THE JOURNAL OF
AVIATION MEDICINE
Official Publication of the Aerospace Medical Association
VOLUME 30 MAY, 1959 NUMBER 5

Simulated Atmospheres and Foreign Environments in Space Operations

A Symposium

Exotic Atmospheres on Earth

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IF a man who had lived some hundred years ago were to return to life again today and glance at the title of this symposium, "Simulated Atmospheres and Foreign Environments in Space Operations," he probably would think that he had reached the wrong planet and might immediately disappear again to his supernatural environment. In fact, our occupation with simulated atmospheres *per se* indicates the revolutionary newness in certain developments we are now facing. The coming penetration of the extra-atmospheric regions of the vacuum of space makes the study of synthetic simulated atmospheres in a closed system urgent. Moreover, the possibility of an eventual approach to other celestial bodies in the not too distant future requires a careful examination of the ecological qualities of their atmospheres in advance.

The physics of our natural atmosphere and its biological functions are known to us. But what is not generally realized is the fact that our atmospheres, with respect to the life supporting elements, represents a closed ecological system on a gigantic scale. It is sealed off from the surrounding vacuum of space by the earth's gravitational attraction. Only lighter elements such as hydrogen and helium, if they reach the critical kinetic energy level, can escape into space. In fact, the high leakage rate concerning these latter elements is responsible for the shift of the chemical composition from the lighter protoatmosphere dominated by hydrogen and hydrogen com-

This symposium was presented on March 24, 1958, at the 29th annual meeting of the Aero Medical Association, Washington, D. C.

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pounds, which existed some two billion years ago, to the heavier present-day atmosphere in which the elements nitrogen and oxygen prevail. Our planet "Terra" with its gravitationally sealed off atmosphere is a giant space ship with 2.8 billion occupants revolving with an orbital velocity of 18.6 miles per second around the sun. And what we must do, if we leave this mother space ship, is to simulate in a closed compartment all the life-supporting and life-protecting atmospheric functions insofar as this is possible. In other words, we must create for the two or three space travelers a little earth—a terrella—which, of course, has no gravity of its own. Such manned sealed gondolas with simulated atmosphere have been flown high into the space equivalent regions of the atmosphere in balloons, and rockets have carried animals in climatized compartments still higher and even in an orbit.

In such closed ecological systems, insofar as the gaseous components are concerned, we are interested in the most suitable air pressure and chemical composition, in the leakage rate, temperature, and humidity and odor control.

Expressed in the language of ecology and logistics, the goal in the climatization of the cabin is to attain a maximum efficiency of the air regenerating devices, a minimum of volume and weight, and an optimum well being of the crew. Laboratory experiments, of course, have to pave the way for actual space operations. Such studies are carried out in space cabin simulators. Fortunately, we can also resort to the long experience with simulated atmospheres which have been made in submarines. All these items will be discussed by other speakers. The presentations also will include the climatization of the pressure suit.

In space flights lasting days and weeks, and even some months, physical and chemical methods will be used for the regeneration of the cabin's air. Our panel discussion will be confined to this type of regeneration. For space flight of longer durations, of course, biological means of the photosynthetic type, either natural or artificial, will have to replace the physical ones (recycling).

Another important topic in space medicine, or bioastronautics, is that of foreign environments, i.e., environments on other celestial bodies. There are two kinds of environments on the celestial bodies in our planetary system: non-atmospheric environments, and atmospheric environments. The first kind is found on our moon and on the planet Mercury. All other environments include atmospheres. We can differentiate between two basic types of atmospheres in our solar planetary system. First, hydrogen and hydrogen compounds, such as methane and ammonia, containing atmospheres. These reducing and reduced atmospheres are found on the outer planets, i.e., from Jupiter to Pluto. This was also the chemical composition of the primordial atmospheres of all our planets some 2½ billion years ago. But on the planets near the sun, these so-called protoatmospheres dominated by hydrogen, due to the effect of solar ultraviolet radiation, in the course of many millions of years have been

transformed into oxygen or oxygen compounds containing atmospheres. In other words, in oxidizing and oxidized atmospheres these are found in three varieties:

1. The atmosphere on earth, a dense oxidized atmosphere with a high content of free oxygen;

2. The Venusian variety, a dense oxidized atmosphere with non- or only small amounts of free oxygen; and

3. The Martian variety, a thin, oxidized atmosphere also with only traces of free oxygen.

Both of these planets have a high planetary leakage rate and have lost their oxygen by escape into space, Venus due to its high temperature, and Mars due to its low gravitational force!

Now space operations in the foreseeable future will probably be confined to what we might call the oxygen belt of planetary atmospheres. The atmospheric hydrogen belt from Jupiter and beyond may be, perhaps, a goal of astronautics in the remote future. The moon, Mars, and Venus, therefore, attract our immediate interest. A man on the moon is, of course, a man in a vacuum and requires respective protective measures. On the lowlands of Mars, such as in the area *Trivium Charontis*, where the air pressure may be somewhat higher than the average 70 millimeter value, oxygen equipment with or without pressure breathing may suffice for the periods when the astronaut is outside the sealed compartment of his ship.

Concerning the possibility of indigenous life on Mars, a new experimental approach has been made by examining the behavior of terrestrial microorganisms under simulated atmospheric Martian conditions in small Mars chambers. Such experiments will be extended under simulated atmospheric Venusian conditions in Venus chambers. All these studies with simulated foreign environments are, of course, of greatest interest, not only from the standpoint of astrobiology, but also from the standpoint of general biology and philosophy.

I would like to conclude my remarks with the question: "Are there foreign environments, or approximations to them, on our earth?"

There are the dangerous "fire damps" occasionally found in coal mines which consist of methane (30 to 90 per cent), nitrogen (4 to 50 per cent), carbon dioxide (2 to 10 per cent) and oxygen (0 to 2.5 per cent). Such a composition shows features of Jupiter's atmosphere and those of the atmosphere of Venus.

The so-called soil atmosphere, found in the pores of the soil, shows a lower concentration of oxygen and a higher concentration of carbon dioxide. This is a trend to the Venusian air. It also shows an enrichment in methane and ammonia. These chemical constituents give the soil air, a protoatmospheric and Jupiter flavor. Greatly responsible for the chemical constitution of this micro-climate are bacteria.

Finally, we find a type of atmosphere resembling that of Venus in volcanic fumaroles, which are little craters, where carbon dioxide has escaped from the interior of the earth and has displaced the air on the ground, because of its heavier weight. Such places are the Grotto del Cane in

Puzzuoli near Naples, the Moffetten (vents in the last stages of volcanic activity) on the eastern shore of Lake Laach in the Rhineland, and the Death Valley on the Dieng Plateau in Java. Some lower places in this valley are barred to animal life on account of their carbon dioxide enrichment of the air. Bodies of birds and mice are sometimes found in these areas; they died when they ventured into this toxic air. This shows that we have on earth places with an atmospheric environment which has a touch of Venus!