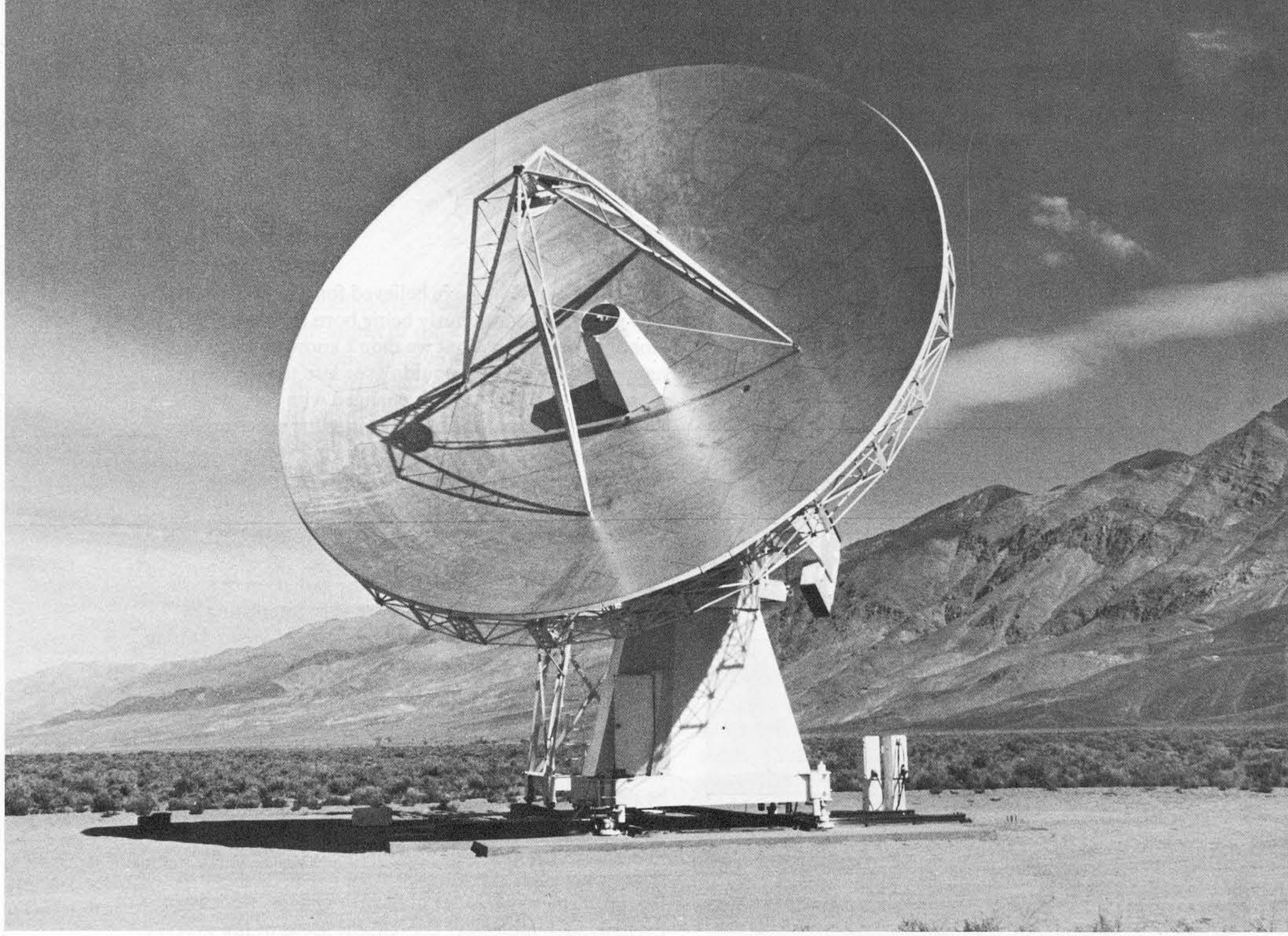

The Millimeter-Wave Telescope

Most work in radio astronomy is carried out in the centimeter-wavelength region. But a new high-precision millimeter-wave radio telescope at the Owens Valley Radio Observatory has now opened up a whole new region of the spectrum to study by astronomers.

The new radio telescope, which has been in operation since November 1977, has already reached the highest resolution ever achieved with a single-dish radio telescope, and it has also achieved several times better sensitivity than any other device for examining millimeter-wavelength radio waves from space.

A pioneer in the relatively new field of radio astronomy, Caltech began operating its Owens Valley Radio Observatory in 1958 with two radio telescopes in the meter and decimeter range. Another was added in 1969. The use of these radio telescopes has led to the discovery of essential information about the universe, including the identification of the first quasars, detailed mapping of the radiation belt around Jupiter, and the mapping of the distribution of hydrogen in nearby galaxies.

Studies of millimeter wavelengths and below should now give astronomers new information about molecules in other gigantic nebulae in outer space where stars condense from gas and dust. Some nebulae are almost certainly sites where new stars are being formed today, and studies at these very short wavelengths will be important in understanding how stars are born.

Until recently astronomers have been nearly "blind" at wavelengths of one millimeter and less, because the technology needed to build the necessary receivers and high-accuracy radio antennas had not been developed. The original Caltech instrument was constructed using high-precision techniques developed by Robert B. Leighton, professor of physics, and his colleagues—Alan Moffet, director of the Owens Valley Radio Observatory and professor of radio astronomy; Gerry Neugebauer, professor of physics; and Duane O. Muhleman, professor of planetary science.

Two more millimeter-wave telescopes will be installed at Owens Valley in the next few years, and the three telescopes, mounted on railroad tracks allowing them to be moved perhaps as much as 1,000 meters apart, will constitute an interferometric array. The millimeter-wavelength array should be capable of resolution up to 100 times higher than that of a single large telescope.

A fourth telescope, with slightly greater precision, will be installed on a mountaintop, to place it above as much radiation-absorbing atmospheric water vapor as possible. It will be used for high-sensitivity studies of sub-millimeter waves, whose wavelengths range from one-tenth to one millimeter.

The construction of the telescopes is being supported by the National Science Foundation. Other support for initial design came from NASA, and the Oscar G. and Elsa S. Mayer Charitable Trust provided funds for the control building. The Kresge Foundation of Troy, Michigan, is supporting construction of the sub-millimeter mountaintop telescope. The telescopes will be operated as nationally available scientific facilities, with as much as half the observing time allotted to visiting scientists.

The instruments are being constructed using high-precision techniques developed by Leighton and his colleagues. Each 10-meter (34-foot) radio dish is constructed with a framework of steel tubing, supporting a reflector surface composed of interlocked hexagonal panels. Each panel is an aluminum honeycomb about three inches thick—which affords both strength and light weight—covered with thin aluminum sheets.

After assembly of the steel framework, and mounting of the honeycomb panels, the entire dish is rotated on a turntable, like a gigantic lazy Susan, and the honeycomb surface is shaved to the precise shape required, using a fine, spinning saw blade. Then the aluminum sheets are glued in place, using a vacuum process to mold them onto the honeycomb. The sheets may then be chemically etched to even finer tolerance.

In order for a telescope to be useful for focusing at millimeter wavelengths and below with little distortion, its surface must be a parabolic curve accurate to better than two-thousandths of an inch or less. The new dishes have surface accuracies of about one-thousandth of an inch, and the sub-millimeter-wave telescope will have an accuracy of less than one-thousandth of an inch. □

Checking the mirror of the prototype telescope after final preparation in the old 200-inch optical shop.