RESEARCH FACILITIES AND PROGRAMS

The Arecibo Observatory

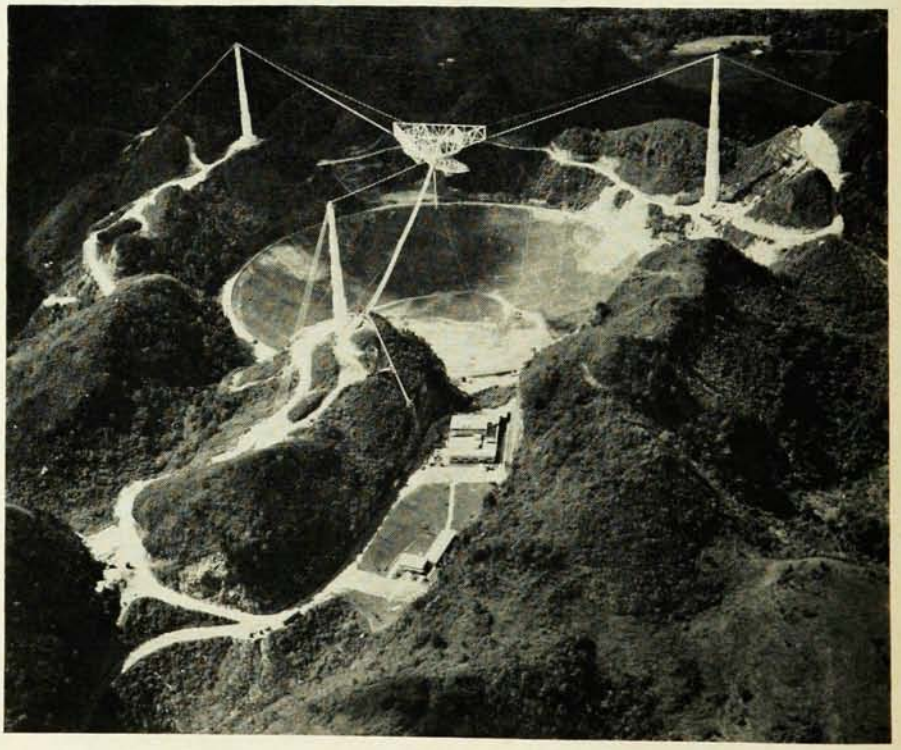
A limestone sink-hole in the mountains of Puerto Rico has been transformed by a team of stateside scientists into a bowl-shaped bed for a large-aperture radio telescope with a reflecting spherical dish measuring one thousand feet from rim to rim. The new antenna, designed to be used both as a highly sensitive receiver for studies in radio astronomy and as a powerful radar scanning device for ionospheric research and radar astronomy, was dedicated on November 1. The surface of the dish, covering an area of more than eighteen acres, consists of a reflecting grid of wire mesh lining a natural concave depression in the hills some twelve miles from the northwestern seacoast town of Arecibo. The project represents a four-year, nine-million-dollar cooperative effort by Cornell University, the Advanced Research Projects Agency, the Air Force Cambridge Research Laboratories, and the Army Corps of Engineers.

Since the spherical reflector is fixed in position, the moving part of the new 430-megacycle antenna is its line-feed mechanism, a 96-foot-long waveguide with amplitude and phase-distribution characteristics suitable to correct for spherical aberration in the system. Suspended 435 feet above the reflecting surface of the dish, the feed device permits radar scanning over a forty-degree conical region. Scanning is accomplished by moving the feed mechanism with respect to the reflector. The antenna's radar transmitter is capable of a peak power of 2.5 megawatts, with pulse lengths ranging from two microseconds to ten milliseconds and pulse repetition rates from 1 to 1000 per second.

At least half of the instrument's operational time will be devoted to studying the ionosphere, and, because of the very high power available, these observations can be conducted over a region extending from about fifty kilometers above the earth's surface to distances of a few earth radii. Measurements of the characteristics of the signal backscattered from the ionized medium of the upper atmosphere will provide information on the electron density and temperature and on the strength of the earth's magnetic field. Although the scattering cross section of electrons has been considered generally inadequate for conventional ionospheric backscattering experiments, the powerful radar beam transmitted by the Arecibo instrument is capable of producing a weak but detectable backscattered signal. The strength of the returning signal depends upon the number of free electrons in the region under observation, and by measuring the backscattering at various altitudes the electron density can be determined as a function of height. In addition, because the electrons are in thermal motion in the ionized medium and in the presence of the earth's magnetic field, analysis of the spectrum of the signal provides a measure both of the temperature of the medium and the strength of the field.

When not engaged in ionospheric studies, the antenna will be used as a radar telescope for investigating various objects in the solar system and as a radio telescope for observing discrete sources of radio radiation in outer space.

The Arecibo Ionospheric Observatory, as the new facility is known, is supported by funds from the Advanced Research Projects Agency as part of ARPA's Project Defender. It is operated by Cornell University's Center for Radiophysics and Space Research, which is under contract with the Air Force Office of Scientific Research. The director of the Observatory is William E. Gordon of Cornell's School of Electrical Engineering. Professor Gordon was largely responsible for the original conception and the planning both of the facility and the program of ionospheric physics to be conducted there. The antenna system was de-



The newly completed Arecibo Ionospheric Observatory in Puerto Rico as seen from the air. The feed mechanism for the antenna is suspended high over the reflector by cables strung between the supporting towers near the rim of the dish. The latter measures 1000 feet across.

signed by staff members of the Cornell Center for Radiophysics and Space Research, which was established at the University in 1959 as an interdisciplinary organization to combine and coordinate the efforts of scientists in various space-related fields and to provide increased opportunities for the training of graduate students in astronomy and the space sciences.

The Arecibo Observatory is intended to be available for research not only to Cornell but also to other qualified research organizations in the United States, with time allocations to be based on the requirements and scientific merits of the programs. A committee of senior radio scientists under the chairmanship of R. N. Bracewell of Stanford University has been established by ARPA to examine the programs and the uses to which the facility is put.

Construction of the Observatory, also financed by ARPA, was carried out with Cornell as the prime contractor, assisted by the Air Force Cambridge Research Laboratories, which provided technical management and support for the program. The Army Corps of Engineers was responsible for constructing the various buildings and facilities associated with the Observatory. The Puerto Rican site (at 18 degrees north latitude and 66 degrees west longitude) was chosen because of its deep natural bowl which minimized construction costs, its hilly terrain which provides some protection against wind and electromagnetic interference, its reasonable proximity to the equator which makes it possible to observe the sun, moon, and planets, and the relatively constant temperature which is an important factor in maintaining the antenna's dimensional stability.

The wire-mesh dish, supported by a network of steel cables, rises as much as forty feet above the ground in some places, and to prevent soil erosion the underlying surface has been densely covered with small trees.

The scientific staff under Professor Gordon's direction includes four senior research workers, four research associates, eight engineers, and four graduate students from Cornell. In addition, Gordon Pettengill serves as the deputy director of the Observatory. Philipp Blacksmith, Jr., was the AFCRL project officer, and Colonel William H. Innes was program director for ARPA. At Cornell's Center for Radiophysics and Space Research, four professors, eight graduate students, and one engineer are associated with the research at Arecibo. The senior research workers and research associates on the Observatory staff are drawn from various universities and laboratories in the United States and abroad. It is estimated that by 1970 the professional staff at Arecibo will total 45, which will be approximately twice the size of the present group.

British Synchrotron

Great Britain's 7-BeV proton synchrotron, Nimrod, is now in operation, according to a report in the October issue of *Atom*, the monthly bulletin of the United Kingdom Atomic Energy Authority. The accelerator, which is located at the Rutherford High Energy Laboratory in Chilton, Berkshire, produced its first fully accelerated beam of protons on August 27. The energy at the time was 6.5 BeV and the intensity 4×10^9 protons per pulse. Before the end of the day, an energy of 8 BeV was reached, and operations continued afterwards at the design energy of 7 BeV with intensities up to 10^{10} protons per pulse. A development program was initiated to bring the intensity up to 10^{12}.

Nimrod, which has cost £11 million, is operated by the National Institute for Research in Nuclear Science, an organization formed in 1957 to provide large and costly research equipment for common use by universities and other institutions. The first design studies for the accelerator were started in 1955 by a group at the Atomic Energy Research Establishment at Harwell. In view of considerable university interest in the project, its administration was transferred to the newly formed NIRNS, and construction was begun in August 1957 on a site adjoining Harwell and subsequently named the Rutherford High Energy Laboratory.

Nimrod's magnet ring is 155 feet in diameter; its preaccelerating linac delivers protons at 15 MeV. The machine is designed to produce up to 10^{12} protons per pulse at a repetition rate of 28 pulses per minute, equalling a current of about 1/16th of a microampere.

Channel 37 Decision

In an order effective November 15, 1963, the Federal Communications Commission has announced that broadcasting stations on the band 608-614 Mc (TV channel 37) will not be authorized anywhere in the United States before January 1, 1974. The order is intended to provide protection from interference by broadcasting stations for radio-astronomy receivers tuned to this waveband. After ten years the question will be reconsidered and it will then be decided whether to continue protection or to begin licensing stations on channel 37.

The decision is the outgrowth of deliberation on a proposed rule change which the Commission made public in March 1963 (see *Physics Today*, June 1963, p. 96), but affords much greater protection to radio astronomy than was proposed at that time. The March proposal was based on the needs of the University of Illinois radio telescope at Danville, Ill., and would have prohibited broadcasting on channel 37 from locations within 600 miles of Danville and would have restricted broadcasting by licensees outside the 600-mile zone to the hours between 7 AM and midnight.

The University had petitioned for protection for its radio telescope in 1960. Later, an immediate conflict arose when applications for broadcasting licenses for channel 37 were received from organizations in New Jersey and Florida. The rule proposed in March was intended to resolve the situation. After the proposal was made public, the Commission received approximately 140 comments on the question, some of which touched upon general policies of frequency allocation. The FCC adopted the present decision on October 4, 1963. In announcing the present rule, the Commission indicated that alternative frequencies would be made available to prospective broadcasters who had sought to use channel 37.

Channel 37 is the first portion of the UHF-TV band (470-890 Mc) to