financial aspects of the energy problem ; thus in energy prices, the impact of such prices on the balance of payments, and the investment needs of the energy industries in the period under review, are considered. In this context, there is recommended the mutual supply of capital needed for the production of energy as well as the pooling of research and development programmes. Again, it is considered to be of mutual benefit for member countries to increase their co-operation in the fields of exchange of energy, of man-power for the production of energy and of information and experience.

In the final chapter of the main report, it is pointed out that only a cursory examination of the many important general problems envisaged was practicable. More detailed examination was therefore necessary, and it proposes the setting up of a new committee of individuals selected for their experience in this field, to act as advisers to the Organization. Not only should this new committee examine the conclusions of the present report and follow their implementation, but also it should review periodically both energy statistics covering the pertinent factors, and, with the help of the economic and other technical committees, the forecasts of energy requirements and supplies. The terms of reference should also include the search for problems which need further investigation.

Extensive appendixes are attached to the report. They indicate the sources of the information obtained, which covered an authoritative field concerned with trade union and managerial responsibility. The forecasts on which the main conclusions have been based were derived by four independent methods. Assumptions were made as to the anticipated level of employment, the standard of productivity, the level of working hours and, most important of all, that no abnormal events would intervene, such as a war.

Most valuable to the general interested reader are the reviews of the energy situations in the individual countries concerned, some twelve in number. They give the individual statistics for the various sources of energy as to production, the reserves and future prospects, the most important of the pertinent factors as to imports and exports of energy, and the developments in the nuclear field.

Of the primary sources of energy in the period 1956–75 in Western Europe, the annual production of coal may increase, according to present plans, from 480 million tons, as at 1955, to 520 million tons ; but some further capacity must be provided to replace exhausted pits, to the extent of 190 million tons per annum. These additions will call for investments in the neighbourhood of £3,000 million, exclusive of coke ovens, pithead power stations and briquetting plant. Lignite, mostly in Germany, will require £570 million. Water developments to result in an increase of about 150 per cent capacity in 1975, as compared with 1955, may cost some £7,600 million. Indigenous sources of oil and natural gas are less tangible factors to assess, but are expected to require a sum equivalent to that of coal, namely, £3,000 million.

For the provision of secondary energy, coke and coal gas will require a sum slightly in advance of this last figure, and for thermal electricity the overall investments may amount to the considerable figure of £17,700 million. This is exclusive of the provision for transmission and distribution of electrical energy. The total investment to cover all requirements in the period 1955–75 could reach the astronomical figure of £50,000 million, or an annual average of £2,500 million. The investment provided in 1955 was £1,580 million. Thus an increase by some 60 per cent of outlay is included in the present plans for development.

The report is illustrated by a number of graphs, relating to the position and the prospects in the United Kingdom, France, Switzerland and Sweden, which emphasize clearly the importance of coal to Great Britain.

R. J. Sarjant

THE MEASUREMENT OF BODY RADIOACTIVITY

CONFERENCE AT LEEDS

THE problem of measuring the radioactivity of the human body is exciting interest in many countries. A conference, the first of its kind devoted to this problem, was held during April 16 and 17, in the Department of Medical Physics of the University of Leeds. Delegates attended from Denmark, Sweden, Germany, the United States, Canada, Australia and Great Britain, and they included representatives from almost all the groups known to be engaged in this field.

In a short introduction, Prof. F. W. Spiers outlined the aims of the conference. Of first importance was the bringing together of as many as possible of those actively working on the problem of body radioactivity and others interested directly in it. It was intended to consider particularly the external methods of measuring body γ-ray emission and their possible limits of sensitivity. High-pressure ion-chamber techniques are already adequate, he said, to measure amounts of γ-emitters in the body of the order of 2 ng. radium equivalent (1 ng. = 10^{-9} gm.,) that is, well below the recommended maximum permissible levels[1]. An improvement in γ-sensitivity of ten times appears to be feasible with scintillation techniques, but perhaps the special importance of the latter is in their possible application to measuring very low levels of β-emitters in the body. The conference would also include consideration of techniques other than external detection giving data on body radioactivity.

Papers were read by representatives of each of the three groups who have used high-pressure ion-chamber methods. Dr. B. Hultqvist (Institute of Radiophysics, Stockholm) discussed results obtained at Stockholm using two arrays each of twelve high-pressure chambers in a laboratory which, being at 55 metres depth below solid rock, is well shielded from cosmic rays. To exclude local radiation, walls, floor and ceiling are lined with tanks containing Thames water (since this has a considerably lower radioactivity than Stockholm water) and the radon content of the air is reduced by forced ventilation. With these precautions to reduce the background, the maximum uncertainty of a single measurement on a human being, taking 3–4 hr., is $\pm$ 1 ng. radium equivalent. Published results[2] include investigations of 306 normal individuals divided into three age groups, and it appears that differences are due to potassium content rather than radium, and that for uncontaminated persons the radium content is well below 1 ng. Differences in the radium content of drinking water supplies are insufficient to account for all the differences in radium content. Dr. Hultqvist also described a survey of the radon and thoron content of air in Swedish homes of various building materials[3], and showed that the accumulated radioactivity is greater in the lungs than in any other part of the body, a factor to be borne in mind in whole-body measurements.

Mr. J. Rundo (Atomic Energy Research Establishment, Harwell, formerly at the Finsen Laboratory, Copenhagen) next described the apparatus at Copenhagen[4] which was designed at Harwell following the pattern of that at Leeds. It uses four measuring cylinders together with four 'backing-off' chambers and a vibrating-reed electrometer feeding into an automatic recorder with an averaging device. Its chief application has been in the study of thorium burdens, a complex problem involving such unknown quantities as the fraction of each daughter product that might be present and, in many cases, the duration of the burden. By calibrating the apparatus with bottled samples of thorium dioxide at different known fractions of radioactive equilibrium and also by means of a model in which the thorium is realistically distributed, it is possible to make reasonable interpretations of the body measurements. Some use of the apparatus has also been made in bremsstrahlung measurements on phosphorus-32 administered to patients.

Experience with the Leeds apparatus was described by Dr. P. R. J. Burch (Department of Medical Physics, University of Leeds). Dr. Burch spoke of the basic considerations concerning the sensitivity and calibration of a body γ-ray monitor. In the case of high-pressure integrating ion-chambers, the cosmic-ray component of the background contributes most of the statistical error. A chamber design was described which should enable errors to be reduced by a factor of from two to three by ensuring that most penetrating cosmic-ray particles would produce roughly equal amounts of ionization both in the register and the backing-off chambers. The principle is being incorporated in an apparatus for recording the γ-ray intensities from the atmosphere and ground, together with the cosmic-ray intensity. Application of the idea to a body γ-ray monitor should enable the normal body γ-ray emission to be measured with a probable error of $\pm$ 5–10 per cent in an observation period of 2 hr. By using different wall materials, different gases and different gas pressures in chambers above and below the body, a considerable measure of discrimination of radiation quality would be possible. However, for clinical studies an apparatus is needed capable of giving a standard error of about 2 per cent in a short ($\frac{1}{4}$-hr.) measurement, and the apparatus under construction designed to achieve this was described. Five tank units containing a liquid scintillator and each viewed by two photomultipliers will be mounted around a chair on which the patient reclines. The components of this apparatus, the steel-shielded room in which it is to be used and also the original high-pressure ion-chamber apparatus[5] were available for inspection.

In the discussion following the three papers on high-pressure chamber techniques, mention was made of the importance of avoiding errors due to contamination from clothing and from radon or thoron in patients' breath, and even due to the potassium-40 content of reading material used by the patient during measurement.

The first afternoon session (with Dr. K. Z. Morgan, of the Oak Ridge National Laboratory, United States, in the chair) was devoted to scintillation techniques. Dr. E. C. Anderson (University of California, Los Alamos Scientific Laboratory) described work with the Los Alamos scintillator[6]. He pointed out that the principal advantage of the large liquid scintillator lies in its high sensitivity, permitting the use of short observation times. This greatly increases the scope and capacity of the apparatus. Moreover, with liquid scintillators, almost the entire solid angle around the patient may be filled, as compared with the 10^{-2} or 10^{-3} convenient with sodium iodide crystals. Since sensitivity is dependent on the ratio (sample)^2/background, the advantage of high counting-rates is obvious. The present Los Alamos apparatus has a cylindrical space 18 in. in diameter in which the patient lies. The surrounding 500 litres of liquid scintillator is viewed by an array of 108 photomultiplier tubes, each 2 in. in diameter. The whole is screened by 5 in. of lead, with 2 in. of lead at the patient's head. An exposure of 2 min. is adequate to estimate the normal potassium content of the body with a standard error of $\pm$ 10–20 per cent. Statistical stability of the background is better than 1 per cent, which corresponds to 5 per cent in the normal body measurements. Measurements of body activity against age and sex give essential agreement with those described earlier by Dr. Hultqvist. An improved correlation has been found if the potassium-40 activity of each patient is plotted not against gross, but against lean, body-weight. The latter is found by a tritium determination of body-water, which is assumed to be 70 per cent of lean body-weight.

It was a disappointment that Mr. Marinelli's group (Argonne National Laboratory), which has made such notable contributions to the subject, could not be represented. Dr. Anderson was able to include in his paper a description of the work being carried out at Argonne with a single large sodium iodide crystal in conjunction with a room lined with 8-in. steel. The extreme sensitivity of the apparatus was indicated by its detection of what may be traces of cæsium-137 from radioactive fallout, the emission of 0·66 MeV. radiation from tested humans corresponding to a level of 0·005 μc. of cæsium-137 if this interpretation is confirmed.

A joint paper on scintillation techniques by Dr. Denis Taylor and Mr. R. B. Owen (Atomic Energy Research Establishment, Harwell) was read by Mr. Owen after a brief reference by Dr. Taylor to preliminary scintillation work done in connexion with the Copenhagen project. It described an apparatus utilizing four sodium iodide crystals ($1\frac{3}{4}$ in. in diameter, 2 in. thick) giving a standard error for normal body radioactivity of 10 per cent for a 10-min. observation. In its application to phosphorus-32, the standard deviation was equivalent to 30 $\times$ 10^{-9} c. of the isotope. It is proposed to use larger crystals ($4\frac{1}{2}$ in. in diameter $\times$ 2 in.) with a reduced potassium impurity, when the standard deviation on a 10-min. exposure should be only 3 per cent. A further reduction may be possible if still purer crystals combined with top-channel analysis are employed. Mr. Owen considered the sensitivity to be expected with the proposed apparatus in the detection of americium-241 and plutonium-239 in the body. He believes that it may be possible to measure 6×10^{-8} c. of americium-241 from the 59-kV. emission and amounts of the order of the maximum permissible level of plutonium-239, utilizing its 17-keV. X-rays.

In the discussion which followed, it was suggested that the location of plutonium in bone may reduce Mr. Owen's estimate, while Dr. Roesch (G.E.C., Richland, Washington) quoted measurements of transmission of plutonium-239 radiation through patients which suggested a factor of 30–40 for absorption from centre to surface of the chest. Although on present evidence it seems that the measurement of a fixed skeletal burden of plutonium would be difficult, the detection of a recently inhaled burden while still in the lungs appears feasible. In closing the scientific session of the first day, Dr. Morgan stressed the need for applying, if possible, the methods of measuring body radioactivity to the determination of the distribution fractions and effective rates of elimination for various organs for cases of single ingestion as well as for continuous exposure.

The second day's scientific programme was devoted to indirect methods of measurement of body burdens. The morning session, under the chairmanship of Dr. Katharine Williams (Atomic Energy Research Establishment, Harwell), was opened by Dr. Wright H. Langham (University of California, Los Alamos Scientific Laboratory) with an account of the application of urine excretion studies to the determination of plutonium in the body. The urinary excretion curve for plutonium is best fitted with a power function ; fæcal excretion is similar but with different parameters. Measurements of urine samples taken on different occasions may be matched to the theoretical power-law curve and the effective limits of exposure deduced. Where the ratio of fæcal to urinary excretion is very high, it is suggested that unabsorbed particles from the lung have found their way up the trachea and have thence been swallowed. Dr. Langham suggested a division of hazard according to the solubility of the plutonium particle and proposed a model of lung mechanism on the basis of which, in the case of insoluble particles, the lung burden is ten times the systemic burden, agreeing fairly well with calculations based on the fæcal/urinary ratio. However, the difficulties inherent in excretion analysis emphasized the desirability of whole-body measurement for plutonium if feasible.

In answer to a question, Dr. Langham said that there is remarkable uniformity in the excretion patterns of different individuals, possibly a consequence of plutonium being chemically unlike any element naturally found in the body.

Dr. J. B. Hursh (University of Rochester) then spoke of the radium content of cremation ashes, natural waters and some common foods. His results[7] for whole-body cremation ashes based on radon assay are about 1/100 of Krebs's earlier value[8] of 10^{-8} gm. average radium content, and Dr. Hursh reviewed other American work giving results in agreement with the lower value. He next described measurements on the radium content of natural and filtered waters in various parts of the United States and showed that they do not bear out the theory that drinking water is the main source of radium burden. The radium content of several common foods has been analysed and suggests that they are a possible source of at least a part of the normal burden.

It was apposite that the next paper was read by Dr. H. Muth (Max-Planck Institute for Biophysics, Frankfurt-am-Main) on measurements of normal radium burdens, for he and his colleagues have likewise measured the activity of cremation ashes of German subjects, and their results are in agreement with those of Hursh and Gates[7]. They measured the radon content by a dual ion-chamber system and also by α-pulse counting. In addition, measurements were made of the activity of various tissue samples, which were consistent with the total-body results. Dr. Muth described determinations of radioactivity of drinking water supplies, wells and thermal springs, and also gave preliminary figures for the radium content of some foodstuffs. The general agreement with Dr. Hursh's results was very satisfactory.

In the discussion, Dr. K. Z. Morgan stressed the importance of a knowledge of the radium content in the gonads, Dr. Muth having included some relevant data in his paper.

The final afternoon session, under the chairmanship of Dr. M. Faber (Finsen Laboratory, Copenhagen), was opened by Mrs. M. M. Hindmarsh (Nuffield Institute for Medical Research, Oxford) presenting studies by herself and Dr. Janet Vaughan on α-track measurements of radium in bone. She described photomicrographic and autoradiographic studies of sections of bone from a man, much of whose working life had been concerned with the handling of radium. In general, radium in the shafts was associated mainly with the Haversian systems, whereas in the ends it was concentrated in regions of high calcification. The calculation of body burden from α-track counting was described[9]. Emphasis was laid on the non-uniformity of distribution and it was pointed out that the dose in a small cavity (5μ) might be twenty times the average assessed on the basis of uniform distribution.

Prof. F. W. Spiers described a joint investigation with Dr. Burch in which γ-ray measurements on the same case were compared with α-track results reported in the previous paper. It had been possible to measure the γ-ray emission from the cadaver eight hours after death and afterwards to measure a number of representative bones in sealed containers after radioactive equilibrium between radon and radium had been attained. The total radium burden (0·48 μgm.) estimated from the bone measurements indicated that at the time of death the radon excretion in breath was 65 per cent. A body radium burden of 0·39 μgm. deduced from the α-track studies is in reasonable agreement with the γ-ray assay in view of the limited number of sections counted. It has been shown that the total life-dose to osteocytes in a 5-μ canal is of the order of 1,200 rad and not very dependent on the assumptions on period of intake. An estimate was also given of the distribution of dose to the bone marrow.

In a paper on the importance of radon and its decay products for the normal radiation dose in humans, Dr. A. Schraub (Max-Planck Institute for Biophysics, Frankfurt-am-Main) considered the influence of geological and meteorological factors on the distribution of radon and its products in the soil, the atmosphere and water supplies. Figures were given for air concentrations in various sites and conditions, and the dose to the lungs of city dwellers estimated on the basis of measurements of air content of closed rooms.

The final paper, by Dr. W. P. Grove (Radiochemical Centre, Amersham), described experience with the measurement of radon in breath, a method which is specific to radium. The procedure for obtaining a representative sample of breath was described and details given of a technique for collecting the charged active deposit electrically on a metal foil coated with a phosphor for scintillation counting. Several cases had been sent to Leeds for total γ-measurement, and comparison with the exhaled radon suggested an excretion of about 60 per cent.

Reviewing the whole meeting with special reference to external methods of measuring body radioactivity, it could be concluded generally that scintillation techniques have reduced the limits of detection of 'hard' γ-emitters from figures of the order of 2×10^{-9} c. in a 2-hr. observation with ion chambers to about 10^{-10} c. obtainable in 15 min.; and that β-emitters such as phosphorus-32 can be detected at levels of the order of 3×10^{-8} c. Detection of levels of this latter order appears to be possible for a weak γ-emitter such as americium-241.

It was generally agreed that the success of the conference was in large measure due to its informality and to the many opportunities for discussion it afforded. Delegates were entertained by the Board of Governors of the United Leeds Hospital during the scientific sessions held in the Leeds General Infirmary, and also by the University of Leeds at a dinner at which the vice-chancellor, Sir Charles Morris, presided.

It is hoped in due course to publish in full the proceedings of the conference in a single volume.

G. W. Reed

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ECOLOGY AND NATURE CONSERVATION

A MOST successful meeting was held in Edinburgh during June 20–28 by the International Union for the Conservation of Nature and Natural Resources, hitherto known by the misleadingly restricted title of International Union for the Protection of Nature. There was an excellent attendance both of animal and plant ecologists, and of administrators, engineers, town-and-country planners, foresters and other interested professions. More than thirty countries were represented. Among the visiting scientists were: Prof. Roger Heim (president of the Union), director of the Paris National Museum of Natural History, and Profs. J. G. Baer (Neuchatel), E. Beltran (Mexico), H. Gams (Innsbruck), T. Monod (Dakar), and Dr. Ira Gabrielson (United States) (all members of the executive board), and also Profs. J. Berlioz and F. Bourlière (Paris), Prof. G. P. Dementiev and Dr. L. K. Shaposhnikov (U.S.S.R. Academy of Sciences), Dr. W. Engelhardt (Munich), Dr. E. H. Graham (United States Soil Conservation Service), Dr. A. Marcello (Italy), Prof. G. J. Van Oordt, Mr. M. F. Morzer-Bruyns, and Dr. V. Westhoff (Netherlands), Mr. Fairfield Osborn (president of the U.S. Zoological Society and the Conservation Foundation), Mr. Roger Tory Peterson (United States), Mr. Hugh M. Raup (director of Harvard Forest, U.S.A.), Mr. F. N. Ratcliffe (Australia), Prof. L. G. Romell (Sweden), Prof. R. Sparck (Copenhagen), Prof. W. Szafer (Poland), Prof. V. E. van Straelen (Belgium) and Dr. E. B. Worthington (Africa).

A number of directors and other officers of national parks, nature reserves, forests, and interested societies also attended, including: Mr. J. H. Baker (executive director of the U.S. National Audubon Society), Mr. H. H. Bennett (recently chief of the U.S. Soil Conservation Service), Mr. M. C. Bloemers (director of the Netherlands Government Nature Protection Department), Mr. H. J. Coolidge (director of the Pacific Science Board), Mr. R. de Vilmorin (president of the French Société d'Acclimatation), M. F. Edmond-Blanc (secretary general of the Conseil Internationale de la Chasse), M. J-P. Harroy (Governor of Ruanda Urundi), Mr. R. Knobel (director of national parks, South Africa) and M. F. Vidron (secretary general of the Conseil Supérieure de la Chasse, France).

The United Kingdom was represented, among others, by Profs. W. H. Pearsall, P. W. Richards, M. L. Anderson and R. Matthew, and by Mr. A. B. Duncan, Sir Basil Neven Spence, Mr. E. M. Nicholson, Dr. F. Fraser Darling and a number of members of the staff of the Nature Conservancy, and representatives of the National Coal Board, the National Parks Commission, the North of Scotland Hydro-Electric Board, the Forestry Commission, and a number of other public authorities and government departments, together with Lord Hurcomb (president), and other representatives of the Society for the Promotion of Nature Reserves, Mr. Peter Scott (director) and members of the research staff of the Wildfowl Trust, Capt. Keith Caldwell and Lieut.-Col. C. L. Boyle (Fauna Preservation Society), and others.

The meeting was notable in bringing together for the first time picked representatives of so many different professions, whose activities affect land use and management, and who are increasingly feeling the need for a concerted approach to their problems. For this purpose the agenda of the technical meeting consisted of four topics, three of which related to land use:

(1) Management of nature reserves on the basis of modern scientific knowledge. This subject elicited several important papers. Ecologically, one of the most interesting was Mr. Raup's reconstruction, based on nearly fifty years of organized studies by Harvard University, of the relation of present to past woodlands in eastern North America. Briefly, he held that the conception of a stable climax forest is an illusion (even where there is no human interference), and that natural catastrophes, particularly wind-throw during storms, and also fire, occur within the life-span of most trees on most areas—while climatic and other environmental changes keep the