extension fund of this Institute, which paves the way for the development of industry in Palestine in so many directions. The Institute prides itself on being almost self-supporting. Eighty per cent of its income is derived from tuition fees and fees paid by industry for the use of the laboratories. This is a very good record for an educational institution, and a closer analysis of its income immediately shows the reason for it. Last year's budget amounted to about £20,500. If one deducts from this a non-recurrent grant from the Palestine Government (ear-marked for new buildings and equipment), the income only amounts to £17,200. This is very small for an institution in which one thousand pupils are trained: it is obviously a starvation figure and must imply either curtailing teaching or research activities or both. The outside observer concludes, with a feeling of uneasiness, that the Jews in Palestine are about to repeat the mistakes of European countries against which men of science and engineers have been fighting in recent years. It is a grave mistake to distribute the income of a community in such a way that it is impossible for scientific institutions to develop all their resources. From the point of view of the present as well as of future generations, scientific work gives by far the highest return for money spent. Considering the particular circumstances of colonization in Palestine, and the small number of scientific institutions concerned, there is no reason why they should repeat errors which are only now being overcome in Europe and America.

There is one other point worth mentioning here. The library of the Hebrew Technical Institute is the only technical library in Palestine, and is much frequented by engineers, men of science, teachers and Government officials from all over the country. Unfortunately, the English section seems to be rather small, and a large number of scientific and technical books and journals published in England are lacking. This is not to be wondered at, as anyone will know who has tried to set up a new scientific library with little money. Jews go to Palestine mainly from the Continent, but are prepared to take up English as their second language to Hebrew and to come into more intimate contact with British thought. The library of the Hebrew Technical Institute at Haifa is therefore commended to the generosity of publishers and learned societies in Great Britain.

Cosmic Rays

A DISCUSSION meeting of the Royal Society was held on May 26 on "Cosmic Rays". The discussion was opened by Prof. P. M. S. Blackett, and papers were read by Profs. P. Auger (Paris), E. Regener (Stuttgart), and J. Clay (Amsterdam). After some further specific contributions from workers in Great Britain, a general discussion followed.

It is now generally agreed that cosmic radiation, as observed at the earth's surface, consists of two components distinguished empirically by their different rates of absorption. The 'soft' component, which constitutes about 20 per cent of the total cosmic ray intensity at sea-level and is practically all absorbed at a depth of 10 m. of water below sea-level, is now believed to consist of high-energy electrons which obey Dirac's relativistic theory. The application of this theory to the emission of radiation by such electrons in nuclear collisions, and to the production of electron pairs by radiation, has in fact provided in a remarkably unforced manner a satisfactory explanation of the absorption of the soft component and the phenomenon of electron-showers which accompanies its passage through matter.

The hard or penetrating component, on which most of the discussion was centred, is of considerable interest in that it is now supposed to consist of particles of a 'new' type, possessing electronic charge but a mass greater than that of an electron and less than that of a proton, provisionally referred to as 'heavy' electrons.* This interpretation of the hard component was suggested about a year ago by Neddermeyer and Anderson on rather circumstantial grounds, but more direct evidence has since been obtained for the existence of such a particle in cosmic rays. This evidence comes from the observation, in a Wilson cloud-chamber, of tracks the ionization and curvature (in a magnetic field) of which are not consistent with electrons or protons, but indicate a particle with electronic charge and a mass about 200 times that of an electron (that is, about one tenth protonic mass).

Examples of such tracks obtained by different workers were shown during the meeting. The comparative rarity of these anomalous tracks may be attributed to the small distance the particles travel after their velocity has fallen sufficiently low to give

* That the hard and soft components consist of different kinds of particles, rather than particles all of the same kind but of different energies, was clearly put forward by Auger in 1935 (NATURE, **135**, 820; 1935). Auger's description of the soft component is almost identical with our present view, and for the hard component he suggested "heavy particles such as protons"

tracks with an ionization clearly distinguishable from that along tracks of the same curvature produced by electrons or protons.

In his opening address, Prof. Blackett set forth the 'birth, life and death' of the heavy electron as the main problems now awaiting solution. Prof. P. Auger described recent experiments which contribute to an understanding of the manner of their creation. In these experiments the frequency of coincident discharges of a number of counters of high resolving power (*c.* 10^{-6} sec.) is observed. The results obtained indicate the existence (in the open) of showers spread over at least 25 sq. m. and containing at least 1,000 particles. The observation of crucial interest, however, is that the particles in these showers have a range of about 15 cm. of lead. This means that the particles are of the penetrating type, that is, heavy electrons. It seems, therefore, that a whole shower of heavy electrons may be created in one act, and the experiments are consistent with the view that the heavy electrons are secondary in origin.

The heavy electrons are penetrating because, owing to their large mass, very little radiation is emitted in nuclear collisions, this emission of radiation being the process which stops high-energy electrons and gives rise to the ordinary 'cascade' showers. However, though the energy lost by the penetrating particles in traversing matter is very much less than that lost by electrons, it is yet appreciably greater than the theoretical energy loss by particles of 200 electron masses. The latter is mainly due to collisions with atomic electrons, with a small contribution from collisions with atomic nuclei. Prof. P. Auger reported measurements carried out in collaboration with P. Ehrenfrest according to which the actual loss is more than three times the theoretical value. The experiments of Blackett and Wilson require a still higher ratio. This discrepancy is of much interest and its further investigation may throw light on the properties of the new particle.

The ultimate fate of the heavy electrons is not yet clear. Comparatively few are observed with energies less than about 2×10^8 volts, suggesting their disappearance or transformation into electrons at this energy (Blackett). However, in this region the velocity of the heavy electron starts to fall appreciably below that of light, and the attendant rapid increase in ionization would in any case reduce the relative number of heavy electrons with energy much below 2×10^8 volts. No definite conclusion regarding this matter can be drawn from existing observations.

The heavy electron is not unwelcome to theoretical physicists. Such a particle was in fact envisaged by Yukawa so long ago as 1935 in order to explain the force between a proton and a neutron. Previous attempts to explain this force on the basis of electron exchange and Fermi's theory of β-decay gave results of a wrong order of magnitude. Yukawa assumed that the role of exchange was taken by a new type of particle and showed that to explain the observed force the new particle would have to be given a mass of about 200 electron masses—in remarkable agreement with the particle now found in cosmic radiation. Thus, in much the same way as the positive electron in cosmic rays bore out the predictions of Dirac's theory of negative energy states, the heavy electron bears out the crucial assumption in Yukawa's theory of nuclear forces. This theoretical aspect of the subject was dealt with by Dr. W. Heitler and Dr. H. J. Bhabha. Dr. Heitler showed how the original theory of Yukawa had to be modified to give the right dependence of the forces between a neutron and a proton on the orientation of their spins, and also showed that the mass attributed to the new particle to explain the forces also corresponds to the departures of the magnetic moments of a neutron and proton from the values required by Dirac's theory for elementary particles. Dr. Bhabha discussed the applications of the theory in the creation and behaviour of the heavy electrons in cosmic rays. In reply to a question, Sir Arthur Eddington stated that while the 'background' particle of his recent theory might be made to play the part in nuclear forces similar to that assumed in Yukawa's theory, he would not expect it to be able to exist in the free state as, for example, a cosmic ray particle.

Matters concerning the effect of the earth's magnetic field were discussed by Prof. J. Clay and Dr. E. G. Dymond. Prof. Clay finds that the line of minimum cosmic ray intensity, though always close to the magnetic equator, shows definite departures from it, and the significance of this was discussed. Another effect reported by Prof. Clay was a decrease in the intensity of the soft component of cosmic rays during a magnetic storm, indicating a disturbing current of about 10^7 amperes at two to four earth radii away. Dr. Dymond gave an account of his experiments made in collaboration with Dr. Carmichael on the variation of cosmic ray intensity with altitude in the region of the north magnetic pole (see also NATURE, **141**, 910; 1938). The agreement of the results with those of Regener in lower latitudes (49°) indicates a lower limit of about 3×10^9 volts to the energy of the cosmic ray particles in this region of the solar system. The suggestion that this cut-off is due to the sun's magnetic field is unacceptable if recent estimates of its magnetic moment are reliable. The cut-off would accordingly refer to the cosmic rays in outer space, and its cause is not yet understood.

Prof. Regener described experiments on the variation with time of the hard component. Periodic variations both with respect to solar and sidereal time are found. The former has an amplitude of 0·25 per cent, with maxima at 10^h and 22^h. The variation with sidereal time has a smaller amplitude with a maximum at about 18^h, and may be attributed to the effect of galactic motion suggested in this connexion by Compton.

While there is obviously much to be cleared up in the field of cosmic rays, the discussion left the impression that the subject is not as much in a state of confusion as it has often been in the past.

E. J. WILLIAMS.

Obituary Notices

Prof. W. Stroud

PROF. WILLIAM STROUD, chairman of the firm of Barr and Stroud, Ltd., died at the age of seventy-nine years on May 27, at Torquay.

At an unusually early age young William Stroud of Bristol entered Balliol College, Oxford. "I was confronted," he wrote, "with the problem whether I should study Latin Hexameters and Greek Iambics or devote myself to what was contemptuously called 'Stinks'." It was a lecture by Prof. Tyndall that determined his choice, and his association with the late Prof. Barr that diverted his physics to industry.

When in July, 1935, the University of Leeds bestowed upon Lord Rutherford and himself the honorary degree of D.Sc., he wrote: "There was Lord Rutherford, the most worthy representative of Pure and Sacred Physics, and here was I, the least worthy representative of Profane Physics," between which and engineering he found it difficult to discriminate, for he was both a physicist and an engineer. How to attain some superlative accuracy from available materials and machines was a question never absent from his mind. For judicious approximation—that characteristic of the skilled engineer—he had a natural gift, but he never acquired the facility in the use of the slide rule of his colleague who, he alleged, in order to multiply two by two, would set these figures on the appropriate scales and, after close scrutiny, declare the product to be 3·96 or 7.

From Balliol, Stroud proceeded to the Universities of Heidelberg and Würtzberg, where, incidentally, he acquired his habit of continuous smoking. Arthur Smithells in the Heidelberger Schloss dared him to smoke a five-pfennig cigar. The results of this unaccustomed experiment were unpleasant. "I determined," he said, "to conquer such squeamishness and eventually achieved such a triumph that up to date I must have smoked over 110,000 cigars—more than half a ton of tobacco—with much satisfaction, and three cigarettes smoked simultaneously in parallel with no satisfaction whatever."

Soon after Stroud's return to England, the Yorkshire College of Leeds in June 1885 lost, by resignation, two of its professors, Sir Edward Thorpe and Sir Arthur Rücker. His friend, Prof. Smithells, was appointed to the vacant chair of chemistry and he, at the early age of twenty-five years, succeeded Sir Arthur Rücker as Cavendish professor of physics. This chair he occupied with great distinction until 1909, when he retired in order to devote his whole attention to the rapidly expanding business he and his partner had established in Glasgow.

During his first session, Stroud thought it necessary to discourse with what he termed "the best Professional dignity he could summon to his assistance". From the results of the terminal examinations he was, however, dismayed to find "that most of the students had learned next to nothing from my lectures". "I resolved," he said, "that the Pontifical Pomposity to which I had been accustomed would be a thing of the past." How well he succeeded in teaching physics effectively with inspiring geniality will always be remembered by his many students, to whom he was affectionately known as 'Billy'.

It was at the Yorkshire College that he met the colleague of his lifetime, the late Archibald Barr, the occupant of the chair of engineering at Leeds and later at Glasgow. Their collaboration in the invention of the rangefinder and many other valuable appliances has already been recorded in the obituary of Prof. Barr (NATURE, **128**, 294; 1931) and is well known. The power of assessing conditions and of rapid readjustment was an outstanding characteristic of Prof. Stroud in all his activities, whether physical, practical or financial, for in all these spheres he was eminently successful. For any problem his penetrating mind would produce not merely one but several solutions and each with its variations. His letters from Leeds abound with coloured sketches of diagrams and mechanisms and such expressions as "Undoubtedly this is the way to do it.—A still better way is this—". "Try turning the mechanism inside out." Gifted with eloquence, he was sparing of unnecessary words. Invariably his letters ended with "Y.v.t., W.S."

By his death, science and industry have lost a very great man.

JAMES WEIR FRENCH.

Dr. C. C. Edgar

WE regret to record the sudden death of Dr. Campbell Cowan Edgar, distinguished as an authority in Egyptian archæology, which took place on May 10 at Berkhamsted.

Dr. Edgar, who was of Scottish extraction, entered Oriel College as a scholar in 1891, and later was attached to the Egyptian Department of Antiquities,