of world availability and use of fertilizer materials were given by H. A. Curtis, who drew on the valuable experience of the Tennessee Valley Authority on the production and use of phosphatic and other fertilizers, and by R. E. R. Grimmett (New Zealand) and J. N. Ray (India).

Conservation in mining and milling was considered under several sub-heads. R. B. Beilby (Great Britain), Sven Dalhammar (Sweden), Paul Audibert (France) and R. Arce (Bolivia) submitted papers on metallic mine mechanization to increase recovery; L. Blum-Picard and J. A. Barr, and others, on the mechanization of non-metallic mines; and papers from Canada, Great Britain, the United States and Austria were read on new processes for the utilization of low-grade ores.

Conservation in manufacture was a topic which covered such subjects as conservation of iron and steel in production, treatment of waste gas, conservation of non-ferrous metals, and design as a factor in conservation. Conservation by corrosion control was discussed in a wide range of papers.

Under conservation by substitution, papers on the future of light metals were presented by H. Sutton, O. C. Ralston and Jean Matter, in which much interesting new information was given on the properties, uses, manufacture and possible commercial production of titanium. This metal, in the mineral ilmenite, occurs in very large quantities, and it would find extensive application if its price could be reduced to within the range of those of commercial metals. Great interest has recently been aroused in this metal because it is now obtainable in a ductile state, and because iron can now be produced from titano-magnetite (ilmenite), leaving slag very high in recoverable titanium. Ralston suggested that if low-cost electric power for production of magnesium is restricted in supply, it would be better to use the magnesium to produce a like weight of titanium which would be twice as useful for structural purposes and would, if substituted for light alloys, conserve the use of copper and zinc.

P. L. Teed described the production of magnesia and magnesium from sea water. In Great Britain, magnesia, for the manufacture of high-grade refractories, has been obtained from sea water, on a commercial scale, since 1937. During the War, such magnesia was used as a source of magnesium in place of imported calcined magnesite. R. Bloch described the use of solar energy in evaporation from the Dead Sea water in the production of potash.

The recovery of metals from scrap was discussed by H. J. Miller and C. W. Merrill. The latter gave estimates of the quantities of minerals-in-use, and showed that the quantity of metal-in-use is a rough measure of a community's potential capacity for industrialization and its standard of living.

In the course of the afternoon plenary meetings, D. N. Wadia and D. H. McLaughlin read papers on metals in relation to living standards. The latter considered that the correlation between metallic production and living standards is low, and that between consumption and living standards only moderately higher; these standards depend upon productivity, a function of integrated regional economics. Wadia considered that in under-developed countries mineral resources affect standards of living in that they can be exchanged for fabricated metals and other needed products from industrially developed countries. F. Blondel presented a paper on mineral research, in which he made a strong plea for a more intensive prospecting of the under-developed countries by modern methods, and the provision of adequate funds for this where necessary.

Part of the work of the Fuels and Energy Section was closely related to that of the Minerals Section. For example, it included consideration of new techniques for increasing coal production, with particular reference to mechanization and strip mining. One session was devoted to the underground gasification of coal, on which large-scale experiments, with continuous operation for many months, are now in progress in the United States, Belgium and Morocco. Another session considered techniques of oil and gas discovery and production; one paper, for example, by M. H. Parks, dealt with petroleum production from continental shelves (to depths of 60 ft.). The techniques and results of aeromagnetic surveying were described by J. R. Balsley, who considered that the airborne magnetometer provides a low-cost and reasonably accurate magnetic map which can be used to delineate localities for more expensive and detailed ground work, both geological and geophysical, but it does not eliminate the need for ground surveys. Other papers described the production of oil from shale in the United States, in Sweden, and in Brazil, while the papers presented at the plenary meetings included a review of critical shortages in world resources of fuel and energy, by J. C. Parker; and one on estimates of undiscovered oil and gas reserves, by A. I. Levorsen.

The work of the Minerals Section was reviewed by G. C. Monture, Department of Mines and Resources, Ottawa, Canada, at the final session of the Conference. He said that the consumption of minerals is increasing and will continue to increase with improving standards of living, but that, given the essential basis of peace, no immediate shortage of minerals is apparent. There are as yet, however, no reliable estimates of the mineral resources of the world, because any such estimates must vary with changes in costs, with technical advances in mining and metallurgy, and with national policies on taxation. Political and economic stability and national policies are the determining factors in the exploitation and development of mineral deposits. It is none the less important that the appraisal of mineral resources of each country should be seriously attempted, and the basis for this is a well-organised and well-staffed geological survey. We will not begin to know the mineral resources of the world until national barriers are broken down; but if problems are approached in a spirit of international co-operation, the results achieved to date in the mineral field can be increased many times.

F. DIXEY

RADIO ASTRONOMY

DURING recent years important advances in astronomical knowledge have accrued from the application of radio methods of observation. The striking progress in this field has followed largely from the improvements in radio and radar techniques developed during the War. At the British Association meeting at Newcastle upon Tyne, three British research organisations which have played a major part in radio-astronomical research were represented in the contribution of papers before Section A outlining some aspects of recent progress.

In the first paper, J. S. Hey described investigations at the Army Operational Research Group on radio emissions from sunspots and solar flares. Intense radio noise emanating directly from the sun was first identified in 1942, when it caused severe interference with Army radar equipments operating at wave-lengths of a few metres. Since the War, more detailed observations of the phenomenon have been made. The radio noise from a sunspot is mostly radiated in a directional beam with its axis approximately normal to the spot. This is indicated by the marked peak of the mean daily intensity which occurs during a few days roughly centred about the passage of the spot across the central meridian of the visible hemisphere of the sun. The intensity often fluctuates rapidly, but in some cases appears fairly steady. Only a proportion of sunspots produce appreciable emissions, the larger spots being the more likely to produce high intensities.

The radio noise associated with solar flares consists of sudden bursts of emission occurring almost simultaneously with the flares, which are normally observed visually as sudden increases of intensity of the $H\alpha$-line from regions in the vicinity of sunspots. Only a proportion of the flares have associated radio bursts, the bigger flares being the more likely to produce strong radio emissions. The radio bursts do not appear to be sharply beamed like the radiation from sunspots, for the chances of a radio burst when there is a flare are fairly evenly distributed with respect to the flare location on the disk of the sun. However, the recordings at a wave-length of 4 m. so far obtained suggest a greater chance of a burst when there is a flare on the eastern, or approaching half of the visible hemisphere of the sun, as compared with the western, or receding half.

Although visual flares grow rapidly, they do not compare in abruptness with radio bursts, which often rise in intensity by more than a hundred times in less than a minute. Time differences of some minutes often occur between the phenomena. Detailed study of the relationships between visual flares and radio bursts is hampered by the incompleteness of visual data, partly owing to the restriction on visibility due to cloud and fog, and partly to insufficient continuity and detail of most visual observations. Valuable secondary data of solar flares are provided, however, by certain geophysical effects, namely, those arising from enhancements of ionospheric D-layer ionization due to ultra-violet radiation from solar flares. These increases of ionization may be observed by their influence on the absorption or reflexion of radio waves at appropriate wave-lengths. Absorption causes weakening or fade-outs of long-distance radio-communication on wave-lengths around 20 m. and of radio noise from the Milky Way on wave-lengths around 10 m. (which are just short enough to penetrate the ionosphere). Reflexion effects which may be observed at very long wave-lengths of the order of 10 km. are the enhancements of received atmospherics or phase shifts in continuous-wave reflexions. When a solar flare is of very high intensity, the elements of the terrestrial magnetic field may undergo a characteristic deviation known as a magnetic crochet. A statistical study is being made of the relationships between radio bursts and the various indications of solar flare activity.

Measurements are also being made of the spectrum of the radio emission. The radio spectrometer consists of a panoramic receiver tuning rapidly over a range of wave-lengths. This necessitates simple tuning while maintaining high sensitivity. A suitable receiver, with the tuning sweeping from 3 to 6 m. wave-length in $\frac{1}{2}$ sec., has recently been constructed and put into operation at the Army Operational Research Group. A conical dipole aerial is used to obtain sufficiently uniform response over the range of wave-lengths.

The second paper was given by F. G. Smith, who described recent investigations at the Cavendish Laboratory, Cambridge, on radio noise from the galaxy. He began by comparing characteristics of visual and radio astronomy. These two branches of astronomy utilize respectively two wave-length bands of electromagnetic radiation which can penetrate the earth's atmosphere, namely, the visual and near-visual range covering about four octaves, and the radio range from about 1 cm. to 20 m. covering ten octaves. But whereas visually opaque gaseous regions may allow radio waves to pass through them, a visually transparent ionized gas may be opaque to radio waves. The sun's corona consists of highly ionized gas at a temperature of about a million degrees, and this is the region which a 'radio telescope' would observe.

A fundamental problem concerning galactic radiation is to determine whether it originates from stars or from diffuse ionized gas in interstellar space. To locate sources of the size of stars requires high resolving power. A resolving power of 1 minute of arc at a wave-length of 4 m. would need an aerial system with an effective aperture of about two miles square. This practical difficulty has been overcome by means of an interference technique. Two aerial systems, each having a broad sensitivity pattern in a north–south plane and a narrow beam (about $\pm 3°$) in the east–west plane, are spaced 120 wave-lengths apart in the east–west direction. The two aerials are connected together, thus dividing the beam in the east–west plane into a series of narrow interference lobes. As the earth rotates, a point source in passing alternately through the maxima and minima of the lobe system would produce a periodic signal at the receiver. The time of passing the central maximum gives the Right Ascension (α) of the source, and the Declination (δ) is found from the periodicity, which is proportional to sec δ. By this method two major sources, of angular diameter less than 5′, have been distinguished in Cygnus and Cassiopeia, and their positions have been determined to an accuracy of about 5 . In addition, twenty-three minor sources have been detected.

None of the sources can be identified with bright visual stars. It is suggested, however, that a star with a dim visual surface may have an atmosphere containing very high-energy electrons possibly accelerated by some electromagnetic process. To deduce the particle energy which could produce the radiation, it is necessary to know the distance and diameter of the sources. The parallax has been shown experimentally to be less than 1 , thus indicating that the distance is greater than one-fiftieth that of the nearest known star As the general distribution of galactic radiation is roughly the same as that of visual stars, the distance may be taken as of the same order as that of the nearest visual stars. The fluctuations which occur in the Cygnus source can be as short as ten seconds, and, if due to variations of emission over the sources, this indicates a diameter less than ten light-seconds, which is the order of size of an average visual star. With these assumptions,

the effective temperature to produce the observed radio emission is about 10^{14} degrees. Unless some special mechanism is responsible for maintaining coherent oscillations in stellar atmospheres, the radiation must be due to electrons in random motion with energy at least 10^{10} electron-volts. In this case, the energies are sufficiently great to suggest that the origin of cosmic rays may be the same as that of the radio waves.

In the third paper of the series, A. C. B. Lovell described recent research in meteor astronomy at the University of Manchester by means of radio reflexion or radar methods. Meteors consist mostly of minute pieces of debris, far too small to be observable by direct radio reflexions. The speed of the meteors is so great that as they rush into the atmosphere of the earth they burn away at heights of about sixty miles. Until recently, the streaks of light produced by the burning meteors provided the only method by which astronomers could study this phenomenon. Such observations are hindered or prevented by cloud and moonlight, and are impossible in daylight. On the other hand, the burning meteor leaves behind it a dense trail of electrons which can reflect radio waves. The development of radio techniques has removed the major visual limitations and now enables meteoric activity to be surveyed by day and night in any weather conditions.

An important consequence of the radio observations has been the discovery of great meteoric activity in summer day-time. The well-known visual meteor showers which occur on about a dozen occasions a year usually last for a few nights. The summer day-time showers detected by the radio method are far more extensive and attain higher rates. The daylight activity, which in May comes from the direction of Pisces, develops rapidly, extending over a wide belt stretching towards the sun, and continues as a great succession of meteor showers until late August.

The origin of the streams of meteoric debris is a most important problem of meteor astronomy. It is almost certain that most of them move in orbits around the sun. A few are associated with comets; but it is unlikely that this is the case with all of them. There is difference of opinion as to whether the meteoric debris is all localized in the solar system or whether some comes from interstellar space. The radio observations now being made will help to answer these questions. The accurate determination of speeds will resolve the problem as to whether any meteors originate from outside the solar system. The high speeds involved—around 100,000 miles per hour—make measurement difficult. The method being used at the University of Manchester is to derive the speed from the fluctuations of amplitude of the radio echo as the meteor trail passes through the region where the perpendicular from the observing equipment meets the trail. A consideration of the Fresnel zones contributing to the reflexion shows that rapid fluctuations occur in this region and the periodicity depends on the speed.

The radio echoes from meteor trails after their formation show many complicated variations. A detailed study is being made of the complex behaviour of the trails, which depends on the atmospheric conditions in the region of formation. Thus, apart from the astronomical value of the radio methods of meteor observation, information of importance in the study of the physics of the upper atmosphere is being obtained.

J. S. HEY

OBITUARIES

Sir Edwin Pascoe

WITH the recent death of Sir Edwin Hall Pascoe, Indian geology has suffered another severe loss, a loss that, as will be seen later, is particularly untimely. Pascoe, who died in London on July 7, was the son of Edwin Pascoe and Mary A. Hall, and was born on February 17, 1878. He was educated at St. John's College, Cambridge, of which he was a Foundation scholar.

After a short period of scholastic work in England, Pascoe joined the Geological Survey of India in 1905, becoming director in 1921. He retired from the service in 1932.

Soon after arriving in India, Pascoe was detailed as one of the party to assist the late Mr. C. S. Middlemiss in the investigation of the Great Kangra earthquake of April 4, 1905, thus receiving a quick introduction to a form of geological investigation that falls too often to the lot of the officers of the Geological Survey of India. In the autumn of the same year, Pascoe was sent to Burma to commence a systematic study of the areas in which European companies were developing oil concessions, and to assist the Government of Burma in problems arising from this development, especially in its effects upon the economic conditions of the hereditary oil-diggers or *twinzas*. This first season's field-work really determined Pascoe's life interest and his career, as so often happens, showing how important it is for the director of a geological survey department to allot the right work to a man as early as possible in his career.

As a result of his first season's work on oil, Pascoe was entrusted with a survey of the oil resources of the whole Indian Empire, and after three field seasons in Burma (1905–9) he surveyed in turn the oil resources of Assam (1910–12), and of the Punjab and the North-West Frontier Province (1912 and 1914–15). In 1913 he was sent to the Persian Gulf, the Arabian Coast and West Persia. With this widespread experience, Pascoe became a recognized authority on the geology of petroleum, and this led to his being appointed to accompany the Slade Oilfields Commission in the Persian Gulf in 1913–14.

Immediately before Pascoe was appointed director of the Geological Survey of India, the sanctioned gazetted strength of the department had been raised from twenty to thirty as a result of the efforts of Sir Henry Hayden. Pascoe, in fact, took over a department with twelve vacancies; these were filled gradually, and the department did not reach its full strength until 1928. This increased strength enabled Pascoe to increase the number of field circles from three to six, and to allot a much increased number of men to Burma. The survey of the coalfields of India had been one of the primary tasks of the Geological Survey of India in its early days, when the topographical maps were very inferior as compared with the results of modern surveys in India. The commercial development of many of these fields had rendered urgent their re-survey geologically on modern maps, where these existed, both in order to help the mining industry, and also because it had become necessary to estimate what proportion of India's coal reserves could be regarded as of superior quality, since Government policy with reference to the mining industry depended fundamentally upon