between the Portland Stone and the Cinder Bed, and 'Durlston Beds' for the sequence from the base of the Hastings Beds down to, and including, the Cinder Bed; the former grouped with the Portland Beds, the latter a subordinate and basal division of the Wealden Beds.

Favourable weather enabled the full excursion programme to be carried out: the botanists visited High Rocks and Eridge, the archæologists were conducted to the Rock Shelters and Iron Age camp at High Rocks by J. Money, while the geologists examined beds within the Wealden, in the vicinity of Tunbridge Wells, under the direction of Dr. R. Casey, who dealt especially with the relation between the Wadhurst Clay and the Tunbridge Wells Sandstone.

The excellent arrangements for the Congress were undertaken by the Tunbridge Wells Natural History Society, for whom Mrs. D. Vernede acted as honorary secretary.

F. J. Epps

THE MATHEMATICAL ASSOCIATION

ANNUAL CONFERENCE

THE Mathematical Association's annual conference held at the University of Nottingham in April was outstanding for the high level of interest sustained throughout the sessions. The Association's membership continues to rise steadily and now stands at more than 5,000.

In his report on current affairs. Mr. Combridge spoke of the formation of the Joint Mathematical Council of the United Kingdom which was announced in the Press on April 3. The Council has set up a fact-finding committee to investigate proposals for setting up an Institute of Mathematics.

The Conference on Mathematics in Education and Industry, of which Mr. Combridge is chairman, had held a meeting on March 23 and had adopted the report of its working party. This report was being abbreviated into a pamphlet which he hoped would be circulated to members of the Mathematical Association this summer. The Conference gave its blessing to a scheme put forward by Mr. B. T. Bellis of Highgate School to form a group of schools which would form links with industry which might assist, in particular, with the teaching of mathematics in the later years of school. Mr. Combridge emphasized the need for strengthening the links between schools and industry, and between schools and training colleges and departments of education.

The Universe

In his presidential address, Prof. V. C. A. Ferraro reviewed the advances made in our knowledge of the universe since Galileo first directed his newly made telescope to our nearest neighbours in space. Galileo's discovery of the satellites of Jupiter demolished the last remaining vestiges of the Ptolemaic system. Then followed the rise of descriptive astronomy associated with the remarkable researches of Sir William Herschel, who stressed the need to build large telescopes for a better understanding of the architecture of the universe. He also suggested, with remarkable insight, that the problem of the Milky Way might be resolved by supposing that the stars extended much farther into space along the plane than in the direction of the poles, so as to appear as a great mass of stars along its edge.

The nineteenth century saw the rise of astrophysics and the use of the spectroscope in unravelling the physical conditions of the stars. The classification of stars according to their spectral classes attained its most important form in the so-called Hertzsprung–Russell diagram in which the luminosities of the stars are plotted against the structural classes. The points are found to lie in a narrow belt running diagonally from the brightest stars to the faint red ones, now known as the mean sequence. This diagram has proved invaluable in the study of stellar evolution.

Our knowledge of the structure and size of the universe could only be obtained by the use of large telescopes and principally by the 100-in. telescope at Mount Wilson and the 200-in. telescope at Mount Palomar. They reveal that the Milky Way consists of hundreds of billions of stars arranged in a flattened disk so large that it would take light travelling at 186,000 miles a second 100,000 years to cross the disk. Herschel had long ago suspected that the nebulosities seen in the Milky Way might be systems of stars similar to our own, but lying outside it. His conjecture was amply confirmed by Hubble from his observations at Mount Wilson. Our nearest nebula, Andromeda, is two million light years away from us, while the farthest nebula so far photographed with the 200-in. telescope at Mount Palomar is about two thousand million light years away. Radio telescopes have probed even farther into space to distances of the order five thousand million light years. Within this great expanse there are probably thousands of millions of these galaxies the distribution of which appears to be uniform in space.

Early in 1930 an observation by an electrical engineer, Jansky, marked the beginning of the study of the new science of radio astronomy. He detected some radiation in the decimetre wave-length which he was convinced came from outer space since the signals he received were not observed at the same time on consecutive days but were observed 4 min earlier each day, corresponding to the lapse of a sidereal day instead of a solar day. Jansky's discovery did not occasion much enthusiasm at the time and it was left to an amateur, Reber, to confirm his conclusions. Later still it was recognized that radio signals could be picked up from regions of space farther away from us than would be possible by observations from optical telescopes. Some of the radiation is now known to originate in the interstellar gas, and a brilliant prediction by the Dutch astronomer van der Hulst that this was radiation of 21-cm wave-length emitted by hydrogen clouds in interstellar space was confirmed by his Dutch colleagues. By this discovery it was recognized that our galaxy has a spiral structure very much like that of the great Andromeda nebula.

Prof. Ferraro then referred to the first-fruits of space research and in particular the discovery of the high-energy particles trapped in the Earth's magnetic field and known as the van Allen radiation belt. This consists of two belts, the inner one, at about 2,000 km from the Earth, being quite stable and generally believed to be produced by neutron decay, while the outer belt, extending from three to five Earth radii or more from the Earth, consists for the most part of high-energy electrons. This is rather variable, especially during magnetic storms.

Recent flights by space probes have also shown the absence of a magnetic field on the Moon and Venus and the high temperature on this planet. In the foreseeable future it seems unlikely, however, that space probes could travel much beyond the confines of the Solar System and that, so far as could be seen, space exploration by probes and satellites was a limited venture. Further knowledge of the vast universe around us must still be derived from observation by conventional optical and radio telescopes.

Prof. Ferraro then briefly referred to cosmological theories which had been proposed and noted that there were, at the present day, two rival theories in the field, the evolutionary theory and the steady-state theory.

In the evolutionary theory the universe evolved from a single act of creation in which the whole of the universe was contained in a primeval atom. Because this high concentration of matter was highly unstable the atom exploded with great violence. After a certain period the matter settled down sufficiently for gravitational force to introduce some degree of stability. Thereafter the galaxies became subject to a repulsion represented by the cosmical constant, so that the galaxies began to recede from one another with speeds proportional to their distance apart in accordance with the observed Doppler shift. In the steady-state theory, although galaxies recede beyond the observable horizons, other galaxies will be formed to take their place so that the universe always presents the same aspect. To maintain this steady-state, the advocates of the steady-state theory have had to invoke that matter, in the form of protons, is continually being created at the rate of about one proton per cubic mile of space per year.

Attempts to discriminate between the two theories by observation of numbers of radio sources in space have so far not proved very conclusive. Prof. Ferraro pointed out that in spite of its many attractive features the steady-state theory, in the form proposed by Bondi and Gold, violates the principles of energy and momentum. There is so far no reason to doubt that these principles are valid universally, and to obviate this feature of the theory Hoyle has proposed a variant in which an as yet undiscovered field of force is invoked. Hoyle's theory has the merit of retaining these conservation principles.

Mathematics in Technical Education

A discussion on mathematics in technical education was opened by Mr. D. G. Tooso, who outlined the structure of technical education. The mathematics courses aim at showing the students the theoretical structure of their technology and include basic courses in mathematics.

In the past few years there has been a demand for mathematicians as technologists in their own right. They need to be competent mathematicians with an ability to convert a physical situation into a mathematical statement. At present the training of an industrial mathematician may be by a course at a university or at a college of advanced technology. Higher National Certificate and Diploma schemes exist, but at present there is no mathematical institute to award a professional qualification comparable with those available to engineers.

Dr. Kerr spoke of the Diploma in Technology in mathematics. The colleges take great care in placing students in industry for the industrial part of their training whose success depends on co-operation between the college and the firm concerned. The problems set in college have to be somewhat artificial so that they can be solved in two or three hours, but from the beginning of their time in industry the students see how problems really occur; this gives them considerable motivation for the academic work on return to college.

The academic courses have honours degree standing. A general course is followed by specialization later. Numerical analysis, statistics and computing are usually introduced early in the courses. Geometry and modern algebra tend, as a result, to get less time than is usual in university mathematics courses. Dr. Kerr was able to report the average attainment at entry as rising.

Continuing the discussion on mathematics in technical education, Mr. M. Bridger pointed out that there are full-time degree courses available at a large number of colleges of technology. Young people are becoming increasingly aware of the opportunities for programmers, numerical analysts and systems analysts. Some dozen colleges have installed computers and some half-dozen are completing their installations in the near future. An adequate number of mathematicians with industrial experience have taken up teaching posts so that a reasonable number of colleges of technology are in a position to offer courses in industrial mathematics. The trend in these and other courses is away from part-time study.

New Developments in the Teaching of Mathematics

Opening a discussion on new developments in the teaching of mathematics, Mr. A. P. Rollett referred to work being done by schoolmasters in different parts of Britain and went on to speak of the work of the School Mathematics Project of which Prof. B. Thwaites is director. It is clear that he has been influenced a little by activities in the United States. There is no objection to this, provided it is clearly realized that conditions are vastly different and that the real difficulty in the United States is a shortage of suitably qualified teachers. In Britain there are still enough of sufficient calibre to be able to discuss with university teachers what topics are desirable and feasible in the schools. With regard to the reforms advocated by recent publications by the Organization for European Co-operation and Development, Mr. Rollett quoted Prof. R. L. Goodstein's review in the February 1962 issue of *The Mathematical Gazette*, and he went on to contrast the classroom atmosphere in the United States, France and England. In Britain traditions exist, and the immediate need is more recording and publication of teachers' impressions and pupils' reactions to new work done in the schools of Britain.

Dr. A. G. Howson, of the University of Southampton, explained that the School Mathematics Project has concentrated on one of a number of present-day problems : How can new mathematical topics be introduced into the syllabuses and syllabuses be designed that are more relevant to present conditions? It is hoped to encourage more pupils to pursue the study of mathematics further and it is also hoped to bridge the gulf which at the moment separates university from school mathematics. One of the major changes made by the School Mathematics Project has been in the increase in the algebraic content of the school course. The aim has been to convey something of the nature of the concepts involved rather than to impart a definite body of knowledge. Euclidean space is studied by means of geometrical transformations and the teaching of geometry by rote is discouraged. Another important part of the syllabus is the introduction to probability and statistics in which it is hoped to show how data can be collected and displayed, and what conclusions can be logically drawn from them. Throughout, the emphasis has been shifted towards mathematical ideas and away from the acquisition of techniques.

Mr. C. Hope told the conference of the origins of the Midland Mathematics Experiment. He outlined some of the aims of the syllabus : the pupils must be able to solve problems which have arisen in the past; the problems must arise out of the experience of the children ; and any topics which are included should have the widest possible applications in science, mathematics, industry, commerce, etc.

The syllabus of the Midland Mathematics Experiment includes the algebras of sets and vectors, vector geometry and matrices, calculus, stage *A* probability, and arithmetic applied to real living and the solution of problems. Mr. Hope spoke of the advantage it would be both to examining bodies and to schools if there could be formed a joint sub-committee which would examine proposed syllabuses so that experiment should not be hindered by the fact that neighbouring schools are often examined by different boards. He suggested that a series of courses should be held at regional centres to consider what can be done with ordinary children, and to stimulate teachers to experiment in their own schools.

Among the other lectures, Mr. G. A. V. Leaf gave an absorbing and refreshing account of some of the practical problems of the hosiery industry, Prof. H. Bondi gave an absorbing lecture in which he introduced special relativity from an unusual point of view, and Prof. D. B. Scott gave a vivid introduction to some of the ideas of topology.

Elections

At the annual general meeting, the election of Mr. J. B. Morgan as president for 1963 was announced. Mr. R. E. Green was elected honorary treasurer and the honorary secretaries, Mr. F. W. Kollaway and Miss R. K. Tobias, were re-elected. Dr. E. A. Maxwell was elected as editor in place of Prof. R. L. Goodstein, who remains honorary librarian. Mr. B. J. F. Dorrington and Dr. E. Kerr were re-elected, and Mr. J. K. Backhouse, Miss E. M. Holman and Mr. C. Steele elected as honorary assistant secretaries. This represents an increase of two assistant secretaries, which reflects the growing amount of work being undertaken by the Association; the annual subscription was raised to 30*s.* in order to finance the Association's commitments. Mr. N. De Q. Dodds was re-elected as honorary assistant treasurer. J. K. BACKHOUSE

THE DANISH ATOMIC ENERGY COMMISSION

THE annual report of the activities of the Danish Atomic Energy Commission for the period April 1, 1961–March 31, 1962*, consists of six chapters dealing respectively with the construction at the Risø Research Establishment; the recent work of the Establishment; international co-operation in the peaceful use of nuclear energy; geological surveys in Greenland and other activities; the technical and administrative organization of the Commission; and the financial accounts of the Commission. The text of Act 170 of May 16, 1962, on nuclear installations (atomic plants), the list of publications and of papers written by members of the staff during the year under review, and a map of the Risø Research Establishment, form annexes to the report.

Eight meetings were held by the Commission, and thirty-six by the Executive Committee during the year. There was no alteration in the membership of the Commission and all members were re-appointed for the period of three years commencing February 1, 1962, with the exception of Profs. J. Bøggild and H. H. Jensen, whose terms of office did not expire until February 1, 1963. The late Prof. Niels Bohr was chairman and Dr. H. P. Christenson vice-chairman of the Commission, with Mr. H. H. Koch, permanent under-secretary of State, chairman of the executive committee. The staff on March 31, 1962, numbered 723, of which 495 were employed in the technical and scientific divisions. The workshop staff consisted of 41 people, including seven apprentices, under the direction of a superintendent, and the library staff of 14 people, headed by the librarian.

The Commission's research activities, which were considerably extended during 1959–60 when the large reactor *DR*3 was completed, have continued to develop and have led in particular to the accomplishment of several joint research projects in co-operation with atomic energy establishments in various countries and with European joint enterprises. Irradiation experiments for the *Dragon* project have been carried out on certain steel samples in the research reactor *DR*2, and work has continued on graphite and uranium irradiation experiments in co-operation with the United Kingdom Atomic Energy Authority.

In the physics department of the Establishment, which houses the meteorological station, the reactor *DR*1, and the linear accelerator, a number of practical courses were held for students from the Technical University of Denmark, for students from the Universities of Århus and Copenhagen, for engineers employed in industry and for operators attached to the reactor *DR*2. The linear accelerator was used for experimental irradiation for both industry and the department. In addition, the sterilization by irradiation of medical equipment, including blood transfusion sets, female catheters, artificial lungs and disposable hypodermic syringes, was undertaken for individual firms. The meteorological station continued its investigation of the meteorological conditions in the lower layers of the atmosphere and the data collected were processed statistically. The neutron crystal spectrometer attached to the reactor *DR*2 was used to measure the total cross-section of organic coolants. A start has been made on the construction of a triple-axis crystal spectrometer for solid-state physical examinations. A low-temperature laboratory is being built and measurements made on superconductive materials. Other work in solid-state physics includes the study of the transport properties of pure metals.

The electronics department was largely concerned with the development and assembly of instruments, but in addition a study was made of tunnel diodes and their use in nuclear instruments, especially discriminators. During the summers of 1961 and 1962 the airborne scintillometer developed by the electronics department was tried out with promising results by the Greenland Geological Survey. The reactor engineering department was occupied with the helium heat transmission experiments *HTTC* for the *Dragon* project, and the organic heat loop was completed. Activities in connexion with the deuterium moderated, organic cooled, reactor (*DOR*) project, included the construction of fuel elements, the hot-cell facility and apparatus for experiments with some of the components for the primary cooling circuit. The reactor physics section, which consists of a theoretical reactor physics group, an experimental reactor physics group and a computer group, concentrated its attention on calculations and measurements in relation to the *DOR* project. A major effort was made to prepare computer codes for use in *DOR* calculations, and, during the year under review, codes were prepared for the calculation of the thermal utilization factor, resonance escape probability, fast-fission factor, and Fermi age. The main tool of the computer group is to be the digital computer *GIER*, which was produced by the Danish Institute of Computing Machinery and which was installed at the Risø Establishment during February 1962. The fast memory of *GIER* contains 1,024 words, each of 42 binary digits, and its magnetic drum memory contains 12,000 words. The addition time is 50 μsec.

The results of the attempt by the chemistry department to obtain, by examination on a laboratory scale, suitable processes for a continuous extraction method for the utilization of the uranium and thorium deposits in Greenland were encouraging. In addition, calculations of the investment and operation costs of an extraction plant showed that the economic use of the deposits in the future is a possibility, and some 200 tons of ore were therefore mined and brought to Risø during 1962 for further experimentation. The radiolysis and pyrolysis of terphenyls, of importance in connexion with the *DOR* project, were studied and the decay schemes for arsenic-78, metastable indium-116 and lanthanum-140 were investigated. The radiochemistry of proteins, the possibility of separation of uranium isotopes in a Ranque–Hilsch vortex tube, and the use of electron spin resonance are some of the other activities of the department mentioned in the report.

During the period under review, more than 6,000 people visited Risø and were shown around the Establishment on conducted tours. The scientific staff of the Commission have co-operated in the teaching at institutes of higher education and several physics courses have been held for primary school teachers and technical college teachers.

* Report on the Activities of the Danish Atomic Energy Commission for the Period from 1 April, 1961, to 31 March, 1962. Pp. 84. (Copenhagen: Danish Atomic Energy Commission, 1962.)