UCLA space program

DECEMBER

1966

UNIVERSITY OF CALIFORNIA, LOS ANGELES

SPACE SCIENCE COMMITTEE

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UNIVERSITY OF CALIFORNIA, LOS ANGELES

S P A C E P R O G R A M

Submitted by
The Space Science Committee
W. F. Libby, Chairman

Space Science Center
Institute of Geophysics and Planetary Physics
University of California, Los Angeles

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INTRODUCTION

The space program at UCLA is designed to accommodate various graduate-level research activities relating to space, stimulate new space-oriented research, and provide the framework in which faculty, staff, and students may undertake interdisciplinary work related to space research. Special objectives are:

(1) To offer and support courses of instruction which, by specialization in space-related subjects, train students to participate in the space effort;

(2) To support research, frequently of an interdisciplinary nature, which is directly inspired by or contributory to the needs of the space program;

(3) To assist other university departments and research units in their own programs as related indirectly to the space program;

(4) To collaborate with NASA, other government agencies, and industry in space research and education.

This report includes summaries of space-related research activities for the period ending December 31, 1966. Detailed progress reports on each project have been submitted to NASA and can be obtained from the principal investigators involved.

SPACE SCIENCE BUILDING

NsG F-10

The new space science building, Slichter Hall, completed and first occupied in January 1966, now houses over 150 faculty members; professional researchers; students; and technical, clerical, and administrative personnel working on the following space-oriented research programs:

Finite amplitude convection
Properties of the solar wind
Iron meteorite studies
Geochemical studies
Propagation of rocket-engine disturbances
Atmospheric physics and orbital mechanics
Spin-orbit coupling in the solar system
Geodetic satellites
Particles in space
Feasibility studies of coordinated radiation experiments from earth-oriented meteorological satellites
Measurement of polarization of radiation emerging from the top of the atmosphere
Mariner IV data reduction and analysis
Cycling of elements in nature
Analysis of geodetic satellite tracking data
Lunar orbiter selenodesy studies
OGO-E, OGO-F, and AT satellites
Planetary interiors
Precessing flows in rotating spheroids
Space biology laboratories (electrooptical, neurochemical, bioinstrumentation, data analysis, physiological and behavioral)
Physiological concomitants of stress
Electrophysiological studies

During the past nine months, Slichter Hall, which contains 30 large laboratories and 60 offices, has become the thriving center of a vast network of space-related research activities on the UCLA campus. Recipients of advanced degrees in the physical sciences and engineering (1420 Masters and 384 Doctorates in the last five years), new graduate students, and new faculty and research appointments will augment the existing staff.

NASA PREDOCTORAL TRAINING GRANT
NsG (T) 4-62

During the academic year 1966-67, 45 graduate students are recipients of NASA predoctoral traineeships. Of that number, 15 were awarded traineeships which began with the fall quarter, 1966, for a period up to three years. These trainees and their fields of specialization are:

Alkaitis, S.A., physical and nuclear chemistry
Asplund, K.K., dynamics of ecology
Baker, C.V., electromagnetic theory
Booth, N.O., experimental plasma physics
Brown, G.H., theoretical physics
Haugh, M.J., physical chemistry
Hedrich, C.L., Jr., theoretical plasma physics
Kindel, J.M., plasma physics
Osgood, W.R., ballistic missiles
Payton, P. H., physical chemistry
Russak, I.B., mathematical statistics
Smith, R.C., seismology
Stoops, E.F., astrodynamics
Vanyo, J.P., astrophysics
Welkowsky, M.S., solid state physics

The following trainees completed doctoral degrees by the end of the fall quarter, 1966: Samuel S. Fisher, Bernard J. Hamilton, Fred Milstein, O. Kenneth Moe, Warren P. Porter, and Allen P. Wang.

Dissertation titles are as follows:

"Translational Relaxation in Free Jets," S. Fisher;

"An Investigation of the Effects of Job Design on Output and Physiological Costs for a Strenuous Task," B. Hamilton;

"The Influence of Hydrostatic Pressure Upon the Magnetic Phase Transitions in Gd-Dy Alloys," F. Milstein;

"Atmospheric Densities Determined from the Spin Decay of Explorer VI," K. Moe;

"Solar Radiation Through the Body Walls of Living Vertebrates with Emphasis on Desert Reptiles," W.Porter;

"Scattering Processes," A. Wang.

P H Y S I C A L S C I E N C E S

THEORETICAL INVESTIGATION OF THE CONSTITUTION OF THE MOON AND PLANETS

NsG 216-62

Analysis of Lunar Satellite Orbits

W. M. Kaula

The selenodetic use of artificial lunar satellites entails a dynamical problem, because the greater magnitudes and longer periods of disturbing accelerations lead to more significant nonlinearities and entails statistical problems, because tracking from the earth coupled with the variety of terms in the lunar gravitational field having similar effects leads to ambiguities and ill-conditioning.

A solution has been made for the dynamical problem in which a von-Zeipel transformation is applied to remove short period effects to obtain a nonlinear intermediate orbit which can be integrated numerically with relatively long time steps.

The statistical problem was investigated by analyzing hypothetical tracking data incorporating the anticipated characteristics of the lunar gravitational field, as well as instrumental error and ionospheric refraction. Regardless of tracking accuracy, it appears that a satellite of high inclination will be more valuable than a satellite of low inclination and that the best solution is obtained by combining the two.

Spin Orbit Coupling in the Solar System

P. Goldreich, S. Peale

The class of planetary spin angular velocities which are commensurate with the planet's synodic period

with respect to a second planet is shown to be more stable as a consequence of the solar torque on the permanent deformation of this planet from axial symmetry. The situation is analogous to the stabilization of an inverted pendulum by oscillating the base at a frequency which is not a harmonic of the natural frequency of the pendulum. This result reduces the value of (B-A)/C necessary to stabilize Venus's spin at the 243.16 day commensurability with respect to the earth by a factor of three below that which is necessary without the solar torque (see Goldreich and Peale, Nature, 209, 1117-1118, March 12, 1966). However, the necessary permanent deformation of Venus for this stability still seems excessive in view of the resulting internal stresses. In addition, there is negligible probability of capture of Venus into this state unless one invokes ad hoc assumptions about the atmospheric torques.

A fourth tidal model was used in the analysis of the spin commensurabilities of a planet with respect to its own orbit. In this case, the tides are Fourier analyzed into separate components, and a constant phase lag for each component is assumed to account for the dissipation. For Mercury this tide yields a very large capture probability for the stable spin angular velocity which is 3/2 times its orbital angular velocity. However, unlike the cases previously treated, this capture probability is independent of (B-A)/C, such that Mercury's occupancy of the 3/2 spin state puts no limits on (B-A)/C other than the much smaller limit required for stability. Another contrast between this tide and those previously treated is that the asymptotic spin state for Mercury would be the synchronous one, which would result if Mercury had escaped all higher order resonances.

Planets and satellites whose spin angular velocity vectors are not parallel to their orbital angular

vectors are presently under study. An entire new series of resonant spin states exist. These states can be stable even for circular orbits if the non-zero obliquity is maintained. The stability in the circular orbit case derives from a minimum in the average potential energy when the longest dynamical axis of the secondary body points toward the primary whenever the primary is at the node of its orbit on the secondary equator plane. Torques on a satellite's permanent deformation can drive the axis of rotation off the principal axis as the satellite approaches resonance near 2n and affords stability in a circular orbit for this resonance, which is unstable for principal axis rotation. A satellite of Uranus may be in the 2n resonance for circular orbits with a stable non-zero obliquity.

Spectra of Ocean Water Temperatures

W. Lee

Recent data from four oceanic stations in the northeastern Pacific permit time-series analysis of ocean water temperature at depths extending from the surface to the bottom. At three of the stations, 12 years' data at about monthly intervals from the surface down to depths of 1000 meters are available. At the fourth station, 14 days' data at five-minute intervals are available at 15 depths, the lowest being just above the sea floor. The computation scheme used to calculate the temperature spectra is especially adapted to the task of analyzing time series with missing data.

Short period variations of ocean water temperatures (from depths 85 to 3803 meters) are dominated by a semi-diurnal periodicity. The results suggest that vertical motions of the sea water associated with this "internal tide" are of the order of 10 meters in amplitude.

Semidiurnal temperature fluctuations of ocean waters may also introduce some errors in the measuring of heat flow through the ocean floor, especially in rough topography. Long period temperature variations at shallow depths are dominated by the annual periodicity which becomes less pronounced below a few hundred meters. The results suggest that heat flow measurements through the ocean floor may be extended to shallow water (up to 200 meters in depth), provided that observations are made below about three meters in the sediment.

Origin of Comets

W. M. Kaula

Analytical theory and computer calculations are being carried out to test the alternative hypotheses that comets were formed by dispersion from the outer parts of a primordial solar nebula or by accretion from interstellar dust clouds.

PARTICLES AND FIELDS IN SPACE
NsG 249-62

Analysis of Data from Mariner 2 Magnetometer

P. J. Coleman

A statistical analysis of the records obtained with the Mariner 2 magnetometer and plasma probe was completed. Various properties of simultaneous variations in the magnetic field and the plasma velocity were established.

During the reporting period, efforts to develop a theoretical model for the diffusion of cosmic rays were extended. An attempt is being made to derive an

anisotropic diffusion coefficient from the observed properties of the interplanetary magnetic field and to determine the effects of such a diffusive medium on the behavior of various types of energetic, charged particles.

Mariner-Venus (1967) Magnetometer Experiment

P. J. Coleman

Planning for this experiment was initiated during the reporting period. Since we are attempting to use a Mariner 4-type magnetometer with the fewest possible changes, the planning to date has primarily concerned data processing.

UCLA Satellite Project

P. J. Coleman

A proposal was submitted to NASA for the design and development of a new earth satellite with which to study the properties of collisionless, magnetized plasmas in space. It is intended to observe the properties of such plasmas by simultaneously measuring, with appropriate time resolution, as many as possible of the variables necessary to describe the state of the plasma. The observables are the electric and magnetic fields and the directional spectral intensity of each species of charged particles. Therefore, it is planned to equip this satellite with plasma probes, energetic particle detectors, electric field meters, and magnetometers.

Electron Spectrometer for OGO-E

T. A. Farley

The UCLA OGO-E experiment is a joint particle-field experiment involving six radiation detectors and a magnetometer. A fixed-price contract for fabrication of prototype and two flight units of the particle instrument was awarded to TRW Systems, Inc.

Construction of flight unit modules was initiated immediately following checkout of the corresponding prototype modules.

A review of low-energy proton intensities in the outer radiation zone has been made in order to evaluate the contribution that these particles will make to our instrument, which is supposed to detect only electrons.

Electron Spectrometer for OGO-F

T. A. Farley

This project involves the prototype and two flight units, the instrument being very similar in principle to the OGO-E instrument. Many changes in detail have been made; unlike OGO-E, the OGO-F will have one detector with a small magnet to eliminate possible proton ambiguities. The threshold for electrons will be kept at 45 kev. A current-measuring device has been added to the omnidirectional detector to extend the range of the instrument.

Radiation Monitoring Instruments

T. A. Farley

The five radiation instruments designed by our group and built by Northrop Space Laboratories with Air Force funding were launched into orbit in October 1965 aboard the OV-2 spacecraft. Although the spacecraft

clock failed after two months and the tape recorder failed a month later, some 500 hours of good data have been recorded at the ground, providing excellent coverage of the inner radiation zone.

Data reduction is underway by Northrop, and scientific analysis will be carried on at UCLA.

Flare Detection Satellite

T. A. Farley

The Air Force has provided an opportunity to use spare units from the OVI-2 flight on another satellite in the second quarter of 1967. The objective of the second flight will be to monitor solar flare particles. The satellite orbit will be below the radiation belt for the most part. Spare units will be refurbished by Northrop; calibration and testing of the units will be accomplished at UCLA.

ANALYSIS OF DATA FROM MARINER 4 MAGNETOMETER
NsG 249-62, NGR 05-007-065

P. J. Coleman

During the reporting period, reduction of the experimenter's extract tapes for the magnetometer experiments was completed. A study was initiated on the radial dependence of the interplanetary magnetic field. A detailed analysis was also undertaken of the properties of variations recorded in the field during the flight of Mariner 4. Properties such as the power spectra of vector components and the coherence and phase differences between pairs of vector components as functions of frequency will be determined. These results will be compared with the results obtained from a similar analysis of Mariner 2

magnetometer data.

In collaboration with the Mariner 4 experimenters at the University of Iowa, we also began a study of the correlations between variations in particle flux and variations in the field. At the same time, studies of variations in polarity distribution of the field were extended to include the last seven periods of solar rotation.

EXPERIMENT FOR THE EARTH SATELLITE OGO-E
NAS 5-9097, NAS 5-9098

P. J. Coleman, T. A. Farley

This experiment was designed to provide simultaneous measurements of variations in the geomagnetic field and variations in the directional spectral intensity of magnetically trapped particles. Progress on the particle detector subsystem is described elsewhere. During the reporting period, testing and calibration of the completed prototype model of the flight magnetometer was continued. At the same time, tests on the breadboard model of this magnetometer were continued.

EXPERIMENT FOR THE EARTH SATELLITE ATS-B
NAS 5-9570

P. J. Coleman

The primary scientific goals of this experiment are: (1) the determination of the dependence of the configuration of the distant geomagnetic cavity upon the sun-earth-satellite angle, and (2) the determination of the dependence upon this angle of the production, characteristics, and propagation of magnetic and hydromagnetic disturbances in the distant magnetosphere. During the reporting period, all deliverable items of hardware were delivered. These included the prototype

and two flight units of the magnetometer and a complete set of ground-support equipment.

CHEMISTRY OF METEORITES
NsG 313-63

G. Wetherill, J. Wasson

An attempt has been made to relate the observed variations in the trace element concentrations--especially gallium and germanium--in iron meteorites to hypothetical models of the nature and history of meteorite parent bodies. While a unique solution of this problem is not yet possible, the present data place strong restrictions on the range of possibilities.

One of the principal limitations arose from the absence of experimental data which would enable prediction of the partition of relevant trace elements between iron silicate and possibly sulfide phases. An investigation of this problem is underway.

Special laboratory facilities have been developed for investigation of Rb-Sr concentrations and isotopic ratios, utilizing small samples, such as individual chondrules, with a minimum of chemical contamination. The results of these measurements have not indicated any difference between the $\sim 4.5 \times 10^9$ year time interval since the chondrites had the same Sr isotopic composition ($Sr^{87}/Sr^{86} = 0.699$) and the time of the most recent equilibration of Rb and Sr within the individual chondrules of Bjurböle.

An investigation of secondary metamorphism of the enstatite achondrites is underway.

HIGH PRESSURE STUDIES OF THE SOLID PHASES OF INERT GASES

NsG 314-63

G. C. Kennedy

The melting curves of argon, carbon dioxide, methane, nitrogen, and ammonia have been determined up to the 25-30 kb region. With the use of an end-loaded pressure chamber, the attainment of 30 kb pressure was routine. The linear relationship between the melting temperature and isothermal compressibility as recently expounded by Kraut and Kennedy (Phys.Rev.Letters, 16, 608, 1966) has also been applied to the gases studied in this investigation.

In determining the melting curves of gases at higher temperatures and pressures it was found that the present pressure chamber could only be taken up to approximately 150°C. Higher temperatures expanded the binding rings to such an extent that the core became unsupported and, as a result, would fracture at approximately 30 kb at these temperatures.

It has therefore been decided to design a larger chamber in order to accommodate an internal heating assembly and avoid the loss of support associated with the externally heated chamber used in the experiments to date. As envisioned the pressure chamber will be large enough to enable accurate volume discontinuity work and, in addition, have the capability of measuring either DTA or resistance changes in order to investigate phase transitions more thoroughly.

Experiments conducted in this laboratory have shown that tungsten carbide pistons can be taken up to 60 kilobars in a normal piston-cylinder apparatus if the amount of free piston travel is kept to a minimum. Utilizing this technique along with the larger internally heated chamber, it is expected that the present experimental

range can be doubled. Experiments are not being conducted on water encapsulated in plastic containers in a one-half inch diameter chamber. When sealing techniques are perfected, the investigation will be extended to gas systems.

FEASIBILITY STUDIES ON COORDINATED RADIATION EXPERIMENTS FROM METEOROLOGICAL SATELLITES

NGR 05-007-041

Z. Sekera, T.A. Hariharan

During the reporting period, the laboratory model of the skylight polarimeter and the associated equipment such as the sun-follower assembly and scanning mechanism have been completed. Some ground-based measurements of skylight polarization have been carried out.

In collaboration with Goddard Space Flight Center and Ames Research Center some high-altitude measurements were carried out on the polarization of visible radiation reflected by various natural surfaces. A Convair 990 jet aircraft was used for the experiments. Measurements were made at various altitudes up to a maximum of 40,000 feet under various experimental conditions. Further experiments of a similar nature are proposed for February 1967, and arrangements are underway to modify the instrument.

A proposal has been submitted to NASA for inclusion of the polarization experiment in the Apollo spacecraft during one of its early earth orbital missions. In connection with this proposal some work has been initiated on a preliminary engineering density study of a satellite-borne polarimeter.

Theoretical investigations are being continued on the inversion problem in radiative transfer; that is, on determination of atmospheric parameters that enter in the scattering phenomena.

SEARCH COIL MAGNETOMETER
JPL #950403

R. E. Holzer

OGO-I records for more than one and one-half years are now available, and it has been possible to observe some significant trends in the mean positions of the hydromagnetic bow shock and the magnetopause. Because apogee is about 24 R_e, the orbit penetrates these boundaries only when apogee is above or near the sunlit hemisphere. Apogee was over the afternoon side of the sunlit hemisphere in the fall of 1964 and again in the fall of 1965. It was above the morning side in the spring of 1965. A study of the first year of data (fall 1964-spring 1965) indicated that the average K_p index was low and substantially the same in fall and spring, presumptive evidence of a steady solar wind. Both the bow shock and magnetopause crossings were found to be symmetrical about an axis in the ecliptic plane inclined four degrees to the west of the earth-sun line. This aberration angle is consistent with a solar wind speed of about 430 km/sec. It is believed that this is the first evidence of the solar wind aberration angle based upon positions of the magneto-sheath boundaries. It was also found that the data for the fall of 1965 indicated a more compressed magnetosphere than the fall of 1964, consistent with a higher wind velocity in the former case. The mean K_p indices for the observation intervals were 1.8 and 1.4, respectively. When OGO-I plasma probe data become available, it will be possible to make quantitative checks with solar wind speeds and pressures.

Programs have been completed for making studies of wave patterns in inertial coordinates, and the detailed study of bow-shock structure has been initiated. Qualitatively, it has already been found that the bow shock

is a source of high frequency magnetic signals up to frequencies of 1000 cycles/sec (upper limit of equipment response). In the lower frequency domain which can be explored by the waveform channels (up to about 5 cycles/sec) there are clear wave patterns at the shock with precursors in the interplanetary medium. Power spectra taken in the vicinity of the shock have a peak near 2 cycles/sec.

OGO-II, a low altitude polar orbiting satellite, was launched in October 1964. Thus far, only 10 days of data from this satellite have been made available. The search coil magnetometer experienced severe interference from boom vibrations and from certain equipment on the spacecraft. However, it is still possible to obtain data from the larger natural signals. The auroral zone has proved to be the source of strong magnetic fluctuations throughout the frequency range of the magnetometer. The regions of disturbance are sharply bounded, usually a few degrees wide, and found near the region where visual auroras are most frequent.

The OGO-II spacecraft is the first one in which the special purpose telemetry was made available for the search coil magnetometer. The more detailed, higher frequency spectral analysis made possible by this equipment has yielded records of several proton whistlers and a tentatively identified helium whistler.

The remaining search coil magnetometers on the next four OGO spacecraft are in various stages of preparation. OGO-B is awaiting launch; OGO-D and OGO-E are in test phases; and OGO-F is in a late design phase.

STATISTICAL AND HARMONIC ANALYSIS OF GEOPHYSICAL DATA

AF 23(601)-4171

W. M. Kaula

The purposes of this study were:

(1) Development of statistical theory pertaining to nonuniform distributions of data over a sphere;

(2) Appraisal of geophysical data related to determination of the gravity field: topographic, seismic, and geothermal data, as well as gravimetry and satellite orbit analyses;

(3) Determination of an optimum representation of the gravity field;

(4) Application of the gravity field to calculation of orbit perturbations.

The scope of these purposes was too ambitious in proportion to the scale of the project. A detailed statistical theory was developed which satisfyingly transferred time-series techniques to the sphere. The evaluations of heat flow and seismic refraction data showed some correlations of mainly geological interest. The comparison of different compilations of topographic elevations indicated some significant biases. However, the theory and data were not effectively combined to obtain a utilization of the topography, heat flow, and seismic crustal thicknesses to determine the gravity field on a global scale; there is needed a better theoretical understanding of the instabilities which can occur using weakly correlated variables in the presence of a high noise level of local variation.

Hence, the representation of the gravity field obtained was a combination of satellite data for the 6th degree and longer wave variation and gravimetry for shorter wave variation. The amount by which the gravimetry had to be adjusted indicated, however, that some modification of the satellite data would be appropriate

for an optimum representation.

Calculation of orbital perturbations by the gravity field was relatively simple and, once the computer programs were debugged, indicated quite clearly that spherical harmonic coefficients are a much more efficient way of attaining a specified precision for a given orbit and time duration than are extrapolations from area mean anomalies. The development of criteria as to what harmonic coefficients to include will depend on more specific statement of orbital characteristics, duration, precision required, etc.

ANALYSIS OF GEODETIC SATELLITE TRACKING DATA
NSR 05-007-060

W. M. Kaula

Analysis of 7,234 Baker-Nunn camera observations of five satellites was completed to determine simultaneously 44 tesseral harmonic coefficients of the gravitational field, 36 station coordinates, and 511 orbital elements. Supplementary observational data incorporated in the solution included accelerations of 24-hour satellites and directions between tracking stations from simultaneous observations; observation equations were also written for the differences between geometrical and gravitational geoid heights at tracking stations. Several variations in relative weighting of different observational data and a priori variances of parameters were tested. The previous independent solution most closely approached was that by Anderle based on Doppler data, from which the rms discrepancy was $\pm$ 0.18 x 10^{-6} for 38 normalized harmonic coefficients, or $\pm$ 7 meters in total geoid height. An equatorial radius of 6,378,160 $\pm$ 8 m. was obtained.

STUDIES OF THE SOLAR SYSTEM AND PROBABLE LUNAR ABUNDANCES OF ELEMENTS OF GEOCHEMICAL AND METALLURGICAL SIGNIFICANCE

NGR 05-007-046

L. H. Aller

Solar Spectrum Studies

Our observational data consist of high resolution spectrum tracings obtained in collaboration with the McMath-Hulbert Observatory of the University of Michigan and some high resolution tracings obtained by Prof. Walter Mitchell with the Snow solar telescope at Mount Wilson Observatory. Many of these tracings were obtained with a monochromator to eliminate scattered light so that accurate line shapes could be obtained. In some instances it was possible to measure the line profile at several points on the solar disk and thus obtain checks on the model atmosphere employed.

We are considering several of the more important, abundance elements and their ions, in addition to several of the less abundant elements such as SbI, BaII, BeI, CdI, NbI, NbII, GaI, GeI, AuI, InI, MoI, RuI, AgI, YbI, YI, YII, ZrI, and ZrII.

One great advantage in solar work is that one can observe the actual line profiles at various points on the solar disk and measure the emergent intensity $I_\lambda(0,\mu)$. Full utilization of the available data permits a much better determination of the quantity log $gf\lambda$ (n/n_H) than does the curve-of-growth method.

Analyses by the curve-of-growth method on Ruthenium have yielded different results from those obtained by GMA, for this metal has a fair number of rather weak, often badly blended lines.

Indium is of considerable geochemical interest, since it appears to be depleted in meteorites. Should this element be found on the moon, it would indicate an early history of lunar material considerably different from that of chondrites. Investigations are underway involving application of the line profile method to analysis of Indium.

The available gold line lies in the far "accessible" ultraviolet at λ3122.784. The big problem is locating the regional continuum, calibrating it in terms of energy units, and allowing for effects of blends. Our curve-of-growth method has been employed; spectrum synthesis has not yet been attempted in this region.

Atomic transition probabilities are under investigation. Whether the solar spectrum synthesis or curve-of-growth method is employed, the result is an evaluation of the product fN_{el}/N_H, where N_{el}/N_H is the quantity sought, and f is the oscillator strength for the transition in question. The final value for the abundance can be no better than the accuracy of the f-value.

In this investigation we have relied on a combination of experimental and theoretical results. Whenever available, we have used f-values measured by R.B. King and his associates at California Institute of Technology. Use has also been made of the new f-values published by Corliss and Bozman of the National Bureau of Standards, but it now appears that their results will have to be revised for a number of elements.

INVESTIGATION OF TECHNIQUES FOR ANALYSIS OF ANCIENT SEDIMENTS AND EXTRATERRESTRIAL MATERIALS

NGR 05-007-077

I. R. Kaplan

During recent months efforts have been directed mainly toward acquisition and assembly of equipment and supplies for a gas manifold system and a gas-liquid

chromatographic system to be used in the capture, measurement, transfer, and identification of light hydrocarbons from soils, sediments, and meteorites. Our stringent requirements for a gas manifold system which could receive and measure the hydrocarbons without changing their composition by contaminative addition or selective removal of compounds has consumed much time even though we have relied on the experience of other researchers. Our third-generation system appears to be operable, and we expect to begin examining samples of sediments. The gas chromatographic apparatus is functioning, and testing and calibration are continuing.

PHYSICAL SCIENCES RESEARCH SUPPORTED BY NsG 237-62

Fundamental Problems in Astronomy

L. Aller

Spectrograms of gaseous nebulae have been obtained at Lick Observatory. Among the objects observed are some which are suspected to be possible x-ray sources, although the positions of the latter are not well enough established to make a definitive statement.

24" Telescope for Planetary and Stellar Observations

L. Aller

Although not yet satisfactorily operative, the 24" telescope purchased from California Institute of Technology has been installed in Ojai, California, and observations have been made with it. A spectrograph has been attached to the telescope, and after its optics were refigured and the instrument was properly assembled, spectrograms of good definition were obtained. At the present time, work continues on alignment of the telescope and correction of mechanical difficulties.

State-Wide Committee on Telescope for the Southern Hemisphere

L. Aller

Funds from the 237-62 grant were awarded to facilitate planning and site testing for the eventual establishment of a large, ground-based reflector under University of California auspices in the southern hemisphere. To date, a double-beam site-testing telescope has been used in Australia for reconnaissance of possible sites. Mt. McKinlay in the Flinders Range, about 300 miles north of Adelaide, appears to be the most favorable location for a large telescope.

The possibility of a partnership on this project between the University of California and the Australian National University is being considered, and the Regents have authorized $0.5 million of University of California funds for the project. Additional funds will be sought from NASA.

Rocket Project

P. J. Coleman, U. Fehr

Data obtained with ground-based detectors during rocket flights were analyzed. Preliminary results indicate that the instruments employed detected variations in atmospheric pressure at the surface of the earth which were produced by the ignition of upper-stage rocket engines in the ionosphere. Four static firings of the Saturn rocket engine were also monitored and are being analyzed at Pt. Mugu, California.

Preliminary redesign work has been done on the variometers utilized in measurements of artificial disturbances in the ionosphere. The basic problems to be overcome are drifts produced by the electronics and

temperature changes and the fact that the instrument will not perform properly during periods in which its altitude is changing significantly.

Magnetically Shielded Test Facility

P. J. Coleman

This facility, designed to yield a laboratory with an environment sufficiently free of magnetic noise to allow testing and calibration of relatively sensitive magnetometers, consists primarily of a magnetically shielded room which provides the working volume with comparatively little magnetic noise. An environmental chamber and a triaxial Helmholtz-coil array are used to test the response of magnetometer probes at various temperatures.

The facility has not yet been completed due to the fact that the equipment had to be used for testing and calibration of hardware for flight projects. Progress has been made in improving the liquid nitrogen temperature control system.

Chemistry and Spectroscopy Under High Field of the Giant Laser Beam

M. El-Sayed

A giant Z-switched laser has been purchased and will be used to study the interaction between high density light beams with matter. The cross-sections for the scattering and other light-loss mechanisms such as multiphoton absorption in organic and inorganic media are to be examined. Results of this study will have importance in regard to the possible future use of lasers in space communication.

Motion of Mass Particles in the Solar System

J. Kane

Research has continued on numerical methods of solving the restricted n-body problem. Two methods seem quite promising: One is a method of choosing the correct variables in phase space so that the dimensionality of the original problem is reduced to the determination of a suitable vector field in two dimensions. Integration of the equations of motion is equivalent to finding the "lines of force" in this two-dimensional phase space. The second approach is one of "digitizing" the equations of motion. Although there is some limitation on accuracy attainable by using this integration procedure, it does offer the major advantage of being computationally stable for unlimited time periods. Representative numerical examples are being computed for a simplified solar system consisting of the sun and Jupiter.

Cycling of Elements in Biosphere, Hydrosphere, and Atmosphere and the Chemical Evolution of Life

I. R. Kaplan

During the reporting period, attention has been focused on obtaining and setting up facilities for investigations of biogeochemistry problems--gaining understanding of environmental changes through study of geochemistry and microbiology. Emphasis is being placed on the cycling of elements in the biosphere, lithosphere, and atmosphere. Most of the work concerns marine problems and the influence of microorganisms in effecting changes at the mud-water interface. Work on the chemical evolution of life, primarily involving investigations of ancient sediments and meteorites, is reported elsewhere.

Tropical Meteorology

T. Krishnamurti

This is a new project involving meteorological satellite work and analysis of Tyros III information (photographic and radiometric) obtained in September 1961. Of particular interest is an examination of tropical convective activity in the Atlantic Ocean preceding formation of a hurricane on September 13, 1961.

Stream lines, contours, iceless arms in conventional meteorological analysis will be carried out. Convective clouds and the problem of parameterization of convective scales and their influence on tropical large scale flows will be examined.

Isotopic Studies of the Solar Wind

D. Lal, W. F. Libby

Experiments are being conducted to test the possibility of collecting a large sample of "solar wind" from outside the earth's magnetosphere. In the scheme under test, the fast moving particles of the solar wind will be trapped in the outer skin of a large balloon inflated in space. Simulated studies involving exposure of several types of metal foils to fast ions (radioactive and stable) having velocities covering the full range expected for solar particles are now being carried out to determine the most suitable "skin" material(s) for the balloon. Selection will be based on observed behavior of the metals, in particular efficiency of trapping of solar particles and degree of retention of particles after trapping.

Experiments so far demonstrate the feasibility of the project; solar particles can be caught with high efficiency and retained in the skin material during exposure in deep space where it will attain temperatures

exceeding 100°C due to absorption of solar radiation. Tests are being carried out, in addition, to evaluate any possible pitfalls and blind alleys in the experiment.

Analysis of Carbon Compounds in Carbonaceous Chondrites

W. F. Libby

The general objectives of this group's existence have essentially been achieved. The group has developed (1) an understanding of the seriousness of the contamination problem, (2) mutual understanding of techniques, and (3) a forum for frank and friendly discussion of results from different laboratories.

At the April 21-22, 1966, meeting of the group in Washington, D.C., the following were in attendance: E. Anders, E. Barghoorn, K. Biemann, I.Breger, A. Birlingame, M. Dayhoff, R. Eck, J. Hayes, T. Hoering, J. Jedwab, W. Libby, S. Markey, B. Mason, W. Meinschein, G. Mueller, B. Nagy, J. Oro, C. Ponnamperuma, F. Quimby, H. Schnoes, and M. Studier. Topics presented on the program were: "Mechanism of production of primeval organic matter by ionizing radiation," Libby; "Synthesis of organic compounds under quasi-equilibrium conditions," Studier; "Recent progress in the application of high resolution mass spectrometry for the detection of organic compounds in extraterrestrial materials," Biemann; "Possible sources of hydrocarbon contamination; C^{13}/C^{12} ratio in organic matter," Hoering; "Optical activity in meteorites?" Anders; "Analysis of carbonaceous sediments," Schnoes,Burlingame; "Thucolytes," Jedwab; "Organic compounds in chondrites," Meinschein; "Further studies on the organic compounds of carbonaceous meteorites," Oro; "Theoretical calculations of the aromatic and aliphatic hydrocarbons formed under prebiotic conditions," Dayhoff; "Reactions caused by silent electric discharge," Ponnamperuma; and "The significance of inclusions in carbonaceous meteorites," Mueller.

Plasma Studies

W. Libby, L. Wood, C. Jensen

The production and study of dense, high temperature plasmas through inductive energy transfer have continued. In the determination of density and electron temperature regimes accessible with present equipment, extensive use has been made of diagnostic techniques derived from modifications of spectral line formation mechanisms by collective interactions in well understood gases (at least with regard to quantum mechanics) such as hydrogen and helium. Quantitative examination of deviations from local thermodynamic equilibrium in portions of the plasmas (both stationary and streaming) into which energy is injected at highest rates has also been carried out. Progress has also been made in the study of plasmas "doped" with elements whose oscillator strengths are poorly known, this lack of knowledge being an impediment to current astrophysical research.

Intense, Short Wavelength Light Sources

W. Libby, L. Wood, C. Jensen

Efforts to develop and employ intense light sources in the ultraviolet and extreme ultraviolet portions of the spectrum and to utilize population inversions developed in some of these sources to sustain coherent optical oscillation (laser effect) at visible and ultraviolet wavelengths have yielded considerable progress. A recent product of these efforts is a monochromatic EUV plasma source which is approximately two orders of magnitude more intense than any hitherto available.

High Magnetic Fields Project

W. Libby, L. Wood, C. Jensen

Effort has principally been placed on fabrication of superconducting solenoids suitable for generation of continuous magnetic fields in the 100 kilogauss regime over liter volumes. These solenoids will be utilized in magnetic bremsstrählung devices functioning as very intense EUV devices which will be employed in solar simulation studies.

Satellite Data Analysis and Solar and Terrestrial Phenomena

W. Libby, L. Wood

Analysis of data from the first Orbiting Solar Observatory with regard to solar-terrestrial relationships and correlative comparison with a number of measurements of atmospheric activity have been fruitful. The nature of energetics and kinetics of solar control of the upper portions of the terrestrial atmosphere have been more thoroughly determined, and considerable information bearing on the evolution of solar activity centers has been obtained.

Measurements of Sky Brightness and Polarization During the Solar Eclipse of 12 November 1966

Z. Sekera, N. Rao

A quantitative evaluation is being made of the role of secondary and higher order scattering in order to define the ambient radiation field in a planetary atmosphere. The evaluation is an attempt to understand the contrast transmission properties of the earth's atmosphere and the physical processes governing the transfer of electromagnetic radiation in inhomogeneous and spherical atmospheres.

Hydrodynamics and Cosmic Dust Studies

U. Shafrir

Research continues on the horizontal oscillations of spheres falling in a viscous fluid, utilizing equipment on loan from UCLA at the Institute of Planetary and Space Science, Tel-Aviv University.

Equipment, including a light gas gun for accelerating particles, was also loaned to the Cosmic Dust Laboratory at Tel-Aviv University. This laboratory has participated in the following programs:

(1) Venus Flytrap--three sampling surfaces were flown and recovered from the July 1965 experiment; contamination of the surfaces precluded any extraction of useful scientific information.

(2) LUSTER--one sampling slide was flown and recovered in this program, organized by NASA's Ames Research Center. Optical microscope, electron microscope, and electron microprobe scanning of the collecting surfaces are underway.

(3) Gemini Mission--two of four collecting surfaces submitted for the Gemini-9 cosmic dust experiment hopefully will be used; a similar experiment is being designed for the Gemini-10 mission.

U.C.L.A. Dec 66

Synoptic Study of the Ionosphere During the Quiet Sun Period NsG 237-62

S. Venkateswaran

Reduction of Alouette-1 ionograms for the year 1962-63 will yield 40,000 electron density-height profiles to provide data for studies of (1) ionospheric tides at F_2 max and above, (2) diurnal and seasonal development of the equatorial anomaly, and (3) the polar trough.

Atomic Absorption Spectrometer

J. Wasson

Study of the Butler iron meteorite, in which it has been found to have a high Ge/Ni ratio, high Ni content, and high Ga and Ge contents, has indicated that this object is an exception to two geochemical generalizations regarding iron meteorites.

Enhancement of the Computing Facility

A research and development program has been underway by the UCLA Computing Facility to investigate and, whenever desirable, incorporate into its system innovations which will enhance its computational, interpretive, and access potential for the UCLA space program.

At the present time, direct data connection between the 7094 computer and peripheral equipment and the Facility has been completed. The connection joins the 7094, the SWAC computer, and one of the 1401 computers. An experimental console consisting of a Tektronix permanent-trace cathode-ray tube and two electric typewriters is also part of the system.

Also operative is a version of the Hellerman PAT system which permits convenient computations of structured operands.

A second telephone data set has been acquired, and experiments in automatic recording of voluminous data are proceeding.

Present plans are for installation of experimental equipment to furnish ionospheric data acquired at NOTS (China Lake, California) via ordinary telephone lines.

B I O L O G I C A L S C I E N C E S

MONITORING BRAIN FUNCTIONS AND PERFORMANCE IN THE PRIMATE UNDER PROLONGED WEIGHTLESSNESS

NAS 2-2503

W.R. Adey, J.D. French

The biosatellite project at UCLA is working toward a launch date in early 1967 of a 30-day orbital primate flight. Data obtained from this flight by means of telemetry and on-board recordings will provide information regarding the space environmental effects of weightlessness and confinement on central nervous, autonomic, and cardiovascular systems. It is anticipated that these measurements will ultimately provide answers regarding states of vigilance, behavioral performance, rhythms of sleeping and waking, and cardiovascular and respiratory functions to be encountered under conditions of prolonged space flight.

Major efforts have been directed principally toward a biosystems test. Cooperating in these tests are USC, UCB, JPL, Harbor General Hospital, NASA Ames Research Center, and General Electric Company. All supporting spacecraft equipment was checked upon arrival from NASA/ARC. A detailed test plan and procedure were written, tape and paper recording equipment was installed in a test trailer, and cables and status panels were fabricated.

An implanted primate was maintained in a mock-up capsule for 30 days to test the compatibility of the experiments with spacecraft hardware and configuration. The restraint subsystem was designed to protect the primate from excessive forces exerted during launch and re-entry periods and to secure him to waste collection systems.

Approximately 15 primates have been implanted and behaviorally trained. The behavioral training of primates is designed to have the monkey work for food biscuits on two tasks. These test his capacity to track a moving target and to discriminate and to remember one of a set of four randomly recurring symbols for a 20-second delay period.

The experimental animal colony is being increased in number due to a flight readiness requirement of 30 days and to a better definition of the support required for qualification and flight acceptance testing. The estimated goal is to have 40 animals of proper weight and training. This requires at least 80 animals to be screened, trained, and housed at UCLA. Consequently, new behavioral trainers are being designed and constructed to accelerate training and to double the number of primates undergoing training.

An operations plan is being developed for launch orbit and recovery activities as well as for the qualification and flight acceptance test support at General Electric in Philadelphia.

Future efforts will be oriented to collection of experiment control data, spacecraft testing, and finally the launch, orbit, and recovery operations.

A STUDY OF BRAIN FUNCTIONS THROUGH ADVANCED COMPUTER TECHNIQUES FOR ANALYSIS OF EEG DATA

NsG 505

J.D. French, W.R. Adey

There has been a significant increment in the capabilities of the laboratory, both in types of computer programs in routine use and in the development of a time-shared console control system for use with the SDS 930 computer.

Based on our previous experience with spectral analysis as the key tool in analysis of brain-wave records, these earlier methods have now been substantially expanded, both in the repertoire of available procedures and in the display methods available for the computed analyses. One technique, which we have called "evoked spectral analysis," allows a full examination of extremely brief epochs of record, where these records cover repeated performances of the same or a similar task in man or animals. This technique permits a very fine analysis both in animals and in data from astronaut candidates, with indications that it will be possible to separate EEG patterns in man accompanying decision-making performed in one second or three seconds. No such capability has existed with any previous analysis technique.

Much effort has gone into the development of three-dimensional display techniques for the purposes of displaying spectral density analyses of the EEG in relation to whole body vibration across a spectrum of 5 to 40 cycles per second.

A console system allowing time-sharing by five investigators of the SDS 930 computer has advanced to the stage of application hardware. Two such consoles have been attached to the SDS 930 and have facilitated input-formation and display of computer results. The console will be installed in three laboratories of the Space Biology Laboratory, and its evaluation will proceed on the basis of actual experimental application. It will be a most flexible device in the hands of a sophisticated mathematician-physiologist, as well as those who wish merely to command rapidly and flexibly the use of prepared subroutines already stored in computer memory.

NEUROPHYSIOLOGICAL AND BEHAVIORAL STUDIES OF CHIMPANZEES

NsG 502

J.D. French, W.R. Adey

Considerable electroencephalographic data were obtained from implanted chimpanzees playing an electronic game of tic-tac-toe. The technique of discriminant analysis was applied to the data and indicated those EEG parameters which most reliably distinguish between different behavioral situations. This new analytic technique was developed in our laboratory by Dr. D. Walter.

In our study of processes of information transaction in the complexly organized brain, a new learning paradigm has been designed and constructed for the chimpanzees. This new apparatus encompasses the chimpanzees' intellectual ability and provides incremental learning opportunities, as well as testing short-term memory. In order to properly acquire and retain this complex data in processable form, we will apply our newly developed on-line time-sharing console system attached to a medium-sized high speed digital computer. This will permit the investigator to define performance criteria, prepare the entire strategy of the experiment, and pass control to his setup and reacquire control whenever desired for modification, delay, or other intervention.

It is planned to combine the various techniques of mathematical analysis of EEG data developed in this laboratory (spectral analysis, pattern recognition techniques, discriminant analysis) with impedance data to study the mechanisms of learning and behavior in the chimpanzees. Brain studies have hitherto been confined to the evaluation of the electrical manifestation of brain function in voltage waves. Impedance techniques permit observation of on-going processes not revealed

in the EEG, particularly processes occurring at the cellular level as tissue undergoes metabolic transition.

COMPUTER ANALYSIS OF EEG DATA FOR A NORMATIVE LIBRARY
NAS 9-1970

J.D. French, W.R. Adey

The normative library of the human EEG, assessed by computer in relation to behavioral states, has been completed under the direction of Dr. D. Walter. EEGs were summarized by spectral analysis, and the technique of discriminant analysis was applied to the spectral data. This analysis indicated those EEG parameters which most reliably distinguish between different behavioral situations.

The pattern of brain waves on the scalp of the "average" Air Force pilot, including quantitative diagrams of the closeness of relationship between the two brain hemispheres, is among the pithy summary results of this large project.

This library of data provides reference points and dimensions for assessment of abnormalities arising either in medicine or in the unusual environments to which men are increasingly subjecting themselves.

CONTINUING BASIC PROGRAM IN SPACE BIOLOGY
AF 49(638)-1387

J.D. French, W.R. Adey

Our studies have placed increasing emphasis on basic cellular mechanisms in brain tissue likely to be modified by exposure to aerospace flight.

The surface phenomena in cultured neuron membranes have been studied by Dr. R. Elul, with examination of the ion-binding properties of macromolecular intercellular substance at the cell surface and the role of this

substance in determining the volume of extracellular fluid in the brain. This work appears to represent a major contribution to the field.

Studies of basic sleep mechanisms have continued under Dr. C. Batini and Miss S. Bawin, with evaluation of sleep-wakefulness patterns of monkeys with brains split down to lower mesencephalic areas. The altered diurnal cyclings found here are considered relevant to problems of sleep control. Other neurophysiological system studies by Dr. R. Berger have included evaluation of spontaneous eye movements over long periods of growth and development in monkeys deprived of light from birth; investigation by Dr. W. Winters of the central action of clinical anesthetic agents; and study by Dr. C. Batini of the organization of afferent systems to cells of the cerebellar cortex, which is a concern in sensory integration necessary for spatial orientation.

In the area of computer analysis of cerebral activity, our systems of production-oriented spectral analysis and presentation programs have been applied to a large and varied spectra of studies, involving both low frequency waves of the EEG and the relation between such waves and the explosive "spikes" generated within single nerve cells.

Work is complete on the establishment of normal baselines and ranges of normal for EEG patterns and their responses to varying situations, a study which involved computer analysis of many segments of data from many individuals undergoing standardized experiences. Some of the graphic methods of presenting these results have been developed through several stages of refinement and represent, we believe, unique accomplishments in the comprehensible compression of voluminous data. Work is also continuing under Dr. D. Walter on the novel methods of discriminating reliably among subjects' experiences solely on the basis of EEG records.

Developments in bioinstrumentation continue, with the miniaturization of the multichannel biotelemetry system for easier attachment to subjects. The systems have been used by R. Zweizig, A. Jacobson, and Dr. A. Kales in a broad range of experiments from the study of sleep patterns in the chimpanzee in the unrestrained state to 24-hour recordings from patients with chronically implanted electrodes. In addition to central and peripheral nervous system monitoring, R. Kado is working on the possibility of implanting a biotelemetry system in the heart to monitor cardiac blood flow and output.

SUMMER INSTITUTE FOR SPACE BIOLOGY AT UCLA

NASr-241

J. D. French

The curriculum for this course, which provides a brief survey of the entire gamut of physiological functions and the possible problems in mammalian physiology which could be and frequently are brought about by exposure to the aerospace environment, is designed to fill the need beyond the immediate requirements for those students who are considering a career in space biology.

Students for this Institute are selected on the basis of replies received following distribution of syllabus information to more than 1200 schools and colleges. Twenty-five students were selected from more than 70 applicants, representing a cross-section of geographic regions of the country. Applications from students are frequently accompanied by strong letters of support for the individual candidate, together with an expression of appreciation of the importance of the subject matter, especially to those students planning a career in life science research. Enrollment is restricted

and includes only those students at the junior and senior levels.

To obtain maximum exposure to this subject, experts in mathematics, physics, and radiology are included among the faculty, and they are augmented by the able assistance of the UCLA Brain Research Institute and its highly qualified staff of specialists in such fields as cardiovascular, renal physiological, metabolic, endocrinological, and environmental physiological studies.

Since the course's aim is to explore and develop the interrelationships of biology, engineering, and mathematics, as well as other disciplines, and their interdependence in the mission of space penetration, the outside assistance of representatives of Douglas Aircraft Company, Jet Propulsion Laboratories, Litton Systems, North American Aviation, and Vandenburg AFB is enlisted in the form of guided tours, demonstrations, and lecture-discussion sessions, thus enabling students to observe first-hand some of the inner workings of the aerospace industry.

PROGRAM TO ASSESS BASIC PHENOMENA UNDERLYING BEHAVIORAL ASPECTS OF COMPLEX LIVING SYSTEMS IN SPACE

NsG 237-62

J.D. French, W.R. Adey

Occupancy of laboratories in the new space science building, which began in January 1966, has proceeded as rapidly as possible in order to fulfill long-standing commitments to programs in cerebral ultrastructure, cytochemistry, and electrolyte mechanisms.

An electron microscopy laboratory will commence operation shortly and has been provided technical staff and ancillary facilities to allow operation on a shared basis by a series of investigators. Programs are now proceeding under Dr. R. Elul to use this facility for investigation of the mucoprotein and mucopolysaccharide

layers covering cerebral neurons and neuroglial cells (the so-called "glycocalyces") and the modifications induced in these substances by divalent cations such as calcium. Current investigations by H. Wang, R. Kado, and Dr. Adey have indicated a key role for calcium ions in the electrical impedance of cerebral tissue through modulation of conductivity in extracellular fluid containing substantial amounts of macromolecular material.

Neurophysiological recording laboratories for experiments have also been activated, with special interests in effects of ionic manipulation in cerebral tissue on electroencephalographic activity, focal cerebral impedance measurements and behavioral performances (Dr. Z. Elazar). Other investigations by J. Hamer and R. Kado include studies in man of the effects of low frequency electrostatic and electromagnetic fields on visual discriminative performances and concomitant EEG activity, with emphasis on establishment of criteria for thresholds under which stimuli may modify performance and cerebral physiological activity. The effects of complete separation of cerebral hemispheres and midbrain structures in the monkey on electrical sleep patterns in the two hemispheres are being evaluated by Dr. C. Batini and Miss S. Bawin.

A comprehensive spectral analysis of more than five hours of EEG data from Astronaut Frank Bowman in Gemini flight Gt-7 has been completed, with assessment of states of sleep and wakefulness throughout this period and comparison with comparable terrestrial records. Certain persistent changes in electrical patterns in the waking state in space were noted, and evaluation is continuing under Dr. Adey, Dr. D. Walter, and R. Kado.

STUDY OF MICRO AND MACRO DISTRIBUTION OF ENERGY ABSORBED BY TISSUE FROM HIGH ENERGY PROTONS

NsG 237-62

N. Baily

Arrangements have been made to use the new cyclotron at Virginia Associated Research Center to supplement the series of centerline depth dose curves obtained through use of broad monoenergetic proton beams having energies of 20 Mev and 45 Mev at Ucla and 630 Mev and 730 Mev at Berkeley. Proton beams having energies of 300 Mev and 600 Mev are available at the Virginia facility. Instrumentation required for these experiments has been prepared.

Data have been obtained on the operating characteristics of spherical proportional counters which will be used to determine microdose distributions delivered to various depths in tissue by the monoenergetic proton beams. Studies include performance characteristics as a function of electrode design, central wire diameter, and guard-ring potential. Additional tests will be conducted with the UCLA cyclotron.

PATTERN RECOGNITION OF SENSORY SIGNALS IN ANIMALS

NsG 237-62

T. H. Bullock

Research activities during the reporting period have centered on two areas: Determining if the nervous system can utilize different temporal patterns in streams of nerve impulses on a fine scale to carry different meanings and study of the mechanism of the circadian or daily rhythm found in so many animals and in man. A series of experiments in these areas has yielded promising results, and data are being analyzed and evaluated.

MIDBRAIN INFLUENCES ON CENTRAL VESTIBULAR ACTIVITY

NsG 237-62

C. Markham

The objective of this research is to better define the role of the vestibular system in the control of posture and eye movement. Attention is being focused on neuronal activity in the vestibular nucleus, vestibular interaction with centers in the midbrain and diencephalon, and compensatory mechanisms in the vestibular complex following injury to different parts of the nervous system. The effects of stimulation of different midbrain sites on vestibular nucleus neurons which are responsive to stimulation from the posterior and anterior semicircular canals and the utricle are being sought in order to determine whether the inhibitory action of the interstitial nucleus of Cajal is a generalized effect on ipsilateral "type I" neurons or is limited to those connected with the horizontal semicircular canal.

AUTONOMIC RESPONSE PATTERNS

NsG 237-62

M. Wenger, T. Cullen

The relationship of patterns of autonomically mediated activity in man to other dimensions of behavior and to the occurrence of psychosomatic and other abnormal responses to stressors is being investigated. A follow-up study of 2112 cadets tested in 1944 is being conducted to determine the value of physiological measurements for the prediction of combat performance and subsequent development of disorders. Comparative investigations of physiological response patterns in other normal and deviant groups are being made.

An investigation has also been made of problems in the quantification of physiological responses. Analysis of data for a study on the operation of the law

of initial value in different physiological functions was completed, and a theoretical analysis was made of the physiological basis of the galvanic skin response, results of which provide a rationale for use of log conductance as the scale of measurement for electrodermal activity.

E N G I N E E R I N G

THEORETICAL AND EXPERIMENTAL STUDIES OF OPTIMUM STRUCTURAL DESIGN

NsG 423-65

F.R. Shanley

The purpose of the current research project is to put optimum design on a sound scientific basis and to substantiate the extension of optimum design methods to more complex structures by test programs. Theoretical and experimental studies have been or are being carried out in the following areas:

Compression

Eccentric Columns--an interaction method for the analysis of beam-columns and eccentrically loaded columns has been developed which includes the effects of inelastic buckling, local buckling, secondary bending, and other factors. The accuracy of the method has been verified by tests and by application to test data available in published literature. A simple method of direct optimum design has been developed, utilizing this method of analysis, which includes the effects of dimensional constraints.

Wide Columns--tests on 26 60° corrugated wide columns show good agreement with theory. A comparison has been made between 60° and 90" corrugated wide columns, showing the efficiency of the 60° corrugations.

Fluted Columns--a study of fluted tubes in compression has been undertaken.

Bending

Wide Beam--14 tests have been conducted to verify the theoretical minimum weight curves for 60° corrugated wide beams. Added efficiency was obtained by arranging the cross-section so that two modes of failure occur at the same time. Good agreement was found between test

and theory.

Torsion

A test fixture capable of applying 300,000 inch-pounds of torque has been constructed. It has been used to test corrugated cylinders and pentagonal tubes in torsion. Ten tests have been completed. The results correspond well with theory.

Shear

A fixture has been constructed for the testing of corrugated shear panels. Several tests have been conducted, and the study is nearing completion.

System Optimization

A theoretical study has been undertaken on the optimization of structural systems. Up-to-date techniques of mathematical programming are being utilized. Emphasis is on formulation of optimization problems for solution by digital computer.

INVESTIGATION OF CERAMICS AS STRUCTURAL MATERIALS
NsG 427

F.R. Shanley, W.J. Knapp

Directed toward the successful utilization of ceramic materials in structural applications, investigations completed during the reporting period are:

Load-Bearing Characteristics of Prestressed Ceramic Plates--this study concerned the load-bearing capacities and load/deflection relationships for uniaxially and biaxially prestressed ceramic plates.

Effects of Directional Cellulation on the Strength of a Ceramic Material--this work concerned development of ceramic structural elements which possess high mechanical strength and lightweight characteristics and which are geometrically designed to facilitate prestressing

of the material for additional structural applications. Directional cellulation was introduced into ceramic structural elements.

Load Deflection Characteristics of a Ceramic Slab Under Biaxial Prestressing--this investigation consisted of determination of the stiffness properties of a two-way prestressed block-ceramic slab and comparison of the empirically determined quantities with elastic plate theory.

Behavior of Biaxially Prestressed Ceramic Plates Subjected to Thermal Shock--the improvement in thermal shock resistance afforded to ceramic plates by the imposition of biaxial prestressing has been quantitatively determined in this study.

Two areas in which investigation is continuing are:

Strength of Some Ceramics Containing Hollow Glass Spheres--this research concerns the bending-strength/weight characteristics of ceramic specimens made by incorporating hollow glass spheres in a glass matrix.

Fabrication and Testing of a Prestressed Ceramic Dome--fabrication of prestressed ceramic elements with double curvature is underway, with particular emphasis on utilization of such elements as building units for larger structures.

BSD (RTD) BALLISTIC MISSILE RETARGETING STUDY
AF 04 (694)-826

C.T. Leondes, E.B. Stear, A.R. Stubberud

Development of Algorithms for Advanced ICBM Reference Trajectory Determination

Sequential Optimization of ICBM Trajectories (D. Isaacs, R.Niemann)--Both algorithms for determining ICBM reference trajectories have been running on the IBM 7094 digital computer. The most recent studies on

the computer have involved simulation of a real time in flight determination of ICBM reference trajectories using these algorithms. The calculations have been very successful, and it appears that these algorithms provide effective methods for explicit advanced ICBM guidance.

Algorithms for Variable Flight Time ICBM Trajectories (R.Niemann, G.Paine)--The sequential optimization techniques developed in this program have included techniques for determining the time of flight as part of the ICBM reference trajectory determination. Studies are also being carried out to determine if more computationally efficient techniques for flight-time determination can be evolved.

Reference Trajectory Determination Optimized With Respect to C.E.P. (E.Volgenau)--The object of this study was to develop a systematic means for developing ballistic missile reference trajectories in a way that will improve missile accuracy.

A number of computer runs have been made, using two different hypothetical boosters, a large, two-stage liquid ICBM and a smaller three-stage solid ICBM. Results showed a significant improvement in missile accuracy over that achieved when a minimum energy trajectory is used.

Advanced ICBM Re-entry Vehicle Techniques

This phase of the program is concerned with determination of techniques for advanced ICBM re-entry vehicles of either the multiple warhead type, the advanced maneuvering re-entry vehicle class, or other classes of advanced ICBM re-entry vehicles.

Work is nearing completion on optimum design and linear guidance law formulation of entry vehicles for guidance parameters and temperature accumulation along optimum entry trajectories.

ICBM Control Law Development

Efforts in recent months in this area of research have started to yield some rather fundamental and apparently important results in relation to suboptimal ICBM control law development (G.Kang) and adaptive control of a two-point boundary problem for advanced ICBM control using sensitivity functions (J.Watson).

Filtering Techniques in Advanced Ballistic Missile Guidance and Control

Nonlinear filtering techniques avoid the necessity of carrying out linearizations and result in the ultimate in system performance. The potential importance of results J.R. Fisher has obtained in this area could be applied in a number of ways to advanced ICBM performance and control.

Maximization of the Attainable Region for a Maneuvering Re-entry Vehicle

For a given set of re-entry initial conditions, a control function is to be determined which allows achievement of the largest possible range of landing sites without exceeding the imposed restrictions at any time during its flight. Consideration must be given to use of three-dimensional dynamic equations of flight for atmospheric re-entry and maneuvering with state variable constraints, including a minimum allowable velocity, maximum heat accumulation, and an acceleration bound so as not to exceed structural capabilities.

Multilevel Trajectory Optimization

Multilevel optimization as applied to ballistic and space systems appears to be a systematic way to attack a very complex problem by decomposing both the trajectory (time) and the system ('state equations), solving these smaller problems and iteratively combining the results to reach the final solution.

ENGINEERING RESEARCH SUPPORTED BY
NsG 237-62

Control of Systems Whose Characteristics Change Randomly at Random Times

M. Aoki

Computer programs have been written and used to obtain performance evaluations of several suboptimal control policies. Additional work in this area is underway.

High Energy Electrodes in Nonaqueous Electrolytic Solutions

D. Bennion

Research in this area is divided into three related projects, and investigations of new, nonaqueous electrolytes for possible battery applications appear quite pressing. Requirements for such solutions are:

(1) High, ionic electrical conductivity;
(2) Stability to reduction by reducing agents such as metallic lithium;
(3) Stability to oxidation by oxidizing agents approaching fluorine in reactivity;
(4) Liquid at near normal temperature and pressures;
(5) Proper solubility characteristics with regard to proposed active electrode materials;
(6) Desirable influence on the chemical reactions taking place at the electrode surfaces.

The three projects underway are directed toward description of these properties for various electrolyte solutions.

Surface Temperature Measurements on Sublimating Surfaces

A. Charwat

Systematic tests on the special distribution of the

luminescence of 20 samples are in progress. Based on temperature range and degree of distortion of the spectrum with temperature, a few indicator materials will be selected for test as aggregates in a body of smothered camphor.

A theoretical analysis of the transient response of ablative material to a heat pulse has been made to serve as a framework for experimental verification of this concept of temperature measurement.

Opposed-Jet Diffusion Flame as a Tool for Chemical Kinetic Studies

C. Chu

Objectives of this project are to exploit the opposed-jet diffusion flame as a tool for chemical kinetics studies, to extend it to some different but related geometries, and to use it for study of various fuel-oxidant combinations. A burner system including reactant-supply lines has been designed; upon completion of the equipment, experimental work will begin.

Material Shaping by Electrolysis at High Current Densities

R. Cole

In order to establish a mass and energy balance for the high current density electrochemical reaction, it was necessary to design and build an electronic coulometer to measure the total electrical charge passing through the electrodes. This instrument has been completed.

Work has continued on pressure and temperature measurements in the electrode gap. Design and assembly of the three channels for study of flow in large width-to-depth ratio and short-length passes have been completed, as well as measurements of temperatures by means of thermocouples evenly spaced along the gap length.

Work is in progress on solving numerically the Laplace equation for current distribution and comparing results with the experimental data.

Two Aspects of the Influence of Dissolved Hydrogen on the Behavior of Iron and Steel

A. Flanigan

Research continues on the effect of interstitial hydrogen on discontinuous yielding in iron.

Plasma Studies on Solids and Microwave Studies on Semiconductors

W. Hershberger

Indium antimonide is being studied because it exhibits the highest electron mobility of any known semiconductor. Research underway should yield important results in the near future.

Quantization Process of Hybrid Computation

W.J. Karplus

The quantization process was examined in the specific context of hybrid computation with the aim of improving the efficiency of the process. The problem space was partitioned into two classes, depending upon whether or not the signals to be quantized had significant intersample correlation.

Results of the research indicate that significant hardware savings could be obtained from the application of predictive quantizing to hybrid computations.

Ultimate Strength and Stress Field of Plates and Shells Under Lateral Pressure and Edge Compression

T. Lin and J.Taylor

Work on numerical calculations in this area has continued and is nearing completion. A final report is forthcoming.

Low Density Gas Dynamics

C. Liu

Determination of the drag force and heat transfer experienced by a vehicle traveling in rarefied atmosphere is the main objective of this new project. Preliminary results for flow over a circular cylinder have been verified by three independent experiments and will be checked further against data obtained from high altitude sounding rockets.

Determination of the Knoop Hardness of Tungsten Single Crystals

J. Neumann

Two molybdenum-mounted Knoop indentors have been received, to be used with the high temperature hardness tester at Atomics International. The equipment for testing the hardness below room temperature had to be redesigned because of insufficient cooling.

Irradiation Strengthening of Titanium and Its Alloys

K. Ono

Preparation has been initiated on tensile specimens, design and construction of an irradiation apparatus, and fabrication of jigs for tensile tests.

Influence of Texture on Fatigue of Titanium and Titanium Alloys

D. Rosenthal

Effort has been directed toward developing grains in commercially available, fine-grain titanium sheets that are large enough for study of the orientation effects.

Along with grain-size studies, work is underway on suitable polishing and etching techniques for grain observation of actual fatigue specimens.

Filament Matrix Structures

M. F. Rubinstein

A model for tensile fracture of unidirectional, fiber-reinforced composites has been developed. The fracture stress predicted by the model agrees satisfactorily with observed values of breaking strength. The model predicts a reduction of fracture stress with size in excellent agreement with observed values. Modification of existing formulas to account for the proportion of strain energy in fiber and that in matrix has resulted in calculated fracture stresses in compression which are in good agreement with observed values and modes of fracture.

Investigation of Ultrasonic Propagation in Ferromagnetic Materials

R. Stern

Ultrasonic propagation in ferromagnetic materials, primarily as a function of applied uniaxial and hydrostatic stress, is being studied. Preliminary measurements of the attenuation of sound in nickel as a function of uniaxial stress are underway.

Automatic Synthesis of Switching Networks

A. Svoboda

Research activity has been directed toward preparation of a set of programs as part of the "Implementer" project. The ultimate goal is to achieve automatic synthesis of switching networks under widely specified constraints. To effect this goal, a program for minimization and a program for the solution of Boolean equations have been prepared.

Development of Far-Infrared Superconducting Photodetector

T. Tao

Two important improvements have been made in thin-film studies: completion of a much better vacuum thin-film evaporation unit and development of a much improved procedure for depositing a thin insulating layer between semiconductor and superconductor. Construction continues on the far-infrared facilities.

Surface-Wave Propagation Along a Bounded Quiescent Cesium Plasma Column

T. Tao

The surface waves on a ferrite rod in x band frequencies have been under investigation. It is hoped that experience gained in these studies can be applied to plasma surface waves.

Analytical Methods for the Optimum Design of Structures

J. Taylor

Effort has been directed to a study of the form and potential for development of energy expressions for the optimization of simple structures. Certain energy forms of optimization constraint have been interpreted

in terms of their physical significance.

Spin-Lattice Relaxation Time Measurement in Laser-Maser Materials

C. Viswanathan

Construction and testing of equipment have proceeded. The new power supply performed quite well with the magnet, and the modulation coils were mounted and put in operation. A sweep unit was constructed to slowly sweep the magnetic field. An additional dewar for use in optical measurements has been added to the cryogenic system. A superheterodyne microwave receiver with excellent stability characteristics is now operative. The lock-in amplifier and recorder which are basic parts of the electronic system have been connected together and work well.

Several crystals of suitable size have been obtained, and two control batches have been evaporated for comparative tests.

Capillary Pressure on Magnetic Interactions in Metals

W. Van Vorst

The technique employed for determination of liquid saturation in a porous medium has proved to be reliable and practical. Capillary-pressure function is being determined for several particle sizes.

Effect of Pressure Upon the Magnetic Interactions of Metals

A. Wazzan

An extensive program of research on the effect of pressure on the magnetic interactions in some rare earth elements and alloys is underway.

Human Performance in Adverse Environments

G. Weltman, G. Egstrom

Attention is being focused on changes in scope of attention which reportedly accompany early experiences with personal, life-support gear in dangerous environments. The experiment involves assigning beginning SCUBA divers three variants of a dual task and determining whether the peripheral response time lengthens as the subjects move from air to the relatively comfortable, mildly dangerous open ocean.

S O C I A L S C I E N C E S

UTILIZATION OF AEROSPACE TECHNOLOGY IN FUTURE AUTOMOTIVE ENGINEERING

NsG 237-62

G. Hoffman

The objectives of this study are to forecast some of the automotive engineering advances and innovations that might occur in the next 20-30 years based on developments within aerospace programs, to investigate alternatives to the internal combustion engine, and to determine socioeconomic implications of these automotive innovations with regard to the abatement of air pollution, better individual transportation, and resource conservation.

B U S I N E S S A D M I N I S T R A T I O N

MANAGERIAL METHODS OF SUCCESSFUL PROJECT MANAGERS WITH A LOOSE REIN

NsG 237-62

G.A. Steiner, W.G. Ryan

Basic managerial philosophies, principles, and practices of 15 project managers in the aerospace industry were investigated. All operated in the research and development phase, and all were highly successful in producing a superior technical product at a minimum of time and cost.

The major conclusion of the study is that more loose-rein arrangements should be made by government agencies. Important benefits can accrue to the government from application of this technique in fairly large and complex research and development programs in terms of superior technical product at lower cost and in less time.

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ALPHABETICAL INDEX TO INVESTIGATORS

NUMERICAL INDEX TO GRANTS