Translation of

"ISSLEDOVANIYE DINAMIKI ATMOSFERY VENERY S POMOSCH'YU AVTOMATICHESKIKH MEZHPLANETNYKH STANTSIY "VENERA-5" i "VENERA-6".

STUDY OF THE DYNAMIC OF THE VENUS ATMOSPHERE USING THE AUTOMATIC INTERPLANETARY STATIONS "VENER-5" and "VENER-6"

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During the motion of the landing capsule (LC) of the automatic interplanetary stations "VENER-5" and "VENER-6", measurements were made of variations in the radial velocity of the LC in the atmosphere of Venus. These measurements were used to determine the wind velocity pulsations. The same methods used during the landing of "VENER-4" [1] were used to measure the velocity and to analyze the results.

During the landing by parachute, the velocity of the LC with respect to "VENER-5" was determined by the wind velocity, atmospheric density, and aerodynamic characteristics of the LC and the parachute. The radial velocity component of the LC, V_r, was determined as

$$V_r = V_s \cos \lambda + V_r \sin \lambda \cos A,$$

where λ is the angle between the direction toward the Earth and the local vertical at the landing point; A is the angle between the horizontal velocity component of the LC and the projection of the direction toward the Earth on the local horizontal plane. Based on the data of the trajectory measurements, the angle λ was approximately 2.5° for the landing point of "VENER-5" and $V_r \approx V_в$, and for "VENER-6", $\lambda \approx 7°$ and

$$V_r \approx V_в + 0,12 V_г \cos \lambda.$$

As the measurements showed, the velocity of both LC changed smoothly. This made it possible to disregard the inertia of the LC-parachute system, and to assume that at any moment of time we have

$$\Delta V_в = W_в; \quad \Delta V_г = W_г,$$

where $W_в, W_г, \Delta V_в, \Delta V_г$ are the vertical and horizontal velocity components of the wind W and the velocity variation of LC under the influence of the wind ΔV. In view of the smallness of angles λ for both LC, the quantity V_r has no significant influence on the radial velocity. Therefore, further estimates pertain only to the vertical velocity component of the wind.

Variations in the radial velocity were measured by a non-interrogating Doppler method. Based on data from studies performed under terrestrial conditions and during the flight of the interplanetary stations, the natural frequency fluctuations of the master LC oscillators for the carrier did not exceed one Hertz, which — when we converted to radial velocity — comprises approximately 0.32 m/sec. When the measurements were analyzed, allowance was made for the regular drift of the oscillator frequency. This drift was caused by an increase in the temperature within the LC during the landing.

After narrow-band filtration, the signal was supplied to the measurement circuit for the Doppler frequency, whose measurement units operated in a frequency measurement regime (regime I) and in a period measurement regime (regime II). The measurement characteristics are given in Table 1. The errors are given as converted to radial velocity.

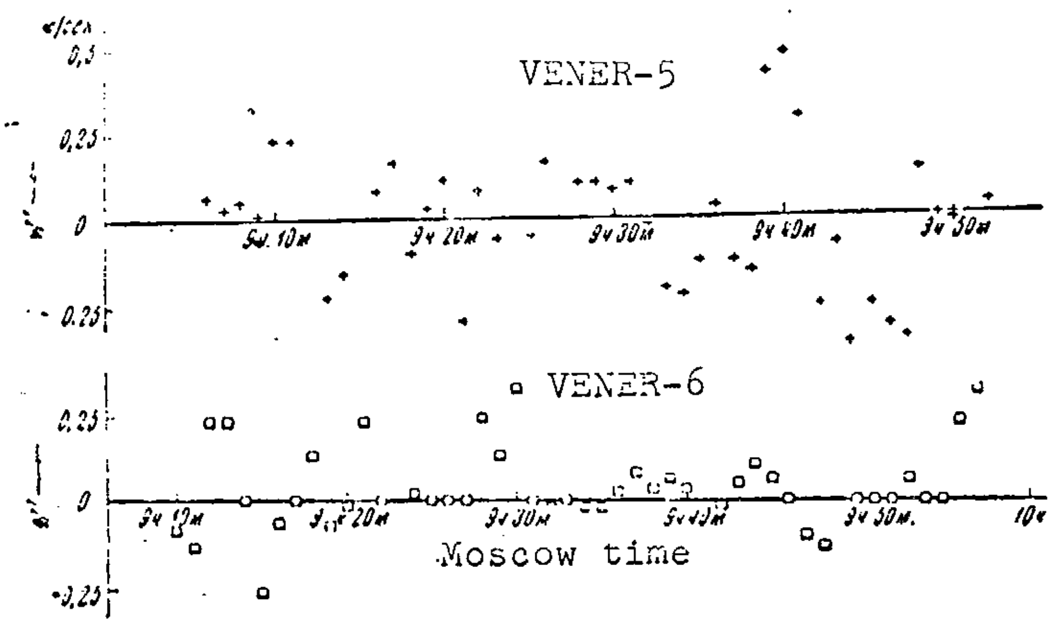

Figure 1. Pulsations of the vertical wind velocity during the landing of "VENER-5" and "VENER-6".

To determine the wind velocity from the radial velocity values obtained, calculations were made of all the known quantities connected with the motion of Venus and the Earth, as well as the radial velocity component of the parachute, calculated from telemetry measurements of pressure and temperature in the atmosphere of Venus.

Figure 1 presents the results derived from determining the pulsations of the vertical wind velocity component during the motion of the landing capsules of "VENER-5" and "VENER-6", which were obtained by averaging the measurements in a one-minute interval. The pulsation velocity $W' = \bar{W} - W_0$ is plotted along the ordinate axis, where $\bar{W}_0$ is the average vertical wind velocity component in one-minute; W_0 is the possible velocity of the vertical flow, which is constant throughout the entire landing of the LC. The mean square measurement error during one-minute averaging was primarily determined by the brief frequency fluctuations of the master operators, and was approximately 0.2 m/sec.

TABLE 1.

	Regime I	Regime II
Measurement time, seconds	1.8	0.8
Averaging time, seconds	1.0	0.4
Recording discreteness error, m/sec	0.32	0.002
Maximum fluctuation error, m/sec	0.2	0.3

These data as well as the results of an analysis with a smaller averaging period show that the maximum pulsation of the vertical wind velocity were within the limits of measurement errors throughout the entire landing of both LC and did not exceed 0.3 - 0.5 m/sec. There were no changes in the velocity of the vertical flow, and its gradient did not exceed 0.02 m/sec·km.

The method employed made it possible to record the pulsations lasting several seconds and more, which corresponds to a spatial turbulence scale of more than 20 - 100 m. Assuming that the turbulence was approximately isotropic, we arrived at a majorant estimate of the horizontal component pulsations on the order 0.3 - 0.5 m/sec.

Using the magnitude of the pulsations, we can make an indirect estimate of the horizontal wind velocity. Since the temperature stratification in the atmosphere of Venus is close to being neutral [2], we may expect that the relative intensity of turbulence is at least on the same order of magnitude as in the atmosphere of the Earth (0.1 - 0.02 according to [3], while the value 0.1 pertains to the wind velocities up to 5 - 6 m/sec . In this case, we obtain the majorant estimate 0 - (3-25) m/sec, for the horizontal wind velocity, and the smaller values are more probable. These estimates are of the same order of magnitude as data derived from direct measurements of the horizontal wind velocity obtained on the last 18 - 20 km of the landing of "VENER-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 in the beginning of the "VENER-4" landing may be related to the difference in meteorological conditions, as well as to the great distance from the landing point.

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