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D. RADIOASTRONOMICAL INSTRUMENTS

(prepared by R. N. Bracewell)

New radio telescopes in several categories have come into use, new receivers have been developed, and techniques of data processing have developed further.

Reflectors

A large altazimuth reflector of 64-m aperture has come into operation in Australia (**1**). In the U.S.A., a meridian mounted reflector of 91 m aperture (**2**), and the fixed parabolic cylinder of 121 × 183 m aperture (**3**) have come into use, and the 305 m fixed spherical reflector has undergone preliminary tests (**4**). Portions of the fixed-tiltable reflectors of Ohio (**5, 6**) and Nançay (**7**) have been used for observations. A fixed spherical reflector 24 m in diameter for operation at 21 cm has been constructed at Mitaka. Construction has begun on a 46 m steerable reflector for 3 cm operation at Algonquin Park.

Interferometers

An interferometer comprising two 27-m reflectors has been constructed in California (**8**).

In the United Kingdom new instruments include a pair of mobile, steerable 25-m reflectors (**9**), a phase-coherent interferometer using microwave links to operate over baselines up to 120 km at a wavelength of 1·89 m (62 100 λ) (**10, 11, 12**), and three 18 m reflectors on rails for generating an equivalent collecting area of 40 000 m^2 by two-dimensional synthesis (**13**). The large meridian interferometers at 7·9 m (**14**) and 1·7 m (**15**) have continued in use for sky surveys, and elements of the latter have been used to map a polar cap by using a computer to reconstruct the brightness distribution automatically from data observed over a range of position angles (**16**).

Compound Interferometers

At Toyokawa, a compound interferometer at 3·2 cm with a resolution of 0·7 minutes of arc was put into operation for measuring the intensity and polarization of solar emission (**17**), and a similar system was assembled at Stanford at 9 cm for solar and also non-solar studies (**18**). A multi-element array with a phase-switched end-aerial was assembled at Fleurs to give a beamwidth of 1·5 minutes of arc (**19**). A 210-m array of 32 reflectors combined with a 1-km array of 6 reflectors on polar mounts is under construction at Algonquin Park for high-resolution solar studies.

Crosses

The 1-km cross at Serpukhov (**20**) is nearing completion. Construction has started on the 1·6-km cross for Sydney University (**21**); the original Christiansen solar crossed grating-interferometer (**22**) is being converted to a pair of north-south and east-west compound interferometers by the addition of two 13-m reflectors to each arm; and a cross with a 1 degree beam at 10 m wavelength is being constructed from the original Shain cross. The 1-km cross in Italy is under construction (**23**). A solar-mapping system, related to the cross, using 100 13-m antennas arranged in a ring 3 km in diameter is under construction (**24**). The 3-minute-of-arc cross at Stanford (**25**) now automatically types out the daily survey of the Sun's disk in a form suitable for publication.

Solar System Radars

Special instruments constructed for radar observations of the solar system, especially of the solar corona, include a 305-m square of 1800 dipoles in Peru (**26**), a 31 × 533 - m array of 1024 dipoles in Texas (**27**), and an array of 48 tiltable logperiodic antennas in California (**28**). In addition, various reflectors (**29, 30, 31**) have been applied to radar studies of the Moon, Mercury, Venus and Mars.

Data Processing

Digital computers have been used to process observational data recorded on punched tape, magnetic tape or punched cards (**32, 15**) and most large installations now being planned depend on automatic processing of observational data. Pictorial presentation is also a feature of several display systems. Processing within the antenna and receiver for the production of multiple beams, multiple channels, or other properties is also important (**33, 34, 35, 36**), and in many cases could in principle be handled by a computer. The design of the antenna, receiver and data analysis have become a fully integrated whole (**33**).

Large Antennas

Deliberations on the design of antennas with beamwidths of a minute of arc or less have been published (**37**), including designs (**38**) for the Benelux cross. Guiding principles have been proposed (**39**) leading to echelon and lattice arrangements within various outlines. The suppression of grating responses, which are inseparable from repetitive arrangements, has been investigated experimentally (**39**) and suppression by suitable data handling has been investigated (**40**). Polarizable line feeds, such as will be required for echelon arrangements, have been studied (**41**).

Satellite- and Rocket-borne Instruments

The Canadian satellite, Alouette, launched 1962 September 29, contains a sweep-frequency receiver with which galactic and solar noise has been observed. Rocket observations of the cosmic radiation at 1·225 and 2·0 Mc/s up to an altitude of 1700 km have been made (**42**) with a short dipole; confirmation of theoretically predicted behavior of radiation resistance in a magneto-ionic plasma (**43**) was found. Several techniques have been proposed (**44, 45**) for using the focusing properties of the ionosphere to perform spatial surveys of the radio sky at frequencies that are not observable at ground level (**46, 47, 48**). At the University of Michigan a 2–4 Mc/s receiver for solar and Jovian bursts has been developed for the Eccentric Orbit Geophysical (EOGO) satellite and a cosmic noise mapping system at 2·5 Mc/s for the Polar Orbit Geophysical (POGO) satellite. Observations of the planet Venus were made by radiometers fired into the vicinity (**49, 50**).

Spectrometers

Several solar spectrometers for the range 7–14 cm were developed (**51, 52, 53**). Reflectors with very wide-band feeds were constructed (**54, 55, 56**). An interference spectrometer (**57**) was applied to observations of Jupiter.

Hydrogen Line Polarimeters

A number of combinations of sensitive receivers with polarimeters have been developed (**58, 59, 60, 61**) at Jodrell Bank.

Low-noise Receivers

A great deal of effort has been devoted to the technology of low-noise amplification by means of traveling-wave tubes, masers, and parametric amplifiers using electron beams, varactor diodes and tunnel diodes. Extensive bibliographies (**62, 63**) have been published that deal with astronomical applications.

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