to carry out the experiment. The same station is also being used for pulsed-ruby, satellite-ranging measurements.

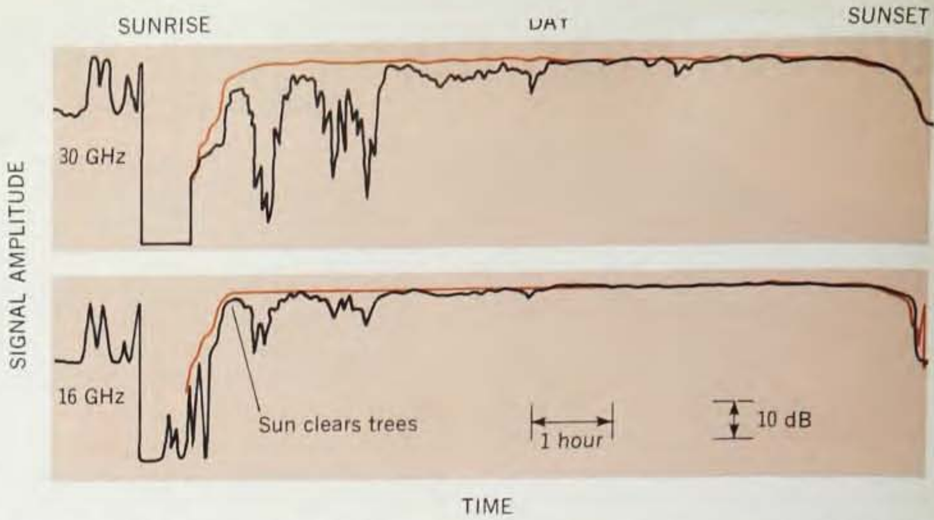
Future projects of this group include development of high-data-rate-capacity space-communication systems using carbon-dioxide laser radiation at 10.6 microns. These will require active optical transmitting and receiving terminals on the spacecraft; so a good deal of further development may be needed. —HEB

NMR Spectra Yield Data On Protein Structure

High-resolution nuclear-magnetic-resonance spectroscopy may be able to correlate biochemical reactions and electronic structure in protein molecules. K. Wüthrich and Robert Shulman (Bell Labs, Murray Hill) and J. Peisach (Yeshiva University) have examined the NMR spectrum of cyanometmyoglobin from the sperm whale; this compound, molecular weight 17 816, contains one iron atom. Its biological function is to store oxygen in muscular tissue.

The NMR spectra of proteins contain many overlapping resonances that cannot be separated by current techniques, but Wüthrich, Shulman and Peisach noticed that, with cyanometmyoglobin and some other proteins, well resolved proton resonances appeared outside the usual range, at both higher and lower fields. Certain of these resolved resonances are interpreted as resulting from hyperfine interactions of the unpaired spin of the iron ion Fe^{3+} with a relatively small part of the molecule— the protoporphyrin IX group. This group, with the iron ion, represents that part of the protein molecule that combines with oxygen. Studies of the resonances as a function of temperature allow these hyperfine interactions to be distinguished from other effects caused by interactions with ring currents in the molecule.

Further identification of these resonances will give information about the distribution of the unpaired spin, which in turn determines the wave function of the iron–porphyrin group within the protein. This information should ultimately lead, says Shulman, to a correlation of the electronic structure of the molecule with its biological function.



EFFECT OF RAIN ON RADIO SIGNALS. **Clear (colored line) and rainy weather (black line) signals are compared at frequencies of 30 and 16 GHz. Rain attenuates the 30-GHz signal more than it does that at the lower frequency.**

Rain Showers Dampen Solar Centimetric Radio Waves

Robert W. Wilson of Bell Labs, Holmdel, is making measurements to see whether the useful radio spectrum for satellite and space-probe communications can be extended to frequencies up to 30 GHz; the aim is to determine the effect of weather (particularly rain) on these high-frequency signals. The sun is a convenient extraterrestrial radio source for these experiments; so Wilson has made a sun tracker that records solar emission at 16 and 30 GHz.

A polar heliostat, consisting of a 1.5×2.75-meter metal reflector rotating about a polar axis and a stationary horn antenna, follows the sun automatically each day; rotation of the reflector about a declination axis corrects for seasonal variations in the solar position through the year. Detection is by a microwave radiometer; background noise is monitored by a 1-Hz oscillation of the heliostat away from the sun.

Absorption and scattering in raindrops cause attenuation, greater in the 30-GHz signal than in that at 16 GHz (see figure). Data taken for a year or more should show whether satellite communication at frequencies greater than 12 GHz (wavelengths less than 2.5 cm) would be seriously hampered by wet-weather losses; perhaps a network of several ground stations could be set up sufficiently far apart that at least one of them would be able to receive strong signals when heavy rain was affecting the signals at others.

Radio Satellite Monitors Low-Frequency Space Signals

A US satellite successfully extended four of its five antennas to 139 meters in late July and has been monitoring low-frequency radio signals from space since then. Space-agency officials were to decide in August whether to attempt deploying the booms to their full 229 meters.

From its vantage point in a circular orbit 5820 kilometers above the earth, the satellite will provide radio astronomers with their first low-frequency (below 10 MHz) map of our galaxy.

The four antennas form two vee shapes above and below the satellite (with respect to the earth). Those above monitor the Milky Way, Jupiter, the sun and other sources of radio emission. Slow-scan television cameras tell ground crews how the antennas are positioned at any time.

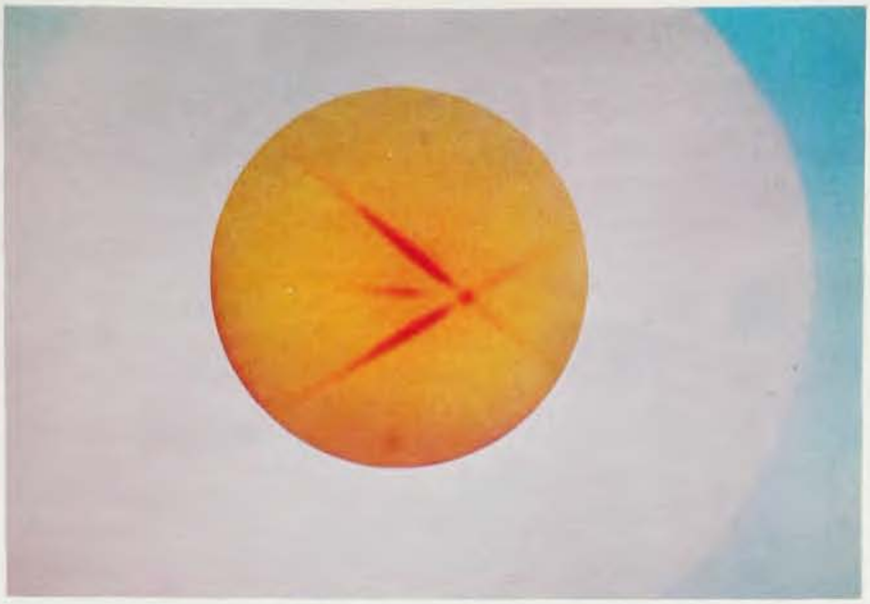
The array below the spacecraft measures low-frequency radio emissions that come from the earth's environment and, because the force of gravity is slightly greater on it, provides the satellite with gravity-gradient stabilization.

A separate 36.6-meter dipole antenna measures bursts of radio signals from Jupiter, the sun and other sources. The sixth and final boom is a 165-meter libration damper.

The radio receivers on board are designed to monitor strong, sporadic bursts of signals. Particular attention will be paid to Jupiter, long known as a source of radio bursts, and to the sun's role in low-frequency radio storms on the earth. Simultaneous observations will be made on the earth at higher frequencies for later correlation with the satellite data.

Robert G. Stone of the Goddard Institute for Space Studies is the principal investigator. The satellite transfers its data to five ground stations in real time when it is within range; at other times the data are stored on a tape recorder for later transfer to a ground station. Tapes made on the ground are flown to Stone at Greenbelt, Md.

The satellite, known as Radio Astronomy Explorer-A, is expected to operate for about a year. A second is to be launched next year. Space officials hope to have both in orbit as the sun passes through the maximum of the current 11-year solar-activity cycle.



PROTON CHANNELING IN SILICON. R. Stuart Nelson (AERE Harwell) used ordinary color film (Agfa CN-17) as an energy analyzer to obtain this picture of 1.5-MeV protons that have passed through a silicon single crystal 30 microns thick. Randomly scattered protons lose some energy in the crystal and are stopped in the yellow emulsion of the film; protons that traverse the crystal along preferred crystal-plane directions known as "channels" lose less energy and can penetrate to the next emulsion layer to yield a red image. Total film thickness is 20–22 microns. Asymmetry in the pattern is caused by a 3-deg tilt of the film plane with respect to the 100 plane of the crystal. The method is reported in *Journal of Materials Science* 2, 171 (1967).

Relativistic Perihelion Shift Refined after Icarus Approach

The asteroid Icarus passed within 6 million km of the earth on 14 June and was studied as never before in the 19 years since its discovery. Its highly eccentric orbit makes it suitable for studying the relativistic precession of its perihelion, and its small size and close approach to the earth allow accurate determination of its position.

Radar contact was made from MIT's Haystack Microwave Research Facility in Tyngsboro, Mass., and the Goldstone station of the Deep Space Network in California's Mojave Desert. Optical observations were made around the world.

The MIT team headed by Irwin I. Shapiro reported that their radar returns were disappointingly weak. Rain reduced the effectiveness of their radar (transmitting at 8 GHz); the returns were near the lower end of the range of possible echo strength calculated in advance. California results (at 2.4 GHz) also were disappointing.

Optical observations, however, fared better. About 100 positions were recorded, compared with the 71 that had been gathered in the previous 19 years. These positions are being forwarded to Shapiro, and during the next few months they will be analyzed by computer.

Shapiro hopes to reduce the standard error in the coefficient of the relativistic terms in the equations of motion. Prior to the June passage of Icarus, this coefficient was computed at 0.97 ± 0.20; it is hoped to reduce the error to 0.09. A coefficient of 1 corresponds to general relativity while 0 corresponds to Newtonian theory.

IN BRIEF

Two new pulsars reported by Anthony Hewish at Cambridge (CP 0808 and CP 0328) and two discovered in Australia by the Sydney University Mills Cross bring the total to nine. Periods are 1.29 and 0.71 sec for the northern ones and 0.56 and 1.96 sec for the Sydney pulsars.

ACCELERATORS

The cyclotron–tandem Van de Graaff combination 30-MeV accelerator at Triangle Universities Nuclear Laboratories in North Carolina is undergoing tests of the components. If the schedule is maintained the machine will be ready for testing as a unit by 1 Nov. One design change, insertion of a bending magnet between the cyclotron and the accelerator, is not expected to delay completion.

Another "Cyclo-Graaff" will be assembled at the Lawrence Radiation Laboratory in Livermore, Calif. The Cyclotron Corp. will provide a 15-MeV negative-ion injector for an existing tandem accelerator, to be operational early in 1969.

Ohio University has ordered an 11-MeV high-intensity tandem Van de Graaff accelerator system under a \$1 million Atomic Energy Commission grant. It will provide a proton beam intensity of 25 microamperes in continuous operation and up to 2000 microamp pulsed.

Ten tons of nuclear-research equipment has been airlifted from Geneva to Serpukhov in the Soviet Union. It will be used in a collaborative experiment by Soviet and CERN scientists in one of the first experiments on the newly commissioned 76-GeV proton synchrotron at Serpukhov. The equipment includes a fast-ejection system and radio-frequency separator. □