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IMPORTANT STEP IN THE KNOWLEDGE OF UNIVERSE

SOVIET INTERPLANETARY STATIONS "VENERA-5" and VENERA-6"

Analysis
of
"Pravda" Editorial

by

Andre L. Brichant

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Highlights of the Editorial
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Analysis of Essential Data
by ANDRE L. BRICHANT.

INTRODUCTION

There have been quite a number of Soviet press releases with reference to recent space feats. Each of them, besides repeating itself, lay considerable emphasis on the political aspects of Soviet achievements, glorifying leadership of the socialists society, and so forth.

Much has been said about the basic stages of Venus' study, namely in the latest Tass communique concerning the landing of VENERA-5" and "VENERA-6", released and translated a few days ago (ST-PR-LS-1083).

To avoid needless repetitions, this analysis will concentrate on the new data regarding the stations themselves, and especially on the scientific results achieved.

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SUMMARY

The present column covers one full page of PRAVDA plus about two-thirds of a page. It discusses the basic stages of development of Venus' study. It describes the setup of the 'sister" stations, giving a fairly complete description of the descending capsule. It discusses the trajectory, the flight itself, the entry and descent in Venus' atmosphere. The last chapter is fully devoted to the description, in a preliminary form, of the scientific investigations in the atmosphere of Venus. While the first chapters will be given a strictly abstracted form, the last chapter, with the conclusions arrived at, will be given full attention, constituting a practically cover-to-cover translation.

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BASIC STAGES IN THE STUDY OF VENUS

One of the earliest events was the discovery by Lomonosov of atmosphere of Venus in 1761. Little additional data were obtained by optical means in the following two centuries. The results of infrared spectrometry yielded during the nineteen hundred fifties some possibilities on judging about the temperature and chemical composition of the atmosphere above the cloud layer and, in particular, on the presence of carbon dioxide. At times opinions were expressed that CO_2 concentration should not exceed 5 to 10 percent, while the main component would be nitrogen, by analogy with the Earth. As to the temperature, spectroscopic measurements had shown that it would be about minus 30°C, with the possibility of its going down to minus 80°C, depending upon which gas prevails in the atmosphere of Venus.

The use of radiotelescopes in the middle fifties pointed to high temperatures of Venus surface, of the order of 250 — 450°C, while the question of pressure remained open, the magnitudes brought forward varying from one to 100 atm. To explain radioastronomical observations, various model atmospheres were proposed, including those assuming the presence at the planet of a powerful ionosphere at comparatively low values of temperature and pressure near the surface.

We shall not review here the accomplishments of the first Soviet Venus probes: VENERA-1, -2, -3, which were discussed in the last Tass communique. Nor shall we dwell upon the accomplishments of VENERA-4, having landed on 18 October 1967 after a journey of more than four months. These results were already reported in a number of scientific papers by Avduyuevskiy et al. We shall recall that VENERA'4's descent lasted 93 minutes, during which measurements of temperature and pressure were made and radiocommunication with the ground was continuous. The main result was the establishment of the fact that the atmosphere of Venus contains 90% of CO_2, instead of the 10% earlier assumed, while the near-surface temperature was found to be no less than 270°C, with pressure of 18 atmospheres or more.

The investigations of Venus'atmosphere were also carried out by the American probe "MARINER-5", which flew by Venus at a distance of about 4000 km one day after the descent of VENERA-4. American scientists used the radio-translucence method for the of Venus' atmosphere. Taking into account the data on gas composition, they could derive information on the higher layers of planet's atmosphere.

At time of preliminary processing of results of VENERA-4 measurements, the length of the measurement portion of trajectory was computed by the registered pressure and temperature using two methods: starting from the condition of hydrostatic equilibrium of the atmosphere amd starting from the equations of motion. The altimeter reading at the beginning of station's operation, showing 28 kilometers, agreed well with the length of the measurement sector. This allowed to draw the conclusion that the measurement of atmosphere parameters was conducted till the surface of the planet.

During subsequent, more elaborate joint processing of the results of atmosphere sounding obtained by VENERA-4 with the radioastronomical and radar investigations of the planet and of measurements by MARINER-5, the hypothesis emerged, that higher pressures and temperatures may exist near Venus' surface. This ties up with the fact that two values of altitude, differing by about 30 to 40 kilometers, might have corresponded to radioaltimeter reading. The indicated ambiguity is inherent to properties of altimeters with periodical frequency modulation. Thus emerged the assumptions that the descending apparatus of VENERA-4, could have ceased measurements above planet's surface. In this case the external pressure of the atmosphere, having reached the threshold of apparatus' strength, could have compressed the upper hood of the instrument compartment, having thus disrupted the entireness of radioinstrumentation complex and prevented the station to pursue measurements over the remaining part of the descent trajectory.

Naturally, the first flight of VENERA-4 could not possibly answer all the questions disturbing the scientists. New questions sprung up, requiring their own solution. With this in view, the investigation of Venus' atmosphere was continued by the launchings of "VENERA-5" and "VEMERA-6", stations of identical types but aiming at different regions so as to obtain practically simultaneous measurements of atmosphere parameters in distinct sectors. This ascribed to the results of study of Venus' atmosphere a new quality.

The following chapter will be devoted to the description of the construction and equipemnt of stations "VENERA-5" and "VENERA-6".

* * *

APPARATUS OF AIS "VENERA-5 and -6"

Both stations are analogous by construction and apparatus composition. They consist of two main parts: the orbital compartment and the descending capsule. The weight of these stations is 1,130 kg.

The orbital compartment constitutes a hermetic frame of cylindrical shape inside of which are installed the various radiocomplex devices, alo gside with those of thermoregulation, astro-orientation, the chemical sources of current and the scientific instrumentation. Installed in the compartment are also the correcting motive installation, the optical sensors, the final control element of astro-orientation, the solar battery panels, antennas and scientific devices' pickups. The descending capsule is fastened to this orbital section.

The descending capsule has a shape close to the sphere, of about 1 meter in diameter and 405 kg weight. The descending capsule has two hermetic compartments, the instrument and the parachute one. The instrument compartment includes radiotransmitters, the telemetry system, an energy storage battery, the program-time device, automation and thermoregulation units, the scientific instrumentation and an altimeter. The lower part of the capsule contains a damper, designed to decrease the oscillations during capsule descent in the planetary atmosphere. The parachute compartment includes two parachutes: a basic and a decelerating one, the sensors of the scientific instrumentation, the radiotransmitter antenna for communication with the Earth and the radioaltimeter antenna.

By comparison with AIS "VENERA-4", some modifications in the construction were found to be necessary. The principal aim being the improved descent through the planetary atmosphere, VENERA-5 and -6 were able to considerably ameliorate the measurement precision of chemical composition and of parameters of the atmosphere, and to more accurately determine the respective heights, increasing by the same token the depth of atmosphere sounding.

The descending capsules were strengthened within the bounds of their weights, with the result that it became possible to conduct measurements of Venus' atmosphere parameters within a range of pressures from 0.5 to 25 - 27 atmospheres. The capability of standing bigger overloads and higher temperatures during aerodynamic braking was also considerably increased. To most substantial remodeling were subject the parts of inner instrumentation of the descending capsule. This required a type of construction capable to withstand overloads up to 450 units during atmosphere entry, which is by a factor of one and one half higher than in the case of VENERA-4. The increase of overloads is explained by the fact that the entry velocity in 1969 was substantially higher than in 1967; this was due to the different respective positions of planets Earth and Venus. The action of a 450 unit overload can be illustrated as follows: a device, weighing one kg on Earth, will weigh during a few seconds 450 kg at entry into Venus' atmosphere. At the same time all parts of instrument fastening must solidly hold it in place.

Besides, in order to curtail the descent time of the capsule in the atmosphere of Venus, the area of the main parachute was decreased by several factors for earlier, it was designed for a lesser atmosphere density. The parachute dome was made up of a special heat-resistant tissue, capable of operating in a medium with temperatures in excess of 500°C. Several improvements were also made in the scientific instrumentation, by increasing their measurement range and precision. The various parts of stations VENERA-5 and -6 were subject to extensive ground tests, simulating the conditions of flight, thus ensuring a faultless performance of all systems during the course to Venus and the descent in its atmosphere.

* * *

FLIGHT TRAJECTORIES OF AUTOMATIC STATIONS

It is well known to our scientists that the selection of trajectories depends on a whole series of requirements, which we shall not discuss here. We shall retain only the facts that, basing themselves on the 584 day repetition of the favorable mutual position of Earth and Venus, the favorable flight time is when the Earth leads Venus by about 45° in the angular motion around the Sun. This resulted in a possible date range of one month for the start of both stations. Thus the respective dates of 5 and 10 January 1969 were chosen in this interval. The duration of flights for these dates constituted respectively 131 and 127 days. This resulted in the arrival to Venus with the interval of one single day. The escape velocity was nearly 3.6 km/sec. The total velocity at the end of the portion of escape constituted relative to Earth more than 11 km/sec. The flight trajectory is schematized in the Fig.

* * *

PHYSICAL INVESTIGATIONS DURING FLIGHT IN THE NEAR-PLANETARY SPACE

During the flight measurements were conducted of solar and galactic cosmic rays and the interplanetary plasma was investigated alongside with the scattering of Sun's ultraviolet radiation.

As was shown by measurements, the total level of the flux of galactic cosmic rays decreased by about 15 percent by comparison with the level of June-November 1967 measured by VENERA-4 and by about 40 percent in comparison with measurements performed in 1965 by "ZOND-3" and "VENERA-2". This effect is linked with the solar activity cyclicity and is evidence of enhanced flux of inhomogenous magnetic fields originating from the Sun.

For the four months of flight numerous increases in intensities of solar proton fluxes with energy of 1 to 4 million ev were recorded. Of these 12 were particularly significant. Four increases were remarkable by their complex structure and long duration: each of them lasted no less than 7 days. Their intensity exceeded by several factors the galactic background level. In this regard the observations during the current flight were quite different from the previous ones. Evidently, these phenomena are linked with the increased solar activity and, namely, with groups of major chromospheric flares having taken place at that time.

New data have been obtained on the structure of the near-planetary plasma in the vicinity of Venus. As was established, the interplanetary space is filled with fluxes of plasma moving from the Sun with velocities of several hundred km per second. This solar wind constitutes a magnetized plasma, carrying along a magnetic field. It is interesting to point out that, prior to measurements directly near the planet, no one knew how the solar wind plasma "behaves" in the vicinity of the planet. It was indeed earlier shown by Soviet and American space probes that the planet is devoid of proper magnetic field. Sharp variations in plasma concentration, linked with simultaneous variation of magnetic field intensity were observed in the vicinity of Venus on 18 October 1967 with the aid of charged particle traps installed on VENERA-4. Now new investigations were conducted in the vicinity of Venus. The most informative investigations were those performed on VENERA-6 with the aid of charged particle traps. As it approached the planet magnitude variations of these fluxes were noted, which are characteristic of solar wind flow past Venus. Just as VENERA-4, both VENERA-5 and VENERA-6 descended on the night side of the planet, but farther from the terminator. Thus, one should have anticipated that the intersection of the front of sharp variation in charged particle flux would take place at a greater distance from the planet than in case of VENERA-4, which crossed that front at a distance of some 20,000 km from the center of the planet. The experiment now conducted has confirmed this assumption: the front of plasma flux variation was observed at a distance of about 30,000 km.

Both stations were equipped with photoelectric photometers to measure in interplanetary space as well as near Venus the scattered ultraviolet radiation. As in the case of VENERA-4, current measurements have shown that the emission intensity in the line of atomic hydrogen increases at approach to the planet. The density of atomic hydrogen was measured at large distances of the near-planetary space. Th first signs of the presence of hydrogen corona were observed beginning with the distance of 25,000 km from the center of the planet, while at the distance of 10,000 km the density of hydrogen corona was found to be about equal to 100 atoms per cubic centimeter. These results confirm and complete the previous results obtained on VENERA-4.

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ENTRY AND DESCENT OF CAPSULES IN VENUS' ATMOSPHERE

The last near-planetary radiocommunication between the stations and the ground took place two hours prior to entry into Venus' atmosphere. At the beginning of the sessions control measurements of velocity were conducted for about 8 minutes, so as to make more precise the influence of Venus' gravitational field. Then began the telemetric transmissions on the state of the onboard systems.

The separation of the descending capsules of VENERA-5 and -6 took place prior to entry into the atmosphere at the distance of 37,000 km and 25,000 km from Venus respectively . The stations' orbital compartments continued to telemeter information till their entry into the dense layers of the atmosphere. VENERA-5 and VENERA-6 entered the atmosphere of Venus with a velocity of 11.18 km/sec at 62° - 65° inclination angles to local horizon. This took place respectively on 16 May at 0901 h. Moscow Time and on 17 May at 0905 hours M.T. Then began the most delicate part of the flight, namely, the aerodynamic braking.

Over the portion of aerodynamic braking the velocity of the descending capsules decreased to about 210 m/sec in a short time. After that parachute system was automatically put into action, the radiotransmitters were switched on and the radioaltimeter antennas opened up, after which began the scientific investigations and the transmission of data to Earth.

During the descent of VENERA-5, radiocommunication sessions lasted 53 min, and in the case of VENERA-6 — 51 minutes. During descent the temperature inside the capsules varied insignificantly: from 13°C at the beginning of descent, to 28°C at its end. This is evidence of the reliable operation of the external heat insulation, preserving the apparatus from brief, but quite high thermal fluxes occurring during the aerodynamic braking, as well as of the perfect operation of the internal heat insulation, which preserved the apparatus from heating in the atmosphere of Venus during prolonged descent on parachute, when the temperature has risen to 320°C.

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THE RESULTS OF SCIENTIFIC INVESTIGATIONS IN THE ATMOSPHERE OF PLANET VENUS

Gas analyzers were installed aboard these probes for the investigation of atmosphere composition. This equipment was completed with a system of pressure and temperature sensors computed for various measurement ranges, with a densimeter for measuring the density if the atmosphere and photoelements for measurement of illumination.

The content in carbon dioxide, nitrogen together with inert gases, oxygen and water at various altitudes above the planet surface was determined with the aid of gas analyzers for various pressures and temperatures. Simplest and most reliable physico-chemical methods were applied for the determination of atmosphere composition, based upon well studied and selective reactions. The gas analyzer constituted in itself a miniature chemical laboratory which conducted all chemical operations with a definite sequence by automation. These devices were entirely autonomous and they were guided by the onboard program-temporal installation. Samples of the atmosphere were taken on command at specific moments of time for their chemical analysis; the switching on and off of the sources of electrical feeding on the different chemical analyzers, the obtaining and memorizing of information were also performed on command.

The system of sensors for measuring pressure and temperature consisted of aneroid-type manometers and resistance thermometers. These comparatively simple devices are best fit for measurements in dense gas media and in conditions of high temperatures. The mutual overlapping of devices' measurement ranges assured the possibility of controlling the correctness of measurmments and their high reliability. To measure the density there was installed a device based upon the amplitude variation of tuning fork oscillator as a function of the density of the surrounding medium.

For the measurement of illumination photoelectric sensors were used. They were computed for the registration of emissions in visible and near infrared regions of the spectrum with threshold response of 0.5 watts per square meter. This value just about corresponds to illumination on Earth at twilight.

Both descending capsules are equipped with decimeter-band radioaltimeters. A series of values of the distance to planet surface could be determined with the aid of the latter during the entire process of descent. The scale of fixed values of altitude that could be measured by radioaltimeters, extended from 50 to 10 km. Such a selection of operating range was based upon preliminary estimates of expected altitudes of parachute opening.

On each descending capsule the sample intake for the analysis of gas composition was performed twice. The first analysis of atmosphere composition on VENERA-5 was realized soon after the opening of the main parachute, when the atmosphere pressure constituted nearly 0.6 atm, with temperature of 25°C. The second time analysis was investigated in a lower region with pressure of 5 atm and temperature of about 150°C. The first analysis of gas composition was made on VENERA-6 with pressure of 1 atm and temperature of 60°C, and the second— when the pressure attained 10 atm and the temperature rose to 225°C.

The new data obtained with the aid of AIS VENERA-5 and -6 confirmed the measurements of VENERA-4 and substantially increased the the accuracy of the knowledge of the chemical composition of the atmosphere of Venus. According to data of VENERA-5 and -6, the concentration of carbon dioxide in the atmosphere of Venus attains 93 to 97 percent, whereas during measurements on "VENERA-4" the value of 90% was obtained with a possible error of about 10 percent. The content of nitrogen, together with the inert gases constitutes 2 to 5 percent, while the amount of oxygen does not exceed 0.4 percent. Measurements on VENERA-4 had shown that the nitrogen content in the atmosphere of Venus is less than 7%, and that of oxygen — less than one percent. The water vapor content obtained on VENERA-4 at levels corresponding to pressure of about 0.6 atm, was within the 1—8 mg range per liter. Measurements on VENERA-5 and -6 have shown that the content in water vapor at the level of altitudes corresponding to pressure of 0.6 atm, constitutes from 4 to 11 milligrams per liter. This points to the absence of saturation by water vapors of the atmosphere of Venus in altitude.

Measurements of pressure and temperature were conducted every 40 - 50 sec. on the average. In all more than 70 measurements of pressure and 50 measurements of temperature were performed during the descent of each capsule. All these soundings in the entire descent interval were performed with a precision to a few percent.

In 1967, AIS VENERA-4 conducted measurements over a trajectory portion where temperature varied from 25°C to 270°C. To this portion corresponded a pressure variation from 0.5 to 18 atm. Stations "VENERA-5 and -6" conducted measurements over portions of atmosphere, where temperature varied from 25°C to 325°C and pressure varied from 0.6 to 27 atm. The course of temperature variation in height differed little from the adiabatic, at least within the measurement interval.

On the basis of the results of measurements of temperature, pressure and chemical composition, the portions of capsule descent in the atmosphere, at which measurements were performed of atmosphere parameters from the instant of parachute openings, the differences between the values of altitudes registered by radioaltimeters, agree well with the computed values by two distinct methods: by the descent velocity of the capsule on parachute and from the condition of hydrostatic equilibrium of the atmosphere. The portion of atmosphere parameter measurements for VENERA-5 constituted 36 km, and for VENERA-6 — 38 km.

According to preliminary data, the altitudes, registered by radioaltimeters on stations VENERA-5 and -6 differed from one another by 12 - 16 km for identical values of temperature. According to the radioaltimeter of VENERA-5, the pressure

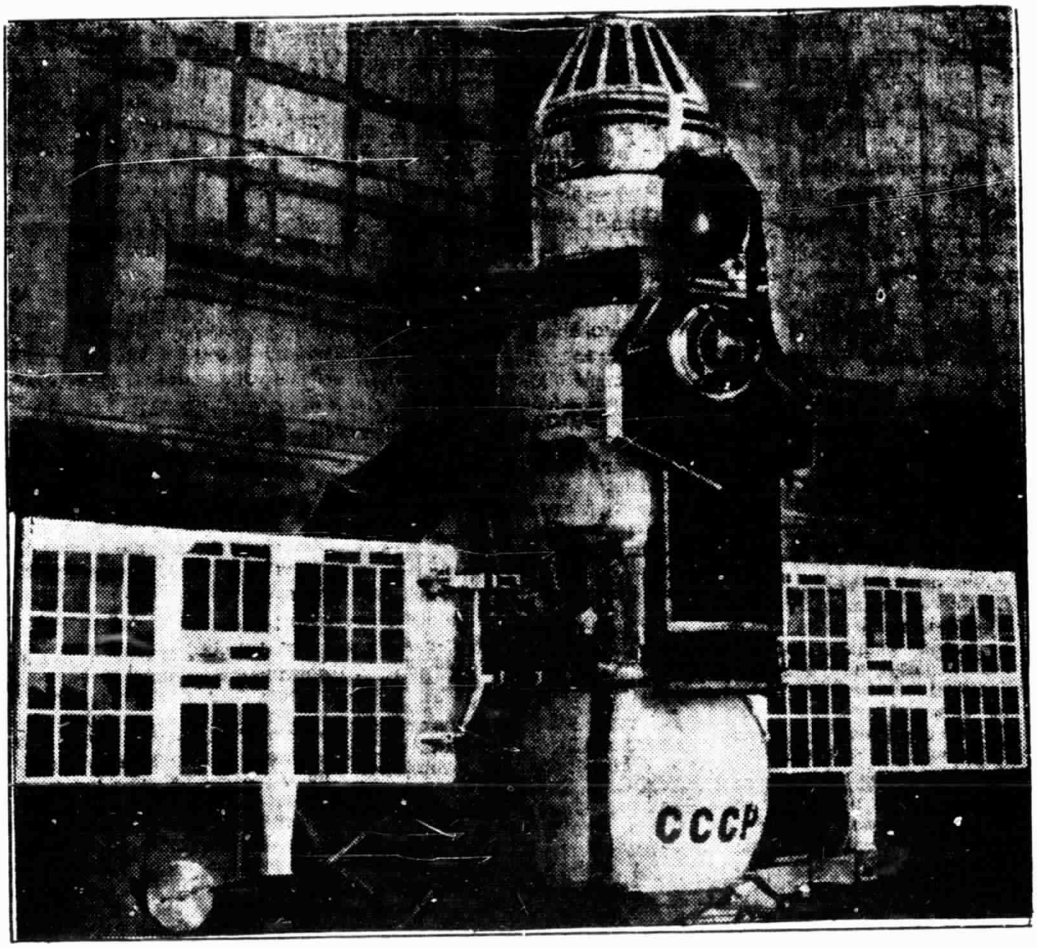

Fig.1

This is the way one of the two "sister-crafts'looked prior to launch (VENERA-5 AND -6)

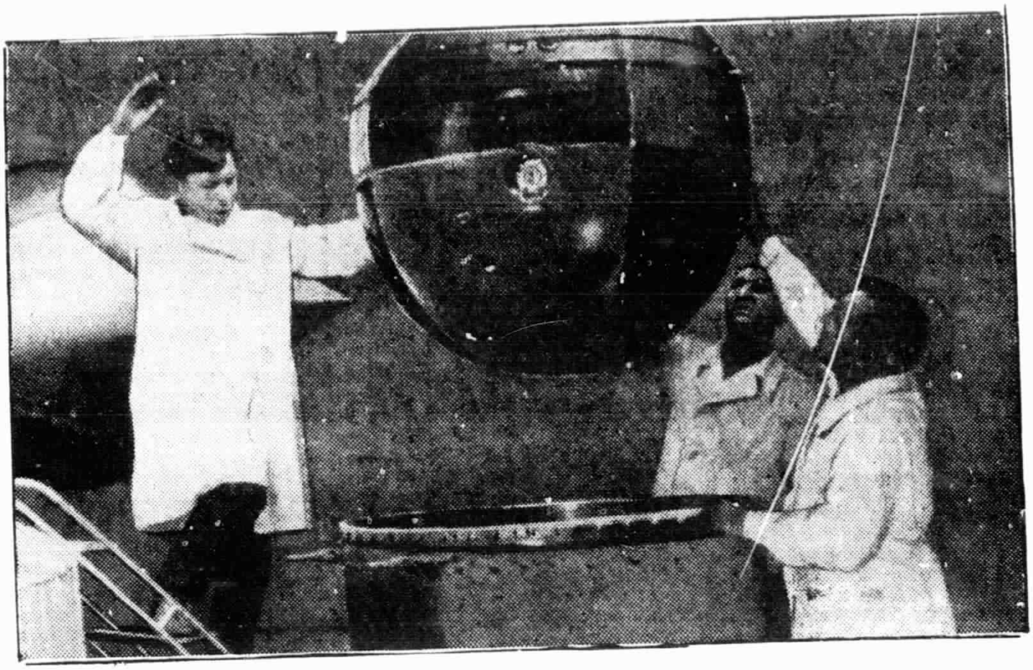

Fig.2

Testing the descending capsule of the two VENERA probes

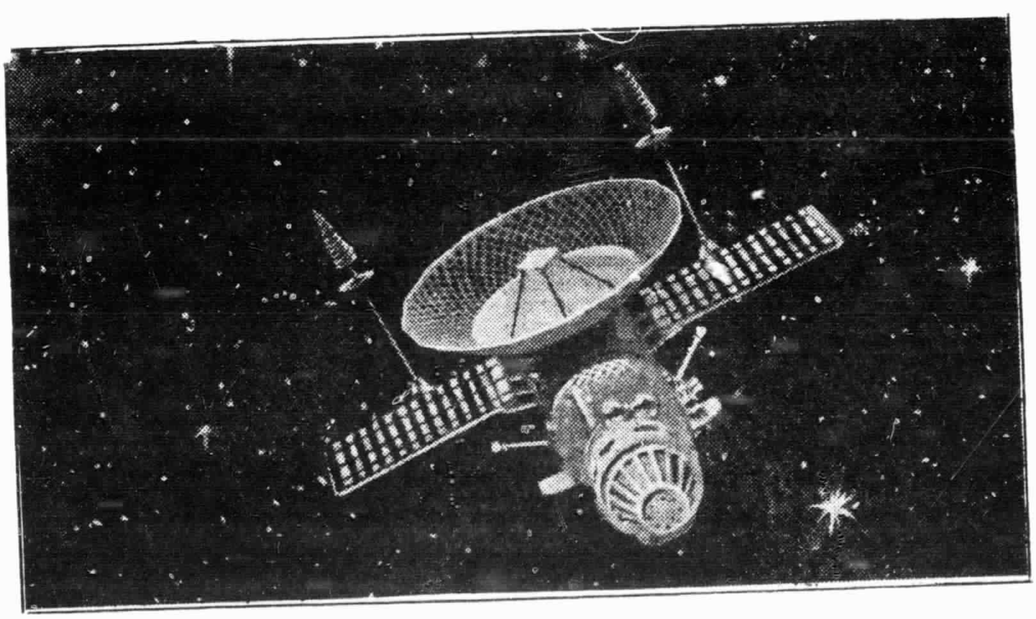

Fig.3

DUMMY OF VENERA-TYPE PROBES

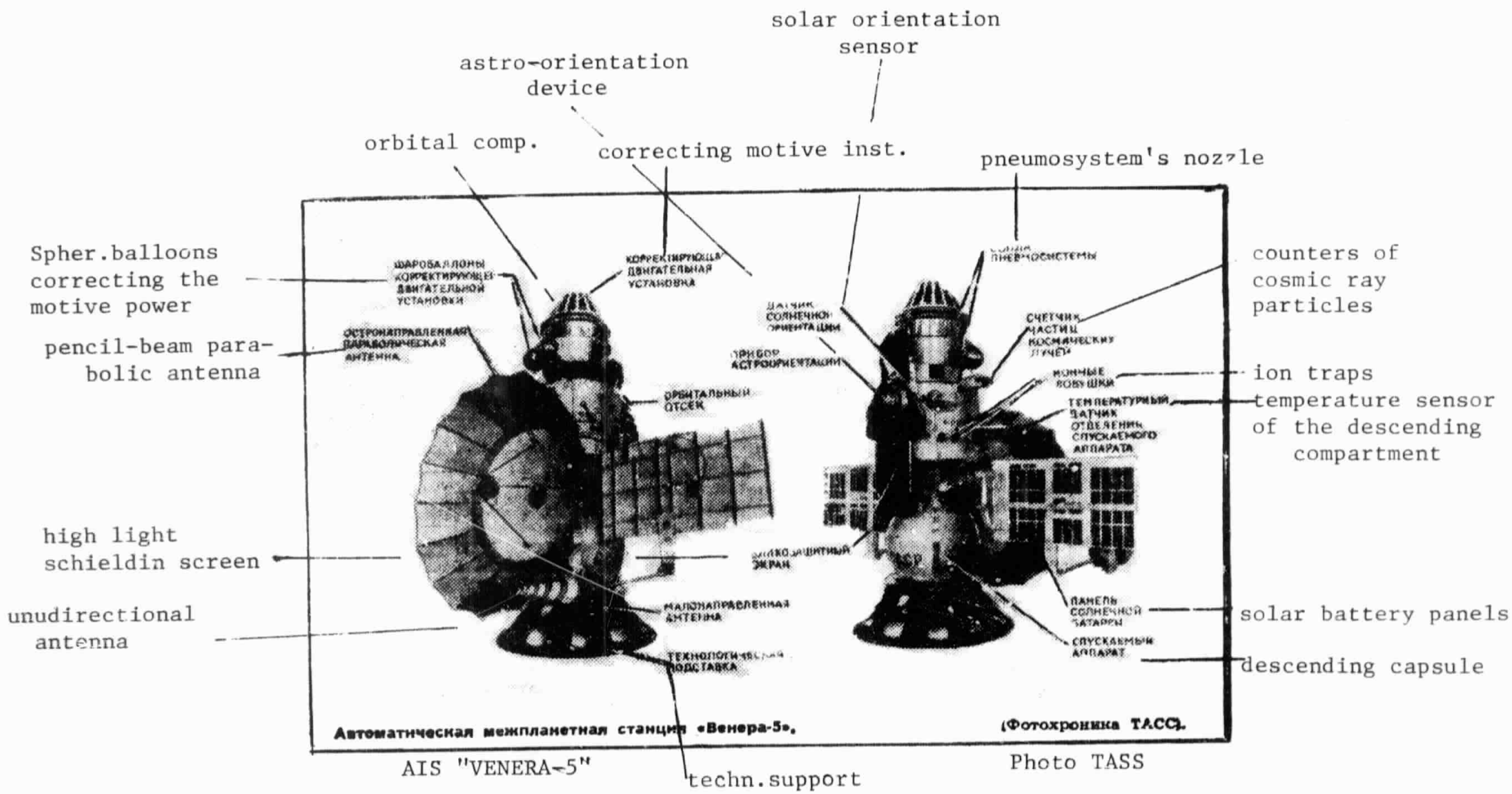
solar orientation sensor
astro-orientation device
orbital comp.
correcting motive inst.
pneumosystem's nozzle
Spher.balloons correcting the motive power
pencil-beam parabolic antenna
high light schieldin screen
unudirectional antenna
counters of cosmic ray particles
ion traps
temperature sensor of the descending compartment
solar battery panels
descending capsule
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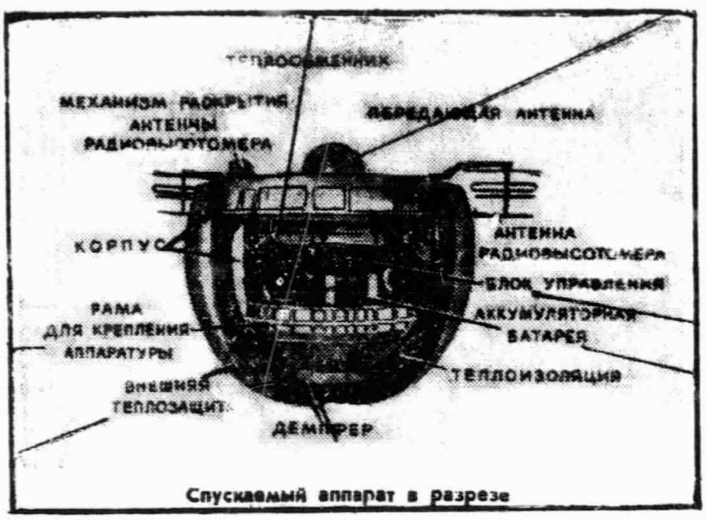
Fig.4



Cutaway of Descending Capsule

Fig.5

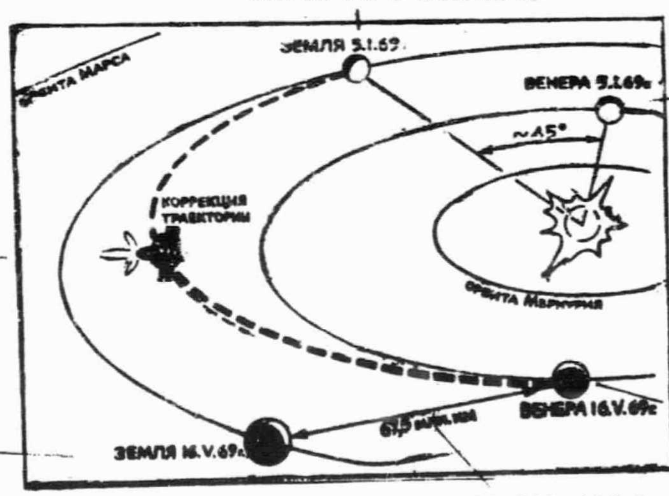


Fig.6

Sketch describing the flight of the automatic station "VENERA-5" of 27 atm. corresponded to the altitude of 24-26 km, while according to data of the radioaltimeter of VENERA-6, the same pressure corresponded to the altitude of 10 - 12 km. This result will be subject to further study. Since the pressure of 27 atm. registered on both stations corresponds to one and the same level of atmosphere, while descent took place above different portions of planet's surface, the probable explanation of the observed discrepancy in the altimeter readings of VENERA-5 and -6 may be the existence of substantial roughnesses or inequalities of surface relief.

Photoelectric sensors failed to register the illumination of the atmosphere of Venus above the threshold of 0.5 watts per square meter. The exception is in the reading obtained by VENERA-5, approximately 4 minutes prior to the cessation of radiocommunication, corresponding to a level of about 25 watts/m^2 . In the following one should analyze whether or not this reading is casual or linked with some atmospheri· ·henomenon.

Therefo·., stations VENERA-5 and -6 transmitted data from deeper layers of the atmosphere than did VENERA-4. They allowed to substantially refine the chemical composition of the atmosphere of Venus by way of direct measurements and to obtain temperature, density and pressure profiles of the atmosphere over a descent trajectory about 40 km long. This exceeds the intervals of previous measurements. The results of all the conducted experiments show that Venus is endowed with a powerful, dense atmosphere and has very high values of pressure and temperature at its surface.

New, direct measurements of chemical composition, temperature, pressure and density of the atmosphere of Venus, realized on Soviet AIS VENERA-5 and VENERA-6, have a great significance for the further understanding of the structure of the atmosphere of Venus........

The processing of these new data is now underway, and the results will be communicated in due course in the scientific press.

(TASS)

***** T H E   E N D *****

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