Mr. W. H. Hogg (Meteorological Office, Bristol) reviewed recent horticultural investigations at Rosewarne and Stockbridge House Experimental Horticultural Stations. At Rosewarne, variations in the local climate between shelter hedges have been observed over a 3-year period. Although higher rates of wind speed and evaporation than at the control station were found with certain wind directions, air temperatures and soil temperatures at 2-, 4- and 8-in. depths were consistently higher than in the controls. At Stockbridge House changes in the degree of shelter in relation to the height growth of a young shelterbelt are being examined.

On the subject of shelter effect on crops, Prof. J. N. Black (Department of Forestry and Natural Resources, University of Edinburgh) pointed out that the Agricultural Research Council was financing a new research programme at Edinburgh, which it was hoped would reveal the role of wind in limiting crop production in the exposed arable and pastoral areas. Reviewing previous work in this field from the point of view of future investigations on crop aspects, Dr. J. M. Caborn (University of Edinburgh) suggested that it was necessary to explore the manner in which environmental changes near windbreaks are translated into crop growth and development. A suitable approach might be a detailed study of the heat and water balance of a sheltered area in conjunction with growth analysis of the protected crop.

In the livestock shelter session, papers were presented on present research projects at the Hannah Dairy Research Institute, the Hill Farming Research Organization and the Rowett Research Institute. Drs. K. L. Blaxter, J. P. Joyce and A. J. F. Webster (Hannah) discussed four aspects of their investigations of environmental stress in sheep and cattle: the effect of wind and rain on metabolism; radiation heat loads on sheep as related to incident radiation on a horizontal surface; the time taken by sheep to attain metabolic equilibrium on exposure to cold; and the derivation of a general equation for estimating the thermal demand of an environment. The effects of heavy rain and of wind are approximately similar so far as heat losses are concerned, and the immediate effect of heavy rain has been found to increase heat production by about 30 per cent, provided the ambient temperature is below the animal's critical temperature. The heat derived from total solar radiation at 55° North under clear skies in mid-winter appears to be about a quarter of that produced by metabolism, whereas in mid-summer it is 10 times as great. Part of the cold stress in Scotland may stem from overcast conditions and consequent diminution of the heating effect of solar radiation. Heavily fleeced sheep also take a longer time than shorn animals to adjust to cold. It is encouraging to note that a rational formula has now been derived which enables heat losses of sheep to be predicted from fleece length, solar radiation, air temperature and wind velocity.

Turning to management aspects, Dr. J. M. Doney (Hill Farming Research Organization) felt that the response to climatic exposure, both physiological and in terms of economic production, was complicated by the nature of the annual cycle of nutrient intake and by the animal genotype involved. At levels of production provided by prevailing hill farm management systems, centred around the present well-adapted hill breeds, the provision of shelter could be quite uneconomic in terms of production increase; on the other hand, changes in management affecting the annual nutrient cycle might demand a change of breed structure and, hence, of the need for shelter. Dr. E. Cresswell (Rowett) reported that energy conservation, in the form of better gains and/or less food consumption, in fattening sheep provided with shelter had not been found so far in their studies. In the discussion which followed it was suggested that, although much of the research in this field so far has concentrated on shelter for the animal, more attention might be given to improving the herbage on hill land, and in this context shelter might be important.

Dr. R. W. Gloyne (Meteorological Office, Edinburgh) surveyed recent developments in instrumentation available for field experiments on shelter and the problems of analysis of data from long-term investigations of the influence of a series of shelterbelts on the climate of a previously exposed hill in North Wales.

In a closing address, the chairman of the Shelter Research Committee, Mr. R. G. A. Lofthouse, referred to the value of these meetings in co-ordinating research related directly or indirectly to shelter, in exchanging information and ideas and, particularly, in reviewing from time to time the present state of research and future needs.

J. M. Caborn

WEIGHTS AND MEASURES

TWELFTH GENERAL CONFERENCE

THE twelfth General Conference of Weights and Measures was held at the Centre International des Conférences in Paris during October 6–13, 1964, under the chairmanship of M. Poivilliers, President of the Paris Academy of Sciences, and was opened by M. Louis Joxe, Minister of State, deputizing for the Minister of Foreign Affairs of the French Republic. Delegations from 37 of the 40 States signatory to the Metric Convention took part in the conference, the United Kingdom being represented by the Director of the National Physical Laboratory and the Superintendent of the Standards Division, National Physical Laboratory. The business of the conference is best summarized by reference to the ten resolutions which were adopted; six were concerned with units and standards of measurement and the remainder with administrative and financial matters.

In the first category the most important was resolution 5 (standard of time-interval) which expressed the need to adopt an atomic or molecular frequency standard for accurate measurements of time-interval but stated that, despite the advances made with the caesium frequency standard, the moment had not yet come to discard the astronomical definition of the second*. This was because the hydrogen atom (and possibly the thallium atom) might furnish a standard more precise even than the caesium atom, which already provides a frequency standard reproducible in different laboratories to the order of 1 part in 10^{11} (equivalent to 1 sec in 3,000 years). Nevertheless, as recognition of the use of atomic and molecular frequency standards in physical measurements of time could not be further delayed, the resolution authorized the International Committee of Weights and Measures to designate atomic or molecular standards for temporary usage for this purpose; it also invited those organizations and laboratories which are expert in this field to continue their investigations so that a final recommendation for an atomic or molecular definition of the second may be prepared in due course.

In the declaration made later by the International Committee the first standard to be so designated is the transition between the hyperfine energy levels $F =$

* The second, adopted by the International Committee of Weights and Measures in 1956 and ratified by the Eleventh General Conference in 1960, is equal to the fraction 1/31 556 925·974 7 of the tropical year for 1900. January 0 at 12 h ephemeris time. This ephemeris second is made available in practice with the aid of atomic clocks, but only retrospectively as an average value over several years, by means of observations of lunar position; it is reproducible at present to the order of 2 parts in 10^9.

4, $M = 0$ and $F = 3$, $M = 0$ of the fundamental state $^2S_{\frac{1}{2}}$ of the atom of caesium-133 unperturbed by external fields; the value assigned to the frequency of this transition is 9 192 631 770 hertz (c/s) (ref. 1). The resolution represents a major step towards the adoption of an atomic constant as the universal basis of time measurement. Effectively it means that for all purposes in physics, and some in astronomy, the caesium transition is recognized as the present basic standard, but the resolution is so drafted that it will be easy to change from the caesium transition to the hydrogen transition if, for instance, the latter should prove in due course to be superior.

Resolution 6 (the litre) abolished the definition of the litre established in 1901 by the third General Conference, declared that the word 'litre' can be used as a special name given to the cubic decimetre and recommended that the name 'litre' shall not be used to express the results of volume measurements of high precision.

The litre was the name given to the cubic decimetre when the metric system was established during the last decade of the eighteenth century and it now reverts to its original meaning. The intention is that this litre shall only be used for ordinary transactions in trade and not for scientific purposes. The experimental evidence is that the litre, re-defined in 1901 as the volume occupied by 1-kg mass of water at its maximum density, is 28 parts in a million larger than the cubic decimetre (1 litre = 1·000 028 dm^3). The litre of 1901 is, moreover, a unit which is non-coherent with the International System (SI) of Units (see British Standard 3763 : 1964), in which the cubic metre, its multiples and sub-multiples, constitute the reference for volume measurements.

Resolution 7 defined the curie (symbol Ci) as having the value $3{\cdot}7 \times 10^{10}$ s^{-1}. The curie, although non-coherent with SI units—the SI unit of activity is the reciprocal second (s^{-1})—has been recognized because of its universal use for practical measurements of the activity of radionuclides.

Resolution 8 (unit prefixes) added 'femto' and 'atto' to the list of recognized prefixes forming submultiples of the SI units. Both words are of Danish origin; femto represents the factor 10^{-15}, symbol *f*, and atto the factor 10^{-18}, symbol *a*.

Resolution 9 (gyromagnetic ratio of the proton) invited the national laboratories and international specialists in the determination of atomic constants to continue studies of the gyromagnetic ratio of the proton with the object of establishing the precise value of this constant for application to improving the reproducibility of the ampere, a basic SI unit.

One method of measuring the proton gyromagnetic ratio is to observe the frequency of free precession of protons (in water) in the calculable magnetic field of a coil carrying a known current. The interest thus lies in improving the method, establishing the value of the constant accurate to 1 part in a million or better, and then using the method to maintain the ampere. The ampere is realized absolutely in terms of the metre, the kilogramme and the second by weighing the forces exerted between current-carrying coils of measured dimensions and disposition; maintenance by this method is laborious and inconvenient, and in the best circumstances the reproducibility obtained in different laboratories is not better than a few parts in a million.

Resolution 10 (International Practical Scale of Temperature, IPST) directed attention to the pressing need to revise the IPST of 1948 (as amended in 1960) and to extend the scale below the present limit at the boiling-point of oxygen (− 182·97° C) down to the boiling-points of hydrogen and helium. It recognized that much work has yet to be done in order that the International Committee may recommend the adoption of a new definition of the scale at the next ordinary General Conference, expected to be convened in 1968. The resolution invited the national laboratories and international specialists in this field to concentrate especially on the following projects: (1) gas thermometry throughout the whole range applicable to the method, including studies of the expansion coefficient of bulb materials especially at high temperatures; (2) measurements of black-body radiation between 630° C and 1,063° C; (3) formulation of a platinum resistance thermometer scale between 630° C and 1,063° C to replace the thermocouple scale specified in the existing scale; (4) verification of the table of values of 'reduced' resistance of platinum below 0° C, including a study of the calibration procedure for platinum resistance thermometers; and (5) new determinations of the boiling-point of oxygen.

Turning now to the administrative and financial resolutions, the first approved the actions taken by the International Committee to establish laboratories and a section at the Bureau International des Poids et Mesures (BIPM) for work on the basic metrology of the ionizing radiations[2], and invited the committee to continue the work at the BIPM. Resolution 2 recognized the need to complete the constructional work on the new laboratories and to purchase the basic equipment still required for the scientific programme of the section. Provision was made to meet this need by granting a third special contribution of 850,000 gold francs (£100,000) to be paid to the BIPM by Governments in accordance with the same rules as apply to the repartition of the annual subvention for maintenance of the BIPM.

Resolutions 3 and 4 (annual subvention to the BIPM) referred to the conference convocation document, issued to Governments by the International Committee in December 1963, which described the modern functions of the BIPM and gave an assessment of the basic monetary requirements for proper maintenance and development of its scientific activities. This document also announced that a proposal would be submitted by the International Committee to the General Conference for an increase of the total annual subvention from the present 900,000 gold francs to 1,750,000 gold francs (£204,000) for the 4-year period 1965–68. When the resolution containing this proposal was submitted for discussion at the conference, two delegations announced that their Governments could not agree to such an increase in the annual subvention on the case put forward by the International Committee. Eventually a compromise resolution (No. 4), proposing a graded increase in the annual subvention rising to 1,750,000 gold francs during 1967 and 1968, received qualified approval (16 votes in favour, 20 abstentions and no contrary vote). The Governments whose delegations abstained from voting were committed to deciding one way or the other by December 31, 1964. If only a single contrary vote is received, the resolution becomes void and an extraordinary General Conference must be convened as soon as possible to consider the finances of the BIPM, which temporarily finds itself in a most unsatisfactory and uncertain position for planning its future programme.

The International Committee, which is responsible for management of the BIPM and for the organization of the General Conference, held meetings during October 1–13. The Committee decided to establish a new advisory committee (comité consultatif) to deal with units of measurement. This step has become essential to ensure that the best advice is received on all questions relating to units of measurement from other specially interested organizations, which will be invited to appoint representatives on the committee. The main task is to consider the improvement and development of the SI units and to make recommendations for their extension to cover all fields of measurement of physical quantities. There are six other advisory committees dealing respectively with length (definition of the metre), time (definition of the second), electricity, temperature, photometry and standards of measurement for the ionizing radiations.

Under the auspices of the International Committee international journal of metrology, *Metrologia*, commenced quarterly publication by Springer in January 1965. The general editor is Dr. L. E. Howlett (National Research Council, Ottawa), chairman of the International Committee, who is assisted by an international editorial board.

H. Barrell

[1] Markowitz, W., Glenn Hall, R., Essen, L., and Parry, J. V. L., *Phys. Rev. Lett.*, 1, 105 (1958).
Barrell, H., *Nature*, **189**, 195 (1961).

NON-CUTTING USES OF INDUSTRIAL DIAMONDS

MOST industrial diamonds are used for cutting purposes where the objective is removal or displacement of relatively hard materials such as metal or rock. There are, however, other important applications of these diamonds which are not so well known, in particular 'non-cutting' uses. In this category are recognized mechanical and non-mechanical applications; the former include processes where the diamond is employed as an integral working part of a machine; the latter implies those instances where it is performing other independent functions. A recently issued publication entitled *Non-Cutting Uses of Industrial Diamonds** briefly describes and illustrates some of the more important non-cutting applications of these diamonds.

In the category of mechanical uses are styli, what are known as 'feeler' styli, diamond distance stops, gramophone styli and bearings. All these uses depend on the factor of extreme hardness of diamond and the facility with which it can be shaped and polished to a very high degree of accuracy and tolerance for the particular purpose in view, with the assurance of retention of shape and high surface finish for a far longer time than any other material. Feeler styli are employed as sensitive feelers in a wide variety of surface measuring instruments; they are ground into cone shape and have an accurate radius polished on the tip; for example, high-resolution types of feeler styli have a tip radius of 0·00005 in. Diamond distance stops are used in distance pieces to ensure accuracy in lapping and honing operations in cases where the finished workpiece is to be of pre-determined thickness. With gramophone styli the diamonds are ground to cone shape and the tip polished to a radius varying according to the type of record to be produced or played; styli for microgroove- and stereo-records require far finer tips than those used to play the old standard 78-r.p.m. records.

As an example of their use as bearings, precision watchmaking may be cited, where in such fine mechanisms diamonds replace natural or synthetic ruby, especially in cases demanding accuracy, long life and frictionless bearings. In the category of non-mechanical applications there are optical uses, electronic functions, and diamond-tipped indenters, such as are used on some hardness testing machines. In the optical field, the diamonds must be of gem quality, clear as optical glass. Electronic applications chiefly concern the use of semiconducting diamonds which have proved extremely efficient as sensitive detector heads in thermistor equipment; they can also be used as radiation counters; for this purpose only very small diamonds are used, and since they are chemically inert they make eminently suitable implant detectors in the living body, apparently without any harmful effects.

* *Industrial Diamond Information Bureau. Non-Cutting Uses of Industrial Diamonds.* Pp. 12. (London: Industrial Diamond Information Bureau, 1964.)

ANGULAR SIZES OF THE X-RAY SOURCES IN SCORPIO AND SAGITTARIUS

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THE angular diameters of the X-ray source regions in the constellations Scorpio and Sagittarius respectively have been investigated in two rocket experiments conducted on August 28, 1964 (flight I), and October 24, 1964 (flight II), at the White Sands Missile Range. These sources were first observed by Giacconi *et al.*[1] as a single unresolved source of cosmic X-rays with wave-lengths around 3 Å and located near the galactic centre. Subsequent observations by Friedman *et al.*[2] and by Giacconi *et al.*[3] established the existence of two separate sources, in this part of the sky, one located near right ascension $16^h\ 15^m$, declination $-\ 15°$, and the other near or coincident with the radio centre of the galaxy. In the present experiments we observed these two sources with a detector using a special collimator which has a high angular resolving power and at the same time a large field of view.

Flight I was launched at a sidereal time of 20 h 56 min, and flight II at a sidereal time of 20 h 20 min. In both flights, the rocket motion consisted of a rapid spin about its long axis and a slow precession of the long axis around a yaw cone of small opening angle. The detectors themselves were banks of Geiger–Müller tubes with beryllium windows 0·002 in. thick. Each bank had a sensitive area of approximately 100 cm². The collimators, which have been described elsewhere[4], consist of two grids of parallel wires. Each wire is separated from the adjacent wires by slightly less than one wire diameter, and the two grids are mounted one in the back of the other and separated by a distance of 1·5 in. (as dictated by the available space in the instrument section of the rocket). Parallel radiation falling on the collimator casts a shadow of the wires forming the front grid on to the back grid. The transmission of the incident radiation passing through the back grid and into the detectors is determined by whether the shadow coincides with the back wires or with the openings between. As the apparatus is rotated around an axis parallel to the wires, the intensity transmitted by the collimator is modulated in a way that is determined by the dimensions of the wire grids and the rate of rotation. On the other

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