SECOND ARIZONA CONFERENCE ON PLANETARY ATMOSPHERES

The large majority of the papers contained in this issue of the JOURNAL OF THE ATMOSPHERIC SCIENCES were included in the program of the Second Conference on Planetary Atmospheres held at Tucson over the period 11–13 March 1968. The conference, held under the sponsorship of the Space Physics Division of the Kitt Peak National Observatory, was devoted primarily to the presentation and interpretation of the Soviet Venera 4 and the U. S. Mariner 5 spacecraft observations of the atmosphere of Venus. Several shorter papers prepared as a result of conference discussions are also included.

A Review of the Venera 4 Flight and Its Scientific Program

V. M. VAKHNIN

U.S.S.R. Academy of Sciences, Moscow

(Manuscript received 18 March 1968)

The automatic interplanetary station Venera 4 was launched towards Venus on 12 June 1967. The flight continued for 128 days and covered a distance of 350,000,000 km. On July 29 a trajectory correction was made. Venera 4 arrived at the planet on 18 October 1967 on the night side near the dawn terminator, and landed slightly above the ecliptic equator.

The flight of Venera 4 had the following scientific goals:

1. Cosmophysical investigations along the entire trajectory of the flight.
2. Cosmophysical probing of the near-planet region.
3. Deep penetration into the atmosphere and direct measurements of its physical and chemical characteristics.

The station consisted of two parts—the interplanetary stage and the descending stage. Throughout the flight, both stages were connected mechanically and electrically. They were disconnected at the time of entrance into the rarefied upper layer of the planetary atmosphere. Thereafter, the interplanetary stage, having completed its mission, was burned by aerodynamic heating. The descending stage was protected from the heat of entry by a special outer layer. It was decelerated by aerodynamic drag as it penetrated into the lower atmosphere. From the time of the opening of the parachute, at an altitude of 26 km, the descent to the surface lasted about 93 min.

The interplanetary block contained experiments invoking a three-component magnetometer with a range of 50 gamma, high-energy particle counters, low-energy plasma traps, and photon counters sensitive to the Lyman alpha line at 1216 Å and the 1304 Å oxygen line.

These devices operated during the entire flight up to the end of the operation of the interplanetary stage, and the data were stored in a special memory device. There were regular sessions of telemetry throughout the flight.

The duration of a telemetry session was usually from 1–2 hr. The interval between sessions was usually several days. During a typical radio communication session, the information that had been stored in the memory device since the previous sessions is transmitted. The rest of the session is used to transmit scientific data in real time as it was being acquired. A long session of real-time transmission began at 30,000 km above the surface and lasted until the end of the flight.

In the descending stage, instruments for investigating the lower layers of an atmosphere included a simple radio altimeter, a barometric device, a thermometer, an atmospheric density gage, and chemical gas analyzers for carbon dioxide, nitrogen, oxygen and water vapor. These instruments began their operation after penetration into the dense layer of the atmosphere, at which time a heat-proof cover was removed and the parachute was opened. Thereafter, continuous transmission of measurements occurred during the entire period of descent to the surface of the planet.

The measurements of temperature continued throughout the entire descent. The pressure and density measurements ended earlier, at a pressure of about 7.3 atm and 14×10^{-3} gm cm^{-3}, respectively, which were the limits of the range of the barometric device and densimeter. The chemical analysis of the atmospheric gases was taken twice, at altitudes of 26 and 19 km above the surface.

Before the flight of Venera 4 there was considerable uncertainty in knowledge of the physical conditions in the planet's atmosphere. Surface pressures suggested ranged from a few to several hundred atmospheres. Therefore, the calculation of the descent time was highly uncertain, ranging from a few minutes to many hours. In such circumstances, it would have been unreasonable to plan any investigations for the surface. Therefore, the construction of the descending stage and all its instruments was subordinated to one mission: deep atmospheric probing. The mechanical rigidity, the thermal characteristics and the electric power supply were designed for operation up to a level of about 25 atm. It was assumed that transmission would end if the pressure rose above 25 atm. In the actual flight, the descending stage probed the entire depth of the lower atmosphere and reached the surface. This conclusion is based on the calculation of the speed of descent, on the equation of hydrostatic equilibrium, and the comparison with radio altimeter measurements. At the predicted time of landing, the radio signal was interrupted suddenly without preliminary attenuation. This fact makes highly unlikely the suggestion that the transmission ceased because the electric cells became exhausted.

Of course, it should be noted that the Venera 4 measurements relate to a local region of the planet. There may be variations of these data over the planet because of the presence of highlands or lowlands or because of displacement of the center of mass. For example, the pressure on the earth varies by a factor of about 2 between sea level and mountain locations.

Important scientific data were received during all stages of the flight. We consider the most important result to be the direct measurements in the lower layers of the atmosphere. The general result of the flight is the reduction of the "field of hypothesis" regarding the nature of Venus. As can be seen, the hypothesis suggesting a nonthermal origin of the radio emission from Venus is eliminated; also, the fact that the atmosphere consists primarily of CO_2 reduces the difficulties in explaining the "greenhouse effect." The latitude in the quantitative characteristics of the planet, such as surface pressure, temperature, and the main chemical composition of the atmosphere, was also reduced. The uncertainty concerning the characteristics of near-planetary space, such as the magnetic field, near-planetary radiation, ionospheric electron density, and rarefied near-planetary gaseous corona, was reduced by some orders of magnitude. Detailed results will be given in the following reports.

The results of Mariner 5 are in good agreement with the Venera 4 data. Special mention may be made of the fact that the radio occultation experiment of Mariner 5 extends the data into regions in which Venera 4 did not conduct investigations.

Since the results of Venera 4 and Mariner 5, the attention of investigators in turning to such problems as the night-day variations of the physical characteristics of the atmosphere, the origin of the carbon dioxide atmosphere, superrefraction, new types of ionosphere and magnetosphere, etc.

The most significant result of both space flights is the expanded scientific interest in Venus and the reduction of uncertainty regarding the nature of the planet.