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INVESTIGATION OF COOLING PROPERTIES OF THE GASEOUS MEDIUM OF A SPACE STATION

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Translation of "Badania wlasciwosci ochladzajacych srodowiska gazowego stacji kosmicznej," Postepy Astronautyki, Vol. 12, No. 4, 1979, pp. 81-84

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16. Abstract

An investigation of cooling properties of the gaseous medium was performed in the biosatellite Kosmos-936 as well as in the orbital complexes Soyuz-28/Salyut-6 and Soyuz-30/Salyut-6 with the aid of an especially constructed electric dynamic catathermometer. In this instrument current was measured which was necessary to keep a steady settled temperature of the sensing device. The investigation was performed because of the disturbed heat exchange of the human body caused by lack of natural convection in weightlessness. The instrument also enabled objective estimation of the temperature of the cosmonaut's body in six optionally selected regions. The results obtained by means of the catathermometer will also enable defining the appropriate hygienic conditions of the gaseous medium of space stations.

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This experiment was designed by Czechoslovak scientists. The experiment was realized jointly with the Soviet Union and Poland. The code name used for the experiment was "Wymiana Cieplna-3" (Heat Exchange-3). The experiment constituted a continuation of investigations started in the Kosmos-936 biosatellite (Heat Exchange-1) and in the Soyuz-28/Salyut-6 Orbital Space Complex (Heat Exchange-2). Heat exchange investigations were undertaken because under weightlessness the cooling of the human body generating heat undergoes certain changes. The latter is caused by the lack of an essential heat exchange component (heat losses as a result of natural convection). Therefore under weightlessness, lack of natural convection is compensated by generating forced airstreams with the aid of a fan. However, such a method cannot be considered entirely adequate for a living organism, since heat exchange by means of natural convection is a self-regulating process. For example under increased temperature conditions of the gaseous medium the rate of thermal convection increases which increases cooling properties; at a lower temperature the convection and cooling rates decrease. Under weightlessness conditions, in the absence of convection, the airstream generated by the fan is forced--not regulated. For these reasons, at the same air temperature, the scope of physical activities at which temperature comfort is retained differs. The above-mentioned fact requires an accurate determination of the optimal magnitude of the airstream generated by fans in airtight spacecraft cabins at a constant temperature. Maintenance of complete temperature comfort and continuous control of these conditions have been realized in recent space flights on the basis of a complex evaluation of the cooling properties of the medium using a catathermometer.

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*Numbers in the margin indicate pagination of the foreign text.

Czechoslovak specialists designed a dynamic electric catathermometer for the heat exchange studies. The first experiments using this apparatus were conducted in the Kosmos-936 biosatellite. The results of these investigations confirmed the usefulness of conducting an experiment with a human participant. A basic element in investigations using a catathermometer is a sensor the temperature of which is accurately maintained at 37°C thanks to the electric current flowing through it. The greater the cooling effect of the medium, the greater the current intensity required for maintaining the programmed temperature of the sensor. A complex indicator of the cooling properties of the medium taking into account all basic characteristics is obtained by measuring the intensity of the current flowing through the sensor spiral. In addition the instrument makes it possible to estimate objectively the body temperature of a cosmonaut as a result of measurements performed at six points (head, face, chest, hands and foot). Heat exchange investigations were conducted three times daily, i.e. in the morning, during the day and in the evening immediately before sleep. Measurements during the day were performed while applying metered physical stress on a cycloergometer. The initial temperature (i.e. temperature before training on the cycloergometer) and the temperature after training were determined in experiments in which a cycloergometer was used. The temperature and pressure of the gaseous medium in the cabin were always taken into account during these determinations. It should be mentioned that identical studies were carried out directly before flight and after landing. The set of data obtained in this manner can be used for an interpretation of the behavior of human thermal regulation under spaceflight conditions. /81

This type of studies was conducted in the orbital Soyuz-28/Salyut-6 complex by cosmonauts A. Gubarev and V. Remek and in the orbital Soyuz-30/Salyut-6 space complex by P. Klimuk and M. Hermaszewski. An analysis of the obtained data made it possible to infer that the increased amount of heat given off by the body is

the reason for the sensation of temperature discomfort recorded by the catathermometer. In cases in which the amount of heat was the same as in experiments conducted on the Earth's surface under comfortable temperature conditions, sensations indicating discomfort were not detected. An objective analysis of heat emission demonstrated that the mean skin temperature was always the same in all measurements and uncorrelated with heat sensations and catathermometer indications. Such a correlation was only observed in measurements of the temperature of the hands and foot.

On the basis of investigations conducted jointly by a Czechoslovak cosmonaut, Polish cosmonaut and Soviet cosmonauts, the inference can be made that the possibilities of cooling the medium under conditions prevailing in the Salyut space station are much greater than those prevailing in laboratories on Earth. In the opinion of all researchers, this phenomenon is related to the greater possibility of cooling the medium in the Salyut-6 station, which follows mainly from the high velocities of the airstream. At an air temperature of 21-22°C this phenomenon may cause a sensation of discomfort. The results of these investigations can be applied in the arrangement and design of fans used onboard space stations and possibly in the development of protective clothing.