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.