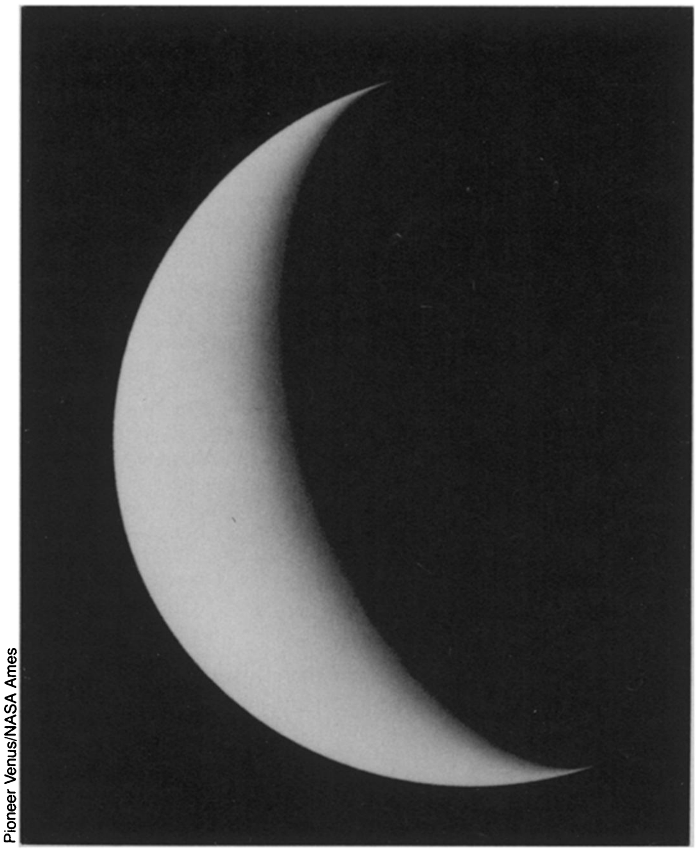
Pioneer Venus: A Crowded Start

It was a veritable invasion of Venus, complete with strategy, tactics and three coordinated assault waves involving the most concentrated armada of spacecraft ever sent from earth to another planet: six, all of them arriving in less than a single week, five in less than two hours.

The first member of the Pioneer Venus fleet took up station around the planet on December 4, following a critical firing of its engine that had to take place while Venus was blocking radio contact with tense flight controllers at the NASA Ames Research Center in California. Entering an orbit that took it as near as 378 kilometers to the haze-wrapped world's surface (and as far as 66,000 km), the craft began a cautious descent: Its next close encounter, a day later, was lowered to 250 km, a drop of 128 km, but the following day's shift was only 50 km. Then 20 more, then 10, then 5, and 5 again, gingerly dipping a well-instrumented toe ever deeper into the fringes of the much studied but little understood atmosphere. The goal: a plunge to or near the 150-km level on each of the 225 terrestrial days making up a full Venus year (the orbiter had actually begun making useful measurements an hour after its May 20 departure from earth, recording powerful bursts of gamma rays from space with a detector which, although nondirectional, can now be triangulated with similiar instruments on at least eight other spacecraft to pinpoint the bursts' heretofore elusive sources).



Pioneer Venus/NASA Ames

Dawn on Venus rendered in ultraviolet light. First image taken by cloud polarimeter aboard the Pioneer Venus orbiter.

The rest of the armada arrived on December 9. No toe-dipping here, but straight-in dives to the surface by four probes equipped to measure temperatures, pressures, winds, cloud particles and atmospheric components on the way. Hot on their tails, came the assault's last wave — the mother ship or "bus" that had carried the probes from earth until their separation last month (SN: 11/25/78, p. 356). The bus, also instrument-laden, lagged far enough behind after the separation to serve as a beacon in the incredibly complex radio-tracking of the probes' descents, key to producing four detailed vertical "profiles" of the Venusian winds. Scarcely half an hour after the last probe hit the surface, the bus itself slammed into the atmosphere, sampling the planet's "air" to within as little as 110 km of the ground before burning up from friction.

Unexpectedly, one doughty probe actually outlasted the bus. Sent to about the 30th parallel in the southern hemisphere's day side (a larger probe went to the sunny equator, while two other small ones descended into night), it was designed, like the rest, merely to reach the surface, not necessarily to survive the impact. The others succumbed on schedule. Yet as amazed scientists and engineers clustered around a monitor and reporters counted off the time, "superprobe's" signals continued to be received for nearly an hour and eight minutes, despite outside temperatures that would melt lead and a pressure of nearly 100 earth atmospheres. Of the eight past Venus craft actually designed to work on the surface — all of them Soviet Venera landers — only four did so at all, and only one (the 1972 Venera 8) yielded a longer report. The most recent, Venera 10, was received for 65 minutes after touchdown. The Pioneer Venus probe carried only limited instrumentation, however, and its radio bonus is likely to provide only a correction factor for atmospheric scintillation in the doppler-shift measurements of the wind-profile experiment. With a lot of luck, an on-board accelerometer (sent along to yield atmospheric densities from deceleration measurements) could turn out to have produced readings of background seismic activity.

It's remarkable that, with its orbiter, multiple probes and bus, the Pioneer Venus project is actually a cut-rate mission, studying its target planet from beyond the ionosphere to the surface from diverse view points and with matched suites of sensors for about $230 million, including the costs of two launchings. The data gathered by the probes and bus during last Saturday's burst of activity will take months or years to analyze, and the orbiter is just getting started. Yet even the limited findings already in hand, many of them far from complete, promise major gains in knowledge of this radically alien world that was once blandly dubbed earth's twin.

The atmosphere is unquestionably the star of the show. Largely carbon dioxide with hazes of sulfuric acid and other vitriolic constituents, it had already been probed from earth and *in situ,* but Pioneer Venus (and two Soviet lander-flyby combinations now on their way) have much to add. Though differing sensors have produced initially conflicting reports on the atmosphere's composition (some key analyses have yet to begin), there are intriguing highlights. Prominent is the case of argon, a constituent of interest in part because while its most common present isotope — argon 40 — is produced by the decay of potassium-40, other argon isotopes are believed to be survivors of the original mixture of materials in the cloud from which the solar system condensed. Argon is chemically inert, preventing it from being bound up in compounds such as oxides, and too heavy to escape into space; thus its primordial isotopes are considered one of the keys to deciphering the materials available when and where the planet in question formed.

One set of Pioneer Venus instruments mass spectrometers — appears (although the mission is still young and another sensor is so far in disagreement) to offer preliminary indications that while Venus and earth may have similar total amounts of argon, Venus has a markedly greater proportion of the primordial isotopes. If true, it is still only part of a complex and yet-evolving picture with many interpretations, but one indication of the scope involved is suggested by Michael B. McElroy of Harvard University, who raises the question of the basic genetic differences among the inner planets.

Some past models of planetary formation have assumed that the solar system's worlds condensed from a roughly homogeneous mixture — that they were made from similar materials. Studies of Mars by the Viking spacecraft had shown a number of key elements such as nitrogen in proportions similar to earth's, and although primordial argon was much lower, McElroy says, alternate ideas were offered to rationalize the discrepancy. Perhaps, for example, when Mars condensed, the nitrogen from the primordial nebula was chemically or otherwise held within the planet more effectively than was the inert argon, letting the argon "outgas" first to form a primitive atmosphere. The early energetic solar wind could then have swept past the planet carrying off much of the argon so that it would be underrepresented in the atmosphere that emerged later (including the nitrogen) after the solar wind had "died down." Earth would not have showed such an effect, since its much stronger magnetic field would have held off the solar wind; Venus, however, already suspected of having a very weak field, would make an excellent test. The field is indeed extremely weak, as the Pioneer Venus orbiter's magnetometer is already confirming, yet some of the mass spectrometer data seem to show a rich supply of primordial argon. The inference, McElroy says, is that the preplanetary nebula may have been not homogeneous but gradated, with the amounts of argon and other gases decreasing with distance from the sun. Venus, closest to the sun of the three inner planets with atmospheres, would thus retain the most primordial argon; earth would be in the middle, while Mars would have least of all — a neat sequence that fuller studies of the data may or may not support.

Another key element on Venus is sulfur, suspected to exist in various forms and believed by some to account for the dark streaks in computer exaggerated versions of ultraviolet images returned by the Mariner 10 spacecraft (since sulfur is an absorber of UV). Although early analyses this week were just beginning to reveal the possibly wide range of sulfur compounds in the atmosphere, even the first of the Pioneer Venus orbiter's UV images added interest by failing to show the dark markings, an indication that they may occur below an overlying haze layer.

Also intriguing, the descending probes revealed the atmosphere's particles and droplets to be grouped in several discrete size ranges — an odd finding made even stranger when all the particulates seemed to abruptly disappear below about 45 km, the bottom of the main haze layer. The thick yet surprisingly clear atmosphere beneath, says Robert Knollenberg of Particle Measuring Systems, Inc., is "immaculate."

A major part of the mission is plotting the hot atmosphere's dynamics — the ways in which the incoming solar heat and that trapped by the "greenhouse effect" are transported up, down and around the planet. Scientists this week were beginning to plug their new data into various proposed circulation systems, including elaborate patterns of convection cells and such concepts as "vertical jetstreams." Infrared data from orbit suggested the visible cloud tops in the polar regions to be warmer than those near the equator, prompting the speculation that the polar clouds are lower, driven down by descending air from lower latitudes. (Unfortunately, temperature readings from the probes' descents seemed strangely to become erratic below about 15-km's altitude, though the information is expected to be extractable from other sensors.)

Meanwhile, above the atmosphere, the planet's weak magnetic field lets the solar wind reach almost unimpeded to the ionosphere, an unearthlike relationship compared by one scientist to "spraying a billiard ball with a firehose." In parts of its ever-shifting orbit the orbiter is enabling the first steps in mapping new details of the interaction region's shape — the close passage of the solar wind past the planet, the shockwave sunward of the ionosphere's boundary — while elsewhere is unpredictable turbulence. A controversial possibility is that the "wind" may actually get close enough to affect the bulk atmosphere, such as in McElroy's highly tentative suggestion that the escape of hydrogen from the top of the atmosphere may be balanced by incoming hydrogen from the sun. Although Venus is virtually a waterless planet at its surface, perhaps such a hydrogen balance could contribute to keeping the atmosphere's minimal amount of water vapor in some sort of steady-state situation.

As for the surface of the planet, Pioneer Venus carries the one known eye that can "see" it from orbit: radar. A tiny swath of the surface is covered each day by the instrument, leading — after lengthy and careful processing — to both images (not photos, but representations of radar brightness) and elevations. Both components are necessary if scientists are to reduce the great uncertainty about the surface of Venus — just one of the many long-range goals of the Pioneer Venus mission. □

Indirect evidence for gravity waves

Physicists — and maybe the rest of the world — have waited many years for a direct confirmation of the existence of gravity waves (SN: 3/18/78, p. 169). The waves are predicted in Einstein's theory of general relativity and involve oscillating gravitational forces as light waves involve oscillating electric and magnetic forces.

Now, thanks to the only radio pulsar known to be a member of a binary star system, there is indirect evidence for gravity waves. Richard A. Taylor of the University of Massachusetts reported to the Texas Symposium on Relativistic Astrophysics meeting in Munich this week that a four-year monitoring of that pulsar by him, Peter M. McCulloch (on leave from the University of Tasmania) and Lee A. Fowler shows that the binary system is losing energy at a rate consistent with gravity wave emission. Theory says binary systems should emit gravity waves. The waves carry away energy, and the loss of energy means that the binary orbit shrinks. A narrower orbit means the pulsar goes around faster, and this orbital motion can be monitored because the pulsar emits sharply timed radio bleeps. □

Resistance is in the genes . . .

Insects become resistant to pesticides, bacteria become resistant to antibiotics and malignant cells become resistant to cancer drugs. A common mechanism may explain these frustrating developments and dictate principles for rational drug therapy.

Resistant in insects, bacteria and cells develops through survival of the organisms most capable of counteracting the drug. Robert T. Schimke and co-workers at Stanford University have analyzed the resistance of laboratory-grown mouse and hamster cells to methotrexate, a drug commonly used in treating malignancy. Generally the cells develop resistance by boosting their production of the enzyme dihydrofolate reductase (DHFR), inhibited by the antimalignancy drug. The resistant cells contain approximately 200 times as much DHFR as sensitive cells, and can survive in concentrations of methotrexate 3,000 times greater than the normal lethal level.

Genes are at the bottom of the sensitivity change, and it is a gross effect, the researchers find. The resistant cells contain approximately 200 times the normal number of DHFR genes, Schimke explains in the Dec. 8 SCIENCE.

The many copies of the DHFR gene are clustered in an expanded region of one chromosome in the resistant cell, Jack H.