developed by Karolus (for the Telefunken-Karolus system of picture transmission), and was kindly supplied to us by the Telefunken Company.

As in all such experiments for velocity determination the light has to be passed twice through the interrupting mechanism, it was thought desirable, as a preliminary step, to see if sufficient light would come out through two cells in succession. After overcoming considerable experimental difficulties, and by using sunlight as source, we were able to get sufficiently intense interrupted light passing out of the second cell. To test if the interruptions were taking place properly, the sunlight was focused on the first Karolus cell placed between crossed Nicols and excited by a valve-maintained oscillator of frequency about 10^6 cycles per second. The restored intermittent light was received on a second cell excited by another oscillator, differing in frequency from the first by a few hundred cycles. The emergent light, after passing through another Nicol, was received in a fall-plate camera, and the slow light beats resulting from the interference of the high-frequency interruptions in the two cells were photographed. Fig. 1 is a reproduction of such a photograph magnified three diameters.

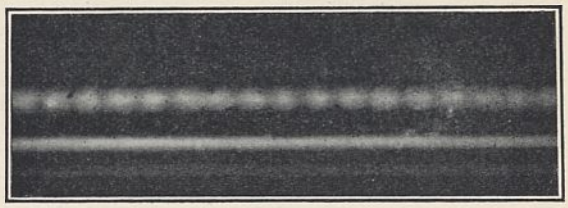

Fig. 1.

The frequency of the light beat was apparently double the frequency of the heterodyne beat note as heard in a telephone. We attempted to detect the light beats visually by bringing down the beat frequency to two or three per second. In this we were unsuccessful, obviously due to the forced synchronisation of the two oscillations (as noticed by Appleton, *Proc. Camb. Phil. Soc.*, vol. 21; 1922) taking place long before the difference in the frequencies becomes sufficiently small to make visual observation possible.

This beat method can be adapted to study the high-frequency interruption of light by resonating quartz, which Prof. Kerr Grant tried to photograph at a frequency of 144 kilo-cycles per second, but was unsuccessful (Nature, Oct. 22, 1927). It is only necessary to replace the first or the second Karolus cell by the resonating quartz. In his note, Prof. Kerr Grant suggests the employment of resonating quartz for obtaining interrupted light of very high frequency up to ten million per second. We are doubtful if this is practically possible. The thickness of a quartz crystal cut and ground to this frequency is very small (only a fraction of a millimetre along the electrical axis and normal to the optic axis, for it is about one millimetre even for a million-cycle) and it would be exceedingly difficult, if not impossible, to make any observation by passing light in a direction parallel to the optic axis.

S. K. Mitra.
D. Banerji.

University College of Science,
92 Upper Calcutta Road,
Calcutta, India, Feb. 16.

The Nature and Function of Golgi Bodies.

PROF. GATENBY says (NATURE, Mar. 24): "Prof. Walker's original position was that *both categories of the cytoplasmic inclusions* [mitochondria and Golgi bodies] *are artefacts*. In his printed paper he merely claims that the Golgi bodies alone are artefacts." My "position" was, continued to be in my "printed paper," and still is, that *some of* the bodies claimed as mitochondria in fixed material are artefacts; and that those among the appearances claimed as Golgi apparatus, the presence of which in the cell cannot be accounted for without assuming the existence of this peculiar "organella," as Prof. Gatenby calls it, are artefacts. Thus it would seem that either he has not read what I have written, or that he is misquoting what he has read.

Both Prof. Gatenby and Dr. Ludford make much of the constant positions taken up by the Golgi apparatus in similar cells. Our knowledge of the chemistry of the cell is so limited that it is impossible to explain in many cases the position taken up by the separated lipins in different cells. I have, however, nearly ready for publication, an account of conditions in which my Golgi bodies may be made to take up a constant position in relation to the artificial nuclei in my mixtures, conditions which may well be produced by the nucleus of the living cell in certain circumstances.

I believe that all microscopic observations upon fresh cells removed from the living body of the multicellular animal should be accepted with caution. Changes must begin at once even under the most favourable conditions. It does not appear to me that the technique of the demonstrators of the Golgi apparatus "takes into account our biochemical knowledge of the solubilities of lipoids and other subtle cell bodies" as Prof. Gatenby says they do. The facility with which the colloids of the cell, more particularly perhaps the lipins, may be separated from each other and from the water with which they are associated, seems to be entirely ignored. Temporary separation might well occur under normal cell conditions, which would be rendered permanent by certain abnormal ones.

The formation of artefacts has been much neglected during recent years. They constitute perhaps the most dangerous pitfall for the cytologist. I cannot enter into the theory and practice of fixation and other processes, but for Prof. Gatenby's information would point out that maceration of material, among many other modes of treatment, is sure to distort the cells and their contents very seriously. What Prof. Gatenby would have us believe is "modern cytological technique" seems to be largely confined to those who demonstrate what he calls "cytoplasmic inclusions" and to neurologists.

If I were, as I certainly am not, the only cytologist living who did not believe in the "Golgi bodies," I fail to agree with Prof. Gatenby that this in itself would be a proof that I was wrong. Much greater men than he or I have occupied that invidious position in the past, and have proved right in the end.

May I point out that I still seek in vain for even a hint as to the function of the "Golgi bodies," which are assumed to exist as definite structures in all the cells of all animals and many plants. Also I have failed to extract information as to what becomes of the lipins in the cells that are treated by the "Golgi apparatus" methods.

I did not write of the archoplasm but of structures contained in it, and pointed out that these had been found in every animal investigated. Dr. Ludford's definition of the Golgi apparatus as a specialised area in the cytoplasm does not seem to agree with Prof. Gatenby's "batonettes." I would refer them both to D. Tretjakoff's paper, *Zeits. f. Zellforschung u. Mikro. Anat.*, Abt. B, 7 Band, 1 Heft., Feb. 1928.

Prof. Gatenby's naïve attitude that the value of his own interpretation of observations is increased by frequent repetition, and that he has reached the limits of cytological technique, reminds me of the Bellman in "The Hunting of the Snark."

> "Just the place for a Snark! I have said it thrice:
> What I tell you three times is true."

CHARLES WALKER.

The University, Liverpool,
Mar. 23.

The Inner Photoelectric Effect with Silver Halides.

CONSIDERATION of the energy steps in the Born cycle for calculating the lattice energies of the silver halides leads to the following conclusions:

1. The photolysis of solid silver halide might occur *directly* to give halogen and metallic silver. This requires only a quantum at 8000 A. or longer, equivalent to the heat of formation of the halides from the elements.

2. This photolysis might occur *indirectly*, by way of separation of electrons from halide ions, followed by acceptance of the electrons by silver ions. This course would require (1) a quantum at $\lambda = 1300$ A., or beyond, to disrupt the lattice, then a quantum at $\lambda = 3000$ A., or beyond, to liberate electrons. In subsequent reactions, of electron acceptance, etc., energy might be freed, either as radiation quanta or by radiationless collisions, so that the final difference of energy equals the heat of formation. However, in this case (2) primary absorption of two quanta appears necessary, at thresholds much higher than those known to be operative in the photochemical decomposition of the silver halides.

Obviously, the contradiction might be simply dismissed by abandoning the view that the photolysis involves the intermediate liberation of photoelectrons from halide ions—a hypothesis suggested independently by K. Fajans and by the writer. But the phenomena of photoconductance definitely point to a relative freeing of photoelectrons, and Dr. F. C. Toy has shown (NATURE, Sept. 24, 1927) that the discrepancy between the photoconductance absorption spectrum of the silver halides and the spectrum photographically active is removed by consideration of the thickness factor. Moreover, recently Dr. W. Vanselow and the writer have obtained independent evidence of the liberation of photoelectrons, *concomitant with the production of free halogen*, in a study of the photopotentials of silver–silver halide electrodes in electrolytes.

The difficulty of the energy quanta required cannot be dismissed therefore. The experimental evidence obtained with these cells has led to a modified theory of the inner photoelectric effect which is consistent with the writer's orientation theory of photographic sensitivity and latent image formation. By considering that both the lattice energy and electron affinity are lowered at interfaces, particularly at true interfaces with conductors, it seems possible for the inner photoelectric effect to occur at the lower wavelengths in question.

An interesting corollary is a possible relation of this to the theory of E. A. Baker (NATURE, May 7, 1927, p. 685; *Proc. Roy. Soc. Edin.*, **47**, 34; 1927), that "*two* quanta are concerned in photographic action, and that the two must be absorbed within a short interval of time, giving the effect of two distinct absorptions when the exposure is short, and of simultaneous absorption when the exposure is long. This indicates

that in the absence of a second absorption the effect of the first quantum is transitory, the action being of the type

$$A + h\nu \rightleftharpoons A'$$
$$A' + h\nu \longrightarrow A''.$$"

If we regard the first quantum as necessary to loosen the lattice (to overcome lattice energy) and the second to release the photoelectron from the halide ion, it will be seen that the considerations advanced may support Dr. Baker's theory of reciprocity failure.

It is hoped to publish the discussion of lattice energy at an early date, and the study of the inner photoelectric effect in relation to latent image formation somewhat later.

S. E. SHEPPARD.
Research Laboratory,
Eastman Kodak Company,
Rochester, New York, Mar. 2.

Vision and Reality.

IF a philosopher may be permitted to take part in a discussion which seems to involve questions of scientific import alone, I would like to point out certain ideas which bear upon the problem of whether the eye has been so adapted as best to use the energy of sunlight. Sir John Parsons suggests (NATURE, Jan. 21, p. 94) that this conclusion is consistent with the fact that the brightest part of the spectrum (of the luminosity curve) coincides with the summit of the curve of radiant energy. But Mr. T. Smith (NATURE, Feb. 18, p. 242) presents another view—not inconsistent with the foregoing conception—in which vision is held to be so constituted as to bring out the sharpness of contours of bodies. This conclusion, while very important, does not seem to me to be especially novel. Prof. Eddington, in his "Stars and Atoms," also suggested that we have in the coincidence of the peak of the visibility curve with the peak of the curve of radiant energy an interesting case of evolutionary adaptation. But aside from these views, Bergson, it might be argued, had proposed something of the sort in his notion of the 'geometrising intellect.' This, at any rate, would be the case if the interpretation which the present writer puts on Bergson is the true one.

In presenting to my students in philosophy the 'problem of reality,' I have for several years employed the practice of pointing out the ways in which our knowledge of the external world is prejudiced by experiences to which our sense organs give rise. I have then always raised the question of how the world would appear if some of the limitations of our senses were overcome. More specifically, how would the world appear if our eyes were so constituted that we could see in the ultra-violet or the infra-red ends of the spectrum? If we could see in the infra-red end, bodies which are not in thermal equilibrium with their environments would then seem to be surrounded by a halo due to the heat rays which were being given off by the radiating bodies. In the same way, if we saw in the ultra-violet, all objects which give off these waves (for example, mercury) would be surrounded by a penumbra. This suggests the conclusion that the apparent sharpness of boundary of some objects is due to the structure of the human retina, that is, to the fact that vision is best in the yellow region of the spectrum.

This fact that sense experience (both in vision and in tactual experience, in so far as sight is 'anticipative touch' and tactual perceptions are synthesised with visual space) exaggerates the sharpness of contours, may be responsible for the sharp opposition between 'matter' and 'empty space.' The intellectual distinction between matter and energy may be a result of the fact that the eye, the organ of vision, is a direct outgrowth of the brain, the organ of thought. It is interesting to note that the 'quantum puzzle' is not being solved by making light corpuscular, but by making matter undulatory. In other words, perhaps the problems in some branches of science will be solved by unlearning some of the cerebral reactions or ideas which developed around sensory experience. Perhaps when we have become accustomed to Schrödinger's notion of substance as a set of wave-patterns, the idea of matter as something eternally and absolutely distinguished from energy-fields will be relegated to the science of mental palæontology as a fossil of human thought.

OLIVER REISER.
University of Pittsburgh.

'Sports' and 'Reversion.'

THE note on Dr. C. J. Bond's Galton Lecture, which appeared in NATURE of Feb. 25, contains the following remarkable sentence (p. 292): "He [*i.e.* Dr. Bond] did not reflect, however, that 'sports,' although hereditary, must owe their origin to definite causes, and that the evidence before us justifies the belief that when these causes cease to operate the 'sport' ultimately reverts to the wild type."

It is, of course, true that sports must owe their origin to definite causes; but it is equally true that we know nothing whatever as to the nature of the causes underlying mutation. How, then, are we to know when such causes "cease to operate"? Further, it would be interesting to know what the evidence in favour of the 'reversion' of sports may be. *Chelidonium laciniatum* Miller, perhaps the best authenticated of mutants, has certainly not been observed to revert during the 338 years for which it has been known to science. The other mutants of known date of origin have shown a similar constancy. Indeed, it might be said to be characteristic of true seminal mutants that they do *not* revert.

If I am not mistaken, the only phenomenon which the geneticist would care to call 'reversion,' even by courtesy, is that exemplified by the appearance of a definite proportion of red-flowered plants among the segregates from a cross between an ivory-flowered snapdragon and a white-flowered snapdragon of a particular genetic constitution. In such a case the appearance of the supposedly ancestral type—in this instance the red-flowered plant—is a necessary consequence of the mating of particular gametes, and is quite independent of the incidence of environmental factors.

MONTAGU DRUMMOND.
Botany Department,
University of Glasgow, Mar. 1.

THE comments on Dr. Bond's lecture to which Prof. Drummond refers, may be justified perhaps by zoological illustrations even if the botanists are unaware of any causes of mutation and have no evidence of reversion. For example, Müller has shown that when the eggs of normal specimens of Drosophila are subjected to X-ray radiation, they give rise to 'mutations' of the same kind as some of those which turn up in Morgan's cultures. Berndt, in discussing the 'fancy races' of goldfish, admits that the cause of the production of 'mutants' is aquarium conditions. In a word, the general cause of mutations may be described as 'germ-damage' due to bad environmental conditions acting at a critical period of growth. As to reversion, Morgan himself encountered this in some of his extreme mutants and described it as 'mutation backwards.' It can be seen any day in the London squares, where a considerable proportion of our escaped dovecote pigeons are rapidly returning to the ancestral form of *Columba livia*.

THE WRITER OF THE NOTES.

On Experimental Growth *in situ*.

ON the hypothesis of senescence elaborated by Robertson ("Chemical Basis of Growth and Senescence," 1923), adult tissue can only revert to a reproductive phase when the so-called *kern-plasma* relation and nutrient level of its elements has been reduced, and the inhibitory products of previous growth (autocatalysts) have been—and continue to be—removed. But Gye and Barnard have shown that ultramicroscopic organisms occur in (and can be cultivated from) the fluids derived from—at least—some cancerous tissues. Such ultramicroscopic organisms also exhibit specificity. Let Robertson's hypothesis be accepted, then it is a reasonable assumption, which can probably be tested, that these ultramicroscopic organisms may primarily be feeding on the products of autocatalysis in the tissues in which they are found. If, therefore, these organisms could be cultivated in fluids derived from healthy tissues homologous with those from which they were derived, or even in the tissues themselves, partial proof of the assumption would be obtained.

Now Gye and Barnard have actually shown that pathological growth may be produced in some cases by a 'specific factor' plus a 'virus.' But apparently it is not possible to stimulate growth in a tissue by merely injecting into it a culture or extraction containing the pathological organisms. Robertson's hypothesis, however, demands two conditions for resultant growth in adult tissues, namely, (*a*) reduction of the *kern-plasma* relation, which may be effected by various stimuli (chemical, physical, mechanical abrasion or irritation, cutting, or agents causing disruption or decay of cells, etc.), as well as (*b*) removal of the autocatalysts. Thus the mere injection of organisms to remove (presumably) the autocatalysts in a tissue may not be enough to stimulate growth, and reproduce the hyperplasia without the concurrent reduction of the *kern-plasma* relationship.

In order, therefore, to induce unrestricted growth in a tissue *in situ* it is necessary *ex hypothesi* (1) to stimulate the tissue in some way to regenerative activity—thereby ensuring the reduction of the *kern-plasma* ratio; and (2) to add pathological organisms which will remove the autocatalytic products of the stimulated growth, and permit continued growth; such organisms having been derived from a tissue homologous with that in which the new growth is required. It is possible that experiments fulfilling the conditions outlined above may not have been tried, and no excuse is needed for advancing any reasonable suggestion on this important subject.

X.

Postulates of Hydrodynamics.

OF a mass of fluid satisfying the condition of continuity and having a continuous velocity field, the mathematical theory of fluid motion postulates that fluid elements—line, surface, volume—not crossing a surface of discontinuity, of which there may be a finite number, maintain their identity and order of magnitude.

As a dynamical consequence, in a perfect fluid, the forces being restricted to surface pressures and potential body forces, the initial distribution of vorticity is inherent in the volume elements of fluid, and remains so in the subsequent motion.

In particular, if the initial motion is irrotational everywhere (except in the sheets of vorticity), the subsequent motion is irrotational (except in the sheets of vorticity).

Without questioning the correctness of these propositions in the realm of mathematical logic, the present writer has found them a formidable barrier to the understanding of actual fluid motions familiar to the physicist and the engineer, and offers the following physical propositions.

Fluid elements—line, surface, volume—can be effectively subdivided into two or more distinct portions separated by intervening fluid.

A mass of perfect fluid consisting of several distinct parts, each with its own velocity potential, and separated by thin sheets of transition (in mathematical limit, vortex sheets) may be effectively redistributed so that the identity of the irrotational elements of volume falls below the threshold of observability, and new mean elements with an effective finite distribution of vorticity become the objects of physical observation and measurement through the whole or part of the joint mass.

A. R. LOW.

The Library, Air Ministry,
Kingsway, W.C.2, Mar. 26.

The Spectrum of Ionised Argon (A II).

FOR some time the spectrum of ionised argon (A II) has been a subject of investigation in the Amsterdam Laboratory 'Physica.' My analysis of the spectrum of neutral fluorine F I (*Verslagen.*, Amsterdam, June 1926, Dec. 1926. *Zeits. f. Phys.*, **39**, 869; 1926) and the analysis of the spectrum of ionised neon Ne II (*Versl.*, Amsterdam, May 1927. NATURE, **119**, 925; 1927. *Zeits. f. Phys.*, **44**, 157; 1927. **46**, 856; 1928) formed preliminary steps for the analysis of the A II spectrum. A great part of the A II lines have now been classified by me. I have found a doublet and a quartet term system. The term structure exhibits a perfect analogy to that of F I and Ne II. The following triplet $4p^4S$-$4s^4P$: (9) 3729,300; (8) 3850,565; (7) 3928,599 involving the deep quartet $4s^4P$ term with the term differences: 844,40 and 515,70, gives the key for the analysis of the spectrum. As examples, the other deep quartet terms are given:

$4p^4P$	: with the term differences	:	307,75 and 357,30
$4p^4D$	,,	,,	439,36; 494,57; and 260,32.
(3)d^4D	,,	,,	153,98; 149,62; and 107,03.

The complete term table for A II, the lists of classified lines, the new measurements, and the analogy with the spectrum of ionised neon will be published in the *Zeits. f. Phys.*

T. L. DE BRUIN.

Physical Laboratory, 'Physica,'
University of Amsterdam, Feb. 21.

The Buoyancy of Whales.

MR. GRAY'S suggestion (NATURE, Mar. 17, p. 421) that whales dying at the surface sometimes float because the air in their lungs is held in by the valves of the blowhole is very interesting, and perhaps helps also in understanding how whales can remain so long under water. There are, however, so many unusual features about whales that one cannot help wondering whether other explanations are not possible. It is, for example, conceivable that whales breathe differently from other mammals, and that the muscular effort they expend in breathing is used not for drawing air into their lungs but for driving it out. On this view the filling of the lungs would be due to the elastic recoil of the thoracic wall and expansion of the cavity following the muscular contraction, and when a whale dies and the muscles relax the lungs would fill with air if the blowhole is above the surface or with water if it is below.

T. H. TAYLOR.

University of Leeds.

Helium in Deep Diving and Caisson Working.[1]

By Prof. J. H. HILDEBRAND, University of California,
and Dr. R. R. SAYERS and W. P. YANT, United States Bureau of Mines.

IN diving and in caisson operations where men are subjected to air pressures above ordinary atmospheric pressure, the amount of air dissolved in the blood stream and body tissues increases. The excess oxygen can be disposed of by the ordinary combustion process, but the excess nitrogen tends to separate in the form of bubbles when the pressure is released. As the amount dissolved is approximately proportional to the pressure, there may be enough separating in the blood stream and tissues of a diver or caisson worker coming up rapidly from a considerable depth to produce 'caisson illness.' This is accompanied by severe bodily pains, and, in more severe cases, unconsciousness or even death.

It is therefore necessary to prolong the time of ascent in deep diving or of decompression in caisson working sufficiently to allow the excess nitrogen to escape from the tissues through the lungs. This period of decompression increases rapidly with the depth or pressure to which the worker has been exposed and with the duration of exposure, and becomes almost prohibitive at depths greater than 200 feet, except in emergencies and for very short exposures. According to present-day diving regulations and practice, it requires but 3 to 8 minutes, depending on the individual diver, to descend to a depth of 200 feet, but after a stay of 45 minutes at the bottom, 2 or more hours would be required to bring the diver to the surface in safety. Mechanical troubles, accidents to the diver, unusually cold water, or stormy weather may make it difficult or impossible to allow such a period, and even at best the proportion of the total time available for work at the bottom rapidly becomes too short to be practical as great depths are approached.

Theoretical studies of the general problem of solubility, begun by the senior writer some years ago, made it evident that the least soluble gas, almost regardless of the solvent, should be helium. As he was familiar with the theory of caisson illness, the idea naturally arose of substituting helium for the nitrogen of air for respiration by divers and caisson workers. Eventually a small amount of helium was obtained from the United States Bureau of Mines through the courtesy of R. B. Moore, former Chief Chemist, with whom the problem had been previously discussed.

Progress was slow, in the absence of suitable equipment, and it became evident that to bring the matter to any practical fruition would require large-scale experiments and access to considerable quantities of helium, of which the United States Government was the only producer. Meanwhile, the sinking of a submarine at a depth that rendered access by divers difficult, suggested that any consideration of personal profit should give way to the prompt working out of the practical problems involved. Accordingly, the senior author wrote in January 1924 to S. C. Lind, then Chief Chemist of the Bureau of Mines, suggesting that the Bureau undertake the necessary experimental work. This suggestion was accepted, and the senior writer was associated with the Bureau as consulting chemist. The work was put into the hands of Dr. R. R. Sayers, Chief Surgeon for the Bureau of Mines, and W. P. Yant, Supervising Chemist, Health Laboratory Section.

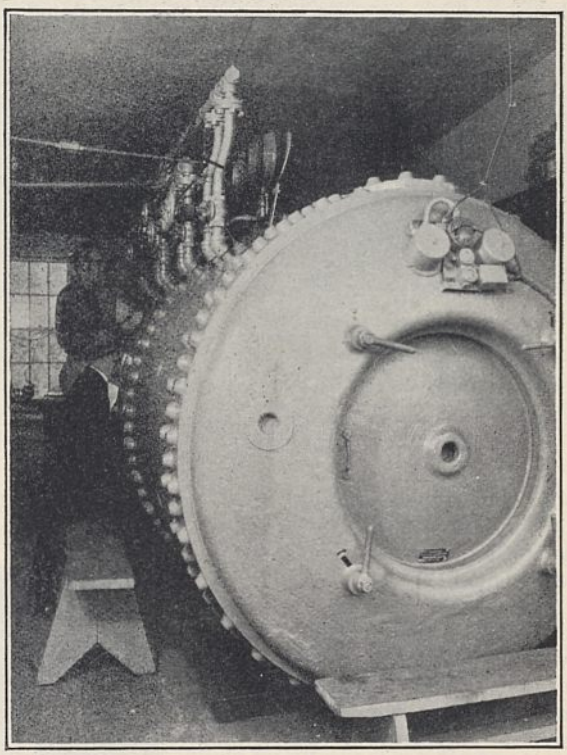

FIG. 1.—Compression chamber used for conducting experiments on men. This was built at the Norfolk Navy Yard and was of 1¼ in. steel and capable of withstanding a working pressure of 600 lb. per sq. in., and a much greater test pressure. Note telephone and electric light connexions above door, and gauges and valves for regulating and indicating pressure. One of the horizontal lines leading from the manifold extends through the reducing valve to the bank of air bottles and the other to a supply of pure oxygen or of helium-oxygen mixture.

As is so often the case, it has since been brought to light that the idea occurred independently to different individuals. On Aug. 15, 1919, an application for a patent was filed, and on Nov. 6, 1923, issued, to C. J. Cooke, of Washington, D.C., for the use of a respirable mixture of oxygen and helium for workers under pressure; and at about the same time Elihu Thomson, it appears, had a similar idea. In a paper, "Helium Production and Uses," by Prof. J. C. McLennan, in NATURE of Aug. 19, 1920, is the following statement:

"It has been suggested by Elihu Thomson and

[1] Published by permission of the Director, U.S. Bureau of Mines. (Not subject to copyright.)

others that if divers were supplied with a mixture of oxygen and helium, the rate of expulsion of carbon dioxide from the lungs might be increased, and the period of submergence as a consequence be considerably lengthened."

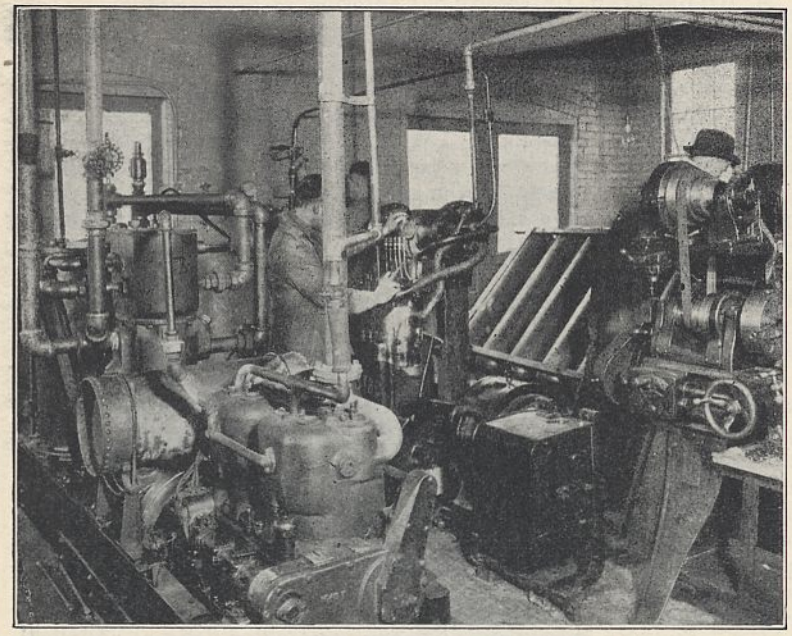

FIG. 2.—Air compressors and apparatus for compressing air into a storage bank consisting of thirty 2-cub. ft. free air capacity cylinders. The air is compressed to approximately 1800 lb. per sq. in., which gives sufficient volume in the bank to fill the large test chamber to a pressure of 100 lb. per sq. in. within two or three minutes. All these cylinders are connected in parallel to a manifold from which the air is released through a reducing valve. One compressor is electrically driven and the other by means of a gasoline engine. This ensures two independent sources of power and an adequate air supply in the event of difficulties being experienced in these experiments, and extended recompression of the men being necessary to allay the occurrence of caisson disease.

As a matter of fact, however, the work at the Bureau of Mines was undertaken and pursued to a considerable fruition before any of those concerned with it became cognizant of the claims of either Mr. Cooke or Dr. Thomson. It may be added also, that if the statement by Prof. McLennan correctly expresses the idea of Dr. Thomson, this was based upon an incorrect assumption, for caisson illness does not depend upon the diffusion of carbon dioxide from the lungs. (For discussion of priority claims see E. Thomson, *Science*, Jan. 14, 1927; J. H. Hildebrand, *Science*, Mar. 15, 1927; and W. P. Yant, *Ind. and Eng. Chem.*, news edition, Mar. 10, 1927.)

The fact remains that the use of helium for deep diving could become practical only after extensive and costly experimentation for the development of a suitable technique. Investigations planned toward this end were initiated by the Bureau of Mines and continued later with the co-operation of the Navy Department. The results of the initial investigations made by the Bureau were published, in part, in its *Reports of Investigations Serial 2670*, February 1925, entitled "Possibilities in the Use of Helium–Oxygen Mixtures as a Mitigation of Caisson Disease," by R. R. Sayers, W. P. Yant, and J. H. Hildebrand. This publication recounts the results of a series of tests with small animals. It was found at the outset that rats could be subjected to a helium – oxygen mixture for 1 hour at a pressure of 20 atmospheres, corresponding to about 600 feet of water, or more than three times the maximum pressure at which extensive diving operations have been conducted; and further, that they could be brought out of this pressure safely in 34 minutes.

It was found important to reduce the proportion of oxygen from 21 per cent. by volume, the proportion in air, to a much smaller proportion, varying from 1·5 to 15 per cent. according to the pressure employed. In most of the studies a pressure of 10 atmospheres was used, with varying periods of exposure, up to 5 hours. It was found that animals could be brought out from the helium–oxygen mixture

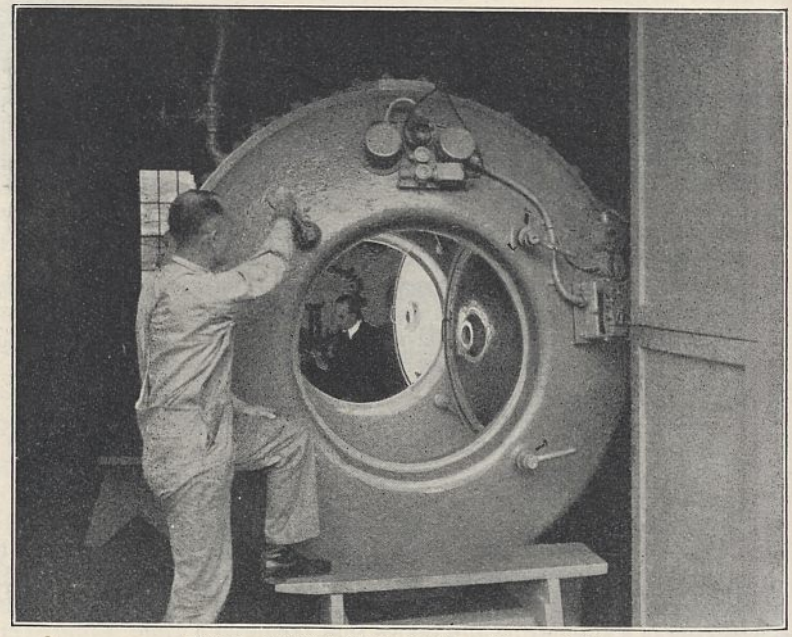

FIG. 3.—Interior of large chamber with men inside.

(*Continued on p* 591.)

Supplement to NATURE

No. 3050 APRIL 14, 1928

New Problems in Quantum Theory.

FIFTEEN years have elapsed since Niels Bohr first published a series of papers which were the beginning of a new epoch in the development of the quantum theory. Adopting the atomic model proposed by Rutherford, in which electrons circle round a massive nucleus under the action of a Coulomb force of electric attraction, Bohr gained immediate success in interpreting the spectrum of hydrogen and of ionised helium. For his purpose he was compelled to assume the existence of 'stationary states,' and the emission of monochromatic radiation in the transition between two such states of an atomic system.

In one sense the new method raised as many difficulties as it removed, and to some of the more conservative physicists the account of Bohr's atom read like a fairy tale. Further progress in the interpretation of line spectra was made through the generalisations of Wilson and Sommerfeld, but in spite of the inclusion of a widening circle of facts and the fulfilment of predictions, it came to be realised that a more radical procedure was necessary before a consistent and complete theory could be evolved. In the forward movement few have been more active than Bohr himself. The employment of a spinning electron by Goudsmit and Uhlenbeck removed many discrepancies, and it seems as if some form of magnetic electron is likely to be accepted as a fundamental constituent of an atomic system. The magneton of S. B. McLaren with its quantum of angular momentum may be regarded as the prototype of all such magnetic electrons.

Within the last few years the matrix mechanics of Heisenberg, Born, and Jordan, the quantum algebra of Dirac, and the undulatory mechanics of Schrödinger, have led to remarkable theoretical developments. The new wave mechanics gave rise to the hope that an account of atomic phenomena might be obtained which would not differ essentially from that afforded by the classical theories of electricity and magnetism. Unfortunately, Bohr's statement in the following communication of the principles underlying the description of atomic phenomena gives little, if any, encouragement in this direction.

In classical mechanics it is assumed that the position of a particle (such as an electron) can be determined at a specified instant of time by means of its co-ordinates. As the time varies it is supposed to be possible to trace the path of the particle through space, or to determine its 'world line' in the four-dimensional world. Further, it is assumed that the concept of causality may be applied in considering the effect of the action of external forces. Thus in classical physics we have a causal space-time co-ordination, based on the assumption that the methods or tools of measurement do not affect the phenomena which are observed.

In the new quantum theory the outlook is changed, for any attempt to observe the position or motion of an electron involves illumination by light, and this implies interaction between the electron and the light employed in making the measurement. The position and the path of an electron become vague. Thus there is introduced in the new quantum mechanics an indefiniteness which contrasts with the clear-cut concepts of classical mechanics. Bohr asserts that in any phenomenon which we may attempt to observe there is an essential discontinuity, or rather individuality, which may be symbolised by Planck's constant h. The causal space-time co-ordination of atomic phenomena must on this view be abandoned, and we are left with a somewhat vague statistical description.

The strange conflict which has been waged between the wave theory of light and the light quantum hypothesis has resulted in a remarkable dilemma. But now we have a parallel dilemma, for a material particle manifests some of the attributes of wave motion. Can these apparently contradictory views be reconciled? According to Bohr, the pictures ought to be regarded not as contradictory but as complementary. Radiation in free space is not open to observation, and is a mere abstraction. An isolated material particle likewise can never be observed and is also an abstraction. It is only through their interaction with other systems that the properties of these abstractions can be defined and observed.

It must be confessed that the new quantum mechanics is far from satisfying the requirements of the layman who seeks to clothe his conceptions in figurative language. Indeed, its originators probably hold that such symbolic representation is inherently impossible. It is earnestly to be hoped that this is not their last word on the subject, and that they may yet be successful in expressing the quantum postulate in picturesque form.

The Quantum Postulate and the Recent Development of Atomic Theory.[1]

By Prof. N. Bohr, For. Mem. R.S.

IN connexion with the discussion of the physical interpretation of the quantum theoretical methods developed during recent years, I should like to make the following general remarks regarding the principles underlying the description of atomic phenomena, which I hope may help to harmonise the different views, apparently so divergent, concerning this subject.

1. Quantum Postulate and Causality.

The quantum theory is characterised by the acknowledgment of a fundamental limitation in the classical physical ideas when applied to atomic phenomena. The situation thus created is of a peculiar nature, since our interpretation of the experimental material rests essentially upon the classical concepts. Notwithstanding the difficulties which hence are involved in the formulation of the quantum theory, it seems, as we shall see, that its essence may be expressed in the so-called quantum postulate, which attributes to any atomic process an essential discontinuity, or rather individuality, completely foreign to the classical theories and symbolised by Planck's quantum of action.

This postulate implies a renunciation as regards the causal space-time co-ordination of atomic processes. Indeed, our usual description of physical phenomena is based entirely on the idea that the phenomena concerned may be observed without disturbing them appreciably. This appears, for example, clearly in the theory of relativity, which has been so fruitful for the elucidation of the classical theories. As emphasised by Einstein, every observation or measurement ultimately rests on the coincidence of two independent events at the same space-time point. Just these coincidences will not be affected by any differences which the space-time co-ordination of different observers otherwise may exhibit. Now the quantum postulate implies that any observation of atomic phenomena will involve an interaction with the agency of observation not to be neglected. Accordingly, an independent reality in the ordinary physical sense can neither be ascribed to the phenomena nor to the agencies of observation. After all, the concept of observation is in so far arbitrary as it depends upon which objects are included in the system to be observed. Ultimately every observation can of course be reduced to our sense perceptions. The circumstance, however, that in interpreting observations use has always to be made of theoretical notions, entails that for every particular case it is a question of convenience at what point the concept of observation involving the quantum postulate with its inherent 'irrationality' is brought in.

This situation has far-reaching consequences. On one hand, the definition of the state of a physical system, as ordinarily understood, claims the elimination of all external disturbances. But in that case, according to the quantum postulate, any observation will be impossible, and, above all, the concepts of space and time lose their immediate sense. On the other hand, if in order to make observation possible we permit certain interactions with suitable agencies of measurement, not belonging to the system, an unambiguous definition of the state of the system is naturally no longer possible, and there can be no question of causality in the ordinary sense of the word. The very nature of the quantum theory thus forces us to regard the space-time co-ordination and the claim of causality, the union of which characterises the classical theories, as complementary but exclusive features of the description, symbolising the idealisation of observation and definition respectively. Just as the relativity theory has taught us that the convenience of distinguishing sharply between space and time rests solely on the smallness of the velocities ordinarily met with compared to the velocity of light, we learn from the quantum theory that the appropriateness of our usual causal space-time description depends entirely upon the small value of the quantum of action as compared to the actions involved in ordinary sense perceptions. Indeed, in the description of atomic phenomena, the quantum postulate presents us with the task of developing a 'complementarity' theory the consistency of which can be judged only by weighing the possibilities of definition and observation.

This view is already clearly brought out by the much-discussed question of the nature of light and the ultimate constituents of matter. As regards light, its propagation in space and time is adequately expressed by the electromagnetic theory. Especially the interference phenomena *in vacuo* and the optical properties of material media are completely governed by the wave theory superposition principle. Nevertheless, the conservation of energy and momentum during the interaction between radiation and matter, as evident in the photoelectric and Compton effect, finds its adequate expression just in the light quantum idea put forward by Einstein. As is well known, the doubts regarding the validity of the superposition principle on one hand and of the conservation laws on the other, which were suggested by this apparent contradiction, have been definitely disproved through direct experiments. This situation would seem clearly to indicate the impossibility of a causal space-time description of the light phenomena. On one hand, in attempting to trace

[1] The content of this paper is essentially the same as that of a lecture on the present state of the quantum theory delivered on Sept. 16, 1927, at the Volta celebration in Como. For a summary of the theory just previous to the development of the new methods the reader is referred to a lecture of the author, "Atomic Theory and Mechanics," published in this periodical (NATURE, **116**, 809; 1925). The rapid development which has taken place since has given rise to a considerable number of publications. The present paper is confined to a few references to recent articles which have a special bearing on the subject now under discussion.

the laws of the time-spatial propagation of light according to the quantum postulate, we are confined to statistical considerations. On the other hand, the fulfilment of the claim of causality for the individual light processes, characterised by the quantum of action, entails a renunciation as regards the space-time description. Of course, there can be no question of a quite independent application of the ideas of space and time and of causality. The two views of the nature of light are rather to be considered as different attempts at an interpretation of experimental evidence in which the limitation of the classical concepts is expressed in complementary ways.

The problem of the nature of the constituents of matter presents us with an analogous situation. The individuality of the elementary electrical corpuscles is forced upon us by general evidence. Nevertheless, recent experience, above all the discovery of the selective reflection of electrons from metal crystals, requires the use of the wave theory superposition principle in accordance with the original ideas of L. de Broglie. Just as in the case of light, we have consequently in the question of the nature of matter, so far as we adhere to classical concepts, to face an inevitable dilemma, which has to be regarded as the very expression of experimental evidence. In fact, here again we are not dealing with contradictory but with complementary pictures of the phenomena, which only together offer a natural generalisation of the classical mode of description. In the discussion of these questions, it must be kept in mind that, according to the view taken above, radiation in free space as well as isolated material particles are abstractions, their properties on the quantum theory being definable and observable only through their interaction with other systems. Nevertheless, these abstractions are, as we shall see, indispensable for a description of experience in connexion with our ordinary space-time view.

The difficulties with which a causal space-time description is confronted in the quantum theory, and which have been the subject of repeated discussions, are now placed into the foreground by the recent development of the symbolic methods. An important contribution to the problem of a consistent application of these methods has been made lately by Heisenberg (*Zeitschr. f. Phys.*, **43**, 172; 1927). In particular, he has stressed the peculiar reciprocal uncertainty which affects all measurements of atomic quantities. Before we enter upon his results it will be advantageous to show how the complementary nature of the description appearing in this uncertainty is unavoidable already in an analysis of the most elementary concepts employed in interpreting experience.

2. Quantum of Action and Kinematics.

The fundamental contrast between the quantum of action and the classical concepts is immediately apparent from the simple formulæ which form the common foundation of the theory of light quanta and of the wave theory of material particles. If Planck's constant be denoted by h, as is well known,

$$E\tau = I\lambda = h, \quad . \quad . \quad . \quad (1)$$

where E and I are energy and momentum respectively, τ and λ the corresponding period of vibration and wave-length. In these formulæ the two notions of light and also of matter enter in sharp contrast. While energy and momentum are associated with the concept of particles, and hence may be characterised according to the classical point of view by definite space-time co-ordinates, the period of vibration and wave-length refer to a plane harmonic wave train of unlimited extent in space and time. Only with the aid of the superposition principle does it become possible to attain a connexion with the ordinary mode of description. Indeed, a limitation of the extent of the wave-fields in space and time can always be regarded as resulting from the interference of a group of elementary harmonic waves. As shown by de Broglie (Thèse, Paris, 1924), the translational velocity of the individuals associated with the waves can be represented by just the so-called group-velocity. Let us denote a plane elementary wave by

$$A \cos 2\pi(\nu t - x\sigma_x - y\sigma_y - z\sigma_z + \delta),$$

where A and δ are constants determining respectively the amplitude and the phase. The quantity $\nu = 1/\tau$ is the frequency, σ_x, σ_y, σ_z the wave numbers in the direction of the co-ordinate axes, which may be regarded as vector components of the wave number $\sigma = 1/\lambda$ in the direction of propagation. While the wave or phase velocity is given by ν/σ, the group-velocity is defined by $d\nu/d\sigma$. Now according to the relativity theory we have for a particle with the velocity v:

$$I = \frac{v}{c^2}E \text{ and } vdI = dE,$$

where c denotes the velocity of light. Hence by equation (1) the phase velocity is c^2/v and the group-velocity v. The circumstance that the former is in general greater than the velocity of light emphasises the symbolic character of these considerations. At the same time, the possibility of identifying the velocity of the particle with the group-velocity indicates the field of application of space-time pictures in the quantum theory. Here the complementary character of the description appears, since the use of wave-groups is necessarily accompanied by a lack of sharpness in the definition of period and wave-length, and hence also in the definition of the corresponding energy and momentum as given by relation (1).

Rigorously speaking, a limited wave-field can only be obtained by the superposition of a manifold of elementary waves corresponding to all values of ν and σ_x, σ_y, σ_z. But the order of magnitude of the mean difference between these values for two elementary waves in the group is given in the most favourable case by the condition

$$\Delta t\Delta\nu = \Delta x\Delta\sigma_x = \Delta y\Delta\sigma_y = \Delta z\Delta\sigma_z = 1,$$

where Δt, Δx, Δy, Δz denote the extension of the wave-field in time and in the directions of space corresponding to the co-ordinate axes. These

relations—well known from the theory of optical instruments, especially from Rayleigh's investigation of the resolving power of spectral apparatus—express the condition that the wave-trains extinguish each other by interference at the space-time boundary of the wave-field. They may be regarded also as signifying that the group as a whole has no phase in the same sense as the elementary waves. From equation (1) we find thus:

$$\Delta t \Delta E = \Delta x \Delta I_x = \Delta y \Delta I_y = \Delta z \Delta I_z = h \quad . \quad (2)$$

as determining the highest possible accuracy in the definition of the energy and momentum of the individuals associated with the wave-field. In general, the conditions for attributing an energy and a momentum value to a wave-field by means of formula (1) are much less favourable. Even if the composition of the wave-group corresponds in the beginning to the relations (2), it will in the course of time be subject to such changes that it becomes less and less suitable for representing an individual. It is this very circumstance which gives rise to the paradoxical character of the problem of the nature of light and of material particles. The limitation in the classical concepts expressed through relation (2) is, besides, closely connected with the limited validity of classical mechanics, which in the wave theory of matter corresponds to the geometrical optics, in which the propagation of waves is depicted through 'rays.' Only in this limit can energy and momentum be unambiguously defined on the basis of space-time pictures. For a general definition of these concepts we are confined to the conservation laws, the rational formulation of which has been a fundamental problem for the symbolical methods to be mentioned below.

In the language of the relativity theory, the content of the relations (2) may be summarised in the statement that according to the quantum theory a general reciprocal relation exists between the maximum sharpness of definition of the space-time and energy-momentum vectors associated with the individuals. This circumstance may be regarded as a simple symbolical expression for the complementary nature of the space-time description and the claims of causality. At the same time, however, the general character of this relation makes it possible to a certain extent to reconcile the conservation laws with the space-time co-ordination of observations, the idea of a coincidence of well-defined events in a space-time point being replaced by that of unsharply defined individuals within finite space-time regions.

This circumstance permits us to avoid the well-known paradoxes which are encountered in attempting to describe the scattering of radiation by free electrical particles as well as the collision of two such particles. According to the classical concepts, the description of the scattering requires a finite extent of the radiation in space and time, while in the change of the motion of the electron demanded by the quantum postulate one seemingly is dealing with an instantaneous effect taking place at a definite point in space. Just as in the case of radiation, however, it is impossible to define momentum and energy for an electron without considering a finite space-time region. Furthermore, an application of the conservation laws to the process implies that the accuracy of definition of the energy momentum vector is the same for the radiation and the electron. In consequence, according to relation (2), the associated space-time regions can be given the same size for both individuals in interaction.

A similar remark applies to the collision between two material particles, although the significance of the quantum postulate for this phenomenon was disregarded before the necessity of the wave concept was realised. Here this postulate does indeed represent the idea of the individuality of the particles which, transcending the space-time description, meets the claim of causality. While the physical content of the light quantum idea is wholly connected with the conservation theorems for energy and momentum, in the case of the electrical particles the electric charge has to be taken into account in this connexion. It is scarcely necessary to mention that for a more detailed description of the interaction between individuals we cannot restrict ourselves to the facts expressed by formulæ (1) and (2), but must resort to a procedure which allows us to take into account the coupling of the individuals, characterising the interaction in question, where just the importance of the electric charge appears. As we shall see, such a procedure necessitates a further departure from visualisation in the usual sense.

3. Measurements in the Quantum Theory.

In his investigations already mentioned on the consistency of the quantum theoretical methods, Heisenberg has given the relation (2) as an expression for the maximum precision with which the space-time co-ordinates and momentum-energy components of a particle can be measured simultaneously. His view was based on the following consideration: On one hand, the co-ordinates of a particle can be measured with any desired degree of accuracy by using, for example, an optical instrument, provided radiation of sufficiently short wave-length is used for illumination. According to the quantum theory, however, the scattering of radiation from the object is always connected with a finite change in momentum, which is the larger the smaller the wave-length of the radiation used. The momentum of a particle, on the other hand, can be determined with any desired degree of accuracy by measuring, for example, the Doppler effect of the scattered radiation, provided the wave-length of the radiation is so large that the effect of recoil can be neglected, but then the determination of the space co-ordinates of the particle becomes correspondingly less accurate.

The essence of this consideration is the inevitability of the quantum postulate in the estimation of the possibilities of measurement. A closer investigation of the possibilities of definition would

still seem necessary in order to bring out the general complementary character of the description. Indeed, a discontinuous change of energy and momentum during observation could not prevent us from ascribing accurate values to the space-time co-ordinates, as well as to the momentum-energy components before and after the process. The reciprocal uncertainty which always affects the values of these quantities is, as will be clear from the preceding analysis, essentially an outcome of the limited accuracy with which changes in energy and momentum can be defined, when the wave-fields used for the determination of the space-time co-ordinates of the particle are sufficiently small.

In using an optical instrument for determinations of position, it is necessary to remember that the formation of the image always requires a convergent beam of light. Denoting by λ the wave-length of the radiation used, and by ϵ the so-called numerical aperture, that is, the sine of half the angle of convergence, the resolving power of a microscope is given by the well-known expression $\lambda/2\epsilon$. Even if the object is illuminated by parallel light, so that the momentum h/λ of the incident light quantum is known both as regards magnitude and direction, the finite value of the aperture will prevent an exact knowledge of the recoil accompanying the scattering. Also, even if the momentum of the particle were accurately known before the scattering process, our knowledge of the component of momentum parallel to the focal plane after the observation would be affected by an uncertainty amounting to $2\epsilon h/\lambda$. The product of the least inaccuracies with which the positional co-ordinate and the component of momentum in a definite direction can be ascertained is therefore just given by formula (2). One might perhaps expect that in estimating the accuracy of determining the position, not only the convergence but also the length of the wave-train has to be taken into account, because the particle could change its place during the finite time of illumination. Due to the fact, however, that the exact knowledge of the wave-length is immaterial for the above estimate, it will be realised that for any value of the aperture the wave-train can always be taken so short that a change of position of the particle during the time of observation may be neglected in comparison to the lack of sharpness inherent in the determination of position due to the finite resolving power of the microscope.

In measuring momentum with the aid of the Doppler effect—with due regard to the Compton effect—one will employ a parallel wave-train. For the accuracy, however, with which the change in wave-length of the scattered radiation can be measured the extent of the wave-train in the direction of propagation is essential. If we assume that the directions of the incident and scattered radiation are parallel and opposite respectively to the direction of the position co-ordinate and momentum component to be measured, then $c\lambda/2l$ can be taken as a measure of the accuracy in the determination of the velocity, where l denotes the length of the wave-train. For simplicity, we here have regarded the velocity of light as large compared to the velocity of the particle. If m represents the mass of the particle, then the uncertainty attached to the value of the momentum after observation is $cm\lambda/2l$. In this case the magnitude of the recoil, $2h/\lambda$, is sufficiently well defined in order not to give rise to an appreciable uncertainty in the value of the momentum of the particle after observation. Indeed, the general theory of the Compton effect allows us to compute the momentum components in the direction of the radiation before and after the recoil from the wave-lengths of the incident and scattered radiation. Even if the positional co-ordinates of the particle were accurately known in the beginning, our knowledge of the position after observation nevertheless will be affected by an uncertainty. Indeed, on account of the impossibility of attributing a definite instant to the recoil, we know the mean velocity in the direction of observation during the scattering process only with an accuracy $2h/m\lambda$. The uncertainty in the position after observation hence is $2hl/mc\lambda$. Here, too, the product of the inaccuracies in the measurement of position and momentum is thus given by the general formula (2).

Just as in the case of the determination of position, the time of the process of observation for the determination of momentum may be made as short as is desired if only the wave-length of the radiation used is sufficiently small. The fact that the recoil then gets larger does not, as we have seen, affect the accuracy of measurement. It should further be mentioned, that in referring to the velocity of a particle as we have here done repeatedly, the purpose has only been to obtain a connexion with the ordinary space-time description convenient in this case. As it appears already from the considerations of de Broglie mentioned above, the concept of velocity must always in the quantum theory be handled with caution. It will also be seen that an unambiguous definition of this concept is excluded by the quantum postulate. This is particularly to be remembered when comparing the results of successive observations. Indeed, the position of an individual at two given moments can be measured with any desired degree of accuracy; but if, from such measurements, we would calculate the velocity of the individual in the ordinary way, it must be clearly realised that we are dealing with an abstraction, from which no unambiguous information concerning the previous or future behaviour of the individual can be obtained.

According to the above considerations regarding the possibilities of definition of the properties of individuals, it will obviously make no difference in the discussion of the accuracy of measurements of position and momentum of a particle if collisions with other material particles are considered instead of scattering of radiation. In both cases we see that the uncertainty in question equally affects the description of the agency of measurement and of the object. In fact, this uncertainty cannot be avoided in a description of the behaviour of individuals with respect to a co-ordinate system

fixed in the ordinary way by means of solid bodies and unperturbable clocks. The experimental devices—opening and closing of apertures, etc.—are seen to permit only conclusions regarding the space-time extension of the associated wave-fields.

In tracing observations back to our sensations, once more regard has to be taken to the quantum postulate in connexion with the perception of the agency of observation, be it through its direct action upon the eye or by means of suitable auxiliaries such as photographic plates, Wilson clouds, etc. It is easily seen, however, that the resulting additional statistical element will not influence the uncertainty in the description of the object. It might even be conjectured that the arbitrariness in what is regarded as object and what as agency of observation would open up a possibility of avoiding this uncertainty altogether. In connexion with the measurement of the position of a particle, one might, for example, ask whether the momentum transmitted by the scattering could not be determined by means of the conservation theorem from a measurement of the change of momentum of the microscope—including light source and photographic plate—during the process of observation. A closer investigation shows, however, that such a measurement is impossible, if at the same time one wants to know the position of the microscope with sufficient accuracy. In fact, it follows from the experiences which have found expression in the wave theory of matter, that the position of the centre of gravity of a body and its total momentum can only be defined within the limits of reciprocal accuracy given by relation (2).

Strictly speaking, the idea of observation belongs to the causal space-time way of description. Due to the general character of relation (2), however, this idea can be consistently utilised also in the quantum theory, if only the uncertainty expressed through this relation is taken into account. As remarked by Heisenberg, one may even obtain an instructive illustration to the quantum theoretical description of atomic (microscopic) phenomena by comparing this uncertainty with the uncertainty, due to imperfect measurements, inherently contained in any observation as considered in the ordinary description of natural phenomena. He remarks on that occasion that even in the case of macroscopic phenomena we may say, in a certain sense, that they are created by repeated observations. It must not be forgotten, however, that in the classical theories any succeeding observation permits a prediction of future events with ever-increasing accuracy, because it improves our knowledge of the initial state of the system. According to the quantum theory, just the impossibility of neglecting the interaction with the agency of measurement means that every observation introduces a new uncontrollable element. Indeed, it follows from the above considerations that the measurement of the positional coordinates of a particle is accompanied not only by a finite change in the dynamical variables, but also the fixation of its position means a complete rupture in the causal description of its dynamical behaviour, while the determination of its momentum always implies a gap in the knowledge of its spatial propagation. Just this situation brings out most strikingly the complementary character of the description of atomic phenomena which appears as an inevitable consequence of the contrast between the quantum postulate and the distinction between object and agency of measurement, inherent in our very idea of observation.

4. Correspondence Principle and Matrix Theory.

Hitherto we have only regarded certain general features of the quantum problem. The situation implies, however, that the main stress has to be laid on the formulation of the laws governing the interaction between the objects which we symbolise by the abstractions of isolated particles and radiation. Points of attack for this formulation are presented in the first place by the problem of atomic constitution. As is well known, it has been possible here, by means of an elementary use of classical concepts and in harmony with the quantum postulate, to throw light on essential aspects of experience. For example, the experiments regarding the excitation of spectra by electronic impacts and by radiation are adequately accounted for on the assumption of discrete stationary states and individual transition processes. This is primarily due to the circumstance that in these questions no closer description of the space-time behaviour of the processes is required.

Here the contrast with the ordinary way of description appears strikingly in the circumstance that spectral lines, which on the classical view would be ascribed to the same state of the atom, will, according to the quantum postulate, correspond to separate transition processes, between which the excited atom has a choice. Notwithstanding this contrast, however, a formal connexion with the classical ideas could be obtained in the limit, where the relative difference in the properties of neighbouring stationary states vanishes asymptotically and where in statistical applications the discontinuities may be disregarded. Through this connexion it was possible to a large extent to interpret the regularities of spectra on the basis of our ideas about the structure of the atom.

The aim of regarding the quantum theory as a rational generalisation of the classical theories led to the formulation of the so-called correspondence principle. The utilisation of this principle for the interpretation of spectroscopic results was based on a symbolical application of classical electrodynamics, in which the individual transition processes were each associated with a harmonic in the motion of the atomic particles to be expected according to ordinary mechanics. Except in the limit mentioned, where the relative difference between adjacent stationary states may be neglected, such a fragmentary application of the classical theories could only in certain cases lead to a strictly quantitative description of the phenomena. Especially the connexion developed by

Ladenburg and Kramers between the classical treatment of dispersion and the statistical laws governing the radiative transition processes formulated by Einstein should be mentioned here. Although it was just Kramers' treatment of dispersion that gave important hints for the rational development of correspondence considerations, it is only through the quantum theoretical methods created in the last few years that the general aims laid down in the principle mentioned have obtained an adequate formulation.

As is known, the new development was commenced in a fundamental paper by Heisenberg, where he succeeded in emancipating himself completely from the classical concept of motion by replacing from the very start the ordinary kinematical and mechanical quantities by symbols, which refer directly to the individual processes demanded by the quantum postulate. This was accomplished by substituting for the Fourier development of a classical mechanical quantity a matrix scheme, the elements of which symbolise purely harmonic vibrations and are associated with the possible transitions between stationary states. By requiring that the frequencies ascribed to the elements must always obey the combination principle for spectral lines, Heisenberg could introduce simple rules of calculation for the symbols, which permit a direct quantum theoretical transcription of the fundamental equations of classical mechanics. This ingenious attack on the dynamical problem of atomic theory proved itself from the beginning to be an exceedingly powerful and fertile method for interpreting quantitatively the experimental results. Through the work of Born and Jordan as well as of Dirac, the theory was given a formulation which can compete with classical mechanics as regards generality and consistency. Especially the element characteristic of the quantum theory, Planck's constant, appears explicitly only in the algorithms to which the symbols, the so-called matrices, are subjected. In fact, matrices, which represent canonically conjugated variables in the sense of the Hamiltonian equations, do not obey the commutative law of multiplication, but two such quantities, q and p, have to fulfil the exchange rule

$$pq - qp = \sqrt{-1}\frac{h}{2\pi}. \quad . \quad . \quad . \quad (3)$$

Indeed, this exchange relation expresses strikingly the symbolical character of the matrix formulation of the quantum theory. The matrix theory has often been called a calculus with directly observable quantities. It must be remembered, however, that the procedure described is limited just to those problems, in which in applying the quantum postulate the space-time description may largely be disregarded, and the question of observation in the proper sense therefore placed in the background.

In pursuing further the correspondence of the quantum laws with classical mechanics, the stress placed on the statistical character of the quantum theoretical description, which is brought in by the quantum postulate, has been of fundamental importance. Here the generalisation of the symbolical method made by Dirac and Jordan represented a great progress by making possible the operation with matrices, which are not arranged according to the stationary states, but where the possible values of any set of variables may appear as indices of the matrix elements. In analogy to the interpretation considered in the original form of the theory of the 'diagonal elements' connected only with a single stationary state, as time averages of the quantity to be represented, the general transformation theory of matrices permits the representation of such averages of a mechanical quantity, in the calculation of which any set of variables characterising the 'state' of the system have given values, while the canonically conjugated variables are allowed to take all possible values. On the basis of the procedure developed by these authors and in close connexion with ideas of Born and Pauli, Heisenberg has in the paper already cited above attempted a closer analysis of the physical content of the quantum theory, especially in view of the apparently paradoxical character of the exchange relation (3). In this connexion he has formulated the relation

$$\Delta q \Delta p \sim h \quad . \quad . \quad . \quad . \quad (4)$$

as the general expression for the maximum accuracy with which two canonically conjugated variables can simultaneously be observed. In this way Heisenberg has been able to elucidate many paradoxes appearing in the application of the quantum postulate, and to a large extent to demonstrate the consistency of the symbolic method. In connexion with the complementary nature of the quantum theoretical description, we must, as already mentioned, constantly keep the possibilities of definition as well as of observation before the mind. For the discussion of just this question the method of wave mechanics developed by Schrödinger has, as we shall see, proved of great help. It permits a general application of the principle of superposition also in the problem of interaction, thus offering an immediate connexion with the above considerations concerning radiation and free particles. Below we shall return to the relation of wave mechanics to the general formulation of the quantum laws by means of the transformation theory of matrices.

5. Wave Mechanics and Quantum Postulate.

Already in his first considerations concerning the wave theory of material particles, de Broglie pointed out that the stationary states of an atom may be visualised as an interference effect of the phase wave associated with a bound electron. It is true that this point of view at first did not, as regards quantitative results, lead beyond the earlier methods of quantum theory, to the development of which Sommerfeld has contributed so essentially. Schrödinger, however, succeeded in developing a wave-theoretical method which has opened up new aspects, and has proved to be of decisive

importance for the great progress in atomic physics during the last years. Indeed, the proper vibrations of the Schrödinger wave equation have been found to furnish a representation of the stationary states of an atom meeting all requirements. The energy of each state is connected with the corresponding period of vibration according to the general quantum relation (1). Furthermore, the number of nodes in the various characteristic vibrations gives a simple interpretation to the concept of quantum number which was already known from the older methods, but at first did not seem to appear in the matrix formulation. In addition, Schrödinger could associate with the solutions of the wave equation a continuous distribution of charge and current, which, if applied to a characteristic vibration, represents the electrostatic and magnetic properties of an atom in the corresponding stationary state. Similarly, the superposition of two characteristic solutions corresponds to a continuous vibrating distribution of electrical charge, which on classical electrodynamics would give rise to an emission of radiation, illustrating instructively the consequences of the quantum postulate and the correspondence requirement regarding the transition process between two stationary states formulated in matrix mechanics. Another application of the method of Schrödinger, important for the further development, has been made by Born in his investigation of the problem of collisions between atoms and free electric particles. In this connexion he succeeded in obtaining a statistical interpretation of the wave functions, allowing a calculation of the probability of the individual transition processes required by the quantum postulate. This includes a wave-mechanical formulation of the adiabatic principle of Ehrenfest, the fertility of which appears strikingly in the promising investigations of Hund on the problem of formation of molecules.

In view of these results, Schrödinger has expressed the hope that the development of the wave theory will eventually remove the irrational element expressed by the quantum postulate and open the way for a complete description of atomic phenomena along the line of the classical theories. In support of this view, Schrödinger, in a recent paper (*Ann. d. Phys.*, **83**, p. 956; 1927), emphasises the fact that the discontinuous exchange of energy between atoms required by the quantum postulate, from the point of view of the wave theory, is replaced by a simple resonance phenomenon. In particular, the idea of individual stationary states would be an illusion and its applicability only an illustration of the resonance mentioned. It must be kept in mind, however, that just in the resonance problem mentioned we are concerned with a closed system which, according to the view presented here, is not accessible to observation. In fact, wave mechanics just as the matrix theory on this view represents a symbolic transcription of the problem of motion of classical mechanics adapted to the requirements of quantum theory and only to be interpreted by an explicit use of the quantum postulate. Indeed, the two formulations of the interaction problem might be said to be complementary in the same sense as the wave and particle idea in the description of the free individuals. The apparent contrast in the utilisation of the energy concept in the two theories is just connected with this difference in the starting-point.

The fundamental difficulties opposing a space-time description of a system of particles in interaction appear at once from the inevitability of the superposition principle in the description of the behaviour of individual particles. Already for a free particle the knowledge of energy and momentum excludes, as we have seen, the exact knowledge of its space-time co-ordinates. This implies that an immediate utilisation of the concept of energy in connexion with the classical idea of the potential energy of the system is excluded. In the Schrödinger wave equation these difficulties are avoided by replacing the classical expression of the Hamiltonian by a differential operator by means of the relation

$$p = \sqrt{-1}\frac{h}{2\pi}\frac{\delta}{\delta q}, \quad . \quad . \quad . \quad (5)$$

where p denotes a generalised component of momentum and q the canonically conjugated variable. Hereby the negative value of the energy is regarded as conjugated to the time. So far, in the wave equation, time and space as well as energy and momentum are utilised in a purely formal way.

The symbolical character of Schrödinger's method appears not only from the circumstance that its simplicity, similarly to that of the matrix theory, depends essentially upon the use of imaginary arithmetic quantities. But above all there can be no question of an immediate connexion with our ordinary conceptions because the 'geometrical' problem represented by the wave equation is associated with the so-called co-ordinate space, the number of dimensions of which is equal to the number of degrees of freedom of the system, and hence in general greater than the number of dimensions of ordinary space. Further, Schrödinger's formulation of the interaction problem, just as the formulation offered by matrix theory, involves a neglect of the finite velocity of propagation of the forces claimed by relativity theory.

On the whole, it would scarcely seem justifiable, in the case of the interaction problem, to demand a visualisation by means of ordinary space-time pictures. In fact, all our knowledge concerning the internal properties of atoms is derived from experiments on their radiation or collision reactions, such that the interpretation of experimental facts ultimately depends on the abstractions of radiation in free space, and free material particles. Hence, our whole space-time view of physical phenomena, as well as the definition of energy and momentum, depends ultimately upon these abstractions. In judging the applications of these auxiliary ideas we should only demand inner consistency, in which connexion special regard has to be paid to the possibilities of definition and observation.

In the characteristic vibrations of Schrödinger's wave equation we have, as mentioned, an adequate representation of the stationary states of an atom allowing an unambiguous definition of the energy of the system by means of the general quantum relation (1). This entails, however, that in the interpretation of observations, a fundamental renunciation regarding the space-time description is unavoidable. In fact, the consistent application of the concept of stationary states excludes, as we shall see, any specification regarding the behaviour of the separate particles in the atom. In problems where a description of this behaviour is essential, we are bound to use the general solution of the wave equation which is obtained by superposition of characteristic solutions. We meet here with a complementarity of the possibilities of definition quite analogous to that which we have considered earlier in connexion with the properties of light and free material particles. Thus, while the definition of energy and momentum of individuals is attached to the idea of a harmonic elementary wave, every space-time feature of the description of phenomena is, as we have seen, based on a consideration of the interferences taking place inside a group of such elementary waves. Also in the present case the agreement between the possibilities of observation and those of definition can be directly shown.

According to the quantum postulate any observation regarding the behaviour of the electron in the atom will be accompanied by a change in the state of the atom. As stressed by Heisenberg, this change will, in the case of atoms in stationary states of low quantum number, consist in general in the ejection of the electron from the atom. A description of the 'orbit' of the electron in the atom with the aid of subsequent observations is hence impossible in such a case. This is connected with the circumstance that from characteristic vibrations with only a few nodes no wave packages can be built up which would even approximately represent the 'motion' of a particle. The complementary nature of the description, however, appears particularly in that the use of observations concerning the behaviour of particles in the atom rests on the possibility of neglecting, during the process of observation, the interaction between the particles, thus regarding them as free. This requires, however, that the duration of the process is short compared with the natural periods of the atom, which again means that the uncertainty in the knowledge of the energy transferred in the process is large compared to the energy differences between neighbouring stationary states.

In judging the possibilities of observation it must, on the whole, be kept in mind that the wave mechanical solutions can be visualised only in so far as they can be described with the aid of the concept of free particles. Here the difference between classical mechanics and the quantum theoretical treatment of the problem of interaction appears most strikingly. In the former such a restriction is unnecessary, because the 'particles' are here endowed with an immediate 'reality,' independently of their being free or bound. This situation is particularly important in connexion with the consistent utilisation of Schrödinger's electric density as a measure of the probability for electrons being present within given space regions of the atom. Remembering the restriction mentioned, this interpretation is seen to be a simple consequence of the assumption that the probability of the presence of a free electron is expressed by the electric density associated with the wave-field in a similar way to that by which the probability of the presence of a light quantum is given by the energy density of the radiation.

As already mentioned, the means for a general consistent utilisation of the classical concepts in the quantum theory have been created through the transformation theory of Dirac and Jordan, by the aid of which Heisenberg has formulated his general uncertainty relation (4). In this theory also the Schrödinger wave equation has obtained an instructive application. In fact, the characteristic solutions of this equation appear as auxiliary functions which define a transformation from matrices with indices representing the energy values of the system to other matrices, the indices of which are the possible values of the space co-ordinates. It is also of interest in this connexion to mention that Jordan and Klein (*Zeitsch. f. Phys.*, **45**, 751 ; 1927) have recently arrived at the formulation of the problem of interaction expressed by the Schrödinger wave equation, taking as starting-point the wave representation of individual particles and applying a symbolic method closely related to the deep-going treatment of the radiation problem developed by Dirac from the point of view of the matrix theory, to which we shall return below.

6. Reality of Stationary States.

In the conception of stationary states we are, as mentioned, concerned with a characteristic application of the quantum postulate. By its very nature this conception means a complete renunciation as regards a time description. From the point of view taken here, just this renunciation forms the necessary condition for an unambiguous definition of the energy of the atom. Moreover, the conception of a stationary state involves, strictly speaking, the exclusion of all interactions with individuals not belonging to the system. The fact that such a closed system is associated with a particular energy value may be considered as an immediate expression for the claim of causality contained in the theorem of conservation of energy. This circumstance justifies the assumption of the supra-mechanical stability of the stationary states, according to which the atom, before as well as after an external influence, always will be found in a well-defined state, and which forms the basis for the use of the quantum postulate in problems concerning atomic structure.

In a judgment of the well-known paradoxes which this assumption entails for the description of collision and radiation reactions, it is essential to consider the limitations of the possibilities of

definition of the reacting free individuals, which is expressed by relation (2). In fact, if the definition of the energy of the reacting individuals is to be accurate to such a degree as to entitle us to speak of conservation of energy during the reaction, it is necessary, according to this relation, to co-ordinate to the reaction a time interval long compared to the vibration period associated with the transition process, and connected with the energy difference between the stationary states according to relation (1). This is particularly to be remembered when considering the passage of swiftly moving particles through an atom. According to the ordinary kinematics, the effective duration of such a passage would be very small as compared with the natural periods of the atom, and it seemed impossible to reconcile the principle of conservation of energy with the assumption of the stability of stationary states (cf. *Zeits. f. Phys.*, **34**, 142; 1925). In the wave representation, however, the time of reaction is immediately connected with the accuracy of the knowledge of the energy of the colliding particle, and hence there can never be the possibility of a contradiction with the law of conservation. In connexion with the discussion of paradoxes of the kind mentioned, Campbell (*Phil. Mag.*, i. 1106; 1926) suggested the view that the conception of time itself may be essentially statistical in nature. From the view advanced here, according to which the foundation of space-time description is offered by the abstraction of free individuals, a fundamental distinction between time and space, however, would seem to be excluded by the relativity requirement. The singular position of the time in problems concerned with stationary states is, as we have seen, due to the special nature of such problems.

The application of the conception of stationary states demands that in any observation, say by means of collision or radiation reactions, permitting a distinction between different stationary states, we are entitled to disregard the previous history of the atom. The fact that the symbolical quantum theory methods ascribe a particular phase to each stationary state the value of which depends upon the previous history of the atom, would for the first moment seem to contradict the very idea of stationary states. As soon as we are really concerned with a time problem, however, the consideration of a strictly closed system is excluded. The use of simply harmonic proper vibrations in the interpretation of observations means, therefore, only a suitable idealisation which in a more rigorous discussion must always be replaced by a group of harmonic vibrations, distributed over a finite frequency interval. Now, as already mentioned, it is a general consequence of the superposition principle that it has no sense to co-ordinate a phase value to the group as a whole, in the same manner as may be done for each elementary wave constituting the group.

This inobservability of the phase, well known from the theory of optical instruments, is brought out in a particularly simple manner in a discussion of the Stern-Gerlach experiment, so important for the investigation of the properties of single atoms. As pointed out by Heisenberg, atoms with different orientation in the field may only be separated if the deviation of the beam is larger than the diffraction at the slit of the de Broglie waves representing the translational motion of the atoms. This condition means, as a simple calculation shows, that the product of the time of passage of the atom through the field, and the uncertainty due to the finite width of the beam of its energy in the field, is at least equal to the quantum of action. This result was considered by Heisenberg as a support of relation (2) as regards the reciprocal uncertainties of energy and time values. It would seem, however, that here we are not simply dealing with a measurement of the energy of the atom at a given time. But since the period of the proper vibrations of the atom in the field is connected with the total energy by relation (1), we realise that the condition for separability mentioned just means the loss of the phase. This circumstance removes also the apparent contradictions, arising in certain problems concerning the coherence of resonance radiation, which have been discussed frequently, and were also considered by Heisenberg.

To consider an atom as a closed system, as we have done above, means to neglect the spontaneous emission of radiation which even in the absence of external influences puts an upper limit to the lifetime of the stationary states. The fact that this neglect is justified in many applications is connected with the circumstance that the coupling between the atom and the radiation field, which is to be expected on classical electrodynamics, is in general very small compared to the coupling between the particles in the atom. It is, in fact, possible in a description of the state of an atom to a considerable extent to neglect the reaction of radiation, thus disregarding the unsharpness in the energy values connected with the lifetime of the stationary states according to relation (2) (cf. *Proc. Camb. Phil. Soc.*, 1924 (Supplement), or *Zeits. f. Phys.*, **13**, 117; 1923). This is the reason why it is possible to draw conclusions concerning the properties of radiation by using classical electrodynamics.

The treatment of the radiation problem by the new quantum theoretical methods meant to begin with just a quantitative formulation of this correspondence consideration. This was the very starting-point of the original considerations of Heisenberg. It may also be mentioned that an instructive analysis of Schrödinger's treatment of the radiation phenomena from the point of view of the correspondence principle has been recently given by Klein (*Zeits. f. Phys.*, **41**, 707; 1927). In the more rigorous form of the theory developed by Dirac (*Proc. Roy. Soc.*, A, vol. 114, p. 243; 1927) the radiation field itself is included in the closed system under consideration. Thus it became possible in a rational way to take account of the individual character of radiation demanded by the quantum theory and to build up a dispersion theory, in which the final width of the spectral lines is taken into consideration.

The renunciation regarding space-time pictures characterising this treatment would seem to offer a striking indication of the complementary character of the quantum theory. This is particularly to be borne in mind in judging the radical departure from the causal description of Nature met with in radiation phenomena, to which we have referred above in connexion with the excitation of spectra.

In view of the asymptotic connexion of atomic properties with classical electrodynamics, demanded by the correspondence principle, the reciprocal exclusion of the conception of stationary states and the description of the behaviour of individual particles in the atom might be regarded as a difficulty. In fact, the connexion in question means that in the limit of large quantum numbers where the relative difference between adjacent stationary states vanishes asymptotically, mechanical pictures of electronic motion may be rationally utilised. It must be emphasised, however, that this connexion cannot be regarded as a gradual transition towards classical theory in the sense that the quantum postulate would lose its significance for high quantum numbers. On the contrary, the conclusions obtained from the correspondence principle with the aid of classical pictures depend just upon the assumptions that the conception of stationary states and of individual transition processes are maintained even in this limit.

This question offers a particularly instructive example for the application of the new methods. As shown by Schrödinger (*Naturwiss.*, **14**, 664; 1926), it is possible, in the limit mentioned, by superposition of proper vibrations to construct wave groups small in comparison to the 'size' of the atom, the propagation of which indefinitely approaches the classical picture of moving material particles, if the quantum numbers are chosen sufficiently large. In the special case of a simple harmonic vibrator, he was able to show that such wave groups will keep together even for any length of time, and will oscillate to and fro in a manner corresponding to the classical picture of the motion. This circumstance Schrödinger has regarded as a support of his hope of constructing a pure wave theory without referring to the quantum postulate. As emphasised by Heisenberg, the simplicity of the case of the oscillator, however, is exceptional and intimately connected with the harmonic nature of the corresponding classical motion. Nor is there in this example any possibility for an asymptotical approach towards the problem of free particles. In general, the wave group will gradually spread over the whole region of the atom, and the 'motion' of a bound electron can only be followed during a number of periods, which is of the order of magnitude of the quantum numbers associated with the proper vibrations. This question has been more closely investigated in a recent paper by Darwin (*Proc. Roy. Soc.*, A, vol. 117, 258; 1927), which contains a number of instructive examples of the behaviour of wave groups. From the viewpoint of the matrix theory a treatment of analogous problems has been carried out by Kennard (*Zeits. f. Phys.*, **47**, 326; 1927).

Here again we meet with the contrast between the wave theory superposition principle and the assumption of the individuality of particles with which we have been concerned already in the case of free particles. At the same time the asymptotical connexion with the classical theory, to which a distinction between free and bound particles is unknown, offers the possibility of a particularly simple illustration of the above considerations regarding the consistent utilisation of the concept of stationary states. As we have seen, the identification of a stationary state by means of collision or radiation reactions implies a gap in the time description, which is at least of the order of magnitude of the periods associated with transitions between stationary states. Now, in the limit of high quantum numbers these periods may be interpreted as periods of revolution. Thus we see at once that no causal connexion can be obtained between observations leading to the fixation of a stationary state and earlier observations on the behaviour of the separate particles in the atom.

Summarising, it might be said that the concepts of stationary states and individual transition processes within their proper field of application possess just as much or as little 'reality' as the very idea of individual particles. In both cases we are concerned with a demand of causality complementary to the space-time description, the adequate application of which is limited only by the restricted possibilities of definition and of observation.

7. The Problem of the Elementary Particles.

When due regard is taken of the complementary feature required by the quantum postulate, it seems, in fact, possible with the aid of the symbolic methods to build up a consistent theory of atomic phenomena, which may be considered as a rational generalisation of the causal space-time description of classical physics. This view does not mean, however, that classical electron theory may be regarded simply as the limiting case of a vanishing quantum of action. Indeed, the connexion of the latter theory with experience is based on assumptions which can scarcely be separated from the group of problems of the quantum theory. A hint in this direction was already given by the well-known difficulties met with in the attempts to account for the individuality of ultimate electrical particles on general mechanical and electrodynamical principles. In this respect also the general relativity theory of gravitation has not fulfilled expectations. A satisfactory solution of the problems touched upon would seem to be possible only by means of a rational quantum-theoretical transcription of the general field theory, in which the ultimate quantum of electricity has found its natural position as an expression of the feature of individuality characterising the quantum theory. Recently Klein (*Zeits. f. Phys.*, **46**, 188; 1927) has directed attention to the possibility of connecting this problem with the five-dimensional unified

representation of electromagnetism and gravitation proposed by Kaluza. In fact, the conservation of electricity appears in this theory as an analogue to the conservation theorems for energy and momentum. Just as these concepts are complementary to the space-time description, the appropriateness of the ordinary four-dimensional description as well as its symbolical utilisation in the quantum theory would, as Klein emphasises, seem to depend essentially on the circumstance that in this description electricity always appears in well-defined units, the conjugated fifth dimension being as a consequence not open to observation.

Quite apart from these unsolved deep-going problems, the classical electron theory up to the present time has been the guide for a further development of the correspondence description in connexion with the idea first advanced by Compton that the ultimate electrical particles, besides their mass and charge, are endowed with a magnetic moment due to an angular momentum determined by the quantum of action. This assumption, introduced with striking success by Goudsmit and Uhlenbeck into the discussion of the origin of the anomalous Zeeman effect, has proved most fruitful in connexion with the new methods, as shown especially by Heisenberg and Jordan. One might say, indeed, that the hypothesis of the magnetic electron, together with the resonance problem elucidated by Heisenberg (*Zeits. f. Phys.*, **41**, 239; 1927), which occurs in the quantum-theoretical description of the behaviour of atoms with several electrons, have brought the correspondence interpretation of the spectral laws and the periodic system to a certain degree of completion. The principles underlying this attack have even made it possible to draw conclusions regarding the properties of atomic nuclei. Thus Dennison (*Proc. Roy. Soc.*, A, vol. 115, 483; 1927), in connexion with ideas of Heisenberg and Hund, has succeeded recently in a very interesting way in showing how the explanation of the specific heat of hydrogen, hitherto beset with difficulties, can be harmonised with the assumption that the proton is endowed with a moment of momentum of the same magnitude as that of the electron. Due to its larger mass, however, a magnetic moment much smaller than that of the electron must be associated with the proton.

The insufficiency of the methods hitherto developed as concerns the problem of the elementary particles appears in the questions just mentioned from the fact that they do not allow of an unambiguous explanation of the difference in the behaviour of the electric elementary particles and the 'individuals' symbolised through the conception of light quanta expressed in the so-called exclusion principle formulated by Pauli. In fact, we meet in this principle, so important for the problem of atomic structure as well as for the recent development of statistical theories, with one among several possibilities, each of which fulfils the correspondence requirement. Moreover, the difficulty of satisfying the relativity requirement in quantum theory appears in a particularly striking light in connexion with the problem of the magnetic electron. Indeed, it seemed not possible to bring the promising attempts made by Darwin and Pauli in generalising the new methods to cover this problem naturally, in connexion with the relativity kinematical consideration of Thomas so fundamental for the interpretation of experimental results. Quite recently, however, Dirac (*Proc. of the Roy. Soc.*, A, **117**, 610; 1928) has been able successfully to attack the problem of the magnetic electron through a new ingenious extension of the symbolical method and so to satisfy the relativity requirement without abandoning the agreement with spectral evidence. In this attack not only the imaginary complex quantities appearing in the earlier procedures are involved, but his fundamental equations themselves contain quantities of a still higher degree of complexity, that are represented by matrices.

Already the formulation of the relativity argument implies essentially the union of the space-time co-ordination and the demand of causality characterising the classical theories. In the adaptation of the relativity requirement to the quantum postulate we must therefore be prepared to meet with a renunciation as to visualisation in the ordinary sense going still further than in the formulation of the quantum laws considered here. Indeed, we find ourselves here on the very path taken by Einstein of adapting our modes of perception borrowed from the sensations to the gradually deepening knowledge of the laws of Nature. The hindrances met with on this path originate above all in the fact that, so to say, every word in the language refers to our ordinary perception. In the quantum theory we meet this difficulty at once in the question of the inevitability of the feature of irrationality characterising the quantum postulate. I hope, however, that the idea of complementarity is suited to characterise the situation, which bears a deep-going analogy to the general difficulty in the formation of human ideas, inherent in the distinction between subject and object.

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safely in so short a time as 4 to 7 minutes, whereas animals brought from a nitrogen–oxygen mixture in 26 minutes or more became paralysed, and many died at once or within a few days. These general conclusions were confirmed in a large number of experiments.

It was interesting to find that the advantage of the helium was considerably greater than was expected on the basis of its smaller solubility. Helium diffuses more rapidly than nitrogen on account of its smaller molecules, which move nearly three times as fast. Hence, not only is less helium dissolved in the blood stream, but also it can escape into the lungs with much greater rapidity during decompression.

Large-scale experiments with men are now in progress under the direction of the Navy Department. The apparatus in use is partly shown in the accompanying illustrations. Considerable time has been spent upon the revision of the decompression tables in order to have an authoritative basis for further work with helium.

On Oct. 4, 1927, United States Patent 1,644,363 was issued to W. P. Yant, R. R. Sayers, and J. H. Hildebrand. Under the terms of this patent, persons under compression are supplied with a mixture for respiration consisting mainly of oxygen and nitrogen and containing a lower percentage of oxygen than air, and while under decompression with a gas comprising mainly oxygen and helium.

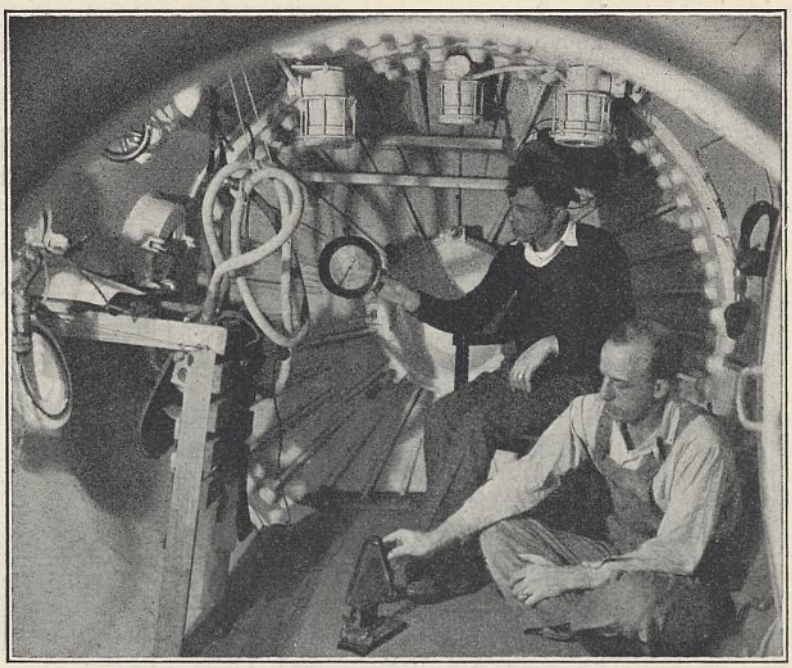

Fig. 4.—Interior of main compartment with test apparatus. Note electric lights, pressure gauge, control valve, hatches for closing windows in event of fracture of windows, and small tending lock at rear. This tending lock is operated similarly to the man lock, and is provided for passing in and out apparatus, food, etc. In connexion with the regulating valves, it should be stated that there are controls inside the chamber as well as outside, but the attendant on the outside can prohibit the use of the inside controls by closing off certain valves. This is done in order to prevent a man whose judgment may be impaired from releasing the pressure at a time or at a rate which is not safe. The oxygen breathing apparatus hanging to the wood support is used for administering helium. This is supplied from an external cylinder through a high pressure line and the man breathes helium from the bag, but at the same time has an air pressure surrounding his body. This obviates the necessity of filling the tank with that gas and conserves the supply of helium.

The Frequency of Rain over the British Isles.

By Dr. John Glasspoole.

THE perennial interest in the chances of good weather in our short English summer is quickened by the advance of spring. While the weather map is the vade-mecum of the forecaster of to-morrow's rain, it cannot help us to arrange our holidays in advance. We can, however, derive a great deal of information from a study of the accumulated statistics of the past.

Rainfall is measured at 9 A.M. at some 4000 stations in the British Isles, the smallest amount recorded being 0·01 inch. A day with 0·01 inch or more is defined as a rain-day. Although the rain-day includes many days with too little rain to be of practical importance, it is only such statistics which are available for any length of time. In considering the frequency of rain over the British Isles, it is necessary, therefore, to consider first of all the distribution of the number of rain-days, and to supplement this information by statistics from the limited number of stations for which more detailed observations are available.

Although a station with a relatively large annual rainfall is usually one with a large number of rain-days, the two quantities do not vary in the same proportion.[1] In the first place, the variations of the number of rain-days over the British Isles are much less than the corresponding variations of rainfall. In other words, both the variations of average monthly and annual values from place to place, and also the variations of average monthly values at one place, are much more uniform in the case of rain-days. The second difference is that, even at stations with the same rainfall, the average number of rain-days increases from the south-east to the north-west of the British Isles. Both these differences can be illustrated from the map reproduced as Fig. 1, which shows the distribution of the average number of rain-days during the six

[1] The question is dealt with in two recent papers: "The Distribution over the British Isles in Time and Space of the Average Number of Days with Rain." "British Rainfall, 1926," pp. 260-279, and "The Distribution over the British Isles of the Average Number of Days with Rain during each Month of the Year," *Q.J.R. Meteor. Soc.*, **54**; 1928.

summer months, April to September (a period of 183 days).

The range of the number of rain-days on the map is from 65 in the neighbourhood of the Thames Estuary to just above 120 in parts of the western Highlands of Scotland. The corresponding range in the summer rainfall is from 9 inches at Shoeburyness to 45 inches in the western Highlands, so that while in the latter locality during the summer rain-days are only twice as frequent as in the former, the rainfall is five times as much. Even a comparison of the values on the map for areas at about sea-level indicates that there is a persistent increase in the frequency of rain-days from the south-east to north-west. In the south-east, therefore, there is a much greater chance of long spells of dry weather. In fact, all records of rainless calendar months have occurred in the south-eastern half of the British Isles. Such occurrences are rare; but small areas in February 1891, July 1911, April 1912, June 1921, and June 1925 were free from rain.

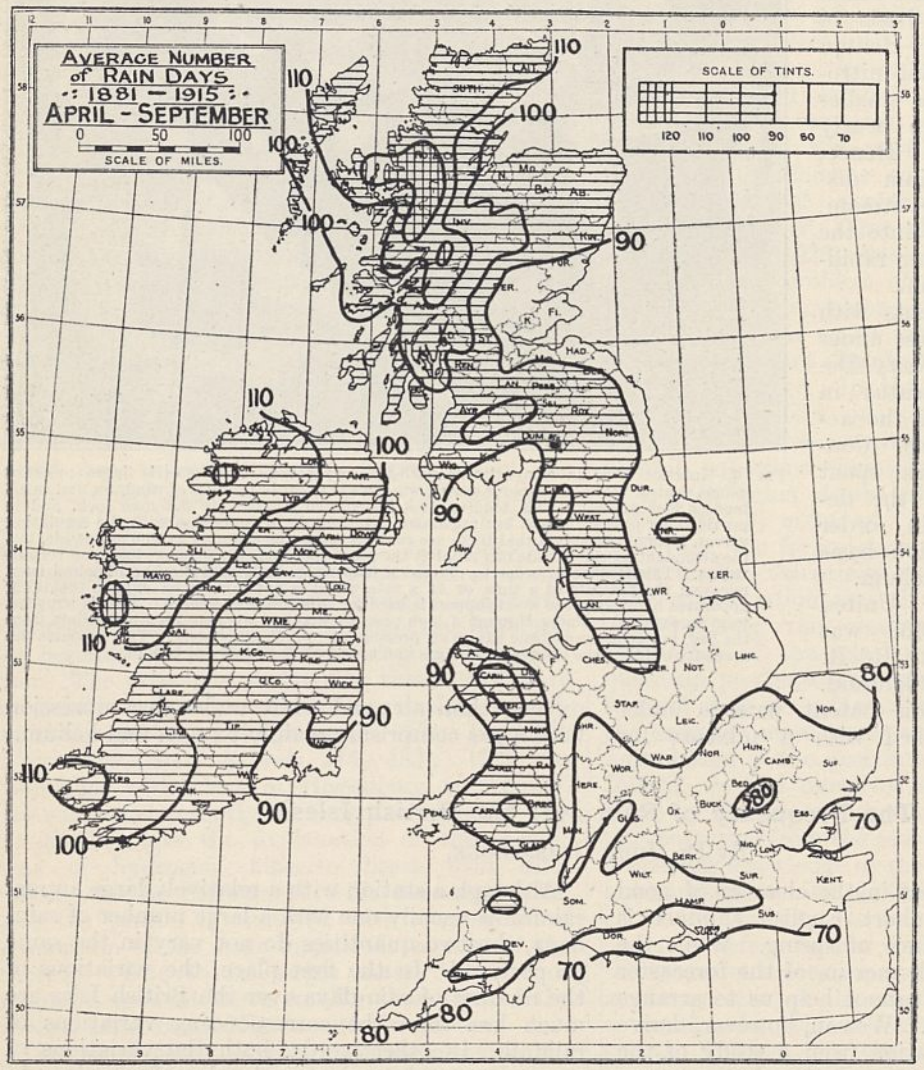

FIG. 1.—Average number of rain-days during the summer.

The main characteristics of the variations in the number of rain-days from month to month are apparent from the general values for the whole country. These are set out below, together with the corresponding values of the rainfall.

The table shows that there are in general 20 more days with rain in the winter than in the summer six months, this being the case nearly everywhere in the British Isles. The three months April, May, and June are the driest months of the year and the months of fewest rain-days, while December gives the maximum value in each column. The subsidiary maximum in August, associated with relatively intense convection rains, is well marked. Of the summer months, May and June are therefore on the average more favourable for holiday makers, both on account of the greater frequency of rainless days and the smaller amount of rain. The mean rainfall per rain-day over the British Isles generally is 0·20 inch, and some conception of this amount is afforded by considering it as the quantity which would fall during 3½ hours of continuous rain, the rate of rain being the average for London. In this connexion it may be of interest to recall that on the average rain falls in London for 1·2 out of 24 hours.

Some indication of the risks of a wet day is afforded by a consideration of the frequency of occurrence of days with specified amounts of rain. At Camden Square (London), with 25 inches a year, 0·01 inch or more falls on 163 days, of which 75 occur in the summer. There are, on the average, 40 days a year with 0·20 inch or more, 9 days with 0·50 inch or more, and only one day with 1 inch or more. The heaviest daily falls are about evenly divided between the intense thunderstorm rains of the summer months and the more persistent and more widespread rains of the winter. Of the two most remarkable falls on record at Camden Square,

in one so much as 3·28 inches fell in two intense downpours, giving in all a duration of only one hour, while in the other about the same quantity (actually 3·43 inches) was spread over 3 days with continuous rain for 58 hours. The mean values for the individual months show that the distribution during the year is fairly uniform. The greatest contrast in the frequency of falls of 0·20 inch or more is afforded by the spring and autumn. In each of the former months there are usually two or three such falls, while in the latter there are four or perhaps five.

The General Number of Rain-days and Rainfall over the British Isles, 1881 to 1915.

	Rain-days.	Rainfall.
		in.
January	19	3·78
February	17	3·26
March	18	3·22
April	15	2·52
May	15	2·61
June	14	2·64
July	16	3·25
August	17	3·88
September	15	3·09
October	19	4·25
November	19	4·19
December	20	4·72
Year	204	41·41

As the number of rain-days increases towards the north-west, it is obvious that of two stations with the same average annual rainfall the one to the north-west will in general record the greater frequency of days with small amounts. Further, as the variations in the number of rain-days from place to place are smaller than the variations in the actual rainfall, the frequency of days with large amounts will be greater at the wetter of two stations. Some indication of the extent of the increase due to both these factors is afforded by setting out statistics for Glasgow alongside those already given for London.

Average Values, London and Glasgow.

	London.	Glasgow.
Annual rainfall (inches)	25	37
Rain-days in year	163	212
,, ,, summer	75	99
Days with 0·20 in. or more during year	40	66
Days with 0·50 in. or more during year	9	12
Days with 1·00 in. or more during year	1	2

The differences which occur at stations in the same locality but with widely different rainfall are illustrated by a comparison of the daily falls made at Ben Nevis Observatory and those made at Fort William at the foot of the mountain, and only about 4 miles away in a horizontal direction. The mean values are set out below :

Mean Annual Number of Days, 1885–1903.

Station. Altitude (feet). Average Annual Rainfall (inches).	Ben Nevis. 4405. 159.	Fort William. 31. 78.
	days.	days.
0·01 in. or more	263	244
0·50 in. or more	106	52
1 in. or more	53	15

Although the total rainfall at Ben Nevis is twice that at Fort William, the number of rain-days is practically the same. Rain falls, however, much more heavily on Ben Nevis, so that the number of days with larger amounts is much greater. At Fort William the 52 days with 0·50 inch or more contribute 62 per cent. of the rainfall, and at Ben Nevis the 106 days contribute as much as 82 per cent. of the total rainfall.

Another important consideration is whether more rain falls during the day than at night.

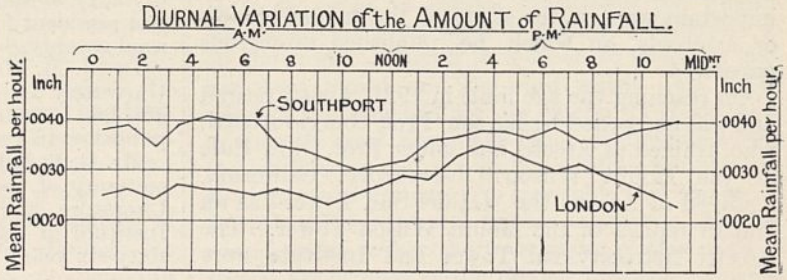

Fig. 2.—Comparison of mean hour values of rainfall.

Precise information from the traces of recording instruments covering a long period has been published at various times for some thirteen stations. Actually the total amount of rain during the day and night at these stations (that is, dividing the day at 6 A.M. and 6 P.M.) is practically identical. The proportion during the day varies at the individual stations from 52 per cent. to 48 per cent. of the total rain. More rain falls at night at stations in the west, for example, Valentia (in the west of Ireland), Falmouth, Southport, Glasgow, and Bidston (in Cheshire), while the inland stations and those to the east give more during the day. At Camden Square (London) there is a slight excess of rain in the day, and this holds good throughout the summer, but there is a reversal of these conditions in the winter, when the rain is greater at night.

Holiday resorts along the west coasts have therefore a slight natural advantage during the summer over those along the well-advertised 'dry east coast.' The actual mean hourly amounts are shown in the diagram for two typical stations, London and Southport, with 52 and 48 per cent. of the total rain in the day respectively. At the former there

is a definite maximum in the afternoon, with a minimum between 9 and 10 in the morning, typical of inland stations, and a subsidiary maximum of midnight. At Southport, the early morning maximum usually found at coast stations is well marked, while there is a subsidiary maximum in the late afternoon. As recording rain-gauges are comparatively rare, and as the generalisations set out in the diagram alone involve more than half a million tabulations, it is not surprising that the complete story of the diurnal variation of rainfall has not yet been written.

Obituary.

PROF. ANTONIO ABETTI.

ON Feb. 20 there passed away at Arcetri, Florence, aged eighty-two years, after a short illness, Prof. Antonio Abetti, the *doyen* of Italian astronomers. Born at Gorizia, in Frioul, in 1846, he took his degree in mathematics at the University of Padua in 1867, and at once entered the astronomical observatory of that city, rendered famous, like that of Pisa and Florence, by Galileo Galilei. As assistant to Prof. Santini, then director, he was one of the Italian astronomical party of 1874 for observing the transit of Venus in India. After Santini's death, he collaborated at Padua with Prof. Lorenzoni and went to Florence in 1893 as director of the Arcetri Observatory, the reorganisation of which, begun by Donati, he completed, raising it, as the Institute of Astrophysics, to one of the most important in Italy. He remounted Amici's famous equatorial and did important work in the study of the minor planets or asteroids, on which he published numerous papers.

On reaching the age limit in 1921, Abetti retired and was succeeded by his son, Prof. Giorgio Abetti, who, trained at Arcetri and under Prof. G. E. Hale at the Mount Wilson Observatory, California, installed at Arcetri the 'Galilei Sun Tower' as an Italian replica of the Mount Wilson Tower. The Arcetri Astrophysical Tower and Institute were described by the present writer in *Engineering* of April 30, 1926. Prof. Antonio Abetti kept up his interest in the institute until a few days before his death. In 1901 he delivered at the opening of the Royal University of Florence an important inaugural address on "Galileo in Arcetri." His son and successor, Prof. Giorgio Abetti, was a member of the astrophysical section of the De Filippi Expedition, 1913–14, to Trans-Himalaya, the Karakoram, and Chinese Turkestan.

C. DU RICHE PRELLER.

WE regret to announce the following deaths:

Prof. Launcelot Harrison, Challis professor of zoology in the University of Sydney since 1922 and president of the Linnean Society of New South Wales, on Feb. 20.

M. Félix Henneguy, professor of comparative embryology at the Collège de France, Paris, since 1900, and president for five years of the Société de Biologie, aged seventy-seven years.

Dr. J. M. Hulth, principal librarian of the Royal University Library, Upsala, known for his "Bibliographia Linnæana," of which the first volume was published in 1907, on Mar. 29, aged sixty-two years.

Mr. G. P. Miln, for more than forty years honorary secretary of the Chester Society of Natural Science, Literature, and Art, and a trustee of the National Institute of Agricultural Botany, on Feb. 14, aged sixty-six years.

News and Views.

THE announcement in the House of Lords on Mar. 29 of the names of the committee on motor spirit containing lead tetraethyl will doubtless serve to quiet somewhat the public controversy over the possible dangers of this spirit. The committee includes distinguished representatives from the fields of medicine, physiology, and chemistry, whose names and reputations are such as to carry the greatest possible weight with the public. The report of the committee will be awaited with interest and confidence. The following are the terms of reference: "To inquire into the possible dangers to health resulting from the use of motor spirit containing lead tetraethyl or similar lead-containing compounds, and to report what precautions, if any, are desirable for the protection of the public or of individuals in connection with the use or handling of such motor spirit."

IT is a matter of regret that in the discussion of ethyl petrol, both in the Press and in the House of Lords, incorrect and misleading statements have been issued through lack of correct information. Thus such statements that the *use* of the spirit (instead of sale) is prohibited in New York City and in the Holland Tunnel under the Hudson River are entirely incorrect; while the reference to deaths by poisoning with lead tetraethyl in the United States in 1924 are misleading, since these fatalities occurred in the experimental manufacture of lead tetraethyl and had nothing to do with the use of the substance in motor spirit. On the contrary, there was read in the House of Lords a letter from the Surgeon General of the United States to the British Ministry of Health, stating that "notwithstanding the late publicity given to the investigations and the general use of the substance all over the United States and Canada, no instance of lead poisoning has been reported in the lay or medical press or to any of our Federal or State Authorities." Final decision, of course, rests with the Government committee, but while awaiting its report, it would appear that the above letter should at least lessen the fears of the extreme alarmists.

A COMMITTEE including the names of the leading physiologists of Great Britain, and also two from the United States, has been formed to issue an appeal for funds to commemorate the work of those great

partners in physiology, Bayliss and Starling. This partnership lasted for about thirty years and was fruitful beyond measure for physiology and its applications to medicine; in addition, it has made the name of University College, London, known throughout the world. Their written works are monuments to their industry and learning, but it is felt that a further memorial, in the form of a studentship in physiology, is necessary, and in this form would have been approved by Bayliss and Starling themselves. It is proposed, therefore, to create a Bayliss and Starling studentship at University College, open to any graduate in science or medicine, for a year or more of such training in physiology and biochemistry as would fit him for research. A small part of the funds collected may be devoted to a simple memorial tablet in the entrance hall of the Institute of Physiology at University College. Subscriptions should be sent to Prof. Lovatt Evans, Institute of Physiology, University College, Gower Street, London, W.C.1.

Dr. A. W. Hill, Director of the Royal Botanic Gardens, Kew, attended the annual meeting of the New Zealand Institute on Jan. 26 last, when he was elected an honorary member. In replying to the president's welcome, Dr. Hill thanked the Board for the honour conferred upon him, and remarked that he noticed among the roll of names of honorary members that of Mr. E. Meyrick, his old teacher at Marlborough College, who had been instrumental in directing his studies into the channel of nature study, and had been a source of much inspiration to him. He remarked that New Zealand possesses a remarkable flora, and promised that he would do his best while in the Dominion to further the idea of the establishment of a National Botanic Garden. In this direction he thought it might be advisable to have one section in Auckland and another in Dunedin, with a director to link the two together as a national institution, and thus to avoid any possible jealousies as had occurred in other countries. In the course of his tour of New Zealand, Dr. Hill climbed Aleck's Knob, in the glacier region, which has not previously been explored by a botanist. This necessitated a climb of 4200 feet, but the array of alpine plants on the meadow at the top repaid the exertion expended in the climb. The plants there were in striking contrast to anything available to European botanists. All the flowers were pure white. Beside the Ourisias, *Ranunculus Lyalli* and *Hebe* (*Veronica*) *maerantha*, there were Lilaepsis and *Caltha novæ-zealandica*, on which Dr. Hill is working in England. The size of these plants on their native heath surprised Dr. Hill, especially the large Celmisias, and he was also much interested in the native hybrid plants.

Warm tribute was paid by Dr. Hill to Dr. L. Cockayne, of the State Forest Service of New Zealand, for his work on natural plant hybrids. Dr. Cockayne was awarded the Mueller Medal for research work in New Zealand over a period of twenty-five years, at the meeting of the Australasian Association for the Advancement of Science, held at Hobart (Tasmania) in January last. The Royal Society of London recently allotted Dr. Cockayne £100 for research work on hybridisation, and on the flora and vegetation of New Zealand. Other scientific workers who have lately visited New Zealand include Dr. J. P. Lotsy, the Dutch botanist, who toured the country in 1925. It will be remembered that Dr. Lotsy, at the Leeds meeting of the British Association last year, discussed New Zealand plants and their hybrids. Dr. O. Olsen, of Oslo, has also visited New Zealand recently, and found during his visit of three months a fertile field for botanical, geological, and ornithological study, where 20 per cent. of the geological specimens are unknown to science. Yet another, Dr. G. Einar Du Rietz, of the University of Upsala, toured New Zealand, and was, by courtesy of the Government, afforded an opportunity of making a voyage round the islands (some uninhabited) south of New Zealand by the steamer that makes the rounds supplying lighthouses and replenishing depots for castaways by shipwreck. He expressed the belief that the high-mountain flora of New Zealand is the best subject in the world for study, and that the country is well suited for the establishment of original botanical species.

The concluding section of "The Oxford English Dictionary" is announced for publication on April 19. It is an event of capital importance for English scholarship and indirectly a matter of moment to all the world. English is the richest language man has ever framed, and the most widely used. The effect of the War has been to extend its vogue, and, as the two great English-speaking communities—the British Empire and the United States—are also the most powerful nations, it is inevitable that the use of English will spread still further in future. Another consideration makes the publication of this work of special importance at the present moment. English is the official language of India and also its accepted medium of higher education. In China, too, English is much the most familiar of European tongues. We may therefore look for a continued extension of some form of English throughout both those countries, which between them contain nearly half the human race; and, if English is to be used, it is essential that it retain some recognisable connexion with correct English as built up and spoken in the land of its birth. This cannot be done by means of English teachers, who are a diminishing quantity in India and still fewer in China. A standard and comprehensive work is therefore of the first importance, from which other and smaller books may be drawn for those who cannot enjoy the monumental original.

Fifty guineas is a 'long' price, and beyond any but fair-sized town libraries and large schools, yet it is not out of proportion to what has been expended on the production of the work. The Oxford Press alone has spent £300,000, and this takes no account of the unpaid labour on which the book was based. All the collectors of the original references were volunteers, scattered over Great Britain and elsewhere. Work of this sort has been going on for nearly seventy years since the dictionary was first thought of by the

Philological Society. In 1884 the Oxford University Press assumed the responsibility, after Sir John Murray had met the Delegates of the Press in 1878 and become charged with the editorship. It is as much a monument of his zeal, industry, and organising powers as it is of the English language itself. Already supplements are beginning to appear, containing words, many of them dealing with science and technology, which have won the rights of citizenship since the work began. Of these supplements, at least the first will be furnished gratis to purchasers of the whole book.

THE recently issued *Annual Report* of the British Research Association for the Woollen and Worsted Industries provides concrete evidence of the increasing attention which the fundamental scientific principles underlying the wool textile industry are receiving both in Great Britain and overseas. In an article on "Research in the Textile Industry," which appeared in NATURE of Nov. 19 last, attention was directed to the fundamental problem of the textile industry, namely, a complete knowledge of the properties of the wool fibre, and a definite measure of the 'quality' of the fibre. The importance of this matter, not only to Great Britain, but also to wool growers in the dominions overseas, has been recognised and, as a result, the Under-Secretary for the Colonies has approved the recommendation of the Empire Marketing Board that a grant should be made for the prosecution of research on the problems connected with the standardisation of raw wool. This research will be undertaken jointly by the Research Association and by the Animal Breeding Research Department of the University of Edinburgh. Other important activities of the Research Association include the determination of standard tests for fastness of dyestuffs, particularly with a view to the prescription of standard tests for fastness to light, washing, and perspiration. An investigation into the determination of a suitable branding substance for sheep is in progress, but the final results are not yet available. The Association is availing itself on a very considerable scale of the existing research facilities in the universities and similar institutions. A mass attack of this kind on the many problems of the textile industry should ensure real progress in the application of science to that industry.

IN our issue of June 11, 1927, p. 864, reference was made to a small booklet published by Mr. E. A. Chapman, 69 Hayter Road, London, S.W.2, on certain so-called "Mystery Pearl Shells" which were in his possession. Various opinions had been expressed as to the origin of these shells, and Prof. Dakin, who examined them at our request, concluded that they had been cleverly cut from large pearl shells. In any event, however, their history (they came from Ireland) was left unexplained. At the request of Mr. Chapman another booklet has been written, and has been published by him in explanation of the previous one. It bears the title, "A Short History of a Notable Irish Family," and is by P. C. Gallagher (formerly of University College, Dublin). The pamphlet, which is very beautifully illustrated, suggests that the shells, which appear to have been heirlooms, were handed down in the O'Donnell family from a certain Hugh Roe O'Donnell, a brilliant figure, chieftain of Tirconnail and King of Donegal in the time of Elizabeth. We are not in a position to comment upon the historical details involving the O'Donnell family, but it is quite conceivable that the shells came originally from a Spanish source, as the booklet suggests, and that they were presented long years ago (possibly by some wrecked member of a Spanish ship) to this Irish family. It seems curious that others are not known to exist, unless these were the only result of some capable carver's whim. If they are shells of some real species, one would expect still more to find specimens in some of the world's museums. The whole matter is surprising.

AUTOMATIC operation of electrical equipment has in several cases made it possible to dispense, at least for a certain period, with human agency entirely. For example, lights on buoys are sometimes operated by a selenium cell, the flow of current through which is regulated by the light falling on it. When darkness comes the alteration in the resistance of the cell, and consequently of the current, switches on the light, and when daylight breaks, switches it off. Similarly, the action of some fire alarms depends on smoke affecting the amount of light falling on the cell. According to a recent *Daily Science News Bulletin*, issued by Science Service of Washington, a somewhat analogous automatic control was used recently to unveil a portrait of George Washington. All that was necessary to perform the operation was to telephone a certain signal. The apparatus used, called a televox, depends upon a device that only responds when a sound of a definite maintained frequency is made. The televox is tuned to a certain note produced either by a tuning-fork or a whistle. When this note is sounded, the movable armature of an electromagnet makes a contact which completes a local circuit. The current in this local circuit may start a motor, turn on or off a light, or do any similar operation. By having several instruments, each with its relay, a complicated mechanical operation can be gone through by sending a series of different notes which may, if desired, be so chosen that they form a tune. Experiments have been made for many years on controlling motor-cars and aeroplanes by radio waves. The televox system, however, is to control by sound.

THE London School of Hygiene and Tropical Medicine has placed an order with Messrs. R. and J. Beck, Ltd., for more than two hundred microscopes for use in the new laboratories now in course of construction in Gower Street. The order has been given on the recommendation of a small committee which has had the matter under consideration for some time, in consultation with the Department of Applied Optics, National Institute for Medical Research. The type of microscope selected embodies certain features that have been evolved to meet the needs of the heads of departments at the School. The base is of rigid construction, with points of support

sufficiently wide spread to ensure stability in any position. The foot is of the type now being produced by Messrs. Beck, combining the advantages of the horse-shoe or Continental model with the so-called English foot. The stage is of the completely built-in mechanical type with travel of $1\frac{1}{2}$ in +1 in., the entire top plate of the stage forming the moving part. On the stage a slide-holder of new design is provided, as suggested by Prof. Topley, in which the slide is firmly held without springs. The fine adjustment is of the double lever pattern, operated by milled heads on either side. The body is 2 in. in diameter and is provided with an adjustable graduated draw-tube. The sub-stage is actuated by rack and pinion, and all sub-stage appliances are carried on Akehurst slides. Thus the interchange of illuminating systems is both easy and accurate. The optical equipment is ample for all bacteriological requirements, and the objectives are to be coloured externally so as to enable them to be recognised at sight. Messrs. Beck have agreed that certain rigid tests shall be applied to the whole equipment before delivery is accepted.

WE have received a copy of the "Descriptive Account and Catalogue of the Home Office Industrial Museum and Exhibits," recently published by H.M. Stationery Office. In the introduction it is explained that the Museum, which is situated in Horseferry Road, Westminster, is intended to serve as a permanent exhibition of methods, arrangements, and appliances for promoting the safety, health, and welfare of industrial workers. The exhibition is the first of its kind in Great Britain, though others exist in Berlin, Munich, Milan, Amsterdam, and other cities abroad. The exhibits may be classified under three main headings. The safety section contains actual machines, plants, and appliances as they would be installed in a factory. Many actual protective devices are shown, but a wider range is exhibited by the aid of models and photographs. In the health section the exhibits include photographs illustrating the prevention of various industrial diseases (lead poisoning, silicosis, dermatitis, etc.), charts indicating the incidence of such diseases, 'cautionary notices' as issued by the Home Office, etc. Two sections are devoted specially to ventilation and lighting—the latter including an excellent series of cabinets illustrating fundamental principles. The welfare section contains rooms fitted up to serve as ambulance rooms, rest rooms, and canteens, and first-aid equipment, protective clothing, etc., are shown. The catalogue contains a detailed account of all exhibits, with illustrations. Various sections, such as machine tools, drilling and milling machines, and machinery used in the textile and printing industries, in bake-houses, etc., are dealt with in turn. Finally, reference may be made to the nature of the building, which in itself serves as a useful exhibit, special attention having been devoted to the ventilation, lighting, and other essentials to health and safety.

THE Easter conference of the Society for Experimental Biology took place at Oxford on Mar. 23 and 24. By kind invitation of Prof. E. S. Goodrich and Prof. A. G. Tansley, meetings were held in the Zoological and Botanical Laboratories. At the first session, among many interesting papers, Mr. G. R. de Beer gave an account of his experiments on the development of the nervous system in Anura, and a paper by Dr. T. A. Stephenson on the nature of 'physiological' species was followed by a lively discussion. Discussions of considerable interest also took place during the second session, particularly after a paper by Mr. P. A. Buxton on the physical factors which determined the behaviour of the mosquito. In a paper by Captain G. C. C. Damant on the secretion of gases in the bladders of seaweeds, the remarkable fact appeared that nitrogen as well as oxygen was secreted into the bladders under a considerable pressure. The last session was occupied chiefly with discussions of the nature of oxidation in living cells and carbohydrate metabolism in various groups of the animal kingdom. The chairman, Dr. D. Keilin, gave an account of the polyphenol oxidase and cytochrome system in cells.

A USEFUL pamphlet on "Rats and how to kill them" has been compiled by Mr. A. Moore Hogarth (London: John Bale, Sons and Danielsson, Ltd., 6*d*. net). It reprints the Rats and Mice (Destruction) Act of 1919, and gives full instructions for trapping, poisoning, fumigating, or otherwise destroying rats. These instructions are practical and ought to increase the effectiveness of the anti-rat campaign. But it can scarcely be said that all the author's suggestions are practical: he advocates that rat-catchers should be taught, amongst much else, elementary pathology; that zoological laboratories in the universities should devote part of their time to the economics of the rat; and that elementary school children should be instructed in rat life-history and the "toxicity of the various raticides in common use." He speaks of the barn owl as if it were the only ratter of its kind, of the pine-marten as if he did not know that it was almost extinct, and of the ferret as if it were a wild creature. With more reason he advocates an international codification of rat laws, a synchronised rat campaign in Britain twice a year, and local bye-laws to encourage rat-proofing. He states that the cost of feeding British rats per annum would pay for 1,864,235,290 bottles of Bass—a less offer in kind should attract a record army of Pied Pipers.

SIR JOHN RUSSELL, Director of the Rothamsted Experimental Station, has been elected an honorary member of the New Zealand Institute.

PROF. G. ELLIOT SMITH will deliver the Huxley Memorial Lecture at the Royal College of Science, South Kensington, on Friday, May 4. His subject will be "Conversion in Science."

IT is announced in *Science* that the Charles P. Daly Gold Medal of the American Geographical Society of New York has been presented to Prof. Alois Musil, of the Charles' University, Prague, for his explorations in northern Arabia and Mesopotamia and his historical researches relating to this part of the world.

DR. E. F. ARMSTRONG, managing director of the British Dyestuffs Corporation, Ltd.; Dr. J. B. McEwen, Principal of the Royal Academy of Music; and Prof. R. W. Seton-Watson, Masaryk professor of Central European history in the University of London, have been elected members of the Athenæum, under the provisions of Rule II. of the Club, which empowers the annual election by the Committee of a certain number of persons "of distinguished eminence in science, literature, the arts, or for public service."

IN April of last year the eighth annual meeting of the American Geophysical Union was held, like its predecessors, at Washington. The transactions of the Union at this meeting have been issued as a *Bulletin of the National Research Council* (No. 61, pp. 295). The Union met usually in six sections, but one resolution passed in general assembly may be noted: since it appears that, in future, reports of much of the seismological work done in Japan will be published in Japanese only, the National Research Council was requested to provide (1) for the translation into English of such reports as are selected for the purpose by the American Geophysical Union, and (2) that mimeographed copies of the translations be distributed under suitable financial arrangements. The reports and papers dealt with in the sectional meetings include many of great interest. Three general symposia were held, one on climatic control, another on the sun's ultra-violet light and the ozone content of the earth's atmosphere, and a third on correlations of various radio phenomena with solar and terrestrial magnetic and electric activities.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A secretary of University College Hospital Medical School—The Dean, University College Hospital Medical School, University Street, W.C.1 (April 18). A technical officer at the Royal Aircraft Establishment, South Farnborough, to assist in design and experimental development work in connexion with aerial beacons and aerodrome illumination generally—A.271, The Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants (April 21). A professor of mechanical engineering in the Engineering College of the Benares Hindu University—Box P4360, 33 Norfolk Street, Strand, W.C.2 (April 30). An assistant lecturer in physics at the University College of the South-West of England, Exeter—The Registrar. A mathematical master, able to teach elementary physics and chemistry, at the Prince of Wales' Royal Indian Military College, Dehra Dun, U.P., India—The Secretary, Military Department, India Office, S.W.1. A junior assistant chemist under the Directorate of Explosives Research of the Research Department, Woolwich—The Chief Superintendent, Research Department, Woolwich, S.E.18.

Our Astronomical Column.

SEARCH FOR A PLANET OUTSIDE NEPTUNE.—Ever since the discovery of Neptune by the perturbations that it produced on Uranus, attempts have been made to extend the method to still more remote regions. Prof. W. H. Pickering is one of those who have attacked this problem; in his research he examined the observations of Saturn, Uranus, and Neptune, and noted discordances between prediction and observation. His latest paper on the subject is in *Popular Astronomy* for March. He notes that if Adams and Le Verrier had used Saturn as well as Uranus in their calculations, they would have had material for making a better estimate of the distance and period of the perturbing planet; the reason being that conjunctions of the unknown planet with Saturn occurred every 36 years, so that the observations covered several conjunctions.

Prof. Pickering gives the shape that the curve of residuals should follow about the time of conjunction of each planet with an external perturbing one. He finds some evidence of conjunction of the unknown with Neptune about 1906, with Uranus about 1841, with Saturn about 1850, 1885, 1917. He finally assigns to the unknown the same period as Neptune, 164·8 years, but a more eccentric orbit. He makes aphelion passage about the year 1891, in longitude 72°. The present position of the planet is given as R.A. 8 h. 51 m., N. Decl. 16½°; mass about half that of the earth, magnitude 12. When in opposition it would retrograde at the rate of 4″ or 5″ per hour, sufficient to show a short trail on photographic plates. Whether the planet is there or not, the investigation seems sufficiently ingenious to be worthy of notice.

SPECTROSCOPIC PARALLAXES OF 125 *B*-TYPE STARS.—Mr. D. L. Edwards has been engaged for some years in deducing spectroscopic parallaxes of *B*-type stars at the Norman Lockyer Observatory. *Mon. Not. R.A.S.* for January contain his fifth paper on the subject. The research is much more difficult than in the case of stars of late type. Two methods are employed: (1) photometric measures of the intensities of certain hydrogen and helium lines by means of a wedge; (2) classification based on spectral type and line character. Standard stars of well-determined parallax were observed in order to check the curves used for converting measures into absolute magnitudes. The magnitudes of the stars in this paper range from 0·6 (Achernar) to 6·9. The absolute magnitudes range from −3·4 (α Camelopardalis) to +0·1 (ν Cassiopeia). The largest parallaxes are Regulus 0·060″ and Achernar 0·040″.

MINIMUM OF ε AURIGÆ.—This star, of spectral type *F5p*, the light of which varies between 3·3 and 4·1, is now approaching minimum, which is predicted to last about 700 days. It is an appropriate time for publishing an elaborate study of its spectrum, which Miss Cecilia H. Payne does in *Harvard Bulletin 855*, basing it on five plates, ranging in date from 1890 until 1927; last year's plate was standardised by comparison with the hydrogen lines in the spectrum of Vega, and it served to calibrate the other four. A list is given of the wave-length, origin, and intensity of about 170 lines. Certain iron lines are found to be suitable for the determination of absolute magnitude. The following absolute magnitudes of stars of this type are given: Procyon 3·1, α Persei −1·3, *b* Velorum −2·5, ι Scorpii −2·8, ε Aurigæ −4·0. This last star is therefore a supergiant at a distance of more than six hundred light-years. Miss Payne notes that search should be made during minimum for possible spectral changes.

Research Items.

DUALISM IN AFRICAN RELIGIONS.—In *Ancient Egypt*, pt. 4, 1927, Mr. G. W. B. Huntingford contributes some further notes on the dualism which can be observed in the various forms of African religions. In the Nilo-Hamitic group the good and evil gods are manifestations of the elements. The Galla, in addition to their god *Wak*, believe that there are two kinds of sunshine, *adu* the white, which destroys, and *biftu* (from *bifti*, colour), the good, which gives life. *Adu* is from the same stem as *adi*, a fabulous being white in colour, apparently a kind of Ἔμπουσα. The black and red gods of the Masai are the heavens in fine weather and in storm, or rather in dry and wet weather. The Nandi do not distinguish the good and bad thunder by colour. The Hottentot beliefs are contrasted. According to Kolben, they have two good deities and one bad, the "God of all Gods," the moon, and the "Father of all Mischief." The Galla, Masai, and Nandi pairs of gods are additional to their supreme god and do not come within their ceremonial system. The beliefs in good and evil forces in opposition may be divided into three groups: (1) Where the forces are the elements and subordinate to the chief deity, as among Galla, Masai, and Nandi; (2) where the forces are spirits, as among the Baganda, Azande, and Lugwari; and (3) where the worship is that of a trinity, the third member of which is evil, as among the Hottentots. It would appear, therefore, that dualism in East Africa is not limited to tribes of Hamitic speech as has been thought. The fact that the same colours appear as attributes of good and evil in other parts of Africa is perhaps a coincidence; though the opposition of red and black which appears on the Gold Coast is singular. Among the Galla the unlucky colour is white.

THE CART TRACKS OF MALTA.—Following closely on Miss Murray's communication to *Man* (see NATURE, Feb. 25, p. 297), Prof. Zammit has published in *Antiquity* for March a study of the cart-tracks of Malta, illustrated by a number of excellent air photographs. His conclusions as to the origin, purpose, and date of these ruts or deep grooves on the limestone, which are of such frequent occurrence in the island, are the result of a long and exhaustive examination. There can be little doubt that they were made by a wheeled vehicle—strong, heavy carts with wooden wheels without metal tyres. The sharp curves preclude the idea of a sledge with runners. They are triangular in section, and can easily be distinguished from the grooves, rectangular in section, made by the modern metal-tyred wheel. Further, it must be concluded that human power was used for traction, as the ancient ways show no sign of being cut up in the way in which modern tracks have been cut up by the hooves of animals. It is also probable that the tracks were started by human labour and deepened later by use. There are definite signs that they were first carefully laid. In only one case does a pair of tracks appear to enter the sea, namely, at the Bay of St. George at Birzebuggia, where they probably appear on the other side of the bay now covered with silt and field soil. There is nothing to suggest the existence of these tracks when the island was connected with the continent, quite independently of the fact that the islands could not have been inhabited by an industrial population at the end of the Ice Age. Nor are they so late as the Roman occupation. Further, they are earlier than the rock-cut tombs of the Phœnician occupation, one of which cuts right across one of the cart tracks. As they do not go near the megalithic monuments they were not used for carting stone for these buildings. They were used by the energetic neolithic population for carting earth for their terrace cultivation made necessary by the bare character of the high lands and for carrying water to the ships of a busy maritime traffic in harbours near which were no springs.

PREPARATIONS OF VITAMINS A AND D.—We have received from Messrs. The British Drug Houses Ltd., London, N.1, samples of their "Radiostoleum" capsules. The oil in these gelatin capsules contains vitamins A and D: the latter is manufactured by irradiation of ergosterol, and together with a vitamin A concentrate is supplied in solution in a tasteless vegetable oil. No cod-liver oil is used in the preparation of this product. The vitamin A and D content is standardised by animal feeding tests and is twenty times that of the finest cod-liver oil: and in the case of vitamin A, the physiological assays are checked by a chemical test. 'Radiostoleum' may be used in all conditions in which cod-liver oil has hitherto been administered. It is supplied in capsules, in boxes of 50, and also in solution, in bottles containing half a fluid ounce.

THE NATURAL HISTORY OF THE HAKE.—In *Min. Agric. Fish., Fishery Invest.*, Ser. 2, vol. 10, No. 2, 1927, Mr. C. F. Hickling gives an account of the food and feeding of the hake, and of the periodic changes in the hake fishery. This paper is of especial interest, as it is based on observations made and experience gained during fourteen months of sea-time on commercial trawlers, and is illustrated to a considerable extent by statistical data supplied by the Ministry's Statistical Section. From a study of the weekly figures of landing of hake at Cardiff during the years 1922–25, it appears that from the fifth to the ninth full moons of the year there is a regular fluctuation in the landings, such that more fish is landed at full moon than at new moon. Mr. Hickling suggests that this is the result of a monthly period of activity in the reproductive organs of the fish. There is also a daily change in the abundance of hake on the sea-bottom. Long experience has taught skippers that there is so little hake on the sea-bottom during the hours of darkness that it is rarely worth while to trawl at night, especially when the hours of darkness are long, as in winter. This apparent nightly migration vertically from the sea bottom is believed by the author to be due to a 'sleep rhythm' in the fish, which is inactive by day but active by night. In support of this theory, it is pointed out that (*a*) it can be shown that the hake feeds at night, but apparently not during the day, and (*b*) the surface methods of catching hake, which are most successful at night, depend upon the hake seizing a hook or becoming entangled in stationary trammel-nets, whereas the method of catching hake on the bottom, which is most successful by day, depends upon the hake being swept along passively into a trawl which may be moving very slowly relatively to the hake's own presumed speed of locomotion.

LEECHES ON FISHES.—Mr. David H. Thompson ("An Epidemic of Leeches on Fishes in Rock River," State of Illinois Department of Registration and Education. Division of the Natural History Survey. Bulletin, vol. 17, art. 3, 1927) describes an epidemic of leeches in the fish *Ictiobus cyprinella*, the co-called 'red-mouth buffalo.' In the winter of 1925–26 almost every fish of this species in Rock River, near Rockford, Illinois, was infested by the leech *Pisciola*

punctata Verrill, from one to fifty on each fish. This leech was rare, and for two years of continuous work on the river during the handling of fish, had not been seen. It appeared quite suddenly in February when the river was covered with ice, and continued throughout March until the temperature was a few degrees above freezing-point over a stretch of twenty miles. By the end of April none was to be seen. The leeches were so numerous that the bottom of the boat in which had been a few hundred pounds of fishes was almost completely covered with them. The next winter at the same time, although several fishes were infested, the numbers were not nearly so great as to cause an epidemic. After the leeches had left their hosts they were found among water plants, where they apparently leave their egg cocoons. The young leeches attach themselves to the fishes, at first feeding on mucus, later on blood, and grow to maturity very quickly in the cold winter months. The leech is said not to harm its host, but in this case they were certainly harmful, as is shown by the large marks left on the fishes in the places of attachment, and also by the fact that the fishes with many leeches were so thin that they were quite unfit for food. This is the first time that this leech has appeared in sufficient quantities to affect the market, and no reason can be brought forward for its presence in such enormous numbers.

STARCH AND CAMBIAL ACTIVITY IN THE WOODY TWIG.—Swarbrick has recently directed attention to the complexity of the problems associated with the appearance and disappearance of starch in the woody twig (*Journal of Pomology and Horticultural Science*, **6**, 296-312; 1928). Curtis has previously drawn conclusions as to the necessity of phloem for translocation from the retention of the starch in a region of the stem isolated between two rings made down to the cambium (*American Journal of Botany*, **7**, 101-124; 1920). Swarbrick now shows that the retention of this starch depends upon the absence of buds in the region lying between the rings and is associated with the absence of cambial activity under these conditions. If buds are present, then cambial activity is initiated in this region and the starch quickly disappears. Experience with disbudded twigs, upon which an occasional adventitious bud regenerates, shows that, whilst a limited amount of cambial activity and xylem formation is found below this bud and nowhere else on the twig, starch hydrolysis begins below this bud and then continues throughout all the tissues of the twig below this bud. In this case starch disappearance seems rather dependent upon cambial activity than the latter upon the food reserves, and both seem to be connected with the initiation of bud development.

WOOD-PULP IN AUSTRALIA.—When ground wood or mechanical pulp was first introduced, the paper industry received considerable impetus in countries where soft wood was easily obtained, and the later development of the sulphite process, or the chemical conversion of wood to pulp, brought about an even greater expansion. In Australia, however, the industry has developed slowly, for owing to the absence of suitable indigenous material, nearly all the pulp has had to be imported. Experiments have been carried out (*Australian Journal of the Council for Scientific and Industrial Research*, vol. 1) with the view of utilising indigenous eucalypts, etc., in order to establish the industry on an independent footing. It has been found that by employing certain modifications of the soda process a pulp suitable for the important type of papers classed as 'book and fine printings' can be produced from the eucalypts. The quick-growing candlenut *Aleurites moluccana* is also promising, but since the pulp is bleached with some difficulty, it is recommended for use in the manufacture of brown paper. There seems little prospect of being able to utilise the indigenous grasses or sedges. With regard to other methods of pulping, the sulphate process has hitherto been considered uneconomic in Australia, but it is of great importance in the production of strong (kraft) pulp. Laboratory and mill trials, however, have shown that it can be successfully used with exotic conifers such as *Pinus insignis*, the results comparing favourably with the pulp from spruce or firs, for which the climate is unsuitable. The possibility of producing a long-fibred sulphite pulp is still under investigation. It is hoped that in this case also *Pinus insignis* will prove suitable, or that the process can be so modified as to allow of its use, in the event of which the paper industry in Australia would be almost self-contained. Further, trials are in progress regarding the manufacture of newsprint from short-fibred eucalypts instead of from the longer fibred spruce and fir. Under special grinding conditions, immature eucalypts have yielded very promising results on a laboratory scale, a paper stronger than the standard newsprint being obtained.

ARCTIC ICE IN 1927.—The *Annual Report* by the Danish Meteorological Office on the state of the ice in Arctic Seas in 1927 has recently been published. In the Barents Sea the most noteworthy features were the congestion of ice off the entrance to the White Sea from March until May, and the open sea up to Franz Josef Land in September. The west coast of Novaya Zemlya was clear in July, and the Kara Sea was almost clear in August and quite clear in September. Around Spitsbergen there was much less ice than usual, except in October and November, when a broad belt of pack lay off the west coast. Bear Island, however, was not clear of ice from the autumn of 1926 until the end of May. On the east coast of Greenland the belt of ice seems, on the whole, to have been wider than usual, but the coasts of Iceland were free throughout the year. In Davis Strait there was less ice than usual, and on the Newfoundland Banks the ice season was short and had ended entirely by August. In Baffin Bay and the channels of the Canadian Arctic Archipelago, ice was scarcer than in most years. Davis Strait was almost clear in July, but Wrangel Island was not approachable until August. The report is furnished with the usual ice distribution charts for the spring and summer months.

THE TASMANIAN TEKTITES.—Sir Edgeworth David, Dr. H. S. Summers, and Mr. G. A. Ampt have made a very valuable study of the remarkable variety of tektite known as Darwin Glass (*Proc. Roy. Soc. Victoria*, vol. 39, pp. 167-190; 1927). The mode of occurrence in what are probably outwash gravels from a Pleistocene ice sheet suggests that a 'hail-storm' of small meteorites fell on the ice, which transported the fragments to the margin. It is shown that the schonite of Sweden, the moldavites of Moldau, the billitonites of Banca, Billiton, and Borneo, the australites of Australia, and the Darwin glass of Tasmania, all occur close to a single great circle. By means of variation diagrams, the genetic relationship between the various tektites is convincingly brought out, and a comparison of the graphs with those for the common acid igneous rocks indicates that the latter are quite distinct in composition. Two fresh analyses of Darwin glass are recorded; they show 86-87 per cent. of SiO_2. Such a percentage is higher than that for any analysed australite, but is approached by some of the moldavites. Various hypotheses of the origin of tektites

—artificial, volcanic, fulguritic, dust fusion by lightning, etc.—are discussed, and by a process of elimination the conclusion is reached that the mysterious fragments are of meteoritic origin.

MAGNETIC MEASUREMENTS.—The September and December (1927) quarterly issues of *Terrestrial Magnetism and Electricity* have recently appeared together under one cover (103 pp.). The principal article is one on earth-resistivity measurements in the copper country, Michigan, by W. J. Rooney, in which interesting details are given of the survey, which proved very successful in locating bodies of copper ore, as tested in cases where direct data obtained by boring were available. The conditions under which magnetic methods of prospecting for underground discontinuities are likely to be of service are discussed. The journal contains also many reports, reviews, and short articles, one of the latter being on magnetic observations made in Spitsbergen in 1927 by a Cambridge expedition, while others deal with questions of computation. In an article by D. Stenquist on the diurnal variation of the normal earth-current in southern Sweden, attention is directed to the fact that in his memoir "Étude des courants telluriques," 1925 (see also NATURE, Feb. 18, p. 242), the values given on pp. 21-23 of that paper are ten times too great.

DEVELOPMENT OF NATURAL GAS.—On Mar. 13, Col. S. J. M. Auld discussed before the Institution of Petroleum Technologists some of the more complex problems affecting natural gas exploitation. Facilities for utilising the gas produced either simultaneously with oil at the well-head, or afterwards by evolution by reduced pressure, vary to some extent with the environment of the field, *e.g.* climatic conditions, and in many limestone fields, such as parts of Texas, Mexico, and Persia, the matter is complicated by the presence of hydrogen sulphide, sometimes exceeding 10 per cent. by volume. The author dealt with a type of gas-oil separator designed for high gas-oil ratios, most proprietary types being more suited to conditions of low gas-oil ratios. The measurement of quantity of gas released was next considered, various standard equations coming up for critical analysis and comment. Equally important is the duration of gas production and, as pointed out, accurate estimates of reserves are always problems of great difficulty; much depends on the gas-oil system involved, and on the degree to which calculations based on gas laws are applicable in particular cases. An interesting section of the paper dealt with the use of highly sulphurous gas as a fuel which, contrary to expectation, results in no serious trouble with modern boilers equipped with efficient methods of firing. It was also shown by experimental data that the active charcoal recovery process is inapplicable to sulphurous gases; in view of recent interest abroad in the possible use of solid adsorbents for gas extraction and gasoline stripping from such extracted gas, this conclusion is not without significance. The author also discussed many of the conditions affecting the oil absorption process for gasoline extraction, and urged the importance of efficient operation depending on knowledge and application of the gas laws.

METEOROLOGICAL INSTRUMENTS.—The latest instrumental catalogue (No. 548) of Messrs. C. F. Casella and Co., Ltd., gives particulars of a wide range of meteorological instruments. We notice that the various types of cup anemometer do not include any with three instead of four cups, nor is there a cup instrument designed to give direct readings of velocity instead of the number of miles of air that have passed the instrument since its erection. The advantages of having only three cups have been proved experimentally by J. Patterson of the University of Toronto, who published his results about two years ago (*Trans. R. Soc. Canada*, Third Series, vol. 20, Sec. 3; 1926), and the *Meteorological Magazine* for September last contains a photograph of such an anemometer adapted for direct reading by the incorporation of a Stewart magnetic speedometer. It is to be hoped that an instrument of this kind will appear in the next catalogue. Accurate thermometry continues to be an expensive matter. It is, however, possible to purchase an outfit of thermometers—maximum, minimum, 'wet and dry'—with a rain gauge, and with a screen that should give good results if properly mounted, for £7. This outfit is designed for schools. A very handy pocket set, with maximum and minimum, as originally designed for Dr. Livingstone, costs £2 10s., and should continue to be in demand among explorers and mountaineers.

NEW SYNTHESIS OF NICOTINE.—The synthesis of an alkaloid generally involves the closing of a ring system containing a nitrogen atom. In the classical synthesis of nicotine, the molecule of which consists of a pyridine ring and an *N*-methylpyrrolidine ring linked together in the β-position to the former and the α to the latter, Pictet employed comparatively violent means to obtain the second ring system attached in the desired manner to the pyridine ring. The new and simple synthesis described in the February issue of the *Berichte* (vol. 61, p. 327) by E. Späth and H. Bretschneider, of the University of Vienna, is therefore very welcome. Prof. Späth employs the novel method of starting with both nitrogen ring systems already formed, in the shape of ethyl nicotinate and *N*-methylpyrrolidone. These compounds are condensed together under the influence of sodium ethoxide, and a ketone is obtained in which the two ring systems are separated by the carbon atom of the ketone group. There is a second ketone group present in the pyrrolidone ring, and by treatment of the compound with hydrochloric acid this group is removed as carbon dioxide. This opens the ring, which is, however, closed again by converting the first –CO– group into –CH(OH)– and thence into –CHI–, for removal of hydrogen iodide now draws the bridge carbon atom into the *N*-methylpyrrolidine ring to replace the carbon atom which had been lost, and (racemic) nicotine is at once obtained. The yields in the synthesis are good, that of the initial condensation being 70 per cent., that of the ring opening 37·5 per cent., and that of the complete ring closure to give nicotine 31 per cent.

RÔLE OF COPPER SULPHATE IN THE DEACON PROCESS.—The work of Hensgen and others has shown that many metal sulphates are decomposed by dry hydrogen chloride gas with the formation of chlorides and liberation of sulphuric acid. If this is the case, it would appear that when the Deacon process is started with copper sulphate as a catalyst, the mechanism is the same as when copper chloride is used. Experiments to test this view have been made by R. A. Beebe and D. B. Summers and are described in the January issue of the *Journal of the American Chemical Society*. Hydrogen chloride, both in the pure state and mixed with oxygen, was passed over pure anhydrous copper sulphate heated to 450° C. (the temperature used in the Deacon process) and the liberated sulphuric acid determined. In each case the sulphate was completely decomposed after several hours, and copper chloride, $CuCl_2$, or oxychloride, $CuO.CuCl_2$, remained. The use of copper sulphate initially in place of cupric chloride does not, therefore, seem to complicate the mechanism of the Deacon process.

Injury by Fire and Bark-beetle Attack.

ABOUT a quarter of a century has elapsed since bark-beetle infestations following fires in coniferous forests came under serious consideration outside European countries. The ideas and opinions then expressed, based admittedly on investigations which still had to stand the test of future corroboration, were at first treated with more or less open scorn by the professional forester both in the United States and in India, the two countries where attention was first paid to the matter. In the former country the commercial lumberer also regarded the scientific worker as a faddist. Of recent years, opinions have undergone a drastic change in both countries, and the present position and opinions held on this important subject are due to the patient work of the entomologist. In India, owing to the difference in climate in the plains, the matter is not confined to the coniferous forests of the mountainous regions, but has to be considered in its relation to the forests of broad-leaved deciduous species. The problem here, however, save perhaps in the native States, has not been complicated during the period alluded to above by the operations of the lumberer and his felling methods in the forest.

Recently two small but important monographs have been issued in the United States. The first, entitled "Preliminary Studies on the Relation of Fire Injury to Bark-Beetle Attack in Western Yellow Pine (*Pinus ponderosa*)," by Messrs. J. M. Miller and J. E. Patterson (*Journal of Agricultural Research*, Washington, April 1927), and the second, "The Relation of Highway Slash to Infestations by the Western Pine Beetle in Standing Timber," by J. E. Patterson (*U.S. Dept. of Agric.*, June 1927). The latter paper has a closer connexion with the danger of infestation from slash in the neighbouring standing forest than with previous damage by fire.

The literature available on the effect of fire in the pine forests of the Pacific slope region is considerable. One phase, the effect of bark-beetle infestations following the fires, has previously received scant treatment. It has been generally recognised that there is a direct relation between fire injury and later insect damage on burned-over areas. Two types of loss are involved—destruction of the marketable value of fire-killed trees by wood-boring insects, and the actual killing by bark beetles of trees that survived the fire. Such damage follows as a result of the sporadic local increase of bark-beetle population within the fire area, which can be explained only by the assumption that numbers of beetles fly into the area from the surrounding forest. The authors hazard the following hypothesis: "Because of fire injury certain trees become especially attractive to the beetles. The physiological basis of this attraction is but vaguely understood. The odour of fire-scorched foliage and cambium may be an attractive influence, or the insects themselves may possess an instinctive ability to select those trees in which sap resistance has been weakened by fire injury, but whatever the influence, it is evidently a very strong one of determining the behaviour of Dendroctonus beetles." The explanation would seem to rather lie in the unerring instinct possessed by the bark beetles, and one may add to these many species of the longicorns and buprestids, which leads them to choose out trees the vitality of which for whatever reason is impaired for the time being. For example, these groups of beetles exhibit the same instinct in infesting wind-blown or snow-broken trees. The heavy windfalls which occurred near Gerardmer in the Vosges in the late autumn of 1903, to quote but one European example, were followed by a heavy concentration of bark beetles on the wind-blown trees the following year. So serious was this attack that a considerable area of forest had to be felled before it was stamped out.

The various aspects of the inter-relation of fire and insect damage raise many questions that are pertinent to the protection of pine forests. The authors set themselves the following questions: What type, and what degree of fire injury make trees attractive to bark beetles? Are such trees capable of recovery if not attacked by insects? Do bark beetles 'breed up' in fire areas, increasing their numbers to an epidemic status, and then become aggressive in uninjured trees in and around burned areas? As they correctly state, the answers to these questions, of extreme importance to the forester, can only be obtained by a careful study on the ground.

The monograph by Messrs. Miller and Patterson is a most valuable piece of work and merits the careful study by all interested in this matter. Briefly, the authors' conclusions are as follows: Forest fires of sufficient severity to scorch the bark and foliage of yellow pine trees produce types of injury which make certain trees especially attractive to the Western pine beetle. Many trees which have been only moderately injured by the fire and are apparently capable of recovering, are attacked and killed by the beetles after a fire of this character. The attraction of fire-injured trees often causes a concentration of beetles within a burned area which lasts for one or two seasons following the fire. This attraction may extend for a distance of two or three miles from the burn. The concentration of bark-beetle attacks in fire-injured trees within a burned area does not develop into an epidemic condition. The loss from bark-beetle attacks in trees not injured by the fire either within the area of the burn or in the surrounding forest is not materially increased as a result of this concentration. Trees which have been defoliated by the fire are not favourable breeding places for the beetles, the resultant mortality amongst the latter, owing to the abnormally moist condition of the inner bark, being high. Finally, the authors' studies show that fires can be of but little benefit in reducing beetle losses through killing the beetles unless the fires are sufficiently severe to kill the trees. They add, in conclusion, "bark beetles supplement and increase timber losses initiated by forest fires, while fires have but little influence in permanently increasing the losses caused by bark beetles."

The second brochure here under review, by Mr. Patterson alone, deals with the inter-relation of slash (lop and top, etc., of trees) and insects, especially bark beetles and borers. In the United States three types of slash are recognised, and the definition is not without its value in Great Britain, namely, logging slash, the waste left in bulk on the ground after logging; line slash resulting from clearing roads, power lines and telephone lines (occurring in narrow strips); and wind-blown slash, *i.e.* wind-blown or snow-broken trees left unremoved. Both foresters and lumbermen have come to recognise, for the matter has been widely discussed, that if only to minimise the danger of fires originating in the slash and spreading into valuable standing forest, its disposal is advisable. The problem is further complicated by insect infestation, the green material being in the condition most suited to the beetles for oviposition.

The study undertaken by Mr. Patterson was to determine definitely whether the insect infestation of the slash threatened the value of adjacent standing

timber, the species investigated being in line slash of the Western yellow pine in Southern Oregon. The following are the conclusions arrived at. The line slash of this species is very attractive to the bark beetle (*Dendroctonus brevicornis*). The attack in the slash is not so heavy as in mature standing timber. The broods developing in slash are characterised by abnormal mortality (64 per cent. increase of beetles as compared with 135 per cent. in adjacent standing timber). Bark beetles from the surrounding standing timber are attracted to the slash at the time of attack, and a temporary concentration of infestation occurs in its immediate vicinity. Normal distribution of the infestation is resumed within the year. The concentration in the slash and the resulting beetles therefrom have little influence on infestations in the surrounding forests. Concluding, the author considers that the infestation of line slash by this beetle is not a serious menace to neighbouring mature timber, and may be disregarded when the problem of slash disposal is under consideration.

These two monographs merit the consideration of those interested in these matters. They exhibit a praiseworthy amount of careful research and experiment, undertaken in the forest, yielding results of practical utility.

Fisheries and their Products.

THE twentieth meeting of the Conseil Permanent International pour l'Exploration de la Mer took place in May 1927 at Stockholm. The report [1] marks the twenty-fifth anniversary of the foundation of the Council, which, mainly through the efforts of Sir John Murray, Prof. Cleve, Dr. Otto Petterson, and Dr. Fridtjof Nansen, owed its existence to the initiative of the late King Oscar II. of Sweden, who summoned in 1889 at Stockholm the first of the two conferences leading up to the foundation of the Council in 1902. The programme of international exploration had for its object the study of the hydrography and biology of the North Atlantic, North Sea, and Baltic, including statistical and industrial problems. With the recent inclusion of Italy, the Mediterranean is now added and fifteen countries are involved.

During the twenty-five years in which the Council has been in existence much work has been done, but most of the problems are so large that they need many years to show any results. Even now, however, in the infancy of the researches, definite results and promises of important results are seen. Direct research on fishes (especially food fishes, but also others indirectly related), with particular reference to their life histories, migrations, fluctuations, food, and environment, come first, and side by side the hydrography and plankton work with bottom sampling. At the same time statistical investigations, comparisons of various nets and methods of fishing, as well as research into the over-fishing of certain areas, are in progress, whilst the work on the whale fisheries is planned to fit in with that of the *Discovery* Expedition.

The hydrographers, continually active in all the countries concerned, maintain regular observations on temperatures and salinities, with special studies of currents and ice conditions. Plankton work in connexion with hydrography and its relation to fish food is undertaken in most of the countries, bottom sampling chiefly in the southern North Sea area. The most important fishes investigated are herring, cod, haddock, and plaice. A large amount has been done on the herring, in the North Sea, particularly the young stages (the main problems of its life history now being known), with regard to races, migrations, and fluctuations. Great Britain, France, Denmark, Norway, Sweden, Germany, and Poland all help in the herring work. The north-eastern area is mainly responsible for the cod. This includes sending specialists on board trawlers for the study of statistics, age, and food. A result of this is found in the comparison of fish from the coast of Finmarken and from the White Sea, showing that they belong to a common stock. Research on the haddock, chiefly in the southern North Sea area, has resulted in important work, carried on at Aberdeen, on age determinations; whilst the plaice, also in this area and in the north-western area, has been investigated particularly in Denmark and the Baltic. It is reported that there is a very large increase in the Baltic fishery in the last few years, and the red tunny has appeared in numbers in the North Sea in connexion with the herrings. Work on salmon and sea trout, together with the study of river pollution, is also being carried on.

The general conclusions to be drawn from this report are that the main facts relating to the spawning areas, life histories, food, age, and migrations of the most important food fishes (especially plaice and haddock, and to a less extent, herring and cod) are now known, and there is a general knowledge of hydrographical data, plankton distribution and bottom communities, especially in the North Sea, all of which form a foundation on which to carry on the enormous amount of detailed work still to be done. The statement of the North Sea Combined Committee that "there are certain features in the life histories of our most important commercial fishes . . . which are still obscure," whilst suggesting special attention to these, only voices the opinion of the Council as a whole, when recommending continuance of the existing programme in all areas and in all sections rather than beginning work on new lines.

A large amount of important and interesting information dealing with sea fisheries and suggestions for their improvement, with regard especially to those products which largely enter into the food of the people of the British Isles, has been published in a recent report of the Imperial Economic Committee on Marketing and Preparing for Market of Foodstuffs produced within the Empire.[2]

The main fishing grounds are almost wholly confined to water of less than 200 fathoms depth, situated in all parts of the Empire, but the North Atlantic and the North Pacific are the only two parts of the world where the fishing industries have been developed on a large scale, the North Atlantic being the most important. There is no evidence pointing to a shortage in the total fish supplies of the world, although the amount of fish on the fishing grounds may vary and some of them may have been over-fished. There are many valuable grounds at present only partially worked, because they are difficult of access and the present methods of preserving are not suitable for prolonged sea voyages. Nevertheless, the tendency is to go farther and farther afield.

In the British Isles, the demand is chiefly for 'white fish,' that is to say, such fish as cod, whiting, and sole, as distinct from 'pelagic' fish such as herring and mackerel, the two divisions representing fish of different habit and therefore requiring an

[1] Conseil Permanent International pour l'Exploration de la Mer, *Rapports et Procès-Verbaux des Réunions*, vol. 45. (Copenhague: Andr. Fred. Høst et fils, 1927.)

[2] "The Report of the Imperial Economic Committee on Marketing and Preparing for Market of Foodstuffs produced within the Empire." Fifth Report: Fish. (London: His Majesty's Stationery Office, 1927.)

entirely different method of catching, resulting in two almost separate trades. Since the War there has been a marked change in the demand for white fish rather than for herring, and the herring trade is faced by a loss of markets both at home and abroad, whilst there is a very large and increasing market for white fish, and almost all that is landed in Great Britain is consumed locally. To meet this demand the vessels must make longer voyages, which necessitate better methods of preservation.

The storage of fish after landing is most important, as at present the fish must be sold directly it is brought in, hence the great fluctuations in the quantities marketed and high prices. If it could be stored in 'live condition' more regular prices could be obtained. High prices limit consumption. This is particularly noticeable in affecting the British market of fresh and refrigerated fish caught off the Newfoundland and Canadian coasts, and discourages this branch of inter-Imperial trade. It follows that anything that will stabilise wholesale prices must have a healthy effect on the trade—the first essential is a better method of preservation at an economic cost. With better methods of preservation a larger consumption would be probable, and it is suggested that economy would be affected if the public were trained to buy filleted fish rather than whole, all the waste parts then being disposed of at headquarters; also that an improved and different method of curing herring would probably reinstate it as a favourite fish.

With regard to by-products, the most important are fish oils, especially cod-liver oil, and fish meals. The British and Newfoundland cod-liver oil is probably superior to foreign oil in essential vitamin content, but at present further research is needed as to methods of refinement. Fish meals are extremely valuable for feeding live stock and should be more fully used.

The recommendations of the Committee are wholly on the industrial side, the most important being that research should be instituted with the view of preserving fish from the moment when it has been caught to the moment when it reaches the consumer. This should be based on two central stations, one in Great Britain and one in Canada, a specially constructed vessel or 'factory ship' being established on which the most essential preliminary parts of the oil and meal industries could be carried on at sea. Other recommendations include the services of a biochemist to determine the scientific problems of economic importance attached to the preservation and curing of herrings, researches into the causes of variation of vitamin content in cod-liver oil and into refining methods, so that the full vitamin content may be retained, and further use of fish meal. With regard to the extension of tropical fisheries, the favourable position of the Malay Government for this purpose is suggested.

University and Educational Intelligence.

CAMBRIDGE.—Mr. W. C. D. Dampier-Whetham, Trinity College, has been appointed by the University a member of the Council of the National Institute of Agricultural Botany. E. J. H. Corner, Sidney Sussex College, has been appointed Frank Smart student in botany, and W. L. Edge, Trinity College, has been awarded the Allen Scholarship.

ST. ANDREWS.—The Senatus Academicus has resolved to confer the honorary degree of LL.D. upon Prof. E. P. Cathcart, Gardiner professor of physiological chemistry in the University of Glasgow, and upon Prof. William Darrach, Dean of the Medical School, Columbia University, New York.

AN election of Beit Memorial Junior Fellows for medical research will take place in July. The annual value of the fellowships is £400 each, and the usual tenure is for three years. Applications, in writing, should be sent to Sir James K. Fowler, Honorary Secretary, Beit Memorial Fellowships for Medical Research, 35 Clarges Street, W.1.

APPLICATIONS are invited for a Busk studentship in aeronautics for 1928–29, to be awarded towards the beginning of next July. This studentship, established in memory of E. T. Busk, who lost his life in 1914 while flying an experimental aeroplane, is awarded to provide opportunity for whole-time research on stability problems in aeronautics, and is open to British subjects of less than twenty-five years of age. Applications must reach Prof. B. Melvill Jones, Engineering Laboratory, Cambridge, before May 12 next.

THE Prince of Wales' Royal Indian Military College, Dehra Dun (United Provinces), was established in 1921 for the education of Indian boys in preparation for entry into the Royal Military College, Sandhurst, and eventually for a military career as officers. The number of pupils is at present seventy, and further expansion is contemplated. The normal age of entry is 11-13 years, and the standard at entry that of the higher primary school. The course extends over six years. The College is controlled by the Army authorities under the Government of India, and the staff includes a Commandant (Lieutenant-Colonel, Indian Army), a headmaster, and five assistant masters. Applications are now being invited for an assistant master, well qualified in mathematics and able to teach elementary physics and chemistry. Candidates must be public school men, preferably with an honours degree and experience of teaching in public schools. They should normally be from 23 to 30 years of age, and good at games. Unmarried men are preferred. Particulars of the pay, leave, and pension can be obtained from the Secretary, Military Department, India Office, S.W.1.

FROM the Universities Bureau of the British Empire we have received a list of "Students from other Countries in the Universities and University Colleges of Great Britain and Ireland: Session 1927–28." The total number is 4875, which is 6 per cent. greater than the total number given in the corresponding list for the session 1926–27. The number of students from each of the countries contributing substantially to this increase is as follows, the increase per cent. on the preceding year's figures being given in brackets: Egypt 384 (14), Canada and Newfoundland 183 (17), United States 487 (9), India, Burma, and Ceylon 1501 (10), France 61 (45), Germany 121 (30), Switzerland 60 (54), Australia 234 (20). Of considerable interest for comparison with these statistics is a tabular statement, published on p. 864 of the American Council on Education's new handbook, "American Universities and Colleges" (Charles Scribner's Sons, 1928), giving the number of foreign students in the colleges and universities of the United States during the past five years. The total number for the last year of the series (1925-26) is 5806, the countries chiefly contributing to this total being China (1317), Japan and Korea (808), Canada (733), Philippines (571), Russia (515), South American States (244), British Isles 310 (England 202, Scotland 52, Ireland 49, Wales 7), Mexico 188, Porto Rico 183, India, Burma, and Ceylon 182, Hawaii 141, British West Indies 125, Germany 124, Italy 117. Germany shows a steady increase during the five years—49, 63, 79, 121, 124; South Africa a decrease—146, 137, 97, 76, 63.

Calendar of Customs and Festivals.

April 15.

LOW OR WHITE SUNDAY.—Said by a seventeenth-century writer to be so called because in the primitive Church neophytes baptised and clothed in white garments at Easter Eve put off their white clothes on this day and were admonished to remember that they were made *low* as little children of Almighty God such as ought to retain in their lives and manners the memory of the Paschal feasts they had accomplished. An alternative was that it was the lowest or latest day for satisfying the Easter obligations.

In the Highlands of Scotland, 'Old Men's Easter' was a repetition of the Easter feast if on a lesser scale. In the Greek Church its popular observance is a continuation of the Easter festivity. In Macedonia on Easter Tuesday the people repair to the open country where the girls dance, in more or less ceremonial dances, and the youths amuse themselves with contests in shooting at a mark, wrestling, jumping, running, and the throwing of heavy stones. On the following Sunday, known as St. Thomas's Day, a similar celebration, but on a more elaborate scale, takes place. Prizes are given for the principal events —for running and wrestling a kid or a lamb, the winners in these events being acclaimed and marching off with their prizes over their shoulders to the accompaniment of shouts and the firing of guns.

It is evident that in the popular observances throughout Lent and at Easter we are dealing with festivals connected with both seed-time and the advent of spring which took place originally on no fixed date, but were observed at different times in different localities, or perhaps even on various occasions within the same community.

That the two classes of festival are not necessarily coincident or immediately consecutive appears in the popular religion of India. The Holi festival in veneration of fire and lights is a spring fertility festival celebrated in northern India in the month of Phālgun (February-March). Fire is lighted on the night of the full moon, fuel being taken from all the villagers for the purpose, or a tree is set on fire. Processions are made round the fire, men and women jump through the fire, and offerings are thrown into the flames. Foul obscenities of act and word are used, and sometimes there is a procession of a mock king—an Easter ceremonial which survived in Cornwall at Lostwithiel, but as a solemn observance. In contrast, the agricultural new year begins with a festival in later April, which is a time of great solemnity. Both plough and seed are consecrated, small portions of the latter being sowed ceremonially; and cutting the first sods in ploughing or digging—evidently an act of peril—are performed by a holy man. Among the Nagas the transplanting of the first five rice plants is done by the village priest, and a libation made. Such a solemn rite is almost necessarily made the occasion for mourning lost relations. Omens are taken of the coming harvest, and ceremonial contests such as mock fights or tug of war between the women and girls on one side and the men and boys of the village on the other, promote fertility or foretell the harvest.

Among the Malabars, in the earlier half of April, but usually between April 10 and April 14, the vernal equinox is celebrated, marking the agricultural new year. The first thing seen on Vishu day is an omen of fortune for the whole year, judicious prearrangement usually securing a desirable object. Presents of money are made to the junior members of the family and the servants. The spade furrow is laid and an offering made to the elephant god. The Chāl is the most important of these agricultural ceremonials, though not now often observed. It demanded the services of a professional astrologer to fix the propitious time and place for cutting the first furrow. A new ploughshare was fitted and a handful of seed was thrown ceremonially into the first furrow. A coconut was cut on the ploughshare to foretell the character of the harvest, in accordance with the direction of the cut and the part at which the nut was divided. The actual seed is not sown until May.

April 17.

ST. PETER GONZALEZ OR ST. ELMO: *b.* in the town of Astorga in Spain, 1190, *d.* 1240. He accompanied King Ferdinand in the expeditions against the Moors and was present at the capture of Cordoba. Afterwards he went on evangelical missions among the degraded peasantry and among sailors. He is especially associated with the protection of the latter. In art he is represented as holding a blue candle, and the confraternities of St. Elmo carry blue candles in their processions. This is in reference to the corposant (*corpo santo*), the blue electric discharge which in the Mediterranean appears on the tops of masts of ships under certain conditions of weather, and is taken to ensure the safety of the ship.

Virtues have been added to St. Elmo to which he is not entitled in making him responsible for this light, for the belief is much older. Several other saints have had the protective light assigned to their province—St. Anselm of Lucca or St. Erasmus, names of which, it is suggested, St. Elmo or St. Telmo may be corruptions. Frequently the saint is duplicated, hence St. Cosmas and St. Damian or St. Crispin and St. Crispian, the last-named pair being especially connected with the protection of sailors and ships in the English Channel, and more particularly in Kent, owing to the proximity of the Goodwin Sands. St. Nicholas is also popular there for the same reason. The twin cult, and its association with maritime activities, however, antedates Christianity. The Dioscuri and other pairs of brothers, such as Romulus and Remus, from whom the name St. Elmo may really be derived by amalgamation, were specially connected with navigation and the protection of sailors as part of a great protective cult.

April 21.

ST. MAELRUBIUS OR MAELRUBHA, a member of the Clan Cinel-Eoghain of Co. Londonderry and a descendant of the famous Niall of the Nine Hostages. He passed over to Scotland, becoming a zealous apostle among the Picts and founding the church of Aporcrossan or Applecross in A.D. 672 or 673. He was patron saint of all the coast from Applecross to Loch Broom. His cult has evidently subsumed a number of local cults, and his name appears in a number of varying forms. Partly for this reason his festival has been identified with others occurring later in the year. His relation to paganism is suggested by his association with a well on Inis Maree noted for the cure of insanity, and by his patronage of several fairs in August and September. For neglect of his festival in August at harvest-time men's houses were burnt, while those of the men who observed it were preserved. The saint's influence has not waned. When the present manse at Applecross was building, the builder was warned in a dream to desist from using a fragment of the saint's tombstone. Later he was thrown from the scaffolding and his skull fractured on this very stone.

Societies and Academies.

LONDON.

Geological Society, Mar. 21.—**F. B. A. Welch**: The geological structure of the Central Mendips. The Central Mendips comprise a rectangular area measuring roughly 80 square miles, lying between Shepton Mallet and Cheddar on the east and west respectively. As a whole, the Mendips consist of a west-north-westerly to east-south-easterly ridge, the structure being that of four periclines arranged *en échelon*. The cores of these periclines are of Old Red Sandstone age, with the Carboniferous Limestone Series succeeding. The Central Mendips include the North Hill, the Pen Hill, and part if the Beacon Hill periclines. Of these, North Hill and Pen Hill are more or less anticlinal in structure; but the Pen Hill pericline has been much disturbed by extensive earth movements. A large syncline, which extends from Cheddar to Wells, has been thrust from the south against the southern limb of the North Hill pericline, while at one point a 'window' occurs in this syncline, revealing beds of the main hill-mass beneath the thrust. Parallel to this thrust, at Ebbor, a second great thrust is developed, isolated remnants of which are seen in the small hills north of Wells. Earth movements seem to have been directed mainly from the south, at first producing the ridge with periclines *en échelon*, and separated one from the other by normal synclines. Pressure continued, and appears to have been greatest in the Pen Hill region, where overfolding was developed. Finally overthrusting resulted, and large blocks of beds, bounded by extensive north-and-south faults, formed at the time of the thrusting, were driven northwards.

PARIS.

Academy of Sciences, Mar. 5.—**G. Ferrié**: The operation of world longitudes (October-November, 1926). An account of work done by the international committee. Fifty-two stations belonging to thirty nations took part in the work, and forty-five of these have already sent to the president accounts of their observations. Twenty-two of these have furnished data bearing on the fundamental triangle, Algiers—Li Ka Wei—San Diego, for which results are given.—**C. Sauvageau**: The development of two Asperococcus.—**Luigi Fantappié**: The calculation of matrices.—**S. Stoïlow**: A class of continued transformations with limited variation.—**Henri Cartan**: A theorem of M. A. Bloch, and questions of unicity in the theory of meromorph functions.—**G. Vranceanu**: Completely stable periodic solutions.—**Jacques Mesnager**: The theory of equilibrium of heavy massifs submitted to pressures from below and its bearing on the stability of barrages.—**Mesnager**: Remarks on the preceding communication.—**Henri Mémery**: An important recrudescence of sunspots on Feb. 2, 1928.—**Marcel Dufour**: The refraction of the astigmatic pencil. The third equation of Sturm.—**M. Ponte**: The various spectra of mercury. Details of the spectrum obtained in a tube fitted with a single electrode and submitted to high frequency discharge with very short wavelength (about 12 metres).—**W. Kopaczewski**: The buffer action of the serum in relation with immunity.—**Jacques Bardet** and **Arakel Tchakirian**: The preparation and properties of some germanous salts. Two direct methods are given, one based on the reduction of germanic salts by zinc and sulphuric acid, the other by reduction with hypophosphorous acid in hydrochloric acid solution. Germanous oxide is soluble with difficulty in solutions of sulphuric or hydrochloric acid, and after filtering and rapidly drying, is stable at the ordinary temperature.—**G. Allard**: The determination of the crystalline network of microcrystalline substances by means of radiograms taken with powders. The method described is general, and is not, like Hull's method, limited to substances crystallising in the cubic, quadratic, hexagonal and rhombohedric systems.—**Henri Termier**: A hypothesis concerning the Permian and Trias of Morocco.—**Marcel Martz**: The anomalies of the androecium in a hybrid of the genus Digitalis.—**A. Jullien**: The significance of the eosinophil granulations of the blood cells of *Sepia officinalis*.—**Maurice Caullery** and **Mlle. Marguerite Comas**: The determination of sex in a nematode (*Paramermis contorta*), a parasite of the larvae of Chironomus. From determinations of the number and sex of parasites present on single worms, it was found that the sex depends largely on the number of parasites on each worm, and hence is probably a question of nutrition.—**Charles Pérez**: The evolution of the apparatus for attaching the abdomen to the thorax in decapods (Dromia, Homola).—**Angel Establier y Costa**: Hyperallantoinuria in artificially produced polyuria and diabetes in man. In all the cases examined the polyuria was accompanied by a large increase in the amount of allantoin excreted.—**Marcel Duval**, **Paul Portier**, and **Mlle. A. Courtois**: The presence of large quantities of amino-acids in insects. Analyses of seven different species showed a very high proportion of amino-acids, ranging from 13 to 36 times the amounts present in the blood of mammals.—**C. Levaditi** and **T. E. Anderson**: The neurotropism of *Spirochæta Duttoni*. From experiments on mice inoculated with *Sp. Duttoni*, the brain was found to be virulent long after the blood was sterile. No typical spirochæte could be detected in the brain in these cases. As in the experiments described by Nicolle, Levaditi, Sanchis-Bayarri, and Schoen, the parasites appear to undergo a cycle of evolution, one of the phases of which is invisible and non-filtrable.—**S. Nicolau**: The histo-pathological modifications of the suprarenal capsules and the salivary glands of rabbits killed by experimental enzootic encephalomyelitis (Borna's disease).—**V. Chorine**: The influence of the hydrogen ion concentration of the culture medium on the virulence of the Coccobacillus of the Pyralis of maize.

ROME.

Royal National Academy of the Lincei, Dec. 18.—**G. Armellini**: Measurement of double stars.—**S. Baglioni**: (1) Action of quinine, eserine, pilocarpine, digitonine, sparteine, and atropine on the nervous centres. Experimental investigations on a preparation of *Bufo vulgaris*. None of the poisons named, when applied locally to the dorsal or ventral face of the posterior intumescence of this preparation, causes increase in the excitability or tetanic or clonic convulsions. An apparent exception occurs with digitonine applied to the dorsal face, this resulting, after the lapse of some hours, in tetanic reflexes similar to those produced by strychnine; such action is, however, almost certainly due to a decomposition product of digitalin which has an action resembling that of picrotoxin. (2) Physiological doctrine of the action of poisons exciting the nervous centres. Consideration of the available experimental data seems to justify the enunciation of the following general theory: All poisons acting selectively by enhancing the excitability of the central co-ordinating elements of the posterior corna of the spinal medulla, cause the abnormal increase in the reflex activity which culminates in the typical tetanic convulsions of central origin (strychnine type), whereas those which act selectively by raising the excitability of the central

elements of the anterior corna (motor neurones) cause increase in the reflex excitability, resulting finally in clonic convulsions of central origin (phenol type). This selective action of different poisons is, moreover, a proof that the neurones of the posterior corna and of the anterior corna are endowed with specifically different functional properties.—**F. Tricomi**: The equation $y\partial^2 z/\partial x^2 + \partial^2 z/\partial y^2 = 0$.—**U. Crudeli**: The elementary geodesic displacement.—**G. Sansone**: The apiristic resolution of the biquadratic congruences.—**Giuseppe Scorza**: Partial minima and maxima for functions of several variables.—**V. Hlavatý**: Complements to the theorem of reduction of orthogonal differential systems.—**G. Krall**: Variation of the field in the equations of elastic motion.—**D. Graffi**: Magnetic induction. A mathematical treatment is given for the problem of magnetic induction for ferromagnetic bodies in the case when the variations in time of the electromagnetic field are so small that the phenomena accompanying such variations may be neglected.—**E. Fermi**: A statistical method for the determination of certain properties of the atom (1). A process is described for calculating statistically the distribution of the electrons round the nucleus. The results obtained render it possible, first, to calculate the energy necessary to ionise the atom completely, that is, to strip it of electrons, and secondly, to determine the variation in potential at different distances from the nucleus and hence to ascertain the electric field in which the electrons of the atoms occur.—**L. De Caro**: The production of lactic acid and of phosphoric acid in 'rigor from thawing.' Quantitative experiments made by Fletcher on the production of lactic acid in striated mammalian muscle subjected to low temperatures showed that, during the freezing of the muscle, there takes place no formation of lactic acid, but some change which disposes it to a more rapid formation of the acid when thawing begins. The results of the author's experiments on muscle from the frog, toad, and dog show that the production of phosphoric acid in the muscle at low temperatures follows a course parallel to that of lactic acid and that this behaviour remains unchanged even after the suppression of the morphological structure of the muscular tissue. 'Rigor from thawing' is accompanied by the same chemical changes as are encountered in the other normal or experimental forms of muscular contraction.—**Camillo Artom**: Effects of cooling the spinal ganglia.—**N. Passerini** and **P. Galli**: Experiments on the action of the sodium chloride contained in irrigation water on certain plants. Under the conditions of pot tests, various annual and perennial plants exhibit for some time marked tolerance towards moderately concentrated sodium chloride solutions, but, owing to the rapid evaporation of the liquid and to consequent accumulation of salt in the soil, even dilute solutions result ultimately in death or damage to the plants. Although such accumulation of salt is not to be feared in the open ground, it is not advisable to employ, for irrigation, water containing more than 1 part of combined chlorine per 1000. For the spontaneous growths of established meadow-land or for arable land with permeable subsoil, this limit may be increased to 2 or, in some instances, 3 parts per 1000.

Vienna.

Academy of Sciences, Jan. 19.—**W. Figdor**: The influence of light on the form of *Bowiea volubilis* and the increase and structure of its bulbs. Both in the light and in the dark, the main and the side axes show opposite tendencies as to growth in length.—**K. Menger**: Notes on theory of dimensions (4). The dimensions of irreducible continua.

Jan. 26.—**A. Franke** and **E. Gigerl**: Researches on the formation of benzal in glycols.—**A. Franke** and **R. Stern**: Glycol from methylethylacetaldehyde and benzaldehyde.—**F. Schweda**: Calculation of the transversal end frame of open bridges.—**K. Menger**: Metrical researches: (1) Theory of convexity, (2) Euclidean metric, (3) n-dimensional metric.—**A. Methlagl**: Trombidioses in Austrian alpine countries. Various species of Trombicula are reported.—**L. Lämmermayr**: Further contributions to the flora of magnesite and serpentine soils.—**A. Kieslinger**: Geology and petrology of the Kor Alps. (5) Marble outcrops in the region of the map sheet Deutschlandsberg-Wolfsberg.

Official Publications Received.

British.

The British Mycological Society Transactions. Edited by Carleton Rea and J. Ramsbottom. Vol. 13, Parts 1 and 2. Pp. 144+7 plates. (Cambridge: At the University Press.) 15*s*.

Air Ministry: Aeronautical Research Committee. Reports and Memoranda. No. 1111 (Ae. 285): A General Theory of the Autogyro. By H. Glauert. (T. 2359: T. 2413.) Pp. 36+5 plates. 1*s*. 6*d*. net. No. 1117 (Ae. 290): Scale Effect on Three Aerofoils at Low Levels of LV, R.A.F. 32, Göttingen 433, and Göttingen 410, with 2 per cent. Centre Line Camber. By F. B. Bradfield. (T. 2512.) Pp. 6+4 plates. 6*d*. net. (London: H.M. Stationery Office.)

Transactions of the Royal Society of Edinburgh. Vol. 55, Part 3, No. 24: The Life-History and Cytology of *Reticularia Lycoperdon* Bull. By Dr. Malcolm Wilson and Elsie J. Cadman. Pp. 555-608+6 plates. 9*s*. Vol. 55, Part 3, No. 26: A Comparative Study of the Stem Structure of the Genus Clematis, with special reference to Anatomical Changes introduced by Vegetative Propagation. By Dr. Edith Philip Smith. Pp. 643-664+2 plates. 3*s*. 6*d*. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.)

Proceedings of the University of Durham Philosophical Society. Vol. 7, Part 4, 1926-1927. Pp. 161-260. (Newcastle-on-Tyne.) 5*s*.

Imperial Agricultural Research Conference, 1927. Report and Summary of Proceedings. Pp. iv+249. (London: H.M. Stationery Office.) 1*s*. net.

Report of the Marlborough College Natural History Society for the Year ending Christmas, 1927. (No. 76.) Pp. 94+4 plates. (Marlborough.) 3*s*.; to Non-Members, 5*s*.

University of London: University College. Report of the University College Committee (February 1927–February 1928), with Financial Statements (for the Session 1926–27), and other Documents, for Presentation to the Senate. Pp. 191. (London: Taylor and Francis.)

The National Physical Laboratory. Report for the Year 1927. Pp. vi+264. (London: H.M. Stationery Office.) 7*s*. 6*d*. net.

A Problem of Empire Suffering: being the Annual Report for 1927 of the British Empire Leprosy Relief Association. Pp. 46. (London.)

List of Council and Fellows of the Royal Society of Edinburgh, October 1927. Pp. 26. (Edinburgh.)

List of the Geological Society of London, March 1928. Pp. 74. (London.)

Agricultural Progress: the Journal of the Agricultural Education Association. Vol. 5, 1928. Pp. 145. (London: Ernest Benn, Ltd.) 5*s*. net.

Proceedings of the Royal Society of Edinburgh, Session 1927–1928. Vol. 48, Part 1, No. 3: On Fourier Constants. By E. T. Copson. Pp. 15-19. 6*d*. Vol. 48, Part 1, No. 4: An X-ray Examination of Saturated Dicarboxylic Acids and Amides of the Fatty Acid Series. By Dr. Edward Henderson. Pp. 20-27. 9*d*. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.)

Imperial Department of Agriculture for the West Indies. Report on the Agricultural Department, St. Kitts-Nevis, 1926–27. Pp. iv+30. (Trinidad, B.W.I.) 6*d*.

University of Bristol: Department of Agriculture and Horticulture. Bulletin No. 2: Sugar Beet Trials, 1927, and Report of Sugar Beet Conference, February 1928. By A. W. Ling and C. W. Linley. Pp. 55. Bristol.)

Memoirs of the Department of Agriculture in India. Botanical Series, Vol. 15, No. 1: Studies in Khandesh Cotton, Part i. By S. H. Prayag. Pp. iii+49+8 plates. (Calcutta: Government of India Central Publication Branch.) 1.4 rupees; 2*s*. 3*d*.

The Tea Quarterly: the Journal of the Tea Research Institute of Ceylon. Edited by T. Petch. Vol. 1, Part 1, February. Pp. 26. (Nuwara Eliya.)

Journal of the Chemical Society: containing Papers communicated to the Society. March. Pp. iv+529-751+x. (London: Gurney and Jackson.)

Foreign.

Department of the Interior: Bureau of Education. Bulletin, 1927, No. 32: Statistics of City School Systems, 1925–1926. Pp. 185. (Washington, D.C.: Government Printing Office.) 30 cents.

Travaux de la Section de Géodésie de l'Union Géodésique et Géophysique Internationale. Tome 4: Rapports généraux établis à l'occasion de la deuxième assemblée générale, 24 septembre-8 octobre 1924. Pp. vi+58+4 planches+79+11+8+38+53+3+4+4+11. (Paris.)

Rapport annuel sur l'état de l'Observatoire de Paris pour l'année 1926 présenté au Conseil dans la séance du 12 mars 1927. Par B. Baillaud. Pp. 20. (Paris.)

Publikace Pražské Státní Hvězdárny : Publications de l'Observatoire National de Prague. No. 5 : The Maps of the Boundaries of the Constellations in the Galactic System of Co-ordinates. By Otto Seydl. Pp. 2+2 maps. (Prague.)

Department of Commerce : Bureau of Standards. Scientific Papers of the Bureau of Standards, No. 569 : Generator for Audio Currents of Adjustable Frequency with Piezo-Electric Stabilization. By August Hund. Pp. 631-637+2 plates. 10 cents. Scientific Papers of the Bureau of Standards, No. 570 : Thermal Expansion of Alloys of the 'Stainless Iron' Type. By Peter Hidnert and W. T. Sweeney. Pp. 639-647. 10 cents. (Washington, D.C. : Government Printing Office.)

United States Department of Agriculture. Technical Bulletin No. 25 : Experiments for the Control of the European Red Mite and other Fruit-Tree Mites. By E. J. Newcomer and M. A. Yothers. Pp. 34. 10 cents. Technical Bulletin No. 42 : Life History of the Codling Moth in Delaware. By E. R. Selkregg and E. H. Siegler. Pp. 61. 15 cents. (Washington, D.C. : Government Printing Office.)

Boletim meteorologico : observações meteorologicas feitas no Observatorio do Instituto Central, do Rio de Janeiro e estações das rêdes federal e cooperativas. Anno 1922. Pp. viii+191. (Rio de Janeiro : Ministerio da Agricultura, Industria e Commercio.)

United States Department of Agriculture. Technical Bulletin No. 34 : The Fall Army Worm. By Philip Luginbill. Pp. 92. (Washington, D.C. : Government Printing Office.) 25 cents.

CATALOGUES.

The Cambridge Bulletin. No. 59, March. Pp. 31+8 plates. (Cambridge : At the University Press.)

A Catalogue of Books published by Bowes and Bowes. (Catalogue No. 442.) Pp. 8. (Cambridge : Bowes and Bowes.)

Mr. Murray's Quarterly List. April. Pp. 32. (London : John Murray.)

Diary of Societies.

SATURDAY, APRIL 14.

INSTITUTE OF BRITISH FOUNDRYMEN (Lancashire Branch) (at College of Technology, Manchester), at 4.—J. Hogg : A Foundry Problem.—W. Holland : Refractories.

INSTITUTE OF BRITISH FOUNDRYMEN (West Riding of Yorkshire Branch) (at Technical College, Bradford), at 6.—W. H. Poole : What has Science done for the Foundry?

INSTITUTE OF BRITISH FOUNDRYMEN (Lancashire Branch—Junior Section) (Annual General Meeting), at 7.—C. F. Brereton : Some Observations on Metallurgical Practice in the U.S.A.

HULL ASSOCIATION OF ENGINEERS (at Municipal Technical College, Hull), at 7.15.—L. Rowland : Rubber as a Shock Absorber.

MONDAY, APRIL 16.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—Rev. Charles Boutflower : Sennacherib's Invasion of Judah 701 B.C.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—E. H. Shaughnessy and others : Discussion on Wireless Reception.

INSTITUTION OF ELECTRICAL ENGINEERS (Mersey and North Wales (Liverpool) Centre) (at University, Liverpool), at 7.—Annual General Meeting.

CERAMIC SOCIETY (at North Staffordshire Technical College, Stoke-on-Trent), at 7.30.—W. E. Box : The Recent Development of Special Electro-magnetic Separators and Applications of Interest to the General Pottery Trade.—Dr. G. Martin : Researches on the Theory of Fine Grinding, Parts 9, 10, and 11.

RAILWAY CLUB (25 Tothill Street, S.W.1), at 7.30.—R. M. Bazley : South American Railways.

ROYAL SOCIETY OF ARTS, at 8.—A. G. Huntley : Applied Architectural Acoustics (Dr. Mann Lectures) (I.).

CHEMICAL INDUSTRY CLUB.

TUESDAY, APRIL 17.

ELECTRICAL ASSOCIATION FOR WOMEN (at Institution of Electrical Engineers), at 11.15 A.M.—Annual General Meeting.

ROYAL STATISTICAL SOCIETY (at Royal Society of Arts), at 5.15.

ROYAL SOCIETY OF MEDICINE, at 5.30.—General Meeting.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—J. H. Lloyd : Abnormalities of *Rana temporaria*, chiefly relating to the Vascular System.—Dr. J. G. Myers : Morphology of the Cicadidæ (Homoptera).—Dr. H. G. Jackson : The Morphology of the Isopod Head. Part II. The Terrestrial Isopods.

INSTITUTION OF CIVIL ENGINEERS, at 6.—C. P. Taylor and Dr. O. Faber : Deep-water Jetty at Bevan's Cement-Works, Northfleet.

LONDON NATURAL HISTORY SOCIETY (at Winchester House, E.C.), at 6.30.—C. L. Collenette : Mothing in the Tropics (Bacot Memorial Meeting).

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Scientific and Technical Group), at 7.—Dr. D. A. Spencer : Photographic Applications of Diazo Compounds.—H. H. Horton and O. Bloch : A Mechanical Developing Appliance for Sensitometric Work.

SOCIETY OF GLASS TECHNOLOGY (at University, Sheffield), at 7.30.—W. Butterworth, sen. : Stained Glass of the Renaissance Period.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.30.—Rev. F. R. Bishop : Native Life in the Mandated Territory of New Guinea.

WEDNESDAY, APRIL 18.

RESEARCH ASSOCIATION OF BRITISH PAINT, COLOUR, AND VARNISH MANUFACTURERS (at Paint Research Station, Waldegrave Road, Teddington), at 2.30.—R. A. Coolahan : Cellulose Lacquers, illustrated by a film entitled Modern Lacquers.

SOCIETY OF GLASS TECHNOLOGY (at University, Sheffield) (Annual General Meeting), at 2.30.—(Ordinary Meeting), at 3.—Dr. S. English, Prof. W. E. S. Turner, and F. Winks : Some New Facts arising from a Study of the Casing of Colourless by Coloured Glass.—A. Cousen, H. W. Howes, and F. Winks : The Control and Distribution of Temperature in Lehrs.

ELECTRICAL ASSOCIATION FOR WOMEN (at Institution of Electrical Engineers), at 3.—Capt. P. P. Eckersley : Technical Problems of Broadcasting.

ROYAL METEOROLOGICAL SOCIETY, at 5.—C. K. M. Douglas : Some Alpine Cloud Forms.—N. K. Johnson : A Strong Wind of small Gustiness.—T. N. Hoblyn : A Statistical Analysis of the Daily Observations of the Maximum and Minimum Thermometers at Rothamsted.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—Dr. G. H. Mitchell : The Succession and Structure of the Borrowdale Volcanic Series in Troutbeck, Kentmere, and Long Sleddale (Westmorland).—L. J. Chubb : The Geology of the Marquesas Islands (Central Pacific).

INSTITUTE OF METALS (Swansea Local Section) (at Thomas' Café, Swansea), at 7.—Annual General Meeting.

INSTITUTION OF ELECTRICAL ENGINEERS (Sheffield Sub-Centre) (at Royal Victoria Hotel, Sheffield), at 7.30.—D. B. Hoseason : Squirrel-Cage Induction Motors.

ROYAL MICROSCOPICAL SOCIETY, at 7.30.—Dr. K. F. Bělař : The Separation of Protoplasm in the *Myxomycete Didymium* by Stimuli.—B. R. Johnson : Some Introductory Experiments dealing with a Quantitative Method of Determining the Resolving Power of Microscope Objectives.

ROYAL SOCIETY OF ARTS, at 8.—A. C. Bossom : American Architecture.

FOLK-LORE SOCIETY (at University College), at 8.—W. J. Perry : The Dramatic Element in Ritual.

ELECTROPLATERS' AND DEPOSITORS' TECHNICAL SOCIETY (at Northampton Polytechnic Institute), at 8.15.—G. B. Hogaboom : Effect of Carbonates in a Silver Solution.

INSTITUTE OF BREWING (Burton-on-Trent Section) (at Queen's Hotel, Burton-on-Trent).—C. F. Wade : Fuel Economy.

INSTITUTE OF CHEMISTRY (London Section).

THURSDAY, APRIL 19.

INSTITUTION OF MINING AND METALLURGY (at Geological Society), at 5.30.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—Sir Oliver Lodge : The Revolution in Physics (Kelvin Lecture).

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Colour Group, Informal Meeting), at 7.—F. T. Hollyer : Some Aspects of Colour Printing.

ROYAL SOCIETY OF MEDICINE (Neurology Section) (Clinical Meeting at West End Hospital for Diseases of the Nervous System), at 8.

BRITISH INSTITUTE OF RADIOLOGY, at 8.30.—C. Wainwright : The Coolidge Cathode-Ray Tube and its Applications.—J. E. Schall : Lantern Slide Projection of Stereoscopic Radiograms.

INSTITUTION OF CIVIL ENGINEERS (Birmingham and District Association) (Annual General Meeting) (at 6 Corporation Street, Birmingham).—R. A. Robertson : The Sandfields Filters of the South Staffordshire Waterworks Company.

INSTITUTION OF MECHANICAL ENGINEERS (Bradford Branch).—Prof. G. F. Charnock : Mechanical Transmission of Power.

FRIDAY, APRIL 20.

ROYAL ASTRONOMICAL SOCIETY (Geophysical Discussion), at 4.30.—Dr. de Graaf Hunter, A. R. Hinks, Sir Gerald Lenox-Conyngham, Capt. G. T. McCaw, and H. L. P. Jolly : Some Applications of the Geoid. Chairman, Sir Charles Close.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—Dr. H. J. Gough and A. J. Murphy : The Causes of Failure of Wrought-Iron Chains and Cable.—Third Report of the Wire Ropes Research Committee.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Mining Institute, Newcastle-upon-Tyne), at 6.—Dr. S. H. Long : W/T Direction Finding for Marine Purposes.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Pictorial Group, Informal Meeting), at 7.—A. Cocking : The Development of Cut Film.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—Re-Exhibition of Slides and Discussion on Paper by W. M. Hurrell on An Outline of the Distribution of Petroleum.

SOCIETY OF CHEMICAL INDUSTRY (Chemical Engineering Group) (jointly with Birmingham Section), at 7.30.—Dr. C. M. Walter : The Heat Treatment of Ferrous Metals.

ROYAL SOCIETY OF MEDICINE (Obstetrics Section), at 8.—R. H. Paramore : Eclampsia and its Treatment : an Experience with Spinal Anæsthesia in one case.—Prof. W. Blair Bell : The Malignant Functions of the Chorionic Epithelium.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Col. Sir Henry G. Lyons : Heirlooms of Industry in the Science Museum.

SOCIETY OF DYERS AND COLOURISTS (Manchester Section).—Annual Meeting.

SATURDAY, APRIL 21.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (Newcastle-upon-Tyne), at 2.30.

CONFERENCE.

APRIL 13–16.

GEOGRAPHICAL ASSOCIATION (at Oxford).

April 14.—Sir Halford Mackinder : The British Empire in Relation to the Geography of the World (Lecture).

April 16.—Col. C. H. D. Ryder : Surveys from Air Photographs (Lecture).—Dr. L. Dudley Stamp and others : Discussion on Practical Steps in Regional Survey Work and Local Studies.