

## VISUAL OBSERVATION OF SATELLITES

ON October 20 there was an all-day discussion meeting at the Royal Society on the subject of visual observation of satellites. The meeting was organized jointly by the Royal Society and the British Astronomical Association, under the chairmanship of Prof. C. W. Allen (University of London Observatory), and was the first gathering of visual observers of satellites to be arranged by the Tracking Working Group of the British National Committee on Space Research.

The first subject discussed was the purposes of making observations. This topic was introduced by D. G. King-Hele (Royal Aircraft Establishment, Farnborough), who explained how visual observations of satellites fitted into the general pattern of satellite observations, and how they could best be used in geophysical studies. Investigations of the changes in satellite orbits have brought about great advances in two quite different branches of geophysics: the study of the Earth's gravitational field and the upper atmosphere. Visual observations will probably not be accurate enough for future investigations of the gravitational field; but they are quite accurate enough for most examinations of upper-atmosphere density and temperature, and, for the vast majority of satellites, visual observations are the only ones available. Visual observations, therefore, continue to be of great scientific importance, and since a large number of observations, ideally about 100 per week, are needed to determine accurately the orbit of a satellite, it is probably best for the limited number of visual observers to concentrate their attention on a relatively small number of satellites, particularly those with lifetimes of less than about twenty years.

Although the determination of orbits is the most important use for visual observations, nine other uses were briefly mentioned, including the improvement of predictions, observations of re-entry, the identification of satellites, observing satellites made of materials which are almost transparent to radar, observing satellites from the same launch which pass over very closely together, timing fluctuations in brightness, and various other uses.

The second subject on the programme was the techniques of observing. First there is the problem of searching for the satellite, especially when the predictions are in error, and the various stratagems for overcoming these difficulties were discussed. Next there is the question of accuracy. Since visual observations are not so accurate as those made by cameras, visual observers always have to strive for the best possible accuracy. Normally, observations are made relative to a pair of reference stars, and it was generally agreed that the best accuracy can be achieved by noting the time and position of the satellite as it passes two stars very close together, such that

the line between them lies perpendicular to the satellite's track. The accuracy to be aimed at by a visual observer, even though it will not often be achieved, is about 2 min of arc in direction and 0.1 sec in time. There was also discussion of the number of observations which an observer should make. Two observations are better than one if they are equally accurate, but there is less to be gained by making a large number of observations because of the bias error in timing. Discussion on the types of instruments used by observers showed very clearly that this is a matter of personal preference and depends more on the temperament of the observer than on objective scientific criteria. Many observers use binoculars and say that they can see twice as well with two eyes as with one, while other observers prefer to use telescopes, though their optical design and mountings are very varied.

The next topic discussed was the timing of observations, introduced by H. G. Miles (director of the Artificial Satellite Section, British Astronomical Association). Visual observers normally time their observations by starting (or stopping) a stop-watch at the time of the observation and synchronizing it with standard time signals, such as the *MSF* radio signals or the Post Office speaking clock. The various possible errors arising from both stop-watches and time signals were reviewed, and the general conclusion was that the various time-standards at present used by observers are just accurate enough to introduce no significant error in visual observations, which can rarely expect to have an accuracy better than 0.1 sec. The stop-watches could introduce errors unless care was taken in rating them frequently, and running them for as short a time as possible before or after the observations.

The final subject for discussion was predictions, introduced by Mr. D. E. Smith (Radio and Space Research Station, Slough). Mr. Smith described some of the difficulties encountered by the Satellite Prediction Service at the Radio and Space Research Station and explained improvements which it was hoped to make in the near future. In the discussion which followed, many suggestions were made for particular improvements in the prediction service, and these suggestions will be taken into consideration in deciding future policy.

The meeting was attended by twenty leading British visual observers, four observers from other countries in Europe who report their observations to the British Prediction Centre, members of the kinetheodolite teams at the Royal Greenwich Observatory, Herstmonceux, and the Royal Observatory, Edinburgh, and representatives of various other organizations concerned with satellite tracking.

D. G. KING-HELE

## SCIENTIFIC AND INDUSTRIAL RESEARCH IN NEW ZEALAND

IN the report of the Department of Scientific and Industrial Research, New Zealand, for 1965\*, the Director-General records a staff on March 31, 1965, of 1,334. Of these, 511 were scientific officers, and the total represented an increase of 32 in the year. In all there were 562 technical officers, and of the 1,334 staff, 175 were employed in the Physics and Engineering Laboratory, 172 in the Chemistry Division, 91 in the Grassland Division and 90 in the Geological Survey. The total expenditure on these four Divisions was £343,611,

£310,086, £141,697, and £163,887, respectively, out of a total expenditure by the Department of £3,024,792. Expenditure on the Geophysics Division, with a staff of 82, was £195,950; on the Plant Diseases Division (68), £127,327; on the Soil Bureau (79), £152,516; on the Antarctic Division (23), £105,380; on the Crop Research Division (58), £107,332; and on the Information Service (47), £104,867. Expenditure on the incorporated Research Associations amounted to £230,840—the major share going to the Dairy Research Institute (£74,205) and the Wool Research Organization (£75,000).

Steady progress has been made in implementing the recommendations of the Mineral Resources Committee,

\* New Zealand. Report of the Department of Scientific and Industrial Research for the year ended 31 March, 1965. Pp. 83. (H. 84.) (Wellington: Government Printer, 1965.) 8s.

and equipment is being built up and the staff strengthened. Sand deposits have been surveyed both for their economic value and also to collect information for shoreline research. The detailed survey so far has covered much of the east coast of Northland, where the modern shore and off-shore flats contain between 50 per cent and 75 per cent of lime soda feldspar. Clay deposits near Coalgate and Hororata in Canterbury, examined by the Geological Survey and Chemistry Division, contained an excellent grade of bentonite. A new series of geological maps of the main cities is being prepared and the Seismological Observatory is investigating the mechanisms of earthquakes, including theoretical research on alternative mechanisms which could cause a sudden change in the conditions of elastic equilibrium within the Earth. Earthquake occurrence has been subjected to statistical analysis, with respect both to position and to time, and members of the Applied Mathematics Division co-operating with the Geophysics Division are making a statistical analysis of the patterns of occurrence and location of earthquakes.

The Physics and Engineering Laboratory is developing a method of presenting information on the radiation output from various types of heaters for guidance in calculating the effect of the radiation on the comfort of people, by engineers and architects. The Chemistry Division has also developed automatic apparatus for separating the two types of silver and cupro-nickel coins in circulation in view of the change-over to decimal currency.

A detailed analysis of results obtained from the Bluff radar during the International Geophysical Year revealed a number of new and unsuspected features in the pattern of behaviour of the radar aurora and gave the first clues as to the over-all pattern. Increases in ground radioactivity from nuclear weapons tests continue to be studied, while the principle of the electromagnetic flowmeter has been applied to the measurement of blood flow in the heart lung machines of the cardio-thoracic surgical unit at Green Lane Hospital and also for measuring fluid flow in the artificial kidney.

Soil studies by the Grassland Division have shown that organic phosphorus may progressively accumulate under permanent pastures forming about 60 per cent of the total phosphorus in such soils. A survey of the vegetation and soils of the Tongariro National Park, initiated in 1960, is now nearing completion. A new variety of oats named 'Mapua', bred at the Cross Research Division, was selected from a 1953 cross of 'Milford', a lodging-resistant Welsh variety, and 'Onward', a plump-grained English oat. In full-scale trials since 1957-58 it was superior to all present varieties, highly resistant to lodging and of reasonably good milling quality. Since 1962 the Division has also produced three promising hybrid varieties of onion for field trials, and commercial release of New Zealand Hybrid No. 1 has already been requested. From crosses of turnips with aphid- and mosaic-resistant swedes, turnips have been selected with high field tolerance to these diseases. The work of the Plant Diseases Division on heat therapy for the control of post-harvest fruit rot has concentrated on hot-water treatment for pip fruits and peaches. With apples and pears *Botrytis* rots were not controlled at temperatures tolerable to the fruits, but the method would appear to have applications in the control of stone fruit brown rot in peaches, especially canning peaches. The new compound zeatin, extracted from the sweet corn kernels, has now been shown to be 6-(4-hydroxy-3-methylbut-2-enyl) amino-purine.

As a preliminary to detailed study of the movement of behaviour of red deer and other animals, the Animal Ecology Division is developing techniques for capture and marking. The Tobacco Research Station has undertaken a programme of breeding for resistance to *Verticillium* wilt black root rot, *Phytophthora* and mosaic virus.

Included with the Director-General's report are reports from the branches and from the incorporated research associations. The seventh annual report of the Ross Dependency Research Committee is appended. Lists of publications are included in the reports from the various branches.

## FOREST HYDROLOGY

**A**N Advanced Science Seminar supported by the U.S. National Science Foundation was held at the Pennsylvania State University, State College, during August 29-September 10. The symposium was conducted by the School of Forestry with three other bodies: the Northeastern Forest Experimental Station, United States Forest Service; the International Association of Scientific Hydrology; and the International Union of Forest Research Organizations. Twenty-one countries were represented at the symposium by eighty-five participants, the largest single group being from the United States. Eighty-five papers and reports were delivered and the proceedings will be published during the next nine months. Sound organization and critical discussion stimulated by several invited scientists made this a successful meeting.

Many countries are concerned about the adequacy of existing and future water resources, and in most, research is being conducted into these and other problems in hydrology. Particular attention has been given to investigating the hydrological significance of different types of land use and, during the past 30-40 years, the hydrological role of forests has been studied in various parts of the world. Some well-known experiments have been conducted, particularly in the United States, Switzerland and South Africa, but investigations commenced more recently have had the benefit of modern instrumentation and better techniques from the start. The aim of these experiments is to compare the water balance of forest

catchments with adjoining catchments of a different vegetational character by showing differences in the volume and distribution of run-off. Now, energy budgets for catchments are being drawn up in addition to water balances and, with the use of neutron scatter devices for soil moisture measurement, considerable advances are being made in the study of forest hydrology. The importance of research of this type and also the timely nature of the symposium were emphasized by the severe water shortage in New York City and surrounding areas during August-September.

The symposium commenced with a review of activities in each country represented. In Israel, a country of few trees, difficulties arise from lack of water, in contrast to Taiwan with too much water and many trees. This distinction between countries where water conservation is important and those with the problem of soil conservation was most apparent. In many countries there seemed to be an unnecessary division of responsibility for hydrological research among a number of different organizations.

The second session considered forests and precipitation—the forest being regarded as a redistributor rather than a stimulator if occult precipitation was not taken into account. The problems involved in assessing precipitation over a catchment were described by Corbett (U.S.A.) using material from San Dimas Watershed. Leonard (U.S.A.) was concerned with the mathematics of inter-