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V. V. KERZHANOVICH, B. N. ANDREEV, V. M. GOTLIB

INVESTIGATION OF THE DYNAMICS OF THE ATMPHERE OF VENUS USING THE AUTOMATIC INTERPLANETARY STATIONS "VENERA-5" AND "VENERA-6"

(Presented by Academician V. A. Kotelnikov, 10 XII 1969)

During the motion of the descent vehicles (DV) of the automatic interplanetary stations "Venera-5" and "Venera-6" in the atmosphere of Venus, measurements were made of variations in the radial velocity of the DV, from which pulsations of the wind velocity were determined. To measure the velocity and process the results, the same methods were used as during the landing of the AMS "Venera-4" ([1]).

During descent by parachute, the velocity of the DV relative to Venus V is determined by the wind velocity, the atmospheric density, and the aerodynamic characteristics of the DV and parachute. The radial component of the DV velocity V_r is determined as

$$V_r = V_{\rm v} \cos\lambda + V_{\rm g} \sin\lambda \cos A,$$

where λ is the angle between the direction to the Earth and the local vertical at the landing point, A is the angle between the horizontal component of the DV velocity and the projection of the direction to the Earth onto the local horizontal plane. According to trajectory-measurement data, for the landing point of the AMS "Venera-5" the angle λ was approximately 2.5° and $V_r \approx V_{\rm v}$; for the AMS "Venera-6," $\lambda \approx 7°$ and

$$V_r \approx V_{\rm v} + 0.12 V_{\rm g} \cos A.$$

As the measurements carried out showed, the change in the velocity of both DVs was smooth in character. This makes it possible to neglect the inertia of the DV-parachute system and to assume that at any instant

$$\Delta V_{\rm v} = W_{\rm v}, \qquad \Delta V_{\rm g} = W_{\rm g},$$

Fig. 1. Pulsations of the vertical wind velocity during the descent of the automatic interplanetary stations "Venera-5" and "Venera-6"

Figure 1: Fig. 1. Pulsations of the vertical wind velocity during the descent of the automatic interplanetary stations "Venera-5" and "Venera-6"

where $W_v, W_g, \Delta V_v, \Delta V_g$ are the vertical and horizontal components of the wind velocity W and the variations in the DV velocity under the action of the wind ΔV. In view of the smallness of the angles λ for both DVs, the quantity V_g does not have a significant influence on the radial velocity; therefore the subsequent estimates refer only to the vertical component of the wind velocity.

The measurement of variations in radial velocity was carried out by an interrogated Doppler method. According to investigations carried out under ground conditions and during the flight of the AMS, the intrinsic frequency fluctuations of the DV master oscillators at the carrier level did not exceed 1 Hz, which, when converted to radial velocity, is approximately 0.32 m/sec. In processing the measurements, account was taken of the regular drift of the oscillator frequency caused by the increase in temperature inside the DV during descent.

After narrow-band filtering, the received signal was fed to the Doppler-frequency measuring circuit, whose counting devices operated in the frequency-measurement mode (mode I) and in the period-measurement mode (mode II). The measurement characteristics are given in Table 1. The error values are given converted to radial velocity.

To determine the wind speed from the obtained values of radial velocity, all known quantities associated with the motion of Venus and the Earth were subtracted, as well as the radial component of the parachuting velocity, determined by calculation from the telemetry measurements of pressure and temperature in the atmosphere of Venus.

Fig. 1. Pulsations of the vertical wind velocity during the descent of the automatic interplanetary stations "Venera-5" and "Venera-6"

The results of determining the pulsations of the vertical component of the wind velocity during the motion of the descent vehicles of the automatic interplanetary stations "Venera-5"and "Venera-6,"obtained by averaging the measurements over an interval of 1 min, are shown in Fig. 1. Along the ordinate axis are plotted the values of the pulsation velocity $W' = \overline{W} - W_0$, where W_0 is the average over 1 min value of the vertical

Table 1

	Regime I	Regime II
Measurement rate, sec	1.8	0.8
Averaging time, sec	1.0	0.4
Reading discreteness error, m/sec	0.32	0.002

	Regime I	Regime II
Maximum fluctuation error, m/sec	0.2	0.3

component of the wind velocity, W_0 is the possible velocity of the vertical flow, constant throughout the entire descent of the descent vehicle. The root-mean-square error of the measurements when averaged over 1 min was determined mainly by short-term fluctuations in the frequency of the reference oscillators and amounted to approximately 0.2 m/sec.

The data presented, as well as the results of processing with a shorter averaging period, show that the maximum value of the pulsations of the vertical wind velocity over practically the entire descent segment of both descent vehicles lay within the limits of the measurement errors and did not exceed $0.3 \div 0.5$ m/sec. Changes in the magnitude of the velocity of the vertical flow itself also were not observed, and its gradient did not exceed 0.02 m/sec · km.

The method used made it possible to record pulsations with durations from several seconds and longer, which corresponds to spatial scales of turbulence greater than $20 \div 100$ m. Assuming the turbulence to be approximately isotropic, we arrive at an upper estimate of the pulsations of the horizontal component on the order of $0.3 \div 0.5$ m/sec.

From the magnitude of the pulsations one can make an indirect estimate of the horizontal wind velocity. Since the temperature stratification in the atmosphere of Venus is close to neutral ([2]), one may expect that the relative intensity of turbulence is at least of the same order as in the Earth' s atmosphere ($0.1 \div 0.02$ according to ([3]), the value 0.1 referring to wind velocities up to $5 \div 6$ m/sec). In this case, for the horizontal wind velocity we obtain an upper estimate of 0—($3 \div 25$) m/sec, with the smaller values being more probable. These estimates are of the same order as the data from direct measurements of the horizontal wind velocity obtained during the last $18 \div 20$ km of the descent of the automatic interplanetary station *Venera-4*, and do not contradict the theoretical estimate of the characteristic wind velocity in the atmosphere of Venus given in ([4]). The larger values of wind velocity and turbulence at the beginning of the descent of the *Venera-4* automatic interplanetary station may be associated with differences in current meteorological conditions, as well as with the considerable separation of the landing points.

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Note: Figure translations are in progress. See original paper for figures.