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Astronomers have for a long time known that interplanetary space is not completely empty and that the skies are not still and serene as they seem to the poet. It comes as an exciting revelation of the first few satellite and rocket flights that space is filled with dynamic physical and chemical phenomena, some of which were not predicted previously. Physical phenomena found in space, the principles of rocketry, space biology and space medicine were discussed in detail at a recent Symposium held in San Antonio, Texas, on November 10 - 12. The Symposium, known as the Second International Symposium on the Physics and Medicine of the Atmosphere and Space, was sponsored by the School of Aviation Medicine of the USAF Air University. The staff of the Southwest Research Institute was responsible for the arrangements and will also edit the manuscripts which are to be published in book form. Over 600 scientists and many scientific leaders of government agencies attended the 42 invited presentations.

Major General Otis O. Benson, Jr., introduced the Symposium on the note that physical and biological sciences must work hand in hand in the conquest of space. The discussions may be divided in the following categories:

Interplanetary Physics and Chemistry - Pressure, temperature and chemistry of the interplanetary space. Electromagnetic and ionization properties of interstellar matter; meteorites and cosmic rays.

Factors in Space of Importance to Biology and Medicine - Gravitational environment, acceleration and weightlessness, biological effects of primary and secondary cosmic rays, time and the relativity theory.

Satellite Physics and Engineering - Methods and limitations of chemical and nuclear rocket propulsion, problems in launching, tracking and re-entry, manned orbital and lunar vehicles and the "rocket booster glider."

Human Factors - The ecology and physiology of sealed cabins. Gas exchange, photosynthesis, metabolism, limits of perception, stress and adaptation, psychological problems. Human tolerance to acceleration, weightlessness, vibration, temperature and radiation.

Problems of Escape and Rescue in Space Operations

Solar and Planetary Environments - Physics of the solar, lunar and planetary surfaces. The possibility of life on planets and survival of living cells under simulated Martian conditions.

A few topics are discussed below in somewhat more detail:

The Van Allen Radiation - An intense new component of cosmic radiation was discovered in Explorer I by James Van Allen and his group working at the University of Iowa. This radiation is most intense above the magnetic equator and is much smaller near the poles. The radiation belt appears to consist of charged particles, trapped by the magnetic field of the earth, which form a giant magnetic bottle akin to those which are being studied in the laboratory for hydrogen fusion. The charged particles, electrons and/or protons spiral around the magnetic lines of force and seem to become accelerated to considerable energies. The new component starts around 600 km altitude where the particle flux starts to increase by about a factor of two for each hundred kilometers increase in altitude. Its maximum intensity is reached at about 2 1/2 earth radii (about 16,000 km) where the dose is as much as 3 - 5 roentgens per hour. At ten earth radii the dose rate drops to 0.2 r/hour.

Several physicists have given theoretical explanations for the radiation belt. According to the model of S. Fred Singer of the University of Maryland, the primary cosmic ray particles, high energy protons, helium ions and light nuclei are responsible for maintaining the radiation belt. Near the top of the atmosphere the primaries undergo inelastic collisions. Some of the neutrons are thermalized and escape. Eventually these decay into protons, electrons and neutrinos. The charged products of the neutron decay are assumed to make up the radiation belt.

Another explanation is the possibility that the particles originate in the sun and travel in ionized magnetic clouds. When these collide with the magnetic field of the earth, exchange of the particles can take place. Crucial to these theories are observations of energy, time and spatial variation of the rays: additional data are being obtained.

The heavy ion primaries, which we know since their discovery by the Minnesota cosmic ray group about ten years ago, were discussed by Herman J. Schaefer of Pensacola. The intensity of these particles is low, but they produce very heavy ionization tracks unlike those familiar to radiobiologists. The heavy ion primaries are associated with solar events, and it is anticipated that during large solar flares there might be as much as a thousand-fold increase in the low energy end of the spectrum.

It is fortunate that some knowledge already exists from work at the 184" cyclotron of the Lawrence Radiation Laboratory as to the nature and severity of biological effects of high energy protons, deuterons and alpha particles. In addition, there are new heavy ion linear accelerators both at Berkeley and at Yale University that have accelerated beams of several heavier ions with about 10 Mev energy per nucleon. Some biological studies on unicellular organisms and animal skin have been in progress for a year. Further reports on cosmic ray effects were made by Jakob Eugster of Zurich who made studies at sea level, high altitude and underground and by Col. J. E. Pickering of Randolph Field, who estimated some "permissible dose levels" for pioneer space fliers. Cosmic rays present definite hazard for the future space flier. However, the radiation belt can be avoided by low or polar orbits, and it is conceivable to shield against it, at the same time cutting out the low energy heavy primaries.

Fred L. Whipple of Harvard University described our knowledge of meteoritic material in space. Larger fragments originate from meteoritic zones of the solar system and are quite rare; interplanetary dust contains tiny particles originating from comets and ending up on the sun or on the planets. Dust counts from Russian and American satellites indicate that perhaps 3,000 tons of dust fall on the earth daily. Falling through the atmosphere, the tiny particles may then act as condensation centers for rain and are thus a factor in meteorology.

John W. Townsend of the U. S. Naval Research Laboratory explained that at very high altitudes the air density is much higher than previously expected. A small protion of the solar corona appears to extend down to the earth. Hans Clamann of the School of Aviation Medicine and Marcel Nicolet of the Royal Meteorological Institute of Belgium discussed the chemistry of the upper atmosphere. Under the influence of sunlight the very noxious gas, ozone, forms. Ozone protects life at the surface of the earth from shortwave ultraviolet rays of the sun, which would otherwise be absorbed by nucleic acids and proteins, and could be lethal. As the altitude increases above 100 km, the air molecules ionize and dissociate. Free electrons and a variety of radical species appear, combinations of atoms N, O, and H. At very low pressures the establishment of thermal equilibrium is being questioned. There is an interaction between photochemical reactions and intermolecular action involving diffusion and collisions. At 1000 km altitude half of all molecular species are ions.

Walter Dierringer of the Max Planck Institute of Aeronomy, Gottingen, discussed the propagation of electromagnetic waves in the upper regions of the atmosphere. If the wave length is below 5 meters, the atmosphere becomes quite transparent. Longer wave lengths are reflected and bent by the electron layers. The Russian satellites obtained particularly useful data in this field: the bending of the signals from the sputniks was correlated to electron density.

Thorough and detailed exposition was given to various phases of rocket engineering aimed at putting man into space. There is no doubt that existing rocket propulsion systems are capable of lifting man into orbit. These were discussed by Major General B. A. Schriever, USAF. L. R. Shepherd, Chairman of the Council of the British Interplanetary Society, claimed that atomic propulsion may extend rocket capability to any place in the solar system. The most promising nuclear systems are: reactor-heat exchanger, ion propulsion, nuclear fusion. Many interesting phases of launching, tracking, cabin design and re-entry were discussed by Wernher von Braun, Ernst Stuhlinger, Dean Chapman and Krafft Ehricke.

R. Wellner of the Bell Aircraft Corporation discussed the space plane or "rocket booster glider." A whole morning was devoted to the problem of emergency escape and rescue from a space vehicle with discussions by Col. P. A. Campbell, R. M. Stanley, Krafft Ehricke, N. V. Pedersen, and A. M. Mayo. Members of the Staff of the School of Aviation Medicine, the Wright Aero Medical Center and the Lovelace Foundation, namely R. T. Clark, G. R. Steinkamp, G. R. Hauty, S. J. Gerathewohl, W. R. Lovelace, II, and J. P. Stapp, reported on parameters of human adaptation and stress, including factors like anoxia, acceleration, weightlessness, heat, diurnal variation and psychological stress. These studies, as well as the statement of Scott Crossfield, famous test pilot and design specialist, make it appear that when the time comes people will be available who can cope with the stress of orbital flight.

If man is to spend considerable time in interplanetary space or on a planet, he will have to take part of his environment along. He will have to produce on a small scale an ecological cycle comparable to what now exists between planets, animals and man on earth. This intricate problem was discussed by Jack Myers of the University of Texas and H. G. Clamann of the School of Aviation Medicine. The final solution should bring much greater insight into the science of bioecology than we now have.

A number of distinguished astronomers discussed the physics of the sun and the environment on the surface of the planets. Walter Orr Roberts of the University of Colorado discussed the role of sunspots and solar flares on terrestrial weather. G. P. Kuiper of the Yerkes and McDonald Observatories showed the best photographs of the lunar surface yet made. Gerard de Vaucouleurs of Harvard University cited evidence for "life" on the planet Mars: infrared spectra obtained from scattered infrared rays from light and dark areas of this planet which resemble spectra obtained from lichens. The problem of extraterrestrial life and of the origin of life is a very fascinating one, which interests some of the most outstanding bioscientists. John D. Fulton of the School of Aviation Medicine simulated Martian atmosphere, soil, moisture and temperature conditions in his laboratory and found three different microorganisms which were still capable of multiplying. Further work is needed in the presence of solar radiations. Hubertus Strughold, the first professor of space medicine and originator of many basic concepts of space biology, discussed interactions of the gravitational fields of the sun, earth, and moon.

Many basic biological questions remained necessarily unanswered at the Conference, among them the exact nature of life we might expect elsewhere in the solar system. When experiment can answer these questions, then the scope of our knowledge on life processes will be greatly widened. For, in the author's opinion, nature is far more resourceful than we can imagine, and life may originate, exist or adapt itself to environments in greater richness of forms than we know.

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