In addition, at all times, the horizon would appear to curve up instead of down, so that to the observer it would appear as if he were standing in a hole.

Even had it had no experiments aboard, Mariner 5 would have made a contribution. Analysis of its trajectory provided pinpoint-accurate calculations that led to new values for the mass of Venus (.815003 times that of the earth), the mass of the moon (1/81.2999 times that of the earth), the astronomical unit or mean distance from earth to the sun (92,955,659 miles, plus or minus 62 miles) and other quantities.

Collecting Mariner's information was a nerve-racking experience. The signal strength at one point got down as low as 10^{-20} watts. One team of experimenters at Stanford even arranged to have the entire town of Woodside, Calif., switched to auxiliary electric power to ensure reliable continuous operation for its experimets, which could only be done once during Mariner's 23-minute trip behind Venus.

Despite the reams of data accumulated from Mariner 5 and Venus 4, Venus seems determined to hold on as long as possible to her title of earth's secretive sister (SN: 7/22). Among the unanswered questions: Why does the planet stubbornly rotate in the opposite direction from all but one (Uranus) of the other planets in the solar systems? And why do the dense clouds that cloak her in mystery scream around the planet 50 times faster than she herself is turning? Venus's hostile environment may never see a live astronaut, but scientists will continue to seek their answers in whatever ways they can. Until money and favorable earth-Venus positions are available, they will delve into the tapes of the Mariner message and whatever raw data the Soviets make available. Hidden there may be answers to innumerable questions that we don't yet know enough to ask. ◈

RADIO ASTRONOMY

Progress in Europe: Envy across the Atlantic

American radio astronomers have good reason to envy their European colleagues; two papers in an international symposium just ended at the Massachusetts Institute of Technology outline European projects for large radio telescopes which have been authorized. By contrast, American projects discussed at the symposium are frozen on the drawing board—and likely to remain there for at least a year, victims of present frostbite climate in money for basic research.

The largest fully steerable radio telescope today is the 250-foot diameter dish at Jodrell Bank in England. This will be surpassed by 1970 when a 328-foot dish, now being built for the University of Bonn, West Germany, goes into action. In 1971 the British will again take the lead with a 400-foot instrument.

Dr. O. Hachenberg, of the Max-Planck-Institut für Radioastronomie, describes the $5.5 million Bonn telescope as able to withstand winds up to 40 miles per hour without deformation. He expects to lose only one day of observing time a month through bad weather. His design team studied the possibility of enclosing the antenna in a radome, but concluded it would cost too much.

The major news of the meeting came when H. C. Husband of Husband and Co., announced that the British Government had granted his firm the contract to design a 400-foot telescope as a big brother for Jodrell Bank's instrument, designed by the same firm. Although the Government has not yet decided to build the instrument, this step is almost certain.

Like the 250-footer, the new instrument will be run by the University of Manchester's Radio Astronomy Department, headed by Sir Bernard Lovell. It will cost $14 million, and should be operating within four years. The antenna will function on a broad range of wavelengths down to 10 cm.

The new telescope will be located some distance from Jodrell Bank. This will permit radio astronomers to perform interferometry experiments with the two large dishes; by making simultaneous observations of objects in the sky with two radio dishes, astronomers achieve a resolution equivalent to that from a giant dish stretching between the two. Microwave radio will connect the pair.

American astronomers, while privately expressing some doubts as to whether the new instrument will achieve its anticipated accuracy, unanimously applauded Sir Bernard's success in obtaining funds for an instrument which, in the words of one American, "will keep the British in the forefront of radio astronomy."

The U.S. answer to the giant European dish is a 440-foot antenna enclosed in a radome, proposed by Northeast Radio Observatory Corporation (NEROC), an association of northeastern universities. A special panel set up by the National Science Foundation recommended in August that the proposal should be deferred until more is known about its performance in comparison to that of fixed spherical dishes of the Arecibo type.

NEROC's studies show that a radome-enclosed structure should cost about $17.7 million, about half as much as an exposed telescope of equivalent performance. And the radome offers many additional advantages, according to Herbert G. Weiss of M.I.T.'s Lincoln Laboratory. It gives the radio astronomer an air-conditioned room in which to operate his telescope. An antenna protected by a radome can be constructed inexpensively of lightweight materials, and thus requires less power for steering. Using computers to process all possible antenna designs and a radome to protect the dish, designers can now give the radio astronomer complete control over the performance of his instrument. And a radome-enclosed antenna gives more aperture per dollar, in Weiss's view.

Obviously, radomes have their disadvantages. The dome on NEROC's proposed 440-footer will reduce its effective diameter to 400 feet. Rain increases the noise from the radome. According to C. Scruton of the National Physical Laboratory in England, little is known, at present, about the effects of high winds on radomes.

However, NEROC proponents believe that they have ironed out most of the problems, and foresee that future larger instruments (above 500 feet) will inevitably require the protection of radomes. Given the funding, there appears to be no reason why fully steerable telescopes so protected should not reach 1,000-feet in diameter. For example, Paul Weidlinger, a consultant for NEROC, announced that he had sketched out a preliminary for a 1,000-foot antenna which appeared perfectly feasible. Possibly, he said, radio astronomers are not brave enough in specifying their requirements. ◈

HOYLE ON STONEHENGE

Building bridges between disciplines

Britain's Stone Age Mt. Palomar—Stonehenge—was apparently built so that ancient sun worshippers could predict when their god would be eclipsed.

Stonehenge is a circular pattern of large stones in southern England that includes 56 stones in the outer ring. The stones are laid out in a scheme that obviously has meaning, but there is no agreement as to what that is.

That Stonehenge served as an astronomical observatory (SN:12/17/66) has been advanced by astronomers since early in this century, but archaeologists have not found the astronomical thinking convincing.

Now, however, Dr. Fred Hoyle, director of England's new Institute for Theoretical Astronomy at the University of Cambridge, has built a bridge between the two sciences. He presented arguments that eliminated many of the archaeologists' reasons for disagreement at the Autumn Meeting of the National Academy of Sciences in Ann Arbor, Mich., last week.

Archaeologists have generally attacked the astronomical theories on the grounds that Stone Age man lacked the sophistication to figure out the theoretical basis of such a complex observatory. Dr. Hoyle suggests that they didn't start with a theory, but with a pragmatic wooden model that they could change as its defects became obvious. Only when the observatory evolved and actually worked did they make it permanent.

Dr. Hoyle believes that the outer part of Stonehenge—the 56 circular markers —was built a little after 3000 B.C., and that the center structure for predicting solar and lunar eclipses was built several hundred years later.

The great stone monoliths at the center of Stonehenge were put in place after a long, painstaking test by trial and error using wooden posts.

The first wooden model tested could have resulted from the insight of a Stone Age genius equivalent to this century's Albert Einstein, Dr. Hoyle believes.

One of the most recent and ardent exponents of Stonehenge as an astronomical observatory is Dr. Gerald Hawkins of the Smithsonian Astrophysical Observatory in Cambridge, Mass. He also suggests that the large stone markers were placed in a pattern for predicting solar and lunar eclipses but thinks the ancient men had worked out the proper positions theoretically. Rather, suggests Dr. Hoyle, the pattern of Stonehenge was worked out as a field experiment by very observant men who noted that every year the sun's position in the sky was the same at the same time, such as mid-summer or mid-winter.

To measure such positions accurately, they would have had to use relatively long distances for sighting, such as a circle about 100 yards in diameter, which is the size of Stonehenge. Many of the stones, however, seem to be slightly out of place for accurate measurements of solar and lunar positions.

Dr. Hoyle has found that 19 of the 23 positions that seem to be out of line would be correct if they were lined up for observing not the actual date of mid-summer, but for two other observations: one during the week it approached its solstice and one as it moved back again. The average of these two observations would give a more accurate astronomical position than a single sighting at the time of solstice.

After several years of such observations, Dr. Hoyle speculates, the Einstein-of-his-time would have noticed that solar eclipses occurred only when the sun, earth and moon were lined up. The group then added the markers necessary to predict solar eclipses, first using wooden posts and then replacing them with the immovable stones so that later generations could not move them out of line. ◈

AUTO POLLUTION

Pursuing the possible

Henry Ford made the internal combustion engine America's means of private transportation—and brought with it economic blessings and social woes. The blessings have been here for decades; the woes—traffic jams and air pollution—are rapidly catching up.

"We're on our way to a public catastrophe; people are going to get killed," said Dean Myron Tribus of Dartmouth's School of Engineering last week. "Carbon monoxide levels in New York City are approaching the lethal level."

Dr. Tribus is a member of the private Panel on Electrically Powered Vehicles which is delivering its report on autos and air pollution to the Department of Commerce. Part I, the general report, is in hand; Part II, report of the technical panels, is on the way.

In effect, the panel's recommendations play down the possibilities of other modes of moving automobiles and concentrate on cleaning up the trail of the internal combustion engine.

The report as could be expected, immediately stirred up controversy. It's bound to stir up more.

The measures recommended to cut auto pollution are tough and expensive. Total emissions should be cut to a seventh of the 1968 national standards by 1980; antiknock lead should be limited; standards should be based on the amount emitted, rather than a percentage of the total exhaust, a procedure which favors big cars.

The panel's approach is based on practical economics. The internal combustion engine is here and the pollution problem demands action. Pollution controls, although expensive, are economically feasible with known devices and those in sight. Any alternate, low pollution propulsion, such as electric cars, steam engines, and turbines, are too far down the road to get in production fast enough to help.

In its enthusiasm to focus immediate attention on cleaning up the internal combustion engine, however, the panel