the academic year of 1959–60, the Cooper Union has started a development program, of which the first step is the construction of a new building for the School of Engineering. The structure is now well under way and is expected to be occupied during the coming year. Its completion will pave the way for renovation of the present buildings and for expansion of the Art School's curricula to full degree-granting status.

Jodrell Bank Radio Telescope Controlled by Computers

The towering structural splendor of Manchester University's radio telescope at Jodrell Bank, England, which in its first months of operation earned an international reputation in satellite tracking, has to some extent obscured a remarkable electronic engineering achievement—the precise mechanical control of the 2000-ton rotating aerial. To appreciate the extent of this achievement, it is necessary to be aware of the really great size of the Jodrell Bank equipment. The parabolic reflecting bowl, a "dish" of steel plates 250 feet in diameter and weighing nearly 800 tons, can be tilted to any angle to control the elevation of shoot of the aerial. It can even be turned upside down to change the aerial.

The paraboloid is pivoted between two steel towers, each rising 180 feet from a system of deep-trussed girders not unlike railway bridges. All this array of steel is supported on bogies that travel on a circular railway track 352 feet in diameter; these allow the structure to be steered in azimuth. The 2000 tons of hardware can be rotated and the bowl can be rocked to aim the aerial with an accuracy in each coordinate of better than 12 minutes of arc. That figure is the required accuracy, but in fact, in reasonable weather an accuracy of 3 or 4 minutes of arc can be achieved.

Change in Design

Initially it had been planned to make the reflector of wire mesh stretched over a system of tangential supporting members; this would have given a deviation from the true paraboloid of several inches. At short wavelengths—in the region of 1 meter—an error of this magnitude would have resulted in considerable loss of signal, so it was decided to change the design and to form the bowl of individually shaped and welded steel plates. This, of course, made a big difference in the weight and windage of the bowl and necessitated a major redesign of some parts of the structure.

The electronic problem was that of providing a driving system sufficiently powerful to move the telescope in azimuth and elevation under all but the most severe wind conditions and a method of controlling this driving source so that the telescope could automatically follow any point in space, irrespective of the rotation of the earth and its movement round the sun. Two identical closed-loop servomechanisms are used; each must control four variable-speed direct-current motors of 50 horsepower each, operating within a speed range of 10 to 1000 revolutions

Control desk of the Jodrell Bank radio telescope.

per minute, by Ward Leonard voltage control; an additional speed range of from 1000 to 1500 revolutions per minute can be obtained by weakening the motor field.

The coordinated movement in azimuth (about a vertical axis) and elevation (about a horizontal axis) is controlled by signals from an analog computer. The small signals from the computer require amplification at ratios up to 30 million to 1, achieved in the main by direct-coupled amplifiers.

Obviously the design and development of the control machinery at Jodrell Bank was a major task. Requirements were set by the Manchester University staff, under A. C. B. Lovell, and the resulting instrumentation, involving new techniques in electronic and mechanical engineering, was the responsibility of Herman Lindars, managing director of the firm that carried out the work, Dunford and Elliott (Sheffield) Ltd. The Brush Electrical Engineering Company Ltd. was responsible for the manufacture of the machines, motor-control gear, and reduction gear that provide the physical motive power for the telescope.

Basic Facilities

The remote control of the telescope gives it these basic facilities:

1) It can be locked in any given azimuth and elevation.

2) It is capable of continuous motion in azimuth with fixed elevation; or in elevation with fixed azimuth, at any required rate.

3) By coordinating azimuth, elevation, and time, the telescope can be given sidereal motion for following any particular star.

4) It can be set on a predetermined program of search in which it can be left to sweep methodically a given area of the sky.

The computer controlling the electronic-mechanical "engines" which give movement to the telescope is a complex one. While the telescope is capable of movement in only two basic coordinates, to follow a star it is necessary to set up the control in its fixed coordinates, right ascension and declination, and the computer must be capable of translating these into the physical voltage changes that control the driving motors. In order for the telescope to scan across or along the Milky Way, another set of coordinates, galactic latitude and longitude must be employed. Again, it is sometimes necessary to scan in azimuth and elevation and at the same time to read off the positions either in right ascension and declination or in galactic latitude and longitude—or both. The computer, therefore, must be capable of solving, instantaneously and continuously, fundamental equations of spherical trigonometry.

The computer consists of an electrical analog in which magslip resolvers solve the equations by giving output signals proportional to the sine and cosine of the angle through which their rotors are turned. Excitation of the stator windings is given through feedback amplifiers deriving the feedback voltage from auxiliary stator windings. High-gain, two-stage resistance-capacitance-coupled amplifiers obviate nonlinearity in output due to electrical losses and unwanted flux.

No Single Equation

There is no single equation that can be used for control over all parts of the sky. This difficulty is overcome by using 14 different equations in the computer. Cams on the shafts of the resolvers automatically switch in the appropriate equations according to the position in the sky of the target. Seven of these equations are used for calculating azimuth and elevation from hour angle and declination (and vice versa), and another seven serve for calculating latitude and longitude from right ascension and declination.

An additional elevation resolver, set by a calibrated potentiometer on the control desk, is used to correct for parallax error arising when a body near the earth, such as the moon, is observed. The equations for distant targets are computed on the assumption that the viewer is at the center of the earth, while, of course, the telescope is mounted at the earth's periphery. Parallax correction is therefore needed when the viewer is working, as it were, "close up."

Similarity to Television Scanning

When the telescope is required to scan a given area, a "target arc" is selected. As each lateral sweep is completed a pulse can be provided to depress or elevate the arc of scan by a given amount, so that a scanning raster is built up; this is faintly similar to the technique of television scanning, except that the direction of sweep is reversed for each successive line. The raster can be arranged in vertical or horizontal scan and control is fully automatic. The coordinates of the scan can be coupled to a time control that will shift the complete raster in accordance with sidereal time.

In all movements of the telescope, indicator dials show at the control desk the position in which the aerial is firing. Dials indicate degrees and minutes of arc and hours, minutes, and seconds of time. Other dials show sidereal time, universal time, and the repeated-back positions in azimuth and elevation of the telescope itself. This information is given with an accuracy of better than 1 minute of arc.

Sidereal time is obtained by a synchronous motor which is controlled by a regenerative oscillator driving through a power amplifier. The speed of this motor is compared every 30 seconds with a pendulum-driven master clock and the motor is driven at a rate very slightly faster than the required sidereal time would call for. If at the time of the 30-second check the motor-driven clock is in advance of the master clock, a capacitor is switched across the input to V.1, reducing the oscillator frequency and the speed of the sidereal motor to bring the clocks back into coincidence.

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Neurology Federation Opens Office: Neurochemistry Commission Formed

The World Federation of Neurology, which was founded only about 2 years ago, now has a permanent secretariat at 59, rue Philippe Williot, Berchem–Antwerp, Belgium, and a full-time medical executive officer, Charles M. Poser, who is on leave from the University of Kansas. The WFN serves as an information center for world neurology. Its present plans include encouragement of international collaborative studies of neurologic and sensory disorders and establishment of a clearinghouse of information to promote exchange professorships, lectures, and consultancies.

The organization also expects to serve as a focal point for the development of scientific registers and repositories of pathologic specimens and scientific literature. Still other projects include the publication of a world directory of neurologists and neurologic scientists, preparation of a dictionary of neurologic drugs and poisons, compilation of lists of neurologic journals throughout the