transferring energy from the solar wind to the ionosphere and atmosphere. It appears that Landau damping of whistler mode waves from the ionosheath by ionospheric electrons is a significant heat source for electrons in the daytime. This is not the case at night where the ionosphere and the shocked solar wind do not seem to be in intimate contact. However, whistler mode waves, associated perhaps with lightning, have often been detected deep in the ionosphere at night.

Measurements by the OPA of the dynamic and direct interaction between the solar wind and the ionosphere and atmosphere of Venus reveal the presence of photoelectrons and shock heated solar wind electrons in the daytime ionosheath. The low energy photoelectron population was absent in the night ionosphere. However, as was already stated, the total ionization rate of the electrons between 50 and 500 eV appears to be adequate to produce observed electron density profiles. There is evidence that ionosheath flow is occasionally deflected into a conical cavity that appears to exist between the boundary of the ionosphere and the ionosheath downstream from the terminator.

Magnetic field. The orbiter magnetometer (OMAG) data on the nightside of Venus indicated sometimes strong but variable fields that were draped around the planet. There was little evidence for a systematic vertical component of the field. The upper limit on an intrinsic planetary moment is shrinking toward a value much less than 10^{22} gauss-cm^3.

Surface and interior. Topographic results obtained by the orbiter radar (ORAD) operating in the altimetry mode indicate that the radar bright feature called Maxwell is a broad plateau with a rough surface 1000 km by 700 km in extent rising 6 km above the surrounding plain. A ridge 6 km higher still runs parallel to the northwest-southeast plateau margins. A smooth pear-shaped region west of Maxwell is a plateau 1000 km across elevated to 5 km above plains to its south and west. This feature appears to be tectonic, whereas Maxwell might be either of tectonic or of complex volcanic origin. The radar bright features Gauss and Hertz may be volcanic. The first data obtained in the imaging mode at a longitude of about 340° in the northern hemisphere appeared to show impact craters about 250 km in diameter with only about 600 m of relief.

Orbital perturbation analysis for gravity field anomalies reveal no gravity signature near the great northern plateau (Maxwell). Hence, this feature appears to be isostatically compensated at depths of 100 km or less. Long wavelength anomalies were analyzed in three representative orbits for the power of the gravity spectrum. The power exceeded the terrestrial average spectrum by a factor of almost 4. It seems likely that these anomalies arise from the mantle as they do on Earth, rather from density anomalies in the lithosphere. Dynamic processes, such as convection in the mantle of Venus, would appear to be much more vigorous than in Earth's mantle.

Gamma bursts. The orbiter gamma burst detector (OGBD) has reported 14 gamma-ray burst events that have also been observed by detectors on other spacecraft. Preliminary locations for three events have been proposed, one of them in the direction of the Large Magellanic Cloud. None of the three lie in the plane of the galaxy. Hence, they appear to be either very near or very far from Earth on a galactic scale.

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Encounter with Venus: An Update

Abstract. *This report is an introduction to the accompanying collection of early results from the Pioneer Venus orbiter and multiprobe missions, which encountered Venus on 4 December and 9 December 1978, respectively. Initial results for the multiprobe mission and for the first 30 days of the orbiter mission were reported in the 23 February issue of* Science. *Additional mission features and updated mission parameters based on refined tracking data and trajectory computations are presented here. New scientific results for both missions are given in the subsequent reports which cover the first 130 days (or orbits) of the nominal 243-day orbiter mission.*

Several mission features and initial scientific results of the Pioneer Venus multiprobe and orbiter missions have been reported (*1*). The reader is referred to (*2*) and the references therein for a basic description of each mission. This report presents additional mission features and corrects other mission parameters, based on refined tracking data and trajectory computations.

Orbiter. Figure 1 is a scale drawing in solar ecliptic coordinates of orbit 5 on 9 December 1978 (multiprobe entry day). Precise orbit parameters are listed in table 1 of (*2*). Periapsis occurred at 180-km altitude, 17°N latitude on the dayside, about 22° longitude from the evening terminator. Figure 2 demonstrates the way certain orbit relationships vary during the course of the nominal 243-day orbiter mission. Venus revolves about the sun once in 224.7 days (sidereal period) in a counterclockwise direction as viewed from the north pole. Meanwhile, she rotates in a clockwise (retrograde) direction about her spin axis once in 243 days (*3*). The Pioneer Venus orbiter rotates about Venus in an inertially fixed frame, once in about 24 hours. Figure 1a is repeated at the bottom center of Fig. 2, although only the line of apsides is shown to represent the Pioneer Venus orbit. Proceeding counterclockwise in Fig. 2, the Pioneer Venus-Venus system is depicted in increments of 1/4 Venus year. (Earth locations at these times are not shown.) Note particularly the manner in which periapsis subsequently "samples" the dayside, crosses the evening terminator and samples the nightside, crosses the morning terminator, samples the dayside, and again crosses the evening terminator at the end of the nominal mission. It is interesting to observe that although all Venus local times can be sampled in 224.7 days, it requires the full 243 days to sample all planetographic longitudes.

As discussed in (*2*), periapsis altitude is strongly affected by solar gravity perturbations in a varying fashion during the mission, necessitating active control to maintain the altitude variations within acceptable limits. Figure 3 shows the his-

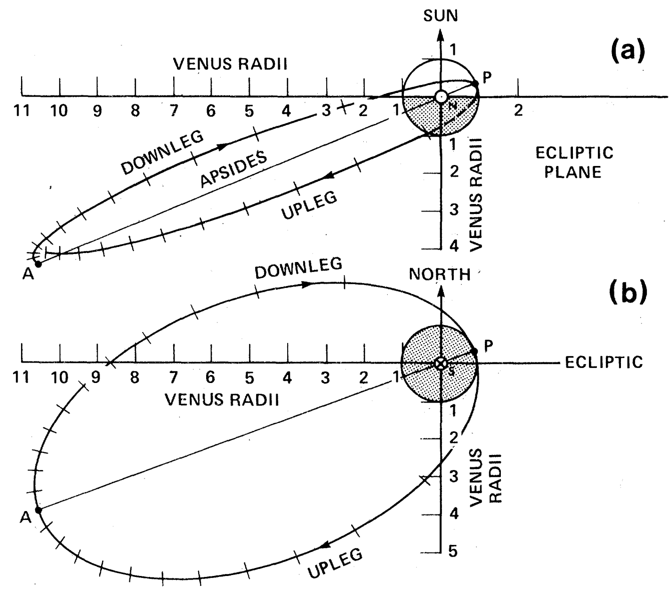
Table 1. Pioneer Venus multiprobe impact locations (semifinal determination).

Probe	Latitude* (deg)	Longitude* (deg)	Solar zenith angle (deg)	Venus local time
Sounder	4.4N	304.0	65.7	0738
North	59.3N	4.8	108.0	0335
Day	31.3S	317.0	79.9	0646
Night	28.7S	56.7	150.7	0007
Bus†	37.9S	290.9	60.7	0830
Subsolar point	0.5S	238.5	0	1200
Subearth point	1.6S	1.7	123.1	0347

*International Astronomical Union 1970 coordinates. †At 200-km altitude.

tory for the altitude of periapsis to date, plus a plan for the remainder of the nominal mission. Note that it was possible to reduce the altitude to about 142 km some five times while periapsis was on the nightside during February 1979. Figure 3 also shows some mission events, such as occultation and eclipse periods, that occur during the nominal mission (*4*).

Despite the apparently large number of orbiter thruster firings required to control periapsis altitude, sufficient fuel is



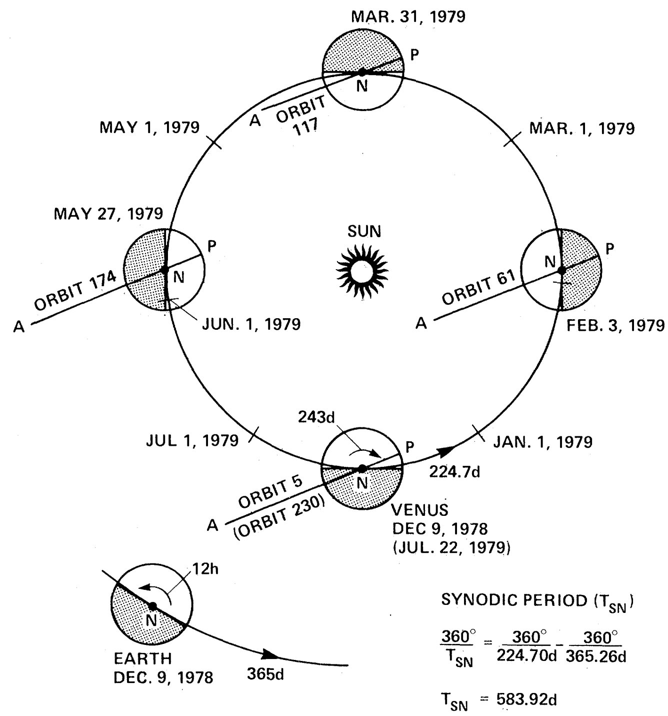


Fig. 1 (left). Pioneer Venus orbit 5, 9 December 1978 (multiprobe entry day), in solar ecliptic coordinates. (a) View of the orbit from the north ecliptic pole with the sun upward. (b) View from the antisolar point with the north pole upward. One-hour time ticks either side of periapsis (*P*) out to apoapsis (*A*) are marked. Whereas the latitudinal components of *P* and *A* remain fixed throughout the mission, the longitudinal or local time component varies (1.6° per day) as Venus revolves about the sun. Fig. 2 (right). The sun-Venus-Pioneer Venus orbit system depicted in increments of 1/4 sidereal year from 9 December 1978 (5 days after orbit insertion) to 22 July 1979 (224 days later). The nominal mission will extend for 243 days to 5 August 1979.

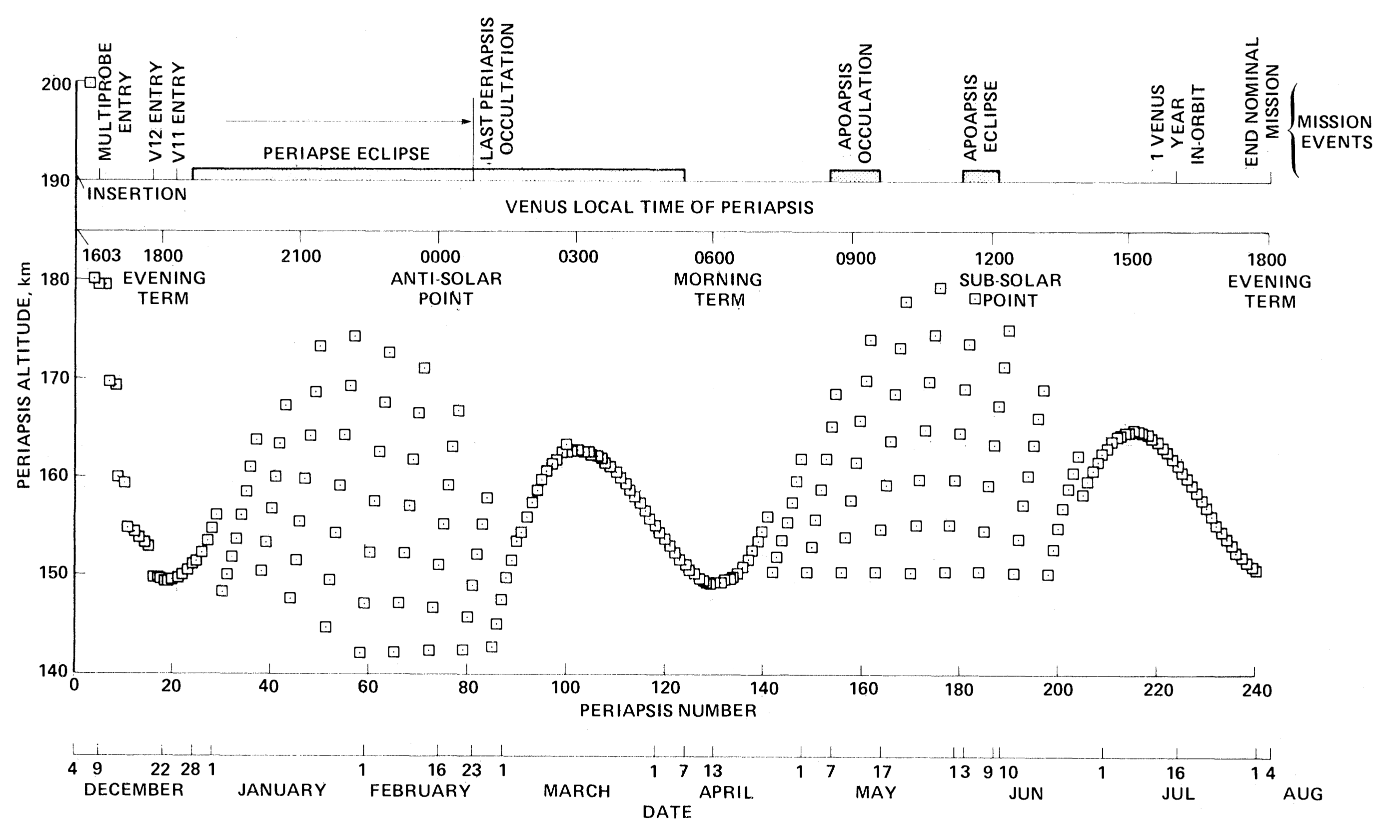


Fig. 3. Periapsis altitude control during the Pioneer Venus nominal orbiter mission. Actual values are shown to date, with a plan thereafter. Not plotted are the orbit insertion altitude, which was maintained for the first periapsis (orbit 0,1: 378.8 km), and the first active change (orbit 2: 247.5 km). Certain mission events and local Venus times of periapsis are shown through the mission. Also shown are the Pioneer Venus orbits of Venera 12 and Venera 11 entry when our orbiter cloud imager obtained pictures of the dayside cloud structure.

expected to remain for at least another 243 days of operation following 5 August 1979. An extended mission has been approved and planning is proceeding to optimize the anticipated scientific bonus.

Multiprobe. Table 1 contains semifinal data on the impact locations of all multiprobe spacecraft (*5*). These locations are extremely close to the targeting points that were planned before release of the probes from the bus in November 1978.

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References and Notes

1. *Science* **203** (1979), pp. 743–808.
2. L. Colin, *ibid.*, p. 743. Since Earth revolves in counterclockwise fashion about the sun in 365.26 days, the synodic period of Venus is 583.92 days, which is thus the time between conjunctions of the Earth-Venus system. Because of the retrograde 243-day rotation period, a Venusian solar day is 116.75 Earth days long, which is almost precisely a factor of 5 less than the synodic period. Thus the same face of Venus is presented to Earth at each interior conjunction.
4. Occultation and eclipse periods are based on tangents at radii of 6139.5 and 6130 km, respectively.
5. These data were obtained as follows. All probes turned on automatically about 22 minutes prior to entry at 200-km altitude and were tracked by the Deep Space Network stations. Trajectory computations were performed at Jet Propulsion Laboratory to provide entry boundary conditions at that altitude. Further computations were performed along a *vacuum* trajectory to 65 km; that is, no atmospheric drag was assumed. The listed impact locations in Table 1 are in fact these 65-km-altitude locations. Future plans call for (i) refining the 200-km-altitude boundary conditions and (ii) providing trajectory computations through a *model* static atmosphere all the way to the surface. Eventually, results of the wind dynamics experiments (differential long-baseline interferometry and the large- and small-probe atmospheric structure experiments) will permit determinations of descent variations from the locations given by the static model.
6. I would like to thank C. F. Hall, J. W. Dyer, and J. R. Cowley, Jr., of the Pioneer Project Office for their review of this report and for obtaining and providing most of the data herein. I would also like to sincerely acknowledge R. W. Jackson, R. O. Fimmel, and J. A. Ferandin for their exceptional efforts at orbiter operation and data processing.

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Thermal Contrast in the Atmosphere of Venus: Initial Appraisal from Pioneer Venus Probe Data

Abstract. *The altitude profiles of temperature and pressure measured during the descent of the four Pioneer Venus probes show small contrast below the clouds but significant differences within the clouds at altitudes from 45 to 61 kilometers. At 60 kilometers, the probe which entered at 59.3° north latitude sensed temperatures 25 K below those of the lower latitude probes, and a sizable difference persisted down to and slightly below the cloud base. It also sensed pressure below those of the other probes by as much as 49 millibars at a mean pressure of 200 millibars. The measured pressure differences are consistent with cyclostrophic balance of zonal winds ranging from 130 ± 20 meters per second at 60 kilometers to 60 ± 17 meters per second at 40 kilometers, with evidence in addition of a nonaxisymmetric component of the winds. The clouds were found to be 10 to 20 K warmer than the extended profiles of the lower atmosphere, and the middle cloud is convectively unstable. Both phenomena are attributed to the absorption of thermal radiation from below. Above the clouds, in the lower stratosphere, the lapse rate decreases abruptly to 3.5 K per kilometer, and a superimposed wave is evident. At 100 kilometers, the temperature is minimum, with a mean value of about 170 K.*

Since our initial report on the atmosphere structure data from the four Pioneer Venus probes (*1*) we have worked toward more precise analysis of the data, filled data gaps, received and interpreted data for an extended altitude range, worked on joining the entry and descent mode data, and attempted initial interpretations of the dynamical significance of the measured contrasts among the probes. The process is still far from complete.

We present here the results for the troposphere in altitude plots to show measured contrasts, discuss the stability of the atmosphere and factors which appear to be affecting it, present improved profiles of the lower stratosphere and compare them with those derived from orbiter remote-sensing (orbiter infrared radiometer experiment). We also discuss some indications of wind oscillations in the upper troposphere. Finally, we make some observations concerning possible dynamical significance of the structure measurements.

The current state of the temperature (T) data is shown in Fig. 1. The descent data from all four probes are shown to a maximum altitude (z) of 66.3 km. Although the first-order result remains that the thermal contrast is small, significant temperature differences are present above 45 km, within the clouds. At the north probe site, the atmosphere is cooler than at the day probe site, by 25 K at 60 km and by 18 K at 50 km. The order of the probes in the upper level temperatures corresponds reasonably to the order of the simultaneously observed infrared radiance at the sites (*2*). Below the clouds, the four curves coalesce to a band with a maximum width of 7 K at 20 km.

All the probes exhibit a temperature offset in the clouds, as compared to the profile below the clouds. This offset is as great as 20 K, defined relative to an extension of the temperature slopes below 40 km. The warming in the clouds is attributed to the absorption of thermal radiation from below as well as to solar absorption, since it occurs on the night probe but to a lesser degree than on the two dayside probes. It is interesting, but probably a result of opposing influences, that the night probe profile tracks the sounder profile very closely at the higher altitudes. The north probe profile, unlike the other three, is warmer than the extended lower atmosphere profile for only a limited altitude range from 40 to 53 km and then cools and drops below it. This may be a consequence of the entry of the north probe into the circumpolar cloud (*3*). Although it is not easy to see in Fig. 1 because of size reduction, there is also a sharp slope change in $T(z)$ at the 270 K levels of all four probes (this slope change is especially noticeable on the sounder profile). It could indicate a phase change in the cloud material, perhaps ice formation, or a change in species beginning at this level (56 to 59 km), which corresponds to the bottom of the upper cloud. [It is noteworthy that 80 percent H_2SO_4 solution freezes at 270 K (*4*).]

The day-night temperature contrast at 30° south latitude is less than 1K at altitudes between 18 and 48 km, that is, below the clouds. A single curve is drawn (Fig. 1) to represent the day and night probes in this range. Below 18 km, the atmosphere at the night probe site is shown to be about 2 K warmer than it is at the day probe site, a somewhat puzzling finding which may be due to inaccuracy. There is work yet to be done in refining these data.

Temperature data in the stratosphere, extending to 110 km, are also shown for the north and day probes in Fig. 1. These were obtained from deceleration measurements during high-speed entry (*1*) and have now been better joined to the descent data. To a first approximation, altitude and velocity are matched at the intersection of entry with descent measurements. The wave structure suggested in (*1*) is still present, with an amplitude of about ±20 K. The waves at the two entry sites are out of phase at an altitude of 97 km. The temperature minimum, including the wave minimum,

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