first examples of the use of an atomic frequency standard with an accuracy greater than that obtained by using a unit of astronomical time. They also represent the highest accuracy ever achieved in the measurement of any physical quantity in terms of a definitive standard.

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[1] Ramsey, N. F., "Nuclear Moments" (John Wiley and Sons, Inc., New York, 1953).
[2] Kusch, P., *Phys. Rev.*, **76**, 161 (1949).
[3] Lyons, H., *Ann. New York Acad. Sci.*, **55**, 831 (1952).
[4] Smith, H. M., *Proc. Inst. Elec. Eng.*, **98**, Pt. 2, 143 (1951).
[5] Essen, L., *Proc. Inst. Elec. Eng.*, **98**, Pt. 2, 154 (1951).
[6] Essen, L., *Proc. Inst. Elec. Eng.*, **100**, Pt. 3, 19 (1953).
[7] Sadler, D. H., *Occas. Notes Roy. Astro. Soc.*, **17**, 103 (1954).
[8] Markowitz, W., *Astro. J.*, **59**, 69 (1954).
[9] Essen, L., *Proc. Inst. Elec. Eng.*, **101**, Pt. 3, 249 (1954).
[10] Pierce, J. A., Mitchell, H. T., and Essen, L., *Nature*, **174**, 922 (1954).
[11] Zacharias, J. R., Yates, J. G., and Haun, jun., R. D., *Proc. Inst. Radio Eng.*, **43**, No. 3, 364 (1955).
[12] Townes, C. H., *Proc. Inst. Radio Eng.*, **43**, No. 3, 364 (1955).

Definition of the Second of Time

THE preceding communication by Essen and Parry describes a means by which frequencies and intervals of time may be measured with an accuracy of 1 in 10^9, and holds out a prospect of even higher accuracies.

Ephemeris Time, on which the definition of the second adopted by the International Astronomical Union and the International Committee of Weights and Measures depends, is derived from the motion of the Moon. If the position of the Moon at any time can be determined to 0·05 sec., a period of four years would be necessary to obtain an accuracy of 1 in 10^9 in time and frequency derived from astronomical observation. Essen and Parry mention Markowitz's proposals for reducing this period to one year ; these depend on a reduction of the errors by repetition of observations. Such a reduction would involve a study of systematic errors in star places and in the corrections for differential refraction that would certainly take many years. During this time the atomic clocks will be improved, probably by a greater factor than the astronomical determinations.

It thus seems probable that for the foreseeable future the accuracy of the measurement of frequency and of time intervals relative to laboratory standards will exceed that by astronomical means, and that the astronomically defined second is therefore incapable of realization with the accuracy necessary for microwave spectroscopy. The natural way of escape from this difficulty is to define a 'physical second' in terms of the natural period of the cæsium atom, choosing the numerical value so that it agrees as well as may be with the current estimates of the second of Ephemeris Time. Experience of the working of the machinery for obtaining international agreement on such matters suggests that some years are likely to elapse before a decision could be reached. The purpose of the present communication is to solicit views on the desirability of abandoning the astronomical second for the most refined physical measurements and to encourage other suitably equipped laboratories to make determinations of the cæsium frequency of the highest accuracy.

It is possible that the new accuracy in the measurement of frequency will reveal some unexpected phenomena. It is not self-evident that the times shown by atomic and astronomical clocks will keep in step indefinitely. In fact, Dirac, Milne, Jordan and others have suggested that what are usually regarded as the 'constants of physics' may change by amounts of the order of $1/T$ per year, where T is the 'age of the universe' in years. If T is about 4×10^9 years, changes of this order may soon be measurable over intervals of a few years. This is a matter that can only be settled by experiment and gives an added interest to the development of methods of precise time-keeping.

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EXPLORATION OF THE EARTH'S UPPER ATMOSPHERE USING HIGH-ALTITUDE ROCKETS

BRITISH RESEARCH PROGRAMME

By SIR DAVID BRUNT, Sec.R.S.

THE wind, temperature, humidity and other properties of the atmosphere up to heights of about twenty miles can be studied directly by means of instruments carried up by free balloons. Observations of this kind are regularly made by meteorological services throughout the world. Although the atmosphere at greater heights is very tenuous, it necessarily plays an important part in many phenomena. Thus long-distance radio propagation is only possible because of the existence of reflecting layers, the ionosphere, at altitudes of 60 miles and above—indeed, a very important region extends upwards from a height of 90 miles. Meteors are mainly evaporated at the 60-mile level, and the aurora, at least in high latitudes, is located at about the same level. The electric currents which give rise to the variations of the earth's magnetic field circulate in this region, and it is also the seat of a night-time air-glow quite distinct from the aurora or the light of moon and stars.

Before the Second World War, information about the upper atmosphere could only be obtained by indirect methods. The remarkable developments of rockets as weapons led to the possibility of carrying instruments into the upper air in vehicles of this kind. This was first achieved in the United States in 1946, using captured V2 rockets. Since that time steady progress has been made and many interesting results have been obtained. The greatest height reached so far has been 240 miles.

A research programme of this kind is expensive, and until recently was exclusively carried out by American scientists and technicians. It is very desirable that work should be carried out in other countries, to obtain data under different conditions and locations and employing different techniques. A programme has already been commenced in France, and an extensive programme is now being initiated in the United Kingdom through the co-operation of the Ministry of Supply, particularly the Royal Aircraft Establishment, and the Gassiot Committee of the Royal Society. The programme aims at having available, within two years, rockets able to carry 100 lb. weight of scientific instruments up to heights of 120 miles or more. The design, development, supply and firing of the rockets will be carried out by the Ministry of Supply. Five university research groups, from University College, London (Prof. H. S. W. Massey), the University of Birmingham (Prof. J. Sayers), The Queen's University of Belfast (Profs. D. R. Bates and K. G. Emeléus), University College, Swansea (Dr. W. J. G. Beynon) and the Imperial College of Science and Technology, London (Prof. P. A. Sheppard), will be initial participants in the scientific programme. The work will be co-ordinated through a special sub-committee of the Gassiot Committee of the Royal Society. The first experiments will include determination of atmospheric temperature and density, the study of the nature of the ionosphere, a search for very fine meteoric dust below 60 miles altitude, and determination of the heights of the regions from which the night air-glow is strongest. While the development of the rockets is proceeding, work on the scientific instruments required will proceed in parallel, so that both should be available at nearly the same time.

Although this programme has been arranged independently of the International Geophysical Year, 1957–58, it is hoped that it will be in operation during this period and add substantially to the British contribution to the Year.

OBITUARIES

Sir Harold Tempany, C.M.G., C.B.E.

Sir Harold Tempany's forty-three years in the Colonial Agricultural Service (now called the Agricultural Branch of H.M. Oversea Civil Service) stretched a good way on either side of the great changes which followed on the Imperial Agricultural Conference of 1927. These gave the Service the beginnings of a unity, enlarged it in numbers and resources, provided training for its cadets and placed at its head an agricultural adviser to the Secretary of State for the Colonies. The late Sir Frank Stockdale was the first to fill this post (1929). Tempany joined him as assistant adviser in 1936 and, succeeding him in 1940, was in office during the hard years up to his retirement in 1946.

Variety in the earlier half of his career gave width to the knowledge of climates, soils, agriculture and administration on which his success in the diversified tasks of the latter half depended. Soon after graduating at University College, London, where chemistry, always central in his technical thinking, was his main study, he was appointed assistant agricultural chemist, Leeward Islands, in 1903, and a few years later chief chemist and superintendent of agriculture. In Mauritius during 1917–29, as director of agriculture, he was also responsible for the co-operative credit societies, and became the first principal of its College of Agriculture and a member of its Council of Government. Malaya was his next Colony. While director of agriculture for seven years from 1929, he put new life into the investigation of the food crops and livestock of its peasant farming, formerly overshadowed by its great export crop, rubber. The training of local assistants and general agricultural education also profited greatly from his interest.

By 1940, when Tempany became agricultural adviser in the Colonial Office, Stockdale had put new spirit into the whole Colonial Agricultural Service and made the Colonial Advisory Council for Agriculture, Animal Health and Forestry an influential body, warm in support of his exertions. Soil erosion throughout the Colonial Territories was, at last, being checked; the basic importance of the peasant economy had become recognized; specialist research had begun to be intelligently related to major problems; and study of husbandry and farming systems to be effectively promoted. Further, it was accepted that agricultural development in a territory could not spring from unconcerted pushing of individual commodities but required a policy based on primary physical and ethnic considerations.

In 1940 Tempany, who in his four years as assistant adviser had had a hand in all these developments, became, as adviser, responsible for doing what was possible to carry them on while also wrestling with the acute war-time food-supply problems of all the Colonial territories.

The Colonial Development and Welfare Act, 1940, greatly enlarged the funds for research, and a committee of the Colonial Advisory Council for Agriculture, Animal Health and Forestry was set up to report on research organization in those subjects. In its prolonged, arduous, discussions it fell to Tempany, particularly, to maintain free scope for technical agriculture and science, while conceding a due authority to administrative control. The present Colonial Agricultural Research Committee was set up, conformably with the recommendations, and the idea of a regional basis for research was also adopted. In 1946, a commission of three, under Tempany, visited East Africa for the conference at which initial arrangements for an East African regional organization were drawn up.

At formal meetings, Tempany's conscientious marshalling of facts sometimes tended to irritate his less-patient colleagues who, none the less, respected his tenacity and his high aims for the Service. It was in travel and when dealing with problems out on the land that he was seen at his best. But, indoors or out, he was unfailingly industrious, conscientious, fair-minded and kindly.

Tempany had periods of service on the board of governors of the Imperial Institute, the governing body of the Imperial College of Tropical Agriculture, the Sudan Government London Scientific Advisory Committee on Agricultural Research, the Chemical Council and the Council of the Royal Institute of Chemistry, and in 1950 he received a silver medal of the Royal Society of Arts. Most of his writing went into official papers: he published "Principles of Tropical Agriculture" (1930: with G. E. Mann); "The Practice of Soil Conservation in the British Colonial Empire" (1949); and "Agriculture in the West Indies" (1942). Leisure for writing, for which he longed, and happy opportunity, came in 1946 when, on retiring, he became editor of *World Crops*.

In 1911 he married Annie Frances Agnes, eldest daughter of Robert Goodwin, of Antigua, who died in 1945; their son died, in Nairobi, only two days before the death of his father in London on July 2. His second marriage, in 1946, was to Kate, youngest daughter of William Welfare. F. L. Engledow

Prof. R. H. A. Plimmer

The distinguished biochemist and one of the founders of the Biochemical Society, Robert Henry Aders Plimmer, emeritus professor of chemistry in the University of London, died on June 18 at the age of seventy-eight.