Wilmington, Mass.) discussed the special case of the winter night-time F-region in polar regions. Anomalously high electron densities are maintained in spite of the long duration of the arctic night (6 months at the pole at winter solstice). Theory and data were presented which suggested that photoionization formed high above the usual ionospheric heights and its subsequent diffusion downward along the magnetic field could account for the observed F-region densities.

Besides whistlers, which have their origin in lightning flashes in the troposphere, there are other very low frequency "sounds," called "VLF emissions," which appear to be generated in the magnetosphere. R. M. Gallet (National Bureau of Standards, Boulder) presented statistics of the diurnal, seasonal, and longer term variations of rate of occurrence of very low frequency emissions at a number of high and middle latitude stations, including geomagnetic conjugate pairs, gathered in collaboration with J. Koch (same laboratory). An unexpected long-term negative correlation was found with 10-cm solar flux, but there was a positive correlation with magnetic activity. All stations showed strong seasonal variations (greater activity in local winter) and a tendency for greater activity at night than during the day. Diurnal variations at conjugate locations were strikingly similar. A calculation of the absorption incurred in traversing the D region of the ionosphere in daytime indicated that this might amount to as much as 30 decibels at 4 kc/sec, which could account for much of the observed diurnal, seasonal, and solar cycle trends.

The phase velocity of very low frequency waves traveling in the magnetosphere is less than the free space velocity and may easily be in the range of velocities of fast electrons. Waves and electrons traveling in the same direction with approximately the same speed will interact and exchange energy. J. M. Cornwall (Aerospace Corp., El Segundo, Calif.) showed that the regions of the magnetosphere where this condition is met depend strongly on L, the parameter which defines a shell in which a trapped electron is confined. He suggested that changes in the mirroring levels of energetic trapped electrons brought about by interaction with very low frequency waves in the preferred L shells could cause their precipitation at corresponding preferred magnetic latitudes. C. S. Roberts (Bell Telephone Laboratories, Murray Hill, N.J.) discussed the implications of an exact solution of the non-relativistic equation of motion of a charged particle in a constant magnetic field in the presence of electromagnetic waves propagating in the "whistler mode" (phase velocity less than that in free space). One important effect is that, at resonance, the kinetic energy of the particle does not increase without limit (assuming unlimited energy in the wave) but is oscillatory instead. This result would lead to the conclusion that the Mev electrons in the Van Allen belts could not result from interaction of slower electrons with very low frequency waves, except in a random-walk fashion.

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Bioastronautics: Fundamental and Practical Problems

Fundamental problems of space biology and some of the important practical considerations necessary to space exploration were reviewed and discussed at a special astronautics symposium held at the AAAS annual meeting in Cleveland, Ohio, on 30 December 1963.

In his introductory remarks the program chairman reminded the audience that, although rockets were developed about A.D. 1100, manned, powered flight observed only its 60th anniversary in 1964. For centuries space travel and exploration has stimulated the imagination of scientists and engineers, as well as writers, but it is less than 45 years since Goddard proposed that it was theoretically possible to send a rocket to the moon and observe its impact there. Goddard's work did not receive favorable publicity and the attitudes of many observers have not changed. Space flights of recent years have been heralded as either man's greatest accomplishments or scientifically useless adventuring. But, in space, it will be possible to validate theory and perform biological research that cannot be accomplished in any earthly laboratory. This symposium was concerned with biological problems to which only experimentation in space can give answers, and with the limitations biology itself imposes on space exploration. A great deal of the work accomplished to date has been an effort to apply the knowledge of terrestrial human physiology in order to protect the man from the extraterrestrial stresses (or absence of stress) imposed by space flight. Space experimentation is a cooperative effort of many fields of science and engineering, and financially supported entirely by government funds. It is subject to costs that almost exceed man's imagination. Thus serious consideration must be given to the value received from experimentation. Because of these conditions unique to any space probe, the topics of the meeting ranged from strictly applied problems of selection and protecting crews, through speculative areas concerning weightlessness, biological rhythms, and extraterrestrial life, to congressional attitudes on space research.

William L. Whitson (president, American Astronautical Society, and president, Clarkson College of Technology) in officially opening the meeting remarked that even though the man in the space program has received a great deal of attention, the original appropriation of funds for space exploration made no provision for biological research. Engineering considerations continue to dominate the program.

L. D. Carlson (Kentucky) reviewed some of the biological problems to which definitive answers can be gained only through experimentation in space and proposed, where man's tolerance is concerned, that the periods of experimentation (space flight) must be gradually increased to determine safely man's limits. Carlson felt that present programming is adequate and reasonable but stressed the necessity for continuing critical evaluation of goals and a soundly based program beginning with experiments in earth laboratories and then progressing to animal experimentation in space and on to critical measurements made during manned flight.

Weightlessness, a condition which can occur for physiologically significant periods only in space flight, and its possible physiological effects were discussed by Michael McCally (Yale). Conclusions based on studies of bedrest, water immersion and immobilization indicate that physiological deconditioning (mainly cardiovascular) appears to be the primary cause for concern. This will manifest itself during the stress of reentry and the return of the astronaut to the normal upright, 1*g* condition on earth. These conclusions are supported to a degree by ob-

servations made on American astronauts and those published about the Russian cosmonauts. The validity of conclusions drawn from experimentation with earthbound analogs will remain questionable until longer space flights can be undertaken. At present, a 4-day exposure to weightlessness seems to present little difficulty.

The many biological rhythms of living organisms were analyzed by Frank Brown (Northwestern). Two widely divergent theories exist concerning the biological clocks. One is that the clock is genetic in character, inherent to the animal, and independent of any external rhythmic forces (Pfeffer). The other postulates that the living clock is controlled by geophysical forces from which it is impossible to shield the organism in any earthly laboratory (Arrhenius). If the first hypothesis is correct, the rhythms will continue when the organism is removed from its usual earth location. Even if the second is true, the rhythms may not be disturbed in earth orbits, but may remain under the control of physical variations that are known to exist about 160,000 kilometers from earth. Another question arises concerning the importance of these rhythms. Are such cycles important enough to prevent survival should they cease to function? Answers to the origin of the cycles and their importance can only be obtained from experimentation during space probes beyond 160,000 kilometers.

Extraterrestrial biology, exobiology, was considered by Allan Brown (Pennsylvania). Here was an exciting, different space biology, the search for extraterrestrial life, its discovery, and its subsequent investigation. Mars is the most likely planet on which to discover some living form, perhaps microbial. Such knowledge could give us a better understanding of the origin of life on earth. Criteria will have to be those which we now have; life of a form we may not recognize cannot be life by our definition. Evidence of living organisms on Mars could be detected by means of unmanned probes which might collect morphological, chemical, physical, or physiological evidence. However, it is essential that all Mars probes be absolutely sterile since contamination could possibly prevent forever unequivocal proof of Martian life. Martian exploration should not become a race to get there first, but an urgency exists if the most propitious opportunity for a probe, which will occur in 1969, is to be exploited. Failing to take advantage of this situation will cause a delay until 1980. Since it is of no consequence who might contaminate the Martian surface, this project offers an excellent opportunity for international cooperation. Discovery of life on another planet will have an enormous and lasting impact on all people but how well we take advantage of our opportunities will depend on how clearly the problem is understood by scientists, the general public, Congress, and the President's office.

Harold Urey, Nobel laureate from the University of California, feels that man's adventurous nature will take him to the moon and beyond as soon as his technical abilities make it possible. Space exploration has so far produced no useful or exciting scientific information: only engineering and technology have advanced. But the exploration of the moon will be one of the greatest experiments ever undertaken by man and will produce information concerning the origin of the moon, the earth, and the solar system. Gathering lunar information with instruments has been proposed, mainly by physicists, but direct visual observation of the lunar surface will give more geological information in a shorter period than can be gained in any other way. A trained geologist should be a space-crew member on the first lunar expedition; a scientific knowledge may be more important than the engineering background and physical training of present astronauts.

D. Flickinger (Medical Corps, U.S. Air Force, retired) who directed the medical evaluation of the Mercury astronauts, insisted that a fundamental qualification for a space-crew member is professional experience as a test pilot. The emotional make-up of such individuals is essential in order to cope successfully with emergencies occurring in flight. Crew members can acquire sufficient scientific background to be competent observers and there are several test pilots who hold medical and advanced academic degrees. Continued examination of the astronauts has confirmed the premises on which their evaluation was based, but there is a dire need for quantitative psychological test procedures.

Present knowledge of man's limits of tolerance to acceleration and the laboratory methods used for their determination were reviewed by N. Clarke (Aerospace Medical Research Laboratories). Limits to vibratory motion are determined by inherent harmonic frequencies of organ systems. Limits to linear acceleration do not present problems with today's launch vehicles but are only about one-half those required for future boosters.

A presentation, which should have been of particular interest to all scientists, was made by Charles Mosher, representative from Ohio and member of the House Committee on Science and Astronautics. What he called the "gee whiz" days of space exploration are over and money will not again be forced on government research agencies. Rather, a pay-as-you-go plan will govern this sort of activity in the future. These changes in attitude are the result of recovery from the first emotional shock of Russian accomplishments and the acquisition of maturity by congressional committees. Appropriations are governed to a large degree by the feelings of the taxpayers and it is difficult to justify funds for unpopular projects. There is a strong need for new understanding between scientists and Congress, and scientists and the public. Congress needs sound scientific advice which now seems difficult to obtain. He proposed that this problem might be corrected by an arrangement in which scientists from universities and industry would accept temporary assignments (6 months) with the government. During this time they would devote their undivided attention to specific problems and on their departure be replaced in government by another group of competent scientists. The public and government are becoming increasingly aware of costs, and they should be made equally aware of science and research and the necessity for their support.

Throughout this meeting, there was an obvious awareness of the need for sound evaluation of projects to determine if attainment of the goal justified the efforts and expenditures.

Calvin Weis (Lewis Research Center, NASA, Cleveland) was general chairman. L. D. Carlson and D. Flickinger presided with the program chairman, W. C. Kaufman, at the morning and afternoon session, respectively.

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