SPACE SCIENCES LABORATORY

INTERDISCIPLINARY RESEARCH IN THE PHYSICAL, BIOLOGICAL, ENGINEERING, AND SOCIAL SCIENCES

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Annual Report on NASA Grant (NsG 243)

Covering the period:
1 October 1967 through 30 September 1968

Space Sciences Laboratory Series 9, Issue 60

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Space Sciences Laboratory
University of California
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INTERDISCIPLINARY RESEARCH IN THE PHYSICAL, BIOLOGICAL, ENGINEERING, AND SOCIAL SCIENCES

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Principal Investigator: Professor Samuel Silver

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INTERDISCIPLINARY RESEARCH IN THE PHYSICAL, BIOLOGICAL, ENGINEERING, AND SOCIAL SCIENCES

NASA Grant
NsG 243

I. INTRODUCTION

The annual report on NASA Grant NsG 243 is designed to serve several purposes. It is a report to the Office of University Affairs of the National Aeronautics and Space Administration on what has been accomplished during the past year, and it provides the background for our proposal for the renewal and extension of the grant. But, it also serves an important function internally by providing the members of the Space Sciences Laboratory with a broad yet comprehensive survey of what is being done here in space research. This report, it should be noted, covers only the work supported by NsG 243. The major part of our support is in the form of special projects under the program offices, and the reports on those projects are made separately according to the requirements of those offices.

The content of NsG 243 has changed considerably over the past year. As of January 1968, the High Altitude Particle Physics Experiment (under the direction of Professor Luis W. Alvarez), which had been funded by Office of Space Science and Applications as a task under NsG 243, was transferred to the Space Science Division of the Manned Space Flight Center in Houston. The work is set up as a separate project and will be reported according to the terms of the contract under which it is now funded.

The procedure for reporting on NsG 243 has also been modified as follows: The semi-annual report for the period October 1 through March 31 now consists solely of scientific project material in the form of the abstracts supplied to the Smithsonian Information Exchange. The annual report, on the other hand, is quite detailed covering all aspects of the operations of the Space Sciences Laboratory as an interdisciplinary unit on the Berkeley campus of the University of California. The reports on the projects

vary in form and scope. Some are quite long, representing the entire endeavor of the investigator during the year; most are relatively short summaries of work in progress.

The report has three main parts: Core Funding, Social Sciences, and Nutritional Sciences. The responsibility for the program in the nutritional sciences and its support has been in a state of flux during the past six months. As will be explained in the general discussion regarding Core Funding, the work in the nutritional sciences has been supported both by project funds from the Office of Life Sciences and NsG 243 core funds. Rather than try to dissect the program in detail on this basis, the whole of the work in the nutritional sciences is dealt with as a unit as it was in the preceding report.

II. THE CORE FUNDING COMPONENT OF NsG 243

The core funds, or sustaining grant, though a small fraction of the total support of the Laboratory, are of immeasurable value in helping us achieve the primary goal of maintaining a broad-based program in the space sciences for faculty and graduate students. The cardinal principle on which this Laboratory has been set up and on which it endeavors to operate is to serve as a stimulus to graduate education in space science and to help faculty members and students interested in space research carry out their work. A research laboratory at a university should not be a substitute for one of the National Aeronautics and Space Administration's Centers, and conversely, neither can a center serve the same total purpose as a university laboratory, which is truly part of the educational system. The university's special contributions are the *advancement of knowledge* and e *development of people*, the two being thoroughly welded one to the other.

Project funding contributes to this process, but it lacks the flexibility to adapt to new ideas and conditions not covered rather explicitly by the grant document. The sustaining funds, on the other hand, enable the Director to institute new programs, to try new avenues of study, and to engage students more freely in the assurance that they will have the freedom to pursue their own research and thus be given the opportunity to grow and to develop.

The Space Sciences Laboratory is a campus-wide organization. That is, it cuts across the boundaries of departments, schools, and colleges and operates directly under the Dean of the Graduate Division and the Office of the Chancellor. The Advisory Committee, which reviews the programs, is made up of the deans of the various colleges whose departments are involved in the program and of representatives from the departments. The original terms under which the sustaining grant to this Laboratory was instituted were to provide the Laboratory with the equivalent of ten full-time (fte) positions, which it can share with departments so as to engage the faculty and to develop the fullest possible participation.

The funds have been used in many ways to effect this desired participation. Stipends are granted to Research Assistants, who are graduate students in the various departments, to work with professors on projects leading to advanced degrees. "Seed" money has been made available to faculty members to start new projects in the space sciences. In some instances, summer salaries have been paid to faculty members, and, also in some instances, part of the annual salary has been paid to a faculty member on research leave from his department. The latter is very limited; the support and the leave are granted only when the research requires more than the normal fraction of time allocated to research in our regular appointments. Another form of support is the purchase of equipment of use to several groups in the Laboratory. Such purchases cannot be made generally with project funds.

Another important use of sustaining grant funds is to tide projects over the period when their contracts or grants are being renegotiated. Usually, the monies are recoverable by appropriate transfers of funds. This past year, however, has been exceedingly difficult. The various holdbacks of funds have put an unduly heavy strain on the sustaining grant, and the excessive delays coupled with the restrictive terms of the new grants and contracts have made transfer of funds impossible. Two notable cases of support rendered by the sustaining funds to preserve continuity are the High Altitude Particle Physics Experiment and the Nutritional Sciences Project. Both would have been wrecked completely without this support.

In the case of the High Altitude Particle Physics Experiment, the funds advanced by the sustaining grant can be recovered only in the form of equivalent services in the field of electronics. Two projects will benefit from this situation. One is the investigation of auroral emission in the infrared, involving a balloon experiment being developed by Professor Samuel Silver, and the other is the x-ray and γ-ray astronomy program being developed by Professor C. Stuart Bowyer. The effective allocation to these projects from the core funds thus turned out to be larger than they normally would have been.

There has been considerable discussion regarding the meaning and purpose of an interdisciplinary grant. In our own case we took the terms of reference to be those of (1) Mr. James E. Webb's letter to Professor Silver establishing the grant, (2) the proposal made to Mr. Webb by Professor Silver to develop a space sciences program that would consist of a national resource in the exploration of space and the training of students, and (3) the *Memorandum of Understanding* between President Clark Kerr and Mr. Webb for the promotion of a broad program *including* the social sciences and the development of an interaction between the research laboratory and the outside community.

We have directed ourselves to this task along several lines. In the areas of the physical, biological, and engineering sciences we have fostered research that cuts across the traditional boundaries of the professional fields and the parochial views of the specialists. We have tried to develop joint projects between physics and electronics; physics, chemistry, and computer science; and microwave radiometry, microwave electronics, and planetary physics, to name but a few. We have developed a social sciences program that is itself interdisciplinary within the social sciences. This is discussed in the section on social sciences. We have, in a limited sense, developed an interchange between the hard scientists and engineers on the one hand and the social scientists on the other. Perhaps most important of all, we have sought to develop a physical and an intellectual environment that stimulates interdisciplinary exchange while at the same time commands the respect of the academic community. The success is, we believe, measured in part by the fact that during the past year we have had 62 faculty members in the program and 100 graduate students. Of the latter, 50 are serving as Research Assistants and are conducting their own research for advanced degrees.

When we try to give an accounting of the expenditures of funds in terms of the people and the work we do, we are forced to discuss problems and projects. Furthermore, since the money that makes up NsG 243 has come from several offices of the National Aeronautics and Space Administration, the demand has been made to report in such a manner that each office can spot the return on its investment. This accounts for the format of our later sections, in which the work is broken down into sets of projects.

The sustaining grant funds have been used to maintain a series of seminars and colloquia. These have been the seminar course type, in which graduate students participate and receive course credit, and the general type, open to the campus and to the public at large. The lecturers are brought to the campus from other universities, NASA Centers, and industrial laboratories, and the Space Sciences Laboratory has shared the cost with the teaching departments. Owing to budgetary problems, which developed this past year, these activities have been curtailed somewhat. The list of seminars is given later in this section.

Another aspect of our program relates to the *Memorandum of Understanding*. We have used the Laboratory as an instrument in the socio-economic sphere in dealing with the problems of minorities. The administrative offices, under the direction of Mr. Robert F. Content, have organized and developed the New Careers Training Program, which has been one of the most vigorous and effective of such programs on the Berkeley campus. This is described in more detail later in this section.

Finally mention should be made of the activities of senior staff members in bringing their research background to bear on current problems before non-technical segments of the community. We reported last year on the symposium arranged for the Episcopal Cathedral Deans. Subsequent to that the members of the staff have participated in a lecture series and in refresher courses for the clergy. An evening seminar was arranged involving clergymen and, in addition to the Space Sciences Laboratory personnel, professors of physics, sociology, civil engineering, and law to discuss the problems of science and technology in society. This was done with the thought of setting up a larger seminar open to the students of the campus. In general, then, we have carried out a number of programs designed to bring the research laboratory into the social scene and to extend the work of the laboratory into the community.

A. *General Operations*

The sustaining grant provides some operational support for the administrative services group, but certainly not as great a percentage as in past years. In addition, partial support is provided to a new

position within the Laboratory — that of the Technical Services Officer, Mr. Jerry H. Zenger. Mr. Zenger's responsibility is to provide the Laboratory with technical advice as required in an interdisciplinary laboratory. The Technical Services Officer will bridge the gap between the various projects and groups by maintaining communication with all groups, both on the central campus and at our Richmond facility.

In the case of new projects initiated by faculty members associated with the Laboratory or new staff members who must prove their ideas before developing proposals and seeking external support for their projects, the services of the Laboratory are put at their disposal and charged to the Sustaining Grant as part of our contribution to the development of new research. Students receive a large amount of support in this way. This will become quite evident in our review of the research work itself. It is interesting to note at this point, as an illustration of the service rendered, some of the proposals prepared with the aid of NsG 243 funds during the period covered by this report:

Investigations in X-Ray Astronomy Employing Large Collecting Area Instrumentation in the Apollo Spacecraft. Professor C. Stuart Bowyer. Submitted to NASA.

A Proposal to Study the X-Ray Emission of the Southern Hemisphere Sky. Professor C. Stuart Bowyer. Submitted to NASA.

A Proposal to Study the X-Ray Emission from Selected Regions of the Southern Hemisphere Sky. Professor C. Stuart Bowyer. Submitted to NASA.

An Experiment to Measure the Variability of Galactic X-Ray Sources. Professor C. Stuart Bowyer. Submitted to NASA.

Studies of Solar X-Ray Spectra from the OGO-V Satellite. Professor C. Stuart Bowyer and Dr. Stephen W. Kahler. Submitted to NSF.

An Integrated Research Program in Space Nutrition. Professors Sheldon Margen and Doris H. Calloway. Submitted to NASA.

Proposal for Study of Returned Lunar Samples: Geological Properties and Mechanical Behavior. Professor James K. Mitchell. Submitted to NASA.

Proposal on Lunar Surface Engineering Properties Experiment Definition. Professor James K. Mitchell. Submitted to NASA.

Analysis of Surveyor Lunar Mechanical Property Data. Professor James K. Mitchell. Submitted to JPL.

Thermionic Emission Properties of Rhenium in Cesium. Professor Thomas H. Pigford. Submitted to NASA.

Proposal for Further Development and Application of a Dynamical Theory of Low Energy Electron Diffraction. Professor Harold P. Smith, Jr. Submitted to NASA.

Proposal on In Situ Permeability Measurement of Lunar Materials. Professor Paul A. Witherspoon. Submitted to NASA.

B. *The New Careers Program*

The Space Sciences Laboratory is the major participant on the Berkeley campus in a program dealing with a subject of great national concern — provision of educational and career development opportunities to the poor and to members of minority races. Specifically, the New Careers Program at the Laboratory is providing on-the-job and academic training for careers in space-related, technical fields.

The program, which began in January 1968, is now being evaluated operationally by Mr. Stephen Zwerling, a graduate student in public administration; a report on the results of his research will serve the University to assess the expansion potential of this concept for a campus-wide training program of non-academic personnel. The results of Mr. Zwerling's research are presented below.

The Mariner Mars Project, the High Altitude Particle Physics Project, and the Editorial-Reports Section were selected as the training sites for the New Careerists. Detailed job descriptions and career ladders were drawn up for the training of three electronics technicians and one technical editor; the supervisor in each section selected the New Careerist from applicants referred by local employment centers.

All of the four New Careerists are black and all reside in designated poverty areas of Oakland. Three men (ages 26, 27, and 40) were chosen for training as electronics technicians; a woman (age 42) was chosen for training as a technical editor. While their cumulative job experiences have been highly varied, they are nevertheless characterized by steady employment. Futhermore, the New Careerists have demonstrated interests in the areas in which they are being trained.

The actual performance of the trainees has been quite encouraging, particularly since this program has been in operation only six months. *Educationally*, the Careerists are performing at least average work; it is interesting to note that the trainee with the least amount of formal education has acquired the best record so far — a B average. It is also noteworthy that while only 25% of the Careerist's time is allocated to formal classwork, the Careerists are carrying class schedules that are at least 65% of those normally maintained by full-time students (this is in addition to their on-the-job training). In fact, this summer, two of the trainees are carrying full-time class loads. *On-the-job performance* has also been adequate. On the standard University performance evaluation for the initial (six-month) period of employment, all four trainees received the maximum rating of "satisfactory." Of course, these evaluations must be interpreted carefully in that the supervisors *want* the Careerists to succeed and may have adjusted their evaluations accordingly. There are other, external factors that indicate great motivation to succeed on the part of the Careerists. One of these factors is the comparatively low rates of take-home pay during the initial stages of training. The second factor is the commute time between home, school, and work; the *shortest* possible travel time on local busses is *three hours per day*.

Several generalizations may be drawn from the New Careers Training experience. First, the University *is* capable of conducting a training program *if* departmental interest can be aroused. At present the commitment exists only at central points within the University and not at the operational levels. Furthermore, the critical ingredient appears to be the *desire* of a particular unit *to become involved*. The larger the size of the unit (in terms of budget and personnel), the lower the cost of these training activities. The more specific the set task, the easier it is to establish a training program. Second, no serious problems will be encountered from the individual trainee, provided the long-range view is operant. The disadvantaged have a history of having performed poorly (i.e., "failing"); as such, it is extremely important that initial tasks be programmed, insofar as possible, to insure successful initial experiences. This presumes, of course, that lack

of confidence is a critical variable. (This lack of confidence is not, however, reserved to the disadvantaged; there is sufficient evidence to support the statement that professional personnel, when confronted with an opportunity to return to school, have serious misgivings concerning their ability to compete at a high level.) Third, there seems to be little utility to channeling funds through an intermediary agency. If the University is sincere in its statements that it ought to play a larger role in community affairs, then it would do well to establish its own structure to administer and to operate such training programs and to procure its own funds from external sources. However, in order to gain the compliance of departmental units in such an effort, it is necessary that University officials announce publicly that there is a need for entry-level personnel and that minority group members will be given preference for training positions.

C. *Faculty and Student Support in New Programs*

The point was made earlier that an important use of the sustaining grant funds is to stimulate new interests and to help faculty members develop new programs. This is one of the most effective means of establishing and maintaining cooperation with the participating departments and of insuring that the Laboratory continues to be a unit of the graduate program. During the past year, we have made allocations to four faculty members in this program.

Note was made last year of the addition of a new faculty member, Professor C. Stuart Bowyer, to the Department of Astronomy for the expressed purpose of developing a new area of work in x-ray and γ-ray astronomy. The Space Sciences Laboratory took an active part in bringing Professor Bowyer to Berkeley and provided him with a laboratory and funds to get his program underway. Reference to the funding of this program was made earlier in the general discussion. The report, rather detailed, of the work done by Professor Bowyer appears later in the portion devoted to astronomy.

Funds were allocated to Professor Francis J. Turner of the Department of Geology and Geophysics for work on the stony meteorites. Professor Turner's attention turned to this subject as a result of the ma-

terial published regarding the findings on the surface of the moon obtained by the *Surveyor* experiments. The requirements of Professor Turner for this work are rather modest at this time. The allocation provides for one Research Assistant.

The Physics Department added a very distinguished scientist, Professor Charles H. Townes, to the faculty. Professor Townes is working in a number of fields, bringing to each his profound knowledge of quantum electronics. The Space Sciences Laboratory allocated funds to help Professor Townes get his work underway, particularly that phase dealing with the study of maser- and laser-processes in astrophysical phenomena.

Note was made last year of the plans to bring Dr. Robert C. Wentworth to the campus to work with Professor Stanley A. Ward in the Department of Mineral Technology to develop a research and course program in Geoscience Engineering. The costs were shared with the Department and other grants. This was a one-year arrangement, and the results of Dr. Wentworth's research are reported *in extenso* in the Atmospheric and Space Physics Section.

Subsequent to conversations with Dr. George Jacobs of the Office of Life Sciences and with Professor Thomas H. Jukes of our Laboratory, we agreed to provide funds to Professor John E. Hearst of the Department of Chemistry to proceed with several important studies in biochemistry and molecular biology. The costs are being shared by NsG 243 and by the Chemistry of Living Systems Project, which is supported by the Office of Life Sciences.

Funds have been allocated to Professor Aaron Wildavsky to continue his work in the City of Oakland. This work was part of the Technology and Urban Management Project, for which the support by the Office of Technology Utilization was terminated. The work of Professor Wildavsky had just reached a really productive stage, and we felt, therefore, that it should continue for the next four months. A report on this work appears later in this section.

D. *Seminars and Colloquia*

The role of the Laboratory in developing seminars and colloquia and the use of sustaining grant funds for this purpose were stated earlier. The following is a partial list of the program carried out this past year:

Ring Currents and Electric Fields in the Magnetosphere, September 26, 1967, Dr. Lars Block, Division of Plasma Physics, Royal Institute of Technology, Stockholm, Sweden.

The Physics of Comets and the Origin of Type I Comet Tails, September 28, 1967, Professor David Beard, Head of Physics and Astronomy Department, University of Kansas, Lawrence. (Jointly sponsored by the Space Sciences Laboratory and the Department of Mineral Technology.)

Wind-Blown Dust Model of Martian Surface Features and Seasonal Changes, October 20, 1967, Mr. Carl Sagan, Harvard College Observatory and Smithsonian Institute, Astrophysical Observatory, Massachusetts. (Jointly sponsored by the Space Sciences Laboratory and the Department of Astronomy.)

Origin of the Solar System — General Principles, November 7, 1967, Professor Hannes Alfvén, Director of the Division of Plasma Physics, Royal Institute of Technology, Stockholm, Sweden.

Origin of the Solar System — Spin of the Planets, November 14, 1967, Professor Hannes Alfvén, Director of the Division of Plasma Physics, Royal Institute of Technology, Stockholm, Sweden.

Origin of the Solar System — Plasma Conditions, November 21, 1967, Professor Hannes Alfvén, Director of the Division of Plasma Physics, Royal Institute of Technology, Stockholm, Sweden.

Solar Coronal Streamers, January 16, 1968, Gerald W. Pneuman, High Altitude Observatory, University of Colorado, Boulder, Colorado.

E. *Review of the Research Supported by the Core Funds*

E.1 *Atmospheric and Space Physics*

This is one of the major areas of graduate work in space science. Students in the Department of Physics, the graduate group on Atmospheric and Space Sciences, the Department of Electrical Engineering, and the Division of Engineering Geoscience of the Department of Mineral Technology participate in various research projects in this area. The following are reports of the various studies supported by NsG 243.

1.1 *Dynamics of the Magnetosphere*

(Ferdinand V. Coroniti, Research Assistant)

The dynamics of the magnetosphere are evolving into a study of the interaction of a hydromagnetic convective flow from the tail of the magnetosphere with the auroral region. The tail flow necessarily produces anisotropies in the velocity space distribution of particles and establishes macroscopic pressure gradients in various regions of the magnetosphere. Thus the flow continuously drives the plasma away from thermal equilibrium, and we might expect the outbreak of plasma turbulence, both microscopic and macroscopic, which attempts to restore equilibrium. It will be this plasma turbulence, which dominates the dynamics of the magnetosphere, that we shall be investigating.

At this time work on several topics is at various stages of progress. We start by summarizing the most advanced work and conclude by outlining future research.

The steady anomalous loss of energetic particles from the earth's magnetic mirror field has been studied by several authors in terms of cyclotron resonant pitch angle scattering by cyclotron turbulence (for protons) and whistler turbulence (for electrons). Electron precipitation, however, is rarely observed to be steady, but is observed to possess a bewildering variety of temporal variations from a few milliseconds to several hundred seconds. For time scales longer than a few seconds, energetic electrons conserve their first two adiabatic invariants. However, it is for these time scales that precipitation modulations are observed to occur in association with micropulsations of the same period. Unless the micropulsation wave fields in the magnetosphere are of the same order of magnitude as the main field, it is difficult to understand how micropulsations could drive a significant precipitation of electrons.

During substorms, when precipitation modulation is observed, the energetic fluxes in the magnetosphere are near or above their stability trapped limit. Thus the electron distribution is in diffusive equilibrium with a turbulent whistler spectrum. Since this equilibrium is a delicate balance between sources and sinks of wave energy and particles, any small perturbation of the electron distribution

can increase the whistler growth rate, and hence, the pitch angle diffusion coefficient. However, since linear changes in the whistler growth produce exponential changes in the pitch angle diffusion coefficient, a large increase in the precipitation rate can arise from a small perturbation.

Since the exact dynamics of the interaction of a micropulsation with the turbulent electron distribution are extremely complicated, we greatly simplify the problem by using a model of the micropulsation that increases the magnetic field seen by the particles. Using this crude model we have estimated the qualitative behavior of the precipitation rate as a function of the low frequency wave period and amplitude and have obtained substantial agreement with observations.

The problem of precipitation modulation leads immediately to consideration of the possible sources of the micropulsation waves. These waves have frequencies well below the equatorial ion cyclotron frequency. No expermental evidence exists for the mode structure in the magnetosphere other than the fact that the waves are observed magnetically on the ground. The precipitation modulation associated with these micropulsations has been observed to be localized in the ionosphere. If the previous whistler ideas are substantially correct, then we can infer from the electron observations that the micropulsations are localized in the direction perpendicular to the magnetic field. The low frequency and the inferred localization immediately suggest that drift wave instabilities are the generation mechanism.

We have concentrated our investigation on the micropulsations whose periods range from 5 — 15 seconds, which are observed in the auroral zone during magnetospheric substorms. Vasyliunas has observed that at these times the boundary of the plasma sheet moves rapidly inward to $L \sim 6$. Since this is primarily a temperature boundary we have been led to look for drift instabilities that are driven by a temperature gradient and have some magnetic polarization to agree with ground observations. Upon investigating the finite Larmor radius dielectric tensor for moderate $\beta(\beta = 8\pi p/B^2)$ plasmas, it can be shown that for wave frequencies above $\Omega_+ \cos\theta$ $(\Omega_+ = \frac{eB}{cm_+})$ $(\cos\theta = K||/K)$ the Alfvén branch has a mixed

electromagnetic-electrostatic polarization and is resonantly unstable to electrons in the presence of a temperature gradient. For appropriate magnetospheric parameters, the fastest growing wave has a period of roughly 10 seconds and perpendicular wavelengths in agreement with the electron pulsation observation.

These two projects have been done in collaboration with Professor C. F. Kennel of the University of California at Los Angeles. A preliminary paper on the micropulsation generation, "Plasma Waves in Space and in the Laboratory," was presented at the NATO Advanced Study Institute, Rösos, Norway, April 1968 (in press, *Proceedings*). Papers on both projects were presented at the national meeting of the American Geophysical Union in April, and two papers are in the final stages of preparation for submission to the *Journal of Geophysical Research*.

A third project, which has attained some measure of fruition, is the investigation of turbulent conductivities in the magnetosphere. In a highly collisionless plasma such as that found in the magnetosphere above the ionospheric E layer, it is unclear what the relationship should be between a current flowing along the magnetic field and the electric field since ordinary Coulomb collisions no longer provide an electron-ion collision frequency, or resistance. If the plasma possesses a spectrum of turbulent waves, however, a particle can scatter off a wave, exchanging energy and momentum, and this interaction can be described as an effective collision frequency. Thus there can exist a turbulent resistance along the field line consisting of wave-particle scattering.

To proceed we must first specify the unstable source of the wave turbulence. Two likely sources of electrostatic waves were considered: the loss cone instability, which derives its unstable energy from the presence of the loss cone in a mirror magnetic field; and the ion sound instability, which is rendered unstable when the current drift velocity exceeds the local ion sound speed. If the current is sufficiently small so that the ion wave is stable, loss cone turbulence provides a passive resistance. If the current itself is ion sound unstable, the impedance to the current flow is an inductance.

Unlike the calculation of ordinary Coulomb scattering, where only the kinetic equation for the particle distribution need be considered, for plasma turbulence we must also solve a kinetic equation for the wave spectrum since the dissipation involves the wave energy dynamics. For both of the above mentioned instabilities, the combined equations were solved approximately to construct a steady turbulent wave-particle scattering rate. For appropriate magnetospheric parameters, loss cone turbulence gave an effective conductivity of $\sim 4 \times 10^{-3}$ mho/meter, and ion sound turbulence gave 3×10^{-5} mho/meter.

A paper on the above project was presented to the Fourth International Conference on the Universal Aspects of Atmospheric Electricity, Tokyo, Japan, May 1968 (in press, *Proceedings*). A more complete paper is in preparation for submission to the *Journal of Geophysical Research*.

A fourth project (which we anticipate to be long term) is the study of hydromagnetic slow shock waves. The reconnection or magnetic field annihilation model of Petschek has been applied to the magnetospheric flow and to several astrophysical phenomena such as solar flares and quasars. Inherent in this model is that the magnetic neutral sheet region be bounded by slow, switch-off hydromagnetic shocks. These shocks stand in the upstream flow into the neutral sheet boundary layer, increase the annihilation rate of magnetic energy, and accelerate the flow of plasma and magnetic field along the neutral sheet.

The first problem in understanding the microscopic turbulence inherent in Petschek's model is to formulate a theory for the structure of slow shock waves. Starting with the two fluid equations with finite electron and ion inertia and resistance, and using the energy equation for the pressure, a wave train differential equation for the structure of both fast and slow shocks has been derived. From this equation it has been shown that the complete switch-off slow shock wave possesses a stable shock transition.

A short paper discussing the complete switch-off wave train is in preparation and will be submitted for publication to the *Journal of Plasma Physics*.

Future research on this problem will be directed toward calculating the microscopic turbulent dissipation processes that provide the necessary resistance to dissipate the magnetic field energy and resolve the shock structure.

1.2 *Interaction of the Moon with the Solar Plasma and the Magnetosphere*

(A. Robert Cannon, Research Assistant, and Professor Samuel Silver)

Of the various terrestrial phenomena, such as rainfall, auroral activity, low amplitude geomagnetic variations, and larger amplitude geomagnetic variations that have been reported to show a correlated dependence on lunar phase, only the correlated variation in geomagnetic activity over and beyond the diurnal variation seems to have stood up under repeated tests.

We have reviewed this subject with some care and have sought to find an explanation among the many possible modes of interaction of the moon with the solar plasma and the magnetospheric tail. The variation in geomagnetic activity as described by the K_p index seems to take the form of a general decrease in activity over a period of some 7 days preceding full moon and a general rise (slightly less significant) over the 7 days following full moon. There is also apparently a latitude effect such that the reported correlation is highest when the moon is near the ecliptic at full moon and disappears for latitudes greater than 4°. The problem thus seems to be that of how the moon perturbs the magnetospheric tail.

A qualitative consideration of hydrodynamic effects, or, more properly, of magnetohydrodynamic effects, seems to be unable to account for the latitude effect, especially the narrow limits in the latitude in which the moon has a measurable effect. We have, therefore, turned to a consideration of the moon as a source of particles that are injected into the magnetosphere. A stream of particles, particularly if they are ionized and moving in the direction opposite to the mainstream of the magnetosphere tail, could produce a significant perturbation and instability in the stream.

The flux of particles from the moon emitted as a result of sputtering under the impact of the solar wind was estimated on the basis of experimental data reported in the literature on sputtering under ion bombardment. The flux from the moon, in the near full moon condition, into the solid angle subtended by the earth is of the order 4×10^{19} atoms/sec. This is to be compared with a proton flux in the tail of the magnetosphere of the order of 10^{22} per sec. The neutral stream of particles would not have a significant effect on the stability of the magnetosphere tail, but it is possible for the particles to become ionized both by collisions with charged particles in the solar plasma and by photoionization.

The possible role of photoionization was investigated taking the composition of the sputtered particles to be that from a lunar surface layer consisting primarily of silicates of Ca, Fe, Mg, Al, and Na. The spectral distribution of the solar radiation was taken from the data of Hinteregger, and ionization was calculated from the ionization potentials and photoionization cross section. The probability of ionization of an atom over the path from the moon to the earth was estimated, and it was found that, while an appreciable fraction of the sputtered atoms would undergo photoionization before injection into the magnetosphere tail, the larger fraction would arrive as neutral atoms. The generation of stream instability by injection of charged particles thus seems less likely.

There are many uncertainties in the calculations. Photoemission from the surface of the moon has been neglected completely. The composition of the sputtered atoms and the estimates of photoionization are, of course, only qualitative. We must refine the analysis considerably before the proposal mechanism can be accepted or rejected. A short report on this work will be issued in the near future.

1.3 *Hydromagnetics of the Magnetosphere — Geomagnetic Micropulsations*

(Professor Stanley H. Ward, and Dr. Robert C. Wentworth, Assistant Research Geophysicist)

The following manuscript, which was submitted for publication to the *Journal of Geomagnetism and Geoelectricity*, describes the work carried out during this report period.

THE GEOMETRY OF THE MAGNETOSPHERE.

II: A WEAKLY CONNECTED MODEL OF THE GEOMAGNETIC TAIL

R. C. Wentworth

INTRODUCTION

It was suggested in Part I (Wentworth, 1967) that the magnetosphere was pressed by the solar wind into three topologically distinct regions, the topologically un-connected upper and lower pole cap-tail flux tubes, and the central, connected core. In order to illustrate this process a model field configuration from two anti-parallel solenoids was discussed. It was suggested that two possible topologically distinct solutions existed, an un-connected solution in a strong, streaming plasma, and a connected solution in a weak, streaming plasma. It was implied that in the un-connected solution the boundaries of the upper and lower flux tubes approached each other asymptotically in the downstream direction.

However, this reasoning leaves out the finite boundary layer thickness. The question of what happens when the pure mathematical solution approaches closer than the boundary layer thickness was not considered. However, it is now felt that the result will be a fundamental change in the topology of the solution, that in fact the tail will be weakly connected across the region of contact as illustrated in *Figure 1a*.

This possibility was suggested by H. Alfvén (private communication), who pointed out that electric fields across the neutral sheet would allow plasma to slip downstream through the weak connecting field without blowing it away, or being turned aside.

WEAKLY CONNECTED FLUX TUBES

The source of the required electric field is the systematic polarization of the plasma entering the region of contact between the two flux tubes. As shown in *Figure 1b*, the protons are deflected to the right by the perpendicular northward magnetic crossing field, and electrons to the left, thus producing a space charge distribution which gives the

required electric field. If v_s is the velocity of the streaming plasma, and B_p the perpendicular component of the magnetic field connecting the two flux tubes across the region of contact, then the corresponding electric field is

$$E_{ns} = -v_s \times B_p$$

If we have a situation similar to that of the geomagnetic tail, where v_s is 10^6 m/x and B_p is 4×10^{-9} weber/m^2, then the electric field is

$$E_{ns} = 4 \times 10^{-3} \text{ volt/m}$$

$$(v_s = 3 \times 10^5 \text{ m/s})$$

$$(B_p = 1.3 \times 10^{-9} \text{ weber/m}^2)$$

With respect to these values it is important to note that measurements by Bame et al. (1967) can not be used here since they were made too close to the inner, connected magnetosphere, i.e. in the wake of the closed magnetosphere rather than in the freely flowing downstream tail.

WEAKLY CONNECTED GEOMAGNETIC TAIL

It is suggested that the geomagnetic tail is weakly connected across the neutral sheet in the same way, as shown in *Figure 2*. Our suggested solution starts with the open, split-tail solution of Part I. Then where this solution has the distance of approach of the upper and lower polar cap-tail flux tubes closer than a proton gyro-radius, magnetic field lines will tend to connect across the area of contact, as in *Figure 2a*. Solar wind plasma flowing into the neutral sheet from

the flanks will be polarized, setting up the required electric field from the dusk boundary across the tail to the dawn boundary, as in *Figure 2b*.

PLASMA SHEET

The same electric field will drive plasma drifting up and down away from the neutral sheet into the tail proper, as shown in *Figure 1c*. The fact that this can happen follows from considering the inverse situation, namely plasma in the interior and a reversal of the electric field which will drive the plasma toward the boundary. The only thing that can happen when the particle reaches the boundary is that it crosses the boundary and escapes to the field-free region. However, since the orbit of the particle in this reversed situation is a mirror image of the orbit of the particle in the direct situation, it follows that a particle from the field-free region can penetrate into the interior. It is suggested that this is the source of the plasma sheet around the neutral sheet observed by Bame et al. (1967).

It is useful to point out at this time that other mechanisms have been suggested which allow plasma exterior to a magnetic field-dominated region to pass across the boundary and enter the interior. First, Piddington (1960) suggested that instabilities of an electrostatic nature exist in the boundary sheath of the magnetosphere, and that these instabilities could scatter ions into the stable trapping region. This suggestion was subsequently amplified by Bernstein et al. (1964), Fredericks et al. (1965), and Scarf et al. (1965). Second, it was suggested by Fejer (1965) and Wentworth (1965) that if the component of the gradient of the interior magnetic field parallel to the boundary was finite then exterior particles could drift across the boundary and on into the interior. In this picture the particles would systematically drift into the interior, while in the first picture they would diffuse into the interior. The present suggestion represents a third possible mechanism whereby plasma outside a magnetic field can cross the boundary into the interior.

Finally, we should comment that specifics of the measurements of Bame et al. (1967) can not be applied directly to the question of the plasma sheet since they were made too close to the wake of the inner, closed magnetosphere, and not in the freely flowing downstream tail. This applies to the question of the energy spectrum of the plasma in the plasma sheet, which is radically different from that in the magnetosheath, and also to the question of whether the plasma sheet should fill the entire tail. It is possible, as later suggested, that the plasma sheet actually does flare out to fill the entire distant, downstream tail (cf. *Figure 3*).

DOWNSTREAM TAIL

The expansion of the flux tube from a single solenoid in a streaming plasma was discussed in Part I. It follows from the conservation of magnetic flux that the magnetic field strength falls off in the manner depicted in the loss-free model of *Figure 3*. However, in our present model flux is lost across the neutral sheet, and a reasonable estimation of this loss, in which the component of magnetic field across the neutral sheet is 25 percent of the main component parallel to the tail, is given in the leaky-flux-tube model, also in *Figure 3*.

However, the tail can not continue to expand beyond the point where the interior field along the boundary is less than the interplanetary field, around 5 gammas. This happens at about $-100\ R_E$ downstream, where the diameter of the tail is on the order of $50 - 60\ R_E$. Beyond this point it is suggested that the tail becomes increasingly inflated by interior plasma which provides the force necessary to maintain the tail against the external pressure.

Finally, if the component of magnetic field across the equatorial plane remains at approximately 1 gamma, then the entire magnetic flux in the tail will have been reconnected by about $-300\ R_E$ downstream, as sketched in *Figure 3*.

EXPERIMENTAL VERIFICATION OF THE WEAKLY CONNECTED MODEL

An experimental verification of the essential features of the weakly connected model is a relatively simple matter for a plasma-gun experiment. The mathematical solution for an anti-parallel solenoids situation, as depicted in *Figure 1a*, could be worked out by computer computations, in which the connections across the area of contact were ignored. Then the plasma-gun experiment could measure the actual topology of the resultant magnetic fields, map the region of contact containing perpendicular magnetic fields, and compare this region of contact with the result of the mathematical analysis.

DISCUSSION

(1) *On the penetration of interplanetary plasma into the geomagnetic field*

It is widely felt that the major difficulty with theories involving solar wind plasma in the neutral sheet is how plasma in the interplanetary space can find itself within a field connected to the earth, as this is assumed to violate the "freezing" condition $E + vXB = 0$ at some stage of the process. This problem has been side-stepped in the present paper, which deals *only* with the steady-state solution in which solar wind plasma does *not* find itself within the magnetosphere. It is in the transient phase, during the formation and re-connection of the geomagnetic tail, such as during the geomagnetic storm, that this problem becomes the most crucial factor. Actually, we would like to comment at this point that it is felt that the anti-solar cusp region is inflated to bursting during the initial and growth phases of the geomagnetic storm, that portions of it are explosively blown downstream, and that these events represent polar sub-storms.

However, returning to the question of interplanetary plasma within the magnetosphere, we point out that in Part I it was suggested and defended that an open-split-tail solution existed for the steady-state geomagnetic tail in which the neutral sheet was topologically part of external space. In exactly the same manner the neutral sheet in the anti-parallel solenoids model of *Figure 1* is also topologically part of external space. Therefore, in these steady-state models of Part I the problem of penetration is rigorously avoided.

The spirit of the present paper is, then, a suggestion as to how a weak connection might exist between the formerly topologically isolated upper and lower flux tubes. However, the solar wind plasma in the neutral sheet is still in external space, so that the penetration of plasma into the magnetosphere is avoided for the moment, until the transient problem is discussed. Finally, somewhat to the point is the fact that the magnetosphere is defined as being that region of space where physical processes are controlled by the geomagnetic field. It must be that in the magnetosphere the energy density of the geomagnetic field is much greater than that of the trapped plasma. This is obviously not true of the neutral sheet where the energy density of the plasma separating the upper and lower flux tubes is much greater than the weak crossing field. Therefore, by definition the neutral sheet can not be part of the magnetosphere.

(2) *Conclusions of the present paper*

It has been suggested in Part I that the primary force responsible for the open, split-tail was normal plasma pressure of solar wind plasma along the boundary rather than more esoteric forces, such as viscous drag of various origins, or internal plasma or hydromagnetic wave pressure. It is still felt that this is the case and that refinements of this model such as that suggested in the present paper can account for the various effects still as yet unexplained. It is concluded:

i) Solar wind plasma in the neutral sheet is flowing downstream away from the earth. The suggestion that the plasma in the neutral sheet would blow a distant neutral point away downstream was first made by Dessler (1964), and the present view is in accord with this suggestion.

ii) This downstream-flowing plasma is electrically polarized by the perpendicular component of magnetic field northward across the neutral sheet, the resultant space charge giving rise to a dusk-to-dawn electric field across the tail. This cross electric field allows the plasma to slip downstream through the perpendicular magnetic field component without blowing it downstream.

iii) The cross electric field causes plasma to drift from the region of contact in the neutral sheet up and down into the tail proper, thus being responsible for the plasma sheet observed by Bame et al. (1967).

ACKNOWLEDGMENTS

I wish to acknowledge a stimulating discussion on this subject with H. Alfvén. Many of these ideas were developed during a recent Guggenheim Fellowship in 1966-67. This research was supported by NASA Grant NsG 243.

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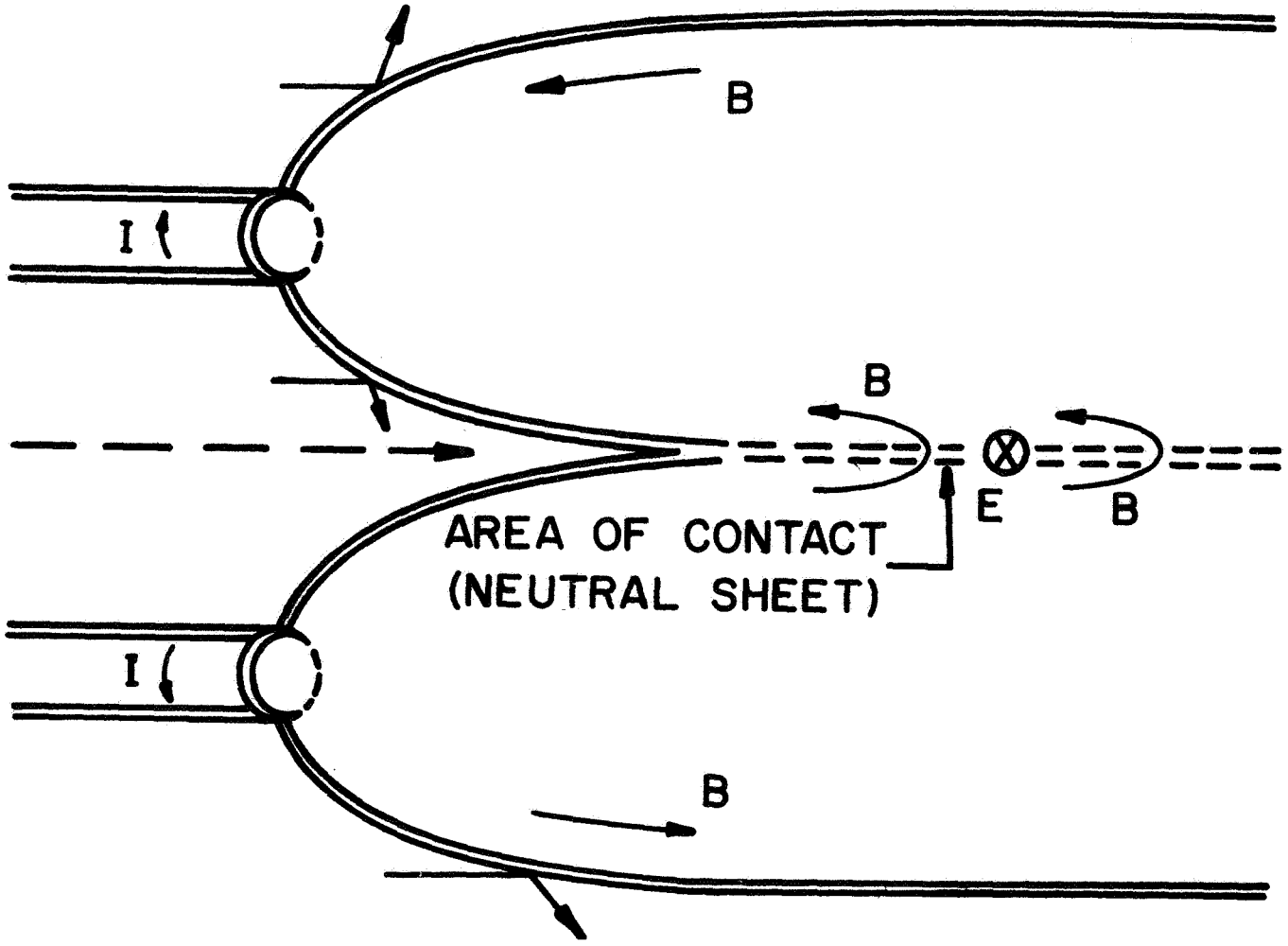
FIG. 1

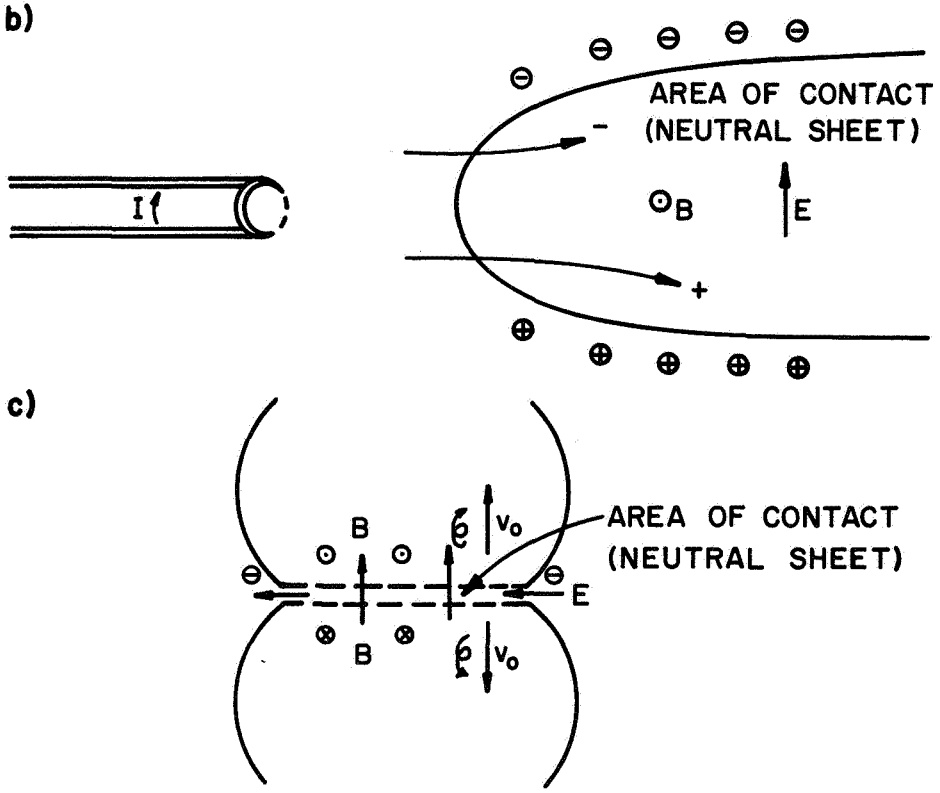
a)



Oppositely directed flux tubes from anti-parallel semi-infinite solenoids. The magnetic field is confined within a cavity bounded above and below (as well as on the sides away from the neutral sheet) by the normal pressure of specularly reflected plasma. The plasma streams through the neutral sheet under the simultaneous influence of the v x B and E terms in the Maxwell force expression.

b) Equatorial plane (or area of contact) viewed from above for the system of Figure 1a. The separation of positive and negative charges by the perpendicular magnetic field produces the space charge along the boundary which gives rise to the electric field necessary to allow the plasma to slip through the magnetic field. c) View looking down the tail in the equatorial plane of the system of Figures 1a and 1b. The electric field across the tail drives plasma drifting into the interior from the neutral sheet, as described in the text.

FIG. 1



a) The 3-component magnetosphere suggested by Wentworth (1967) with a weak connection of the upper and lower flux tubes across the neutral sheet. b) Polarization of solar wind plasma flowing into the neutral sheet from the flanks as viewed from north of the equatorial plane.

FIG. 2

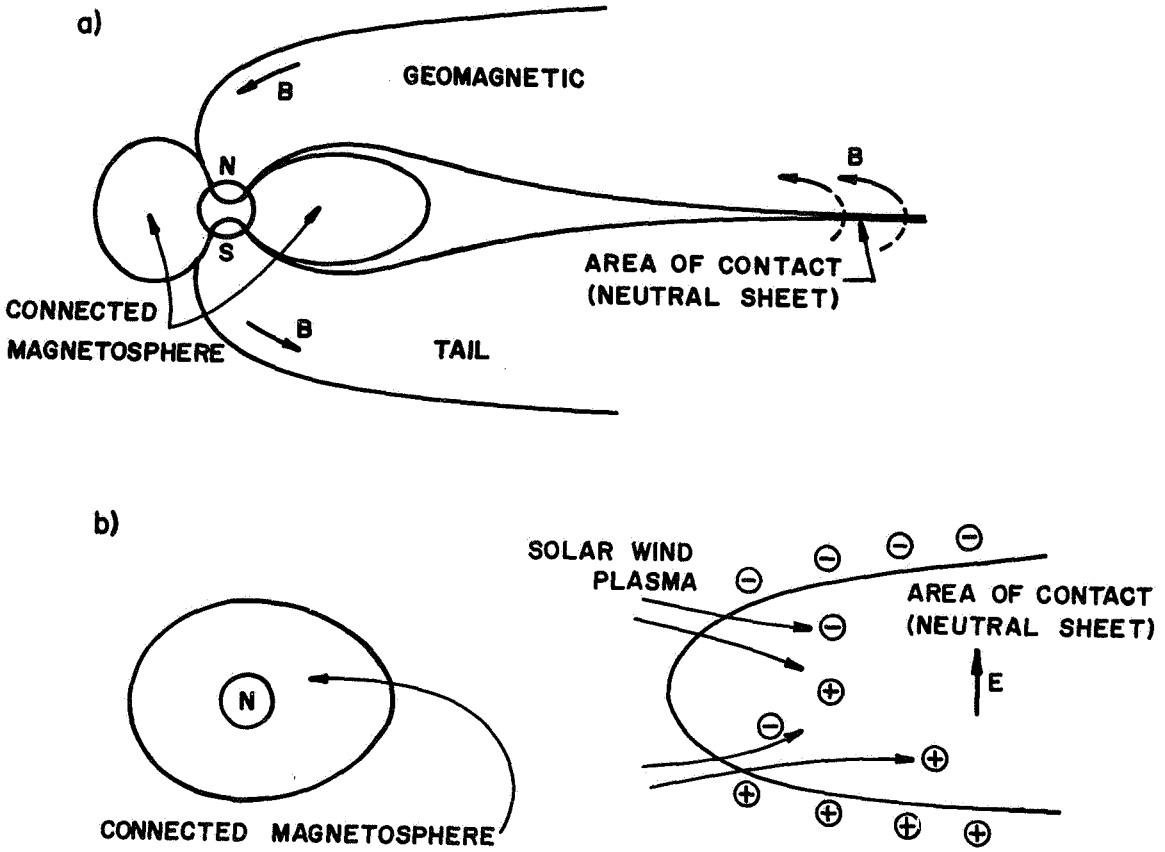
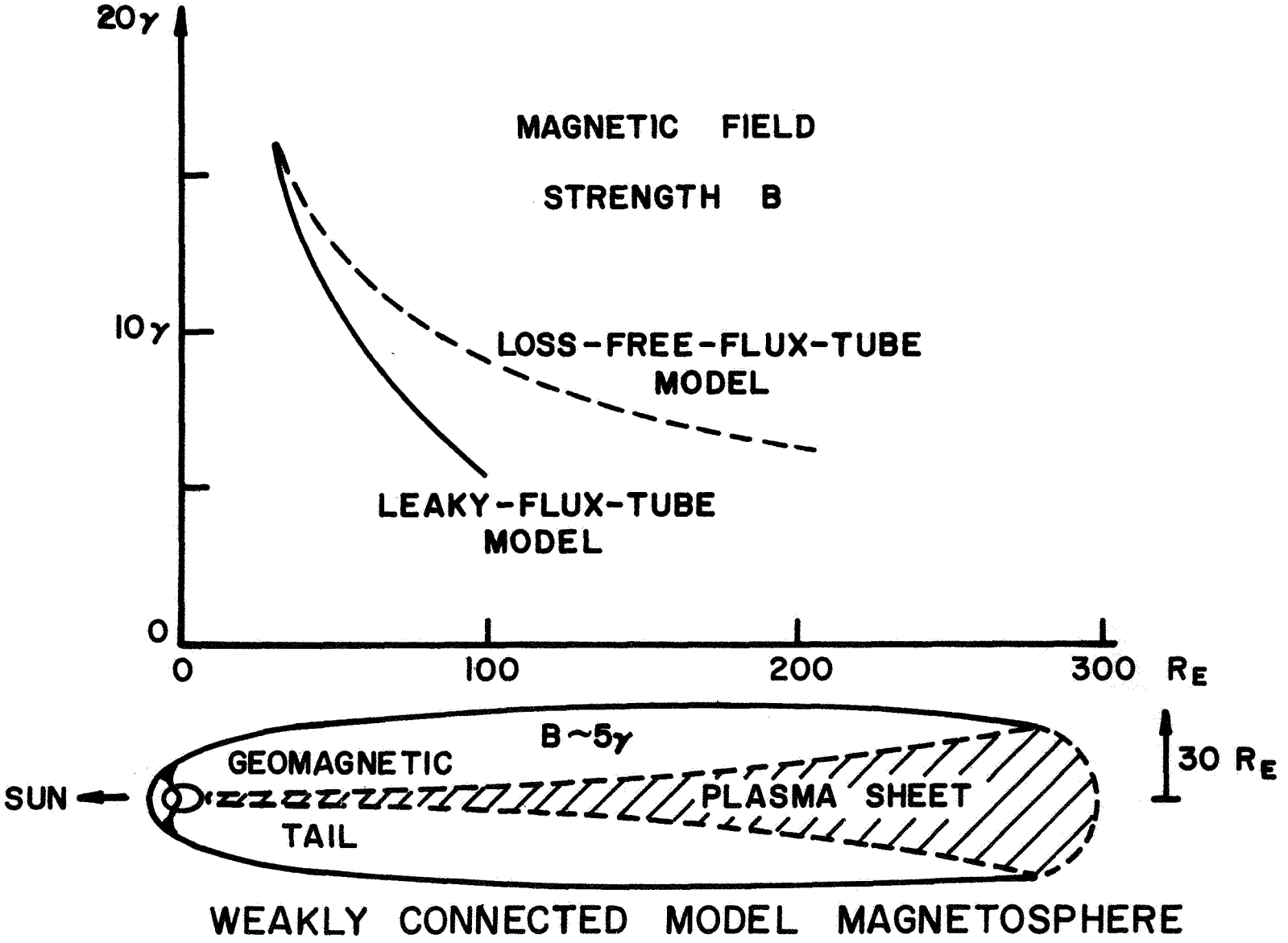


FIG. 3

Magnetic field strength and geometry of the geomagnetic tail for the weakly-connected model magnetosphere.



1.4 *Energy and Flux Variations of Nearly Monoenergetic Auroral Electrons*

(Dr. Richard D. Albert, Research Physicist)

Analysis of protons, electrons, and alpha particle energy spectra and their pitch angle distributions obtained in the 1966 Fort Churchill launches is continuing. Payloads are being prepared for two *Javelin* flights from Fort Churchill and a *Brandt IV* flight from Natal, Brazil, to be launched next winter.

The present status of the data analysis is as follows. Final proton and alpha energy spectra have been obtained from the Fort Churchill rocket launch into a visible aurora. Pitch angle distributions of the heavy ion data, as well as the electron data, are being processed by computer program to yield angular information having about 2 degrees resolution. This information will be useful to obtain further details on the nature of auroral acceleration mechanisms. Work has begun on analysis of the data obtained during the daytime launches by means of the computer program referred to above, which gives high resolution pitch angle information. The variation of mirror point altitudes during the course of the flights will be obtained for both day and night conditions.

Payloads for the future *Javelin* and *Brandt* flights were breadboarded and calibrated with accelerators. Design of the space packages is in progress.

Publications:

Auroral electrons. Albert, R. D. *Encyclopaedic Dictionary of Physics*. Suppl. Vol. 3, Oxford: Pergamon Press, 1968 (in press).

Rocket observations of charged particles in the auroral zone. Lampton, M. L., R. D. Albert, K. A. Anderson, and L. M. Chase. Birkeland Symposium on Auroral and Magnetic Storms, *Annales de Geophysique* (in press).

Low energy electron and proton spectra in the auroral zone. Albert, R. D. *Transactions of the American Geophysical Union, 48*, 180 (1967).

Detection of the presence of alpha particles in auroral fluxes. Albert, R. D. *Transactions of the American Geophysical Union, 48*, 866 (1967).

Energy and flux variations of nearly monoenergetic auroral electrons. Albert, R. D. *Journal of Geophysical Research, 72*(23), 5811 (1967).

Nearly monoenergetic fluxes detected during a visible aurora. Albert, R. D. *Phys. Rev. Letters, 106*, 369 (1967).

Reply. Albert, R. D. *J. Geophys. Res., 73*, 4453 (1968).

1.5 *Infrared Emissions in the Auroral Zone*

(Professor Samuel Silver, and Steven G. Halverson, Associate Development Engineer)

Extensive studies have been made by workers in this Laboratory and in other universities and research centers of particle precipitation into the atmosphere and auroral emissions. The studies have been largely on x-rays, as indicators of particle precipitation, and on optical and ultraviolet emission. Work on the infrared region of the spectrum has been considerably less, and much has yet to be learned by exploring the infrared.

As was explained in last year's report, we set ourselves the task of repeating a balloon-borne experiment performed previously by Dr. Robert L. Wax, a former graduate student at Berkeley. The objectives of our experiments are:

1. To observe the excitation of N_2 and O_2 in an auroral event and to try to determine the temporal characteristics of the emission.
2. To try to verify the previously reported dependence of the OH emission, i.e., the nightglow, with altitude. The emission does not vary monotonically, and this has not been explained satisfactorily.
3. To try to determine if the nightglow emission is affected by an auroral event and, if so, the nature of this effect.

The first attempts at the experiment were made in September 1967. Professor Robert R. Brown of the Physics Department placed three of his balloons at our disposal, and we launched two payloads out of Fort Wainwright, Alaska. We obtained rather ambiguous data and could not derive from them any definitive results pertaining to the objectives

stated above. However, we did learn a great deal about the technique of such an experiment and, after the analysis of our work and the data, found ourselves in a better position to design a new payload.

We embarked on the next stage, particularly in view of the funds that had been advanced to the High Altitude Particle Physics Experiment (see the general discussion on Core Funding). Arrangements have been made with the Office of Naval Research to supplement the NsG 243 funds and to provide operational assistance in flights to be launched from Fort Churchill in October 1968. The new payloads make use of new detector assemblies. The mechanical rotary wheel chopper has been replaced by tuning fork choppers. The data transmission system has been redesigned to be compatible with the nature of the phenomena and the data rate to be encountered. Instead of switching filters, we shall use a set of detectors and fixed filters to measure simultaneously the 0.75 μ — 1.7 μ band and the 1.7 μ — 2.7 μ band and the thermal background $\lambda > 2.7$ μ. Thermocouples will monitor temperature differences between the crucial sections of the payload. We have benefited greatly from the experiences of the High Altitude Particle Physics Experiment group and of the *Mariner 1969* (I.R. Spectrometer) group in the design of our payloads. *Figures 1* and *2* show the essential features of the system in block form.

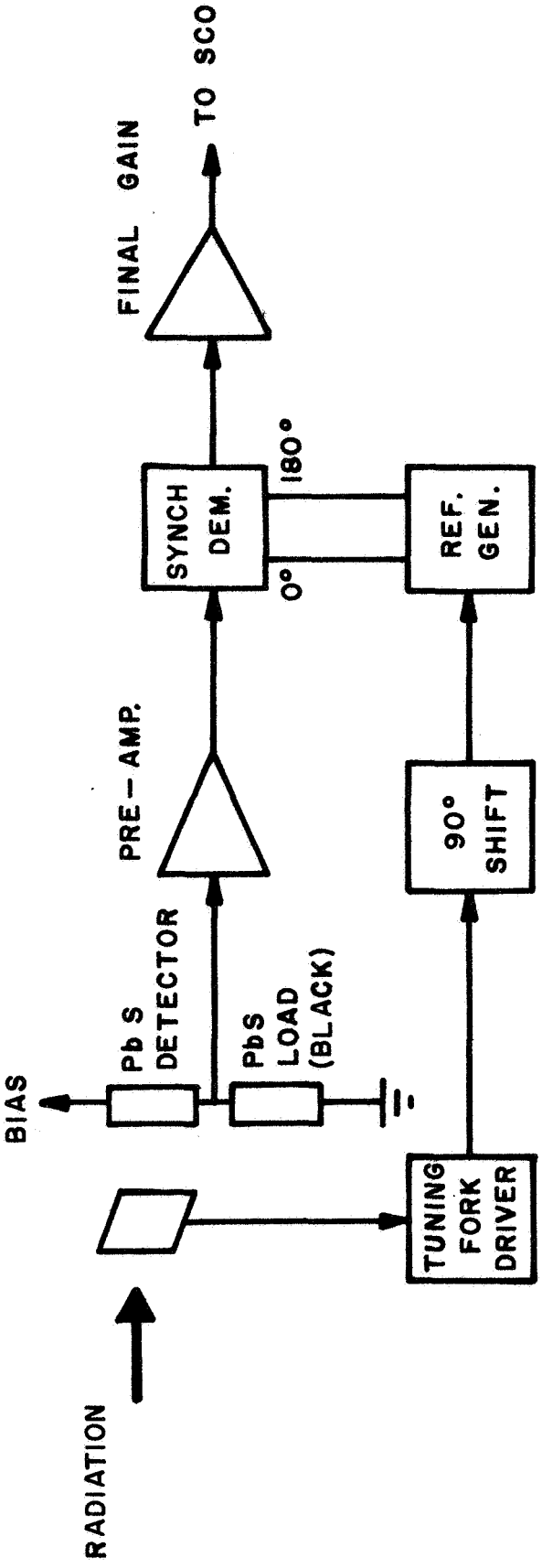


FIG. 1 DETECTOR ELECTRONICS

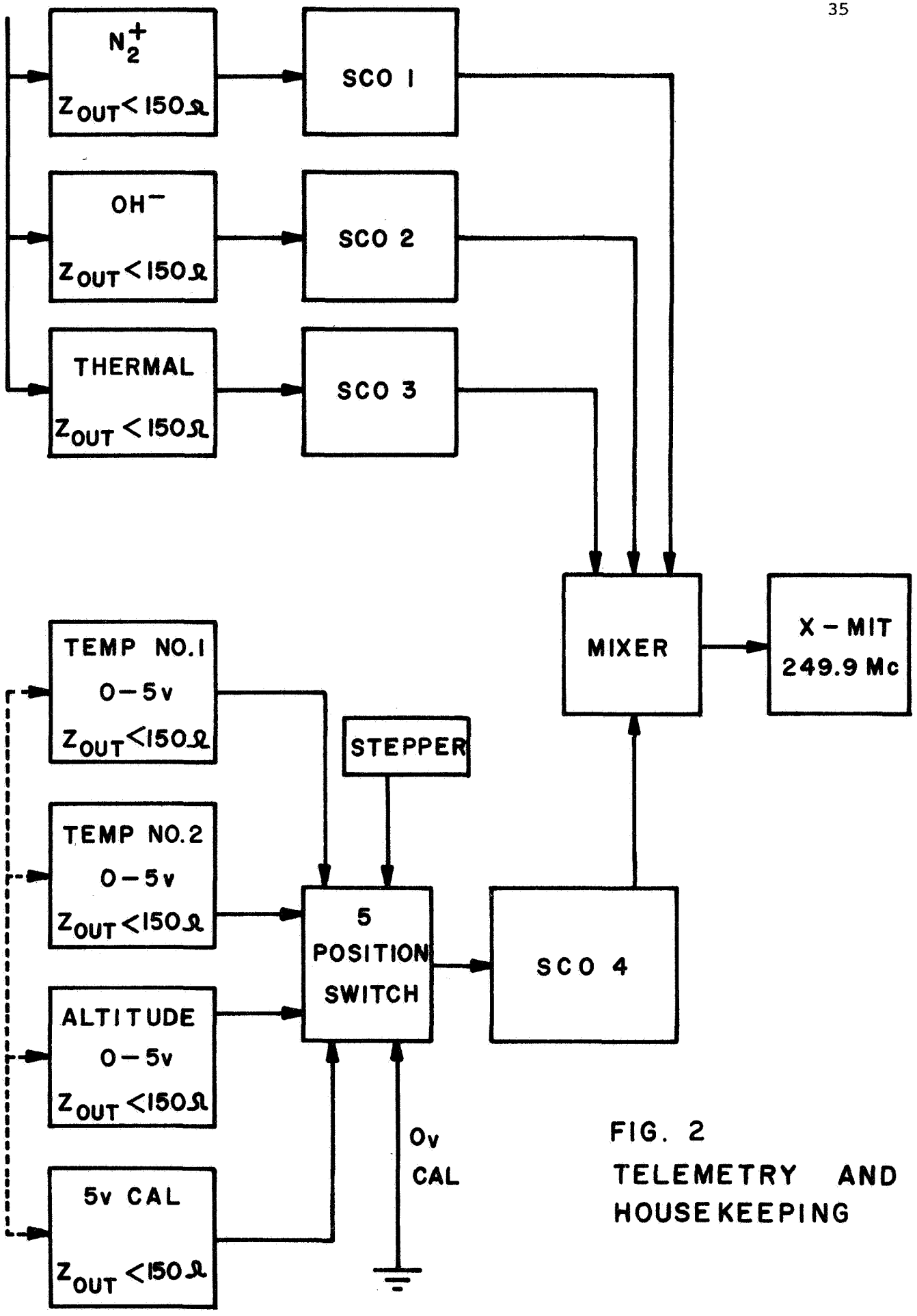


FIG. 2
TELEMETRY AND
HOUSEKEEPING

1.6 *Atmospheric Absorption and Emission in the Millimeter Wave Region*

(Professor Samuel Silver, Professor William J. Welch, and Douglas D. Thornton, Specialist)

The millimeter wave atmospheric research program is oriented along two different lines: a) studies in the earth's atmosphere, and b) studies of the atmospheres of the nearby planets. Emission and absorption by atmospheric ozone and oxygen are being studied for their potential use in remote sensing of the structure of the atmosphere. The ozone work is supported by ONR Contract Nonr 222(54), the O_2 work by AFCRL Contract F19(628)-68-C-0022; NsG 243 funds have been used to supplement the program.

Emission from the planets is studied with the aid of a 20-foot diameter millimeter wave radio telescope. The installation of this telescope has been completed, and calibrations are nearly complete. The antenna gain has been accurately measured at 4 wavelengths in K_a band (7 — 11 mm) and found to be high; the aperture efficiency is close to 60%. Observations of both Venus and Jupiter and a few bright quasars have been made at 8 mm. The temperature of Jupiter agrees closely with the value of about 140°K measured at this Laboratory a few years ago. The observations of Venus have been made with the planet close to superior conjunction and are interesting in that they do not appear to show the phase effect previously reported in the literature. Observations of Mercury, Saturn, and Uranus are now in progress.

A multichannel spectrometer with an effective bandwidth of 800 MHz has been built for the telescope and will be used to search for spectral features, such as those due to NH_3 on Jupiter and H_2O vapor on Venus. This latter work is largely sponsored by NSF Grant GA 527 and ONR Contract Nonr 222(54).

Publications:

Gain measurements of standard electromagnetic horns in the K and K_a Bands. Gerard Wrixon. Space Sciences Laboratory Technical Report, Series 9, Issue 12.

A selective review of ground based passive microwave radiometric probing of atmosphere. William J. Welch. Presented at the IUGG/WMO Symposium on Radiation, Including Satellite Techniques, Bergen, Norway, August 27, 1968.

1.7 *Solar Magnetic Field Structures*

(Dr. John M. Wilcox, Research Physicist)

The purposes of this investigation are to study the large- and small-scale configurations of the photospheric magnetic and velocity fields using observations obtained with the solar magnetograph and to relate these configurations to observations of the interplanetary magnetic fields and plasmas using satellites and space probes.

Mr. Hans Westin has been working with Mr. Andrew Tanenbaum to investigate dynamic effects associated with solar flares, surges, or other disturbances in our scanning observations obtained with the Mount Wilson solar magnetograph. As part of this investigation they have developed a computer-produced motion picture that can display the solar observations in a dynamic fashion. In the first trial each scan across the sun is represented on one frame of the motion picture film, with the velocity field plotted as a function of position on the sun. When the movie is projected, the 5-minute oscillations are quite visible, and we expect that this technique may aid in the identification of interesting features for more detailed analysis. It also should be a useful way to scan large amounts of observations (we have 200 hours of observations) in order to pick out the interesting phenomena.

Andrew Tanenbaum has returned, after a summer of observations at Mount Wilson Observatory, with over 200 hours of observations on 65 reels of magnetic tape. Analysis of these observations using some of the programs developed during the past year is proceeding, but it seems advisable to wait until the results are more firmly developed before describing them.

Professor Hannes Alfvén visited us for several weeks in November, and we had many interesting discussions on various aspects of our investigations. Professor Alfvén gave a series of three Space Sciences Laboratory Colloquia — "On the Origin of the Solar System" — which were

very well attended and are discussed in a Space Sciences Laboratory report ("On the Origin of the Solar System" by H. Alfvén, Space Sciences Laboratory Series 8, Issue 105, November 1967).

Dr. Edward Frazier has joined us after completing his post-doctoral year at Heidelberg. He is continuing work on a manuscript begun in Heidelberg that describes his fine-scale analysis of the photospheric velocity fields. Dr. Frazier has developed a useful representation to describe the velocity fields in terms of a wave number-frequency plane, and Mr. Tanenbaum will adapt this technique to his observations.

Mr. Kenneth Schatten is analyzing the extension of the photospheric fields into the lower solar atmosphere, such as to form finally the source for the interplanetary magnetic field. For the large-scale quasi-stationary situation it is assumed that a concentric sphere exists around the sun such that inside this sphere the magnetic lines for the most part loop back toward the photosphere and outside this sphere the magnetic lines are convected by the solar wind to form the interplanetary magnetic field. The radius of such a sphere can be determined approximately from observations on the basis of several separate properties, such as the magnitude of the photospheric and interplanetary fields and the period and shape of the interplanetary sector pattern. These methods agree in fixing approximately 1.6 solar radii as the radius of such a sphere. Mr. Schatten has prepared a mapping of the interplanetary field, beginning with the spacecraft observations at 1 AU and extrapolating inward to 0.5 AU and outward to 1.5 AU, assuming that the radial component of the interplanetary magnetic field scales as $1/R^2$ and that the azimuthal component scales as $1/R$. An Archimedes spiral is a special case of these assumptions. With this technique he has studied the details associated with the birth of a new away sector in the middle of a large toward sector. This process is associated with a bipolar photospheric magnetic field that appeared approximately one month before the birth of the new sector. Thus it appears that there may be a lapse of several weeks between the time when a new photospheric field is first observed and the time at which it may change the configuration of the interplanetary field.

A clearly evident large-scale pattern in the interplanetary magnetic field during 1964 has been used to search for a similar large-scale pattern in the solar magnetic field. It was found that such a pattern did exist in the photospheric field observations on both sides of the equator over a range of at least 40°N through 35°S. The pattern is basically similar at all these latitudes and differs from that to be expected from solar differential rotation in three important respects. It was found that the solar magnetic pattern changed at all latitudes investigated within an interval of a few solar rotations.

Participating Personnel:

Dr. John M. Wilcox	—	Research Physicist
Dr. Carl M. Noble, Jr.	—	Assistant Research Physicist
Dr. Edward N. Frazier	—	Assistant Research Astronomer
Mr. Hans Westin	—	Post Graduate Research Astronomer
Mr. Kenneth H. Schatten		
Mr. Andrew S. Tanenbaum		
Miss Jean Ann Eilek		Research Assistants
Mr. A. Robert Cannon		
Mr. Phillip H. Scherrer		
Mr. Walter A. Graf, III	—	Laboratory Technician
Mrs. Jane K. Reading	—	Senior Coder

Papers Presented at Meetings:

1. *American Astronomical Society*, February 1968 meeting, Tucson, Arizona:

   Wilcox, J. M., and R. Howard. Large-Scale Structure of the Photospheric Magnetic Field.

   Frazier, E. N. A Spatio-Temporal Analysis of Fine Scale Velocity Fields in the Photosphere.

   Schatten, K. H., J. M. Wilcox, and N. F. Ness. Interplanetary Magnetic Field Structure and Sector Evolution.

   Tanenbaum, A. S., J. M. Wilcox, and R. Howard. A New Method of Magnetograph Observations of the Photospheric Brightness, Velocity, and Magnetic Fields.

2. *Midwest Cosmic Ray Conference*, February-March 1968, Iowa City, Iowa:

   Wilcox, J. M., K. H. Schatten, and N. F. Ness. A Mapping Representation of the Interplanetary Magnetic Field.

3. *American Geophysical Union*, April 1968 meeting, Washington, D. C.:

   Schatten, K. H., J. M. Wilcox, and N. F. Ness. Convective Surface Model for the Determination of Interplanetary and Coronal Magnetic Fields.

4. *American Physical Society*, April 1968 meeting, Washington, D. C.:

   Wilcox, J. M. Invited paper: Large-Scale Structure of the Solar Magnetic Field.

5. *COSPAR*, May 1968 meeting, Tokyo, Japan:

   Wilcox, J. M. Invited paper: Solar Wind Disturbances Associated with Flares.

   Wilcox, J. M., and R. Howard. A Persistent Solar Magnetic Field Pattern.

Publications:

Alfvén, H. On the origin of the solar system. Space Sciences Laboratory Series 8, Issue 105 (November 1967).

Ness, N. F., and J. M. Wilcox. Interplanetary sector structure, 1962-1964. *Solar Physics 2*: 351-359 (1967).

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Howard, R., A. S. Tanenbaum, and J. M. Wilcox. A new method of magnetograph observation of the photospheric brightness, velocity, and magnetic fields. *Solar Physics* (to be published).

Wilcox, J. M., and R. Howard. Persistent solar magnetic pattern extending over equatorial latitudes. *Phys. Rev. Letters 20*, 1252 (1968).

Schatten, K. H., N. F. Ness, and J. M. Wilcox. Influence of a solar active region on the interplanetary magnetic field. *Solar Physics* (to be published).

Wilcox, J. M. Solar and interplanetary magnetic fields and plasmas. Invited paper, 13th General Assembly, IAU, Prague (August 1967). To be published in *Highlights in Astronomy*, Ed. G. Fazio, D. Reidel Publishing Company, Dordrecht, Holland.

Wilcox, J. M., N. F. Ness, and K. H. Schatten. Active regions and the interplanetary magnetic field. Symposium No. 35, IAU, Budapest, 4-8 September 1967 (to be published).

Schatten, K. H., J. M. Wilcox, and N. F. Ness. A model of interplanetary and coronal magnetic fields. Submitted for publication to *Solar Physics*.

Wilcox, J. M., and R. Howard. A large-scale pattern in the solar magnetic field. *Solar Physics* (to be published).

Wilcox, J. M. Asymmetry in geomagnetic response to the polarity of the interplanetary magnetic field. *J. Geophys. Res.* (to be published).

1.8 *Microscopic Study of Stony Meteorites*

(Professor Francis J. Turner, Department of Geology and Geophysics, and Mrs. Mabel Ulbrich, Research Assistant)

The last comprehensive account of the microscopic mineralogy and texture of stony meteorites was that of Tschermak, 1885. Intensive study of meteorites in recent years has concentrated almost entirely on problems of chemistry, age, and the identification of mineral species. The purpose of the present project is to begin to investigate the mineralogy and microstructure of stony meteorites with the standard methods of modern microscopic petrography. (This is the essential technique through which most of what we know about the origins and the cooling history of common igneous rocks has been revealed.)

All necessary material, in the form of thin sections cut from meteorites, has been provided on loan from the Smithsonian Institute (Dr. B. H. Mason, Curator of Meteorite Collections). Prior to the funding of this project through the Space Sciences Laboratory (July 1, 1968), we had gone through some 50 sections provided by Smithsonian and selected about a dozen sections for concentrated analysis. Work completed to date consists of optical measurements (with a universal stage) on twinned feldspar crystals in a peculiar meteorite whose mineralogy and structure appear to resemble those of certain terrestrial rocks (eucrites). Some preliminary measurements have also been made on crystals of olivine (Mg_2SiO_4) in one of the chondrite meteorites.

Work along these lines will continue. Results are very encouraging, and if the necessary funds are acquired, the work will continue over a three-year period. There is an advantage in that all of the necessary materials may be obtained without cost, and our laboratory is fully equipped with the necessary universal stages. In the field of universal-stage petrography, we have more experience than any other laboratory in the world. Fortunately, Mrs. Ulbrich proves to be exceptionally capable and reliable in this kind of work. It is hoped that we shall be able to continue.

E.2 *Atomic Physics Program*

(Dr. Marvin H. Mittleman, *et al.*)

The theoretical atomic physics program has continued along the general lines reported previously, namely, a study of collision cross sections and reactions of importance to the understanding of the upper atmosphere. The work is surveyed briefly in the following, the details being left to publications that are in press or have appeared during the year.

2.1 *A critical assessment of the polarized orbital method in atomic scattering*

(Dr. Marvin H. Mittleman, and Dr. Jerry L. Peacher, Assistant Research Physicist, Space Sciences Laboratory)

The method of polarized orbitals used in calculating electron-atom scattering amplitudes has two obvious flaws: the wave function is discontinuous, and the method is not variationally based. These are corrected in a somewhat arbitrary manner, and it is found that the results depend sufficiently strongly upon a parameter of the theory that there are serious doubts about the predictive nature of the theory. (Submitted for publication to *Physical Review*.)

2.2 *Rotational excitation of polar molecules by electrons*

(Dr. Marvin H. Mittleman and Dr. Jerry L. Peacher; Dr. Balazs F. Rozsnyai, Physicist, Lawrence Radiation Laboratory, Livermore, California)

A previous calculation[2] of the scattering of electrons by a fixed point dipole has been used to calculate the rotational excitation of polar molecules. The method is justified in an energy range bounded

from above and below. The corrections to the method that introduce these bounds are investigated. An effective cross section is defined and shown to be temperature independent when the approximations of the paper are made. In particular it is shown that any temperature dependence of this quantity must be attributed to a violation of the fixed orientation approximation for the molecule. (Submitted for publication to *Physical Review*.)

2.3 *Positronium formation in positron-helium scattering*

(Dr. Marvin H. Mittleman, and Margaret Fulton Fels, Graduate Student, Department of Applied Science, University of California, Davis)

The method previously used to describe positronium formation in positron-helium scattering[3] has been applied to the positron-helium scattering problem in anticipation of results of an experiment in progress. The calculations are complete, showing surprisingly small positronium formation cross sections. The work will be described in a Ph.D. dissertation by Mrs. Fels. (A condensed version will be submitted for publication to *Physical Review*.)

2.4 *Polarization of atomic radiation excited by electron impact at threshold*

(Dr. Marvin H. Mittleman, and Dr. R. H. McFarland, Lawrence Radiation Laboratory, Livermore)

An attempt to explain the discrepancy between theory and experiment in polarization of radiation from atoms excited by electrons near threshold has recently appeared. We have shown that this explanation, which was given only at threshold energy, can not apply to an energy where experiments have yet been done. In the process we have shown that the usual threshold laws, which are consequences only of conservation of angular momentum, are not quite correct because of the neglect of spin dependent forces. (*Physical Review Letters 20*: 899, 1968.)

2.5 *Excitation of two atoms by a single photon*

(Dr. Marvin H. Mittleman)

Absorption of a photon by a pair of atoms colliding to form a quasi-molecule is considered. The effect provides an absorption line in the continuum. Ignorance of molecular wave functions and eigenvalues forces us to deal only with long range collisions of the atoms, which is in effect a restriction to low density media. For this case we estimate the magnitude and width of the absorption line for excitation of two helium atoms in the states 2^1S and 2^1P. We find the effect to be a small one for this example. However, the effect exists for many pairs of states so that the total absorption via this mechanism may not be small. (*Physics Letters 26A*: 612, 1968.)

2.6 *Formal problems in the theory of dissociative attachment and recombination*

(Dr. Marvin H. Mittleman, and Professor J. C. Y. Chen, University of California, San Diego)

This manuscript[4] has been submitted for publication to *Physical Review*, but has received considerable negative reaction from a referee. (This is not too surprising in that the main thrust of the paper is to point out the mistakes in previous formulations of the theory.) The manuscript has been rewritten to clarify some points, and in the process, a new theorem concerning the necessity for non-adiabatic effects in such reactions has been proven. The manuscript has been resubmitted.

2.7 *Structure of heavy atoms*

(Dr. Marvin H. Mittleman)

The theoretical work directed at the determination of a Hamiltonian describing many electrons in the field of a high Z point nucleus, previously described,[5] is continuing. In addition to this approach, an attempt to obtain that Hamiltonian from a Bethe-Salpeter equation is also being pursued. This involves new analyses of the B-S equation. In particular, the reduction of the two-body equation

to a single-time equation (a Hamiltonian form), which has been accomplished by Salpeter, has never been done for more than two bodies. This is the first task being investigated in this program.

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[2] Mittleman, M. H., and R. von Holdt. *Phys. Rev. 140*: A226 (1965).

[3] Fels, M. F., and M. H. Mittleman. *Phys. Rev. 163*: 129 (1967).

[4] Mittleman, M. H. Space Sciences Laboratory Semi-Annual Progress Report, Series 8, Issue 100 (September 30, 1967), p. 250.

[5] *Ibid.*, p. 251.

E.3 *Astronomical and Related Research*

3.1 *Interaction between Radiation and Matter and Astrophysical Applications*

(Professor Charles H. Townes, and Assistant Professor R. Y. Chiao, *et al.*)

New aspects of the interaction between radiation and matter are being investigated, both to understand the processes involved and to develop new approaches to astrophysical problems. These include: development and utilization of quantum electronics, non-linear optics, new detectors, and new types of antennas; and study of a wide variety of radiative phenomena of apparent importance in astronomical objects. It is hoped that technical developments can be made that will increase substantially the usefulness of infrared and millimeter-wave radiation for astrophysical studies. Work is also being carried out on interpretation of certain astrophysical phenomena such as the OH maser, quasi-stellar objects, and possible photo-disintegration of solids.

The Space Sciences Laboratory sustaining grant has been very helpful in the initiation of this program, but contract support from the U. S. Army and from NASA now provide most of the necessary funding.

The work was initiated in the fall of 1967 and now has the following associated personnel.

Academic Staff Members: Professor C. H. Townes;
Assistant Professor R. Y. Chiao

Post Doctoral Research Personnel: Dr. David Rank; Dr. Margarite Denariez

Graduate Students: Albert Cheung; Michael Chui; Jean-Louis Etienne; Neal Evans; Marc Feldman; Lawrence Greenberg; James Holtz; Michael Johnson; Peter Lovely; Howard Smith

Visitors (of more than one month): Dr. Marvin Litvak; Professor C. Heer; Jean-Pierre Taran

Undergraduate Student: Eric Hannah

Secretarial and Administrative Assistants: Paula Dalapas; Elaine Cousins

Publications which have been partially supported directly by funds from the Space Sciences Laboratory are the following.

1. The Big Maser in the Sky. C. H. Townes. Presented to the International Conference on Quantum Electronics, Miami, May 14-17.
2. Phase Modulation of Trapped Laser Beams. D. M. Rank. Presented to the International Conference on Quantum Electronics, Miami, May 14-17.
3. Phase Modulation of Q-Switched Laser Beams in Small-Scale Filaments. A. Cheung, D. Rank, R. Y. Chiao, and C. H. Townes. *Phys. Rev. Letters 20,* 786 (1968).
4. Energy Requirements and Mechanism for OH Galactic Masers. J. Holtz, *Astrophysics Letters* (in press).

H. Smith is in the process of preparing a manuscript on the occurrence of maser action in SII and OII in interstellar space. His paper on "Frequency Conversion and Detection of Infrared Radiation," to be published in a volume honoring Professor A. Kastler, was not supported directly by the Space Sciences Laboratory, but is part of the program outlined above.

3.2 *Interstellar Shock Waves*

(Professor George B. Field, Department of Astronomy; Dr. Jeffrey Scargle, and Mr. Per A. Aannestad)

a) *Summary.* The objective is to evaluate theoretically the generation and propagation of shock waves in the interstellar medium. Such waves are very probably the cause of supersonic motions observed in the medium, but thus far they have not been observed directly.

Hence a major objective of this work is to identify the wavelengths of radiation that should be emitted by such shock waves as an aid to observational programs. We have shown previously[1,2] that discrete atomic and molecular lines between 4 μ and 156 μ in the far infrared should be detectable. The work reported for this period relates to: (i) the effect of a magnetic field on the shock structure and, indirectly, on the infrared emission; (ii) the possibility of detecting OH molecules generated in the shock wave via their emission at 18-cm wavelength; (iii) the observation of the line λ 6300 of neutral oxygen; and (iv) the generation of shock waves in supernovae.

b) *Effect of magnetic field.* The earlier calculations[1] of shock waves propagating at speeds between 4 and 16 km/sec into a neutral hydrogen gas (T = 100°K, $\rho = 2 \times 10^{-23}$ g cm^{-3}) have been modified to include the effect of a magnetic field parallel to the shock front. The effects are twofold. First, the temperature rise is reduced (typically, from 7000°K to 3500°K), thereby reducing the infrared emission. Second, the density rise is reduced. This greatly increases the distance over which the shock moves before it can radiate its energy, but it has only a secondary effect on the infrared emission. The conclusion is that the overall reduction of infrared radiation will make shock waves hard to detect when they propagate across a magnetic field. The results of this work have been published.[3]

c) *OH molecules.* Recently interstellar OH molecules have been detected via their 18-cm Λ-doublet emission. Studies by Goss[4] in the Radio Astronomy Laboratory at Berkeley show that OH/H $\simeq 4 \times 10^{-8}$. Even this relatively small amount is hard to account for if OH is formed in typical regions because its lifetime against photodissociation is only 6,000 years. We therefore considered whether or not it could be produced in the hot region behind a shock wave. The reaction O + H → OH is dependent upon temperature through the factor exp(− 3700/T), and hence it can occur only in hot regions. The results[5] indicate that OH/H attains 2×10^{-7} immediately behind the shock. However, this value is degraded to 2×10^{-10} by photodissociation occurring in the interval between shock passages — smaller by 200 times than the observed value of OH/H.

The reaction $O + H_2 \rightarrow OH + H$ is about 10^4 times faster, but ordinarily the amount of H_2 in interstellar space is very small. We are now investigating a two-step process in which H_2 is catalyzed by exchange reactions on interstellar dust particles in the shock wave and then is used to produce OH. Preliminary calculations indicate that this process is about 50 times as effective as the first, which greatly narrows the discrepancy between theory and observation. However, two effects — the relative motion of dust and gas and the photodissociation of H_2 — have not yet been taken into account. Since one effect should increase the OH production — and the other decrease it — it is not yet clear what the net effect will be. If the theoretical predictions are favorable, OH measurements currently in progress should yield information about interstellar shock waves.

d) *Observation of λ 6300 of oxygen from shock waves.* Several plates of emission nebulosities were made by Dr. Scargle using an interference filter combined with the 36-inch Crossley reflector. It was hoped that shock waves generated by the nebulosities might be visible because of excitation of this 2-volt line in the hot region behind the shock. While radiation was observed, it cannot definitely be attributed to shock excitation. It is planned to try this again using the superior speed and the dark sky of the 48-inch Palomar Schmidt telescope.

e) *Generation of shock waves in supernovae.* Dr. Scargle has shown[6,7] that hydromagnetic waves of moderate amplitude are propagating in the Crab Nebula (a supernova remnant, which began expanding in 1054 A.D.). Two questions arise: (i) why these waves do not appear to develop into shock waves, as indicated by elementary theory, and (ii) whether or not the energy in these waves is responsible for the continuous acceleration of relativistic particles that is observed in the nebula. Theoretical calculations of the coupling between waves and particles using the theory of Sturrock and Hall have been undertaken. Preliminary indications are that the drain of energy from the waves into the particles may account for both of the phenomena cited above.

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[1] Space Sciences Laboratory Semi-Annual Progress Report, Series 8, Issue 100, September 30, 1967, pp. 63-82.

[2] Field, G. B., S. A. Orszag, J. D. G. Rather, and B. Basu. *Proc. Conf. on Infrared Astronomy* (New York: NASA Goddard Institute for Space Studies, April 1, 1966, in press).

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[4] Goss, W. M. *Astrophys. J. Supplement,* No. 137 (1968).

[5] Field, G. B., P. A. Aannestad, and P. M. Solomon. *Nature, 217,* 435 (1968).

[6] Scargle, J. Ph.D. Thesis, California Institute of Technology (1968).

[7] Scargle, J. *Astrophys. J.* (in press, 1968).

Participating Personnel:

Professor George B. Field	—	Principal Investigator
Dr. Jeffrey Scargle	—	Post Graduate Research Astronomer
Per A. Aannestad	—	Research Assistant

Professor Field and Dr. Scargle also received partial support through NSF Grant GP 4975.

3.3 *Development of a Large Area Tracking X-ray Telescope*

(Assistant Professor C. Stuart Bowyer, Department of Astronomy)

A large area balloon-borne x-ray detector of the photomultiplier-scintillator type was built and flown. The instrument incorporates both larger area and better pointing capability than those of previously flown detectors and is designed for long time studies of celestial x-ray emitters of known location. The instrument seemed to function properly for several hours at maximum altitude, but since the balloon never reached the predicted altitude, no scientific information was obtained from the main experiment.

A secondary experiment, designed to detect high energy x rays, was also flown. The basic element was a Cerenkov detector with a lead flouride absorber. The lead flouride crystal, one of the first to be made clear and large (2 inches O.D. x 2 inches long), was loaned to us by Professor Robert Hofstader's group at Stanford University.

The data obtained with this detector are in the process of being analyzed. It is hoped that these data will provide information about the isotropic background above 300 Mev.

Introduction. The objectives of this experimental program fall into the following main categories:

1. To moniter the x-ray output of the galactic center region during a lunar occultation of the center
2. To obtain the precise locations and the high energy spectra for known x-ray sources
3. To moniter short term variations in the x-ray flux of intense emitters and to correlate these with variations in the light flux
4. To scan unusual astronomical objects with greater sensitivity than has been available previously in the hard x-ray band
5. To obtain information on the very hard γ-ray background flux

The last objective is distinct from the main experiment and will be discussed later. The first four goals require:

1. Tracking and pointing ability
2. Large detector area
3. Suppression of unwanted background counts

Because x rays are highly attenuated by the atmosphere, the experiment must be carried out at high altitudes. The present experiment was designed to function at 120,000 — 130,000 feet, suspended from a large (10.5×10^6 cu. ft.) helium-filled balloon.

The gondola. The detectors were mounted on a large plate that was carried on an equatorial mount axis fixed with respect to the gondola frame. Two views of the package on the launch site are presented in *Figures 1* and *2*.

An equatorial mount axis is designed to be parallel with the earth's rotational axis, so that the apparent motion of the celestial sphere can be canceled by counter-rotation of the detector about a single axis. Thus, the first requirement is a stable frame of reference. We relied on the experience of others, which indicated that the package would remain stable in the "pendulum" mode, and thus stabilized it only in azimuth.

A magnetometer senses magnetic north and gives an error signal proportional to the offset of the telescope axis from true north. This activates a pair of gas jets at the ends of the gondola, which correct the offset.

The counter-rotation to the earth's rotation is provided by a stepping motor driven by an accurately timed pulser. The stepping frequency is adjustable to compensate for the effects of wind drift to the east or the west in flight.

This clock-driven stepping motor is linked to the drive mechanism through a differential gear box. This allows another ground-controlled stepping motor to override the automatic drive. A similarly controlled motor, without the differential feature, controls motion in the north-south direction. This arrangement allows different objects of interest to be pointed at in flight and then tracked by the automatic drive.

The gondola also provides a frame to carry the battery rack, the gas bottles, the telemetry system, and the command and information terminal.

The detectors. Fifteen identical detectors are imprinted in parallel on the telescope plate. Each consists of a NaI(Th) scintillating crystal, mounted on a 1-inch thick quartz diffuser and protected by a 0.010-inch aluminum window. The crystal is 6-inches in diameter and 1/8 inch thick. The crystals are viewed by four 2-inch photomultiplier tubes whose outputs are summed. The entire unit is encased in a plastic scintillating cup, the output of which is read in anticoincidence with the main crystal output. This rejects charged particles, which

penetrate the assembly and produce pulses in both the crystal and the plastic shield. The entire assembly is housed in an aluminum can with a 1/16-inch lead shield on the side. The field of view is restricted by a stainless steel honeycomb collimator, which provides a triangular response with 5.8° full width half maximum.

The resolution of an individual detector is 35% at 22 Kev. This means by definition that the width of the output pulse-height distribution at half its peak value is 35% of the pulse height at the peak of the distribution.

The overall resolution is 45% FWHM at 22 Kev. In order to attain this resolution, we balanced the gains of the 60 phototube outputs before each flight attempt.

The shower counter experiment. An experiment sensitive to electrons and photons in the range between several Mev through 1 Gev was developed and flown. The motivation for this project was twofold:

1. Only upper limits have been obtained as yet on photons in the range 1 – 100 Mev. Spectral data or even positive identification of fluxes in this range are non-existent. No data are available for energies above 100 Mev.

2. The Cerenkov effect has long been known to have potential as a detection mechanism and, in fact, has been used to study extraterrestrial electrons. Its utility has recently been enhanced by the development of a large, clear lead flouride crystal by the Harshaw Chemical Company.* We were able to borrow one of the three such crystals in existence and felt that this justified the inclusion of a rather rapidly constructed detector incorporating this crystal.

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*Cleveland, Ohio

The detector that we developed is shown schematically in *Figure 3*. It operates on Cerenkov's principle that visible radiation is given off when a particle travels in a medium with a speed greater than the velocity of light in the medium. For a photon to be detected, it must convert into a pair of electrons by pair production. This is efficiently done in a very dense material. PbF_2 is such a substance, with $\rho \sim 8.3$.

A photon coming from the region of acceptance of the detector passes with negligible scattering or absorption probability through the 1-inch PM tube and the scintillating plastic viewed by this tube. It is converted to a relativistic electron and positron pair in the PbF_2 crystal, which produces Cerenkov light in an amount proportional to their path length. This is sensed by the 2-inch PM tube, as the crystal is quite transparent to the characteristic blue Cerenkov light. The output of this tube is read in anticoincidence with the output of the other two tubes, thus rejecting charged particles from the acceptance region or a charged particle or photon from any other region. The function of the lead enclosure is to convert photon events to electron showers that excite scintillation in the plastic.

Electrons coming from the acceptance region are distinguished from all others by the fact that they are seen by the 1-inch tube. Thus information on the spectra of both electrons and photons at high altitudes is obtainable.

If the large anticoincidence shield is called A, the Cerenkov counter C, and the small plastic shield E, the requirement that an event be interpreted as a photon is $C \cdot \overline{A} \cdot \overline{E}$. For an electron, it is $C \cdot E \cdot \overline{A}$.

Our device had to be calibrated after the flight due to the fact that the flight time is set by considerations involving the main experiment. It appears that our detector is sensitive above 300 Mev. However, analysis of the data obtained in the flight has not yet been carried out.

Flight performance. The package was launched on June 12, 1968, from Holloman Air Force Base, New Mexico. Due to circumstances beyond the experimenters' control, the balloon never reached the minimum altitude (> 120,000 feet) required for observations in the x-ray range. The altitude history of the flight is presented in *Figures 4, 5,* and *6.* Housekeeping data were constantly received, which indicated that the orientation system and the data-handling system functioned satisfactorily for several hours.

Summary and future prospects. The essential elements of the system are being mothballed for a future flight. Certain features of the system will be redesigned, primarily the data-handling. For this flight the telemetry system of the Alvarez High Altitude Particle Physics Experiment was borrowed whole. This is a non-directional system — hence a fairly short-range one. This in turn necessitated tracking the package with the University's DC-3 aircraft. The system is not ideal for performance over land, considering the multitude of restricted areas encountered.

Although the results of the first flight were disappointing, indications are that a useful instrument has been developed. It is hoped that the performance of the package in tests and in flight will attract funding for future flights.

Participating Personnel:

Space Sciences Laboratory

C. Stuart Bowyer	—	Assistant Professor of Astronomy
James Bartschi	—	Associate Development Engineer
Leroy Colombe	—	Senior Development Engineer
William B. Full	—	Junior Development Engineer
Dr. Michael L. Lampton	—	Assistant Research Physicist
John E. Mack	—	Post Graduate Research Physicist
Penny Moore	—	Research Assistant
Ralph Alphonse Thompson	—	Senior Development Engineer
Susan Tuttle	—	Electronics Technician

Lawrence Radiation Laboratory

Maurilio Antuna	—	Electronics Designer

Figure 1. Gondola before flight

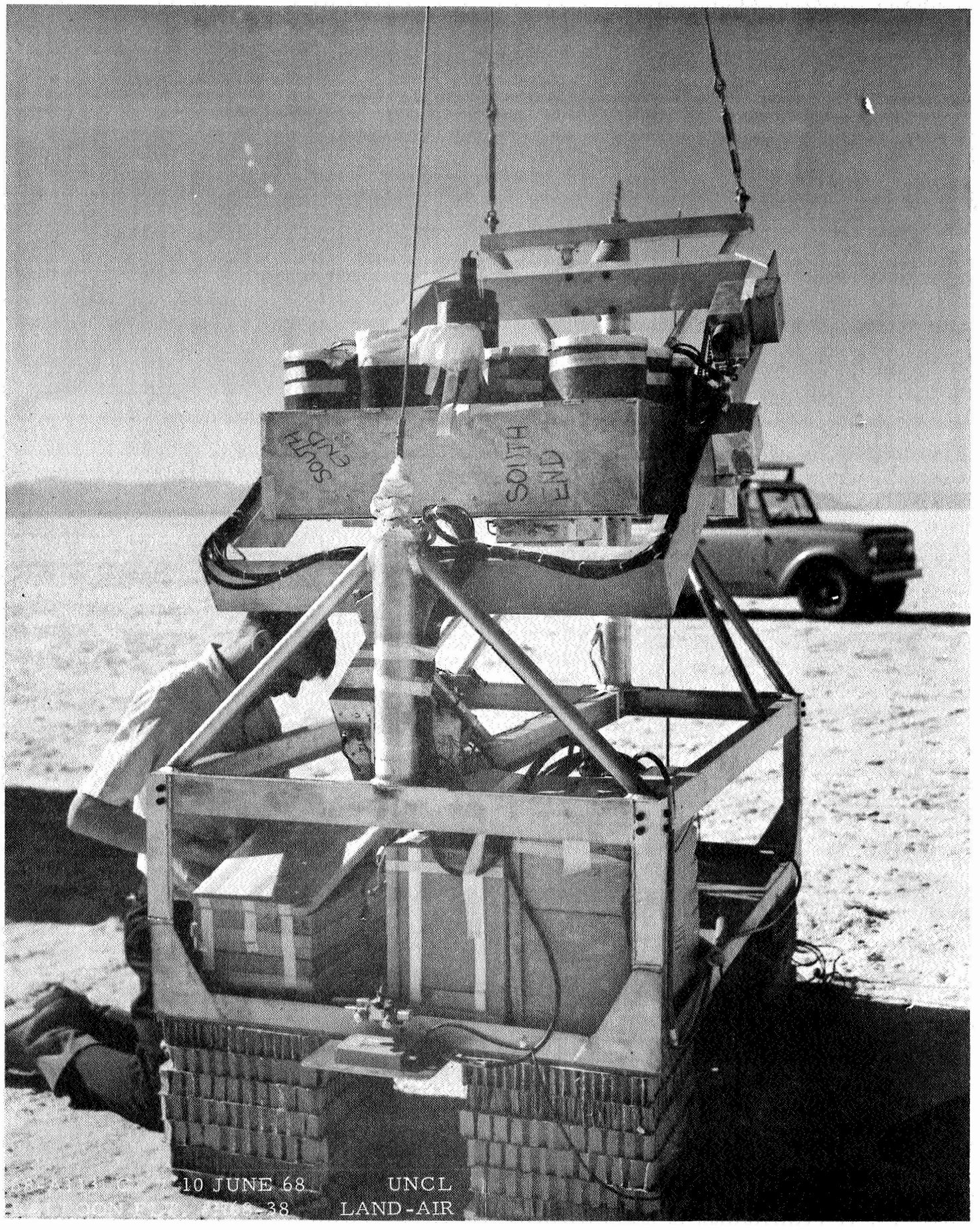

Figure 2. Gondola before flight

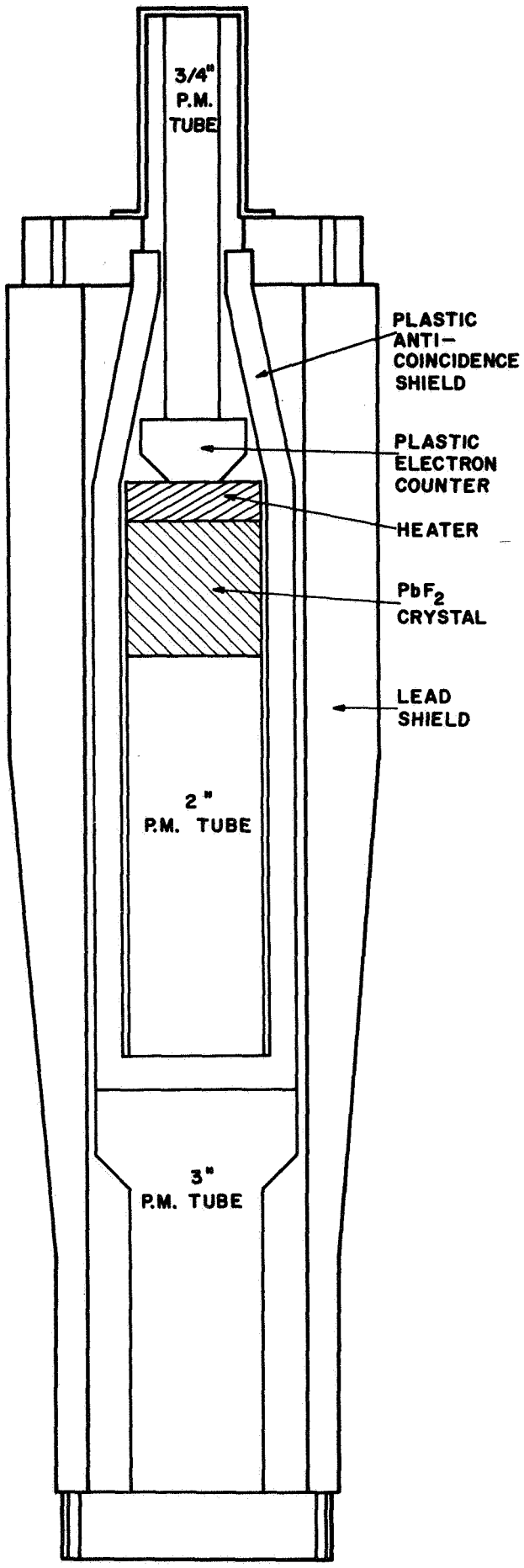

Figure 3. **SHOWER COUNTER**

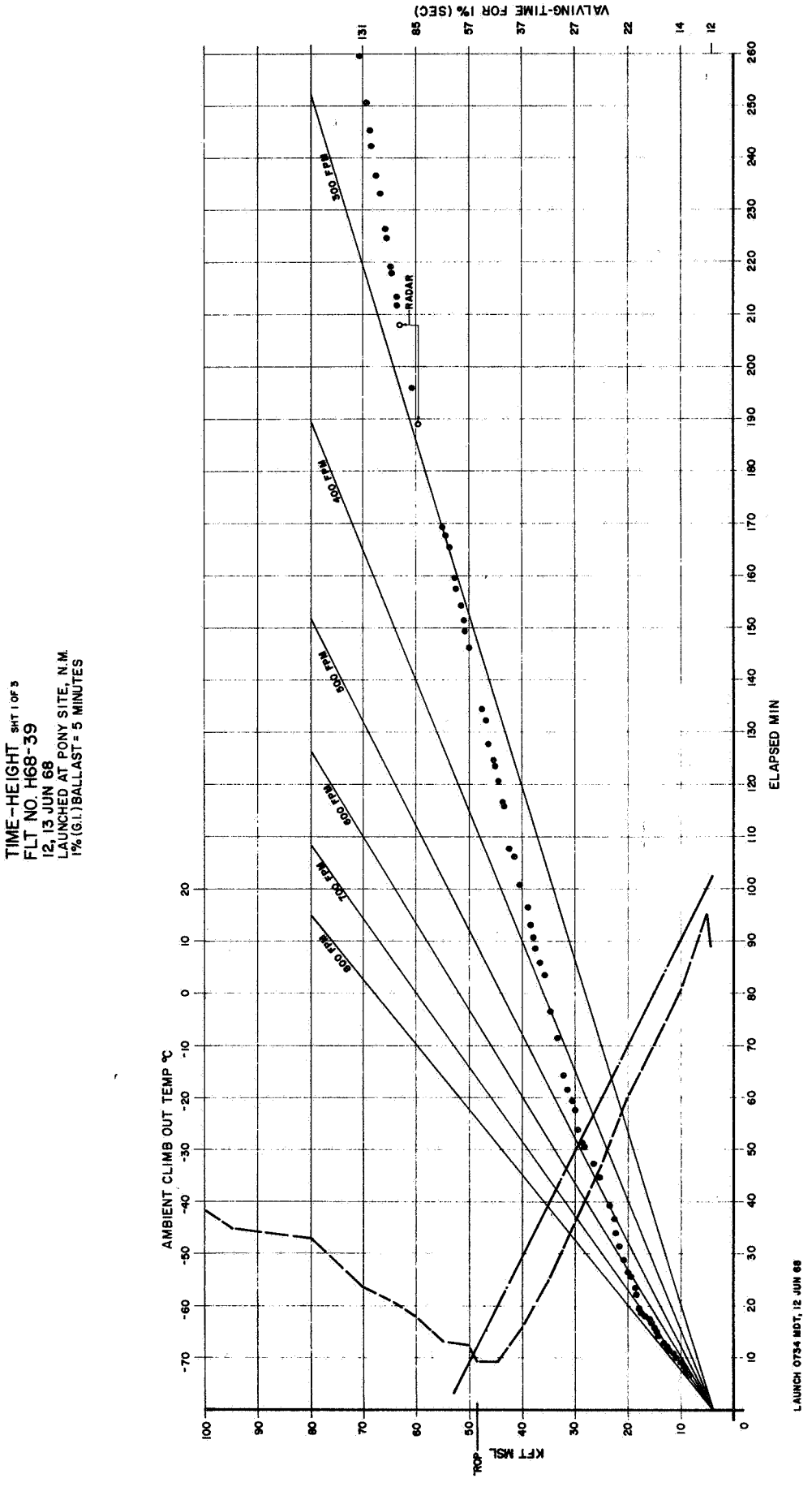

Figure 4. Flight history (first 260 minutes)

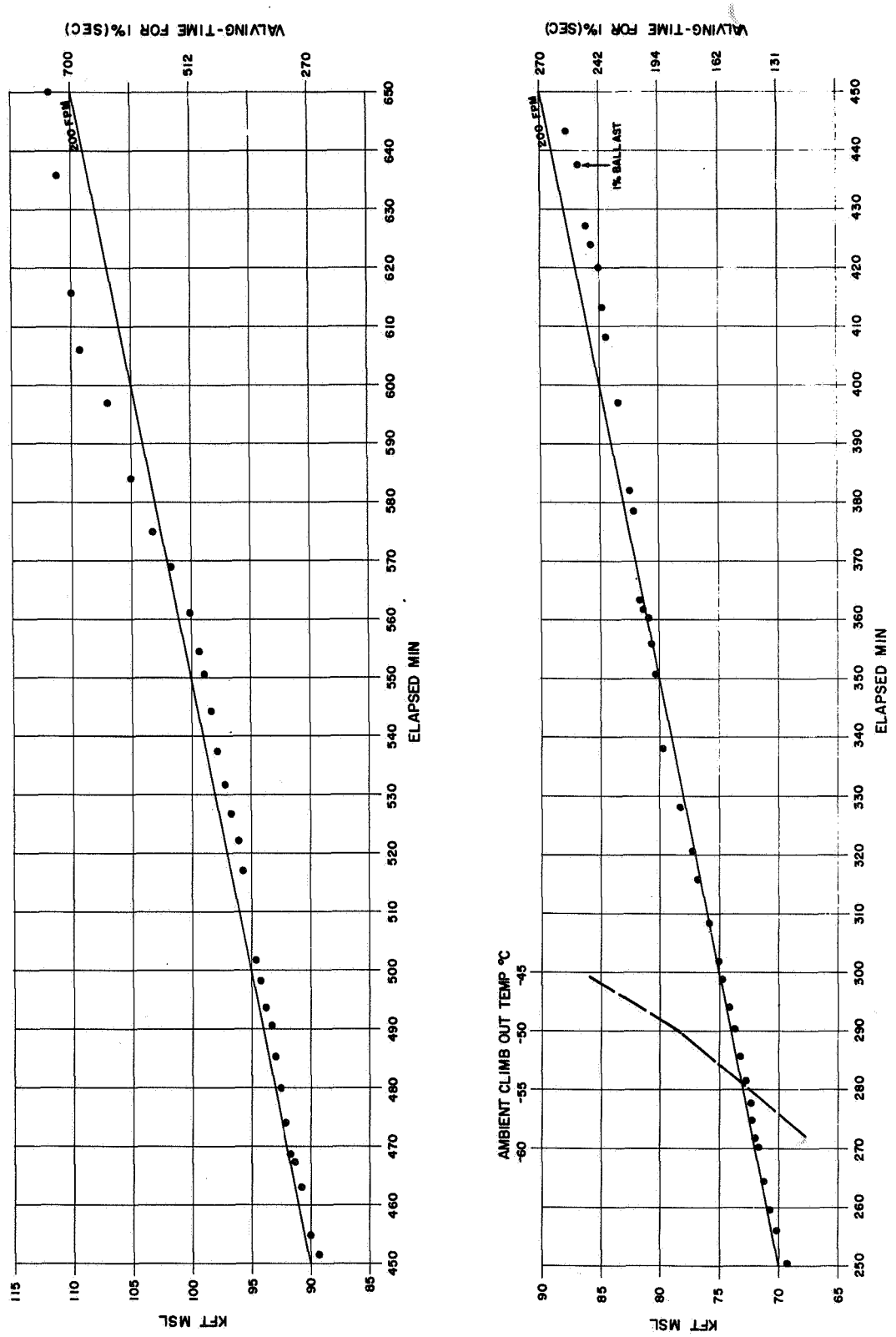

Figure 5. Flight history (250 — 650 minutes)

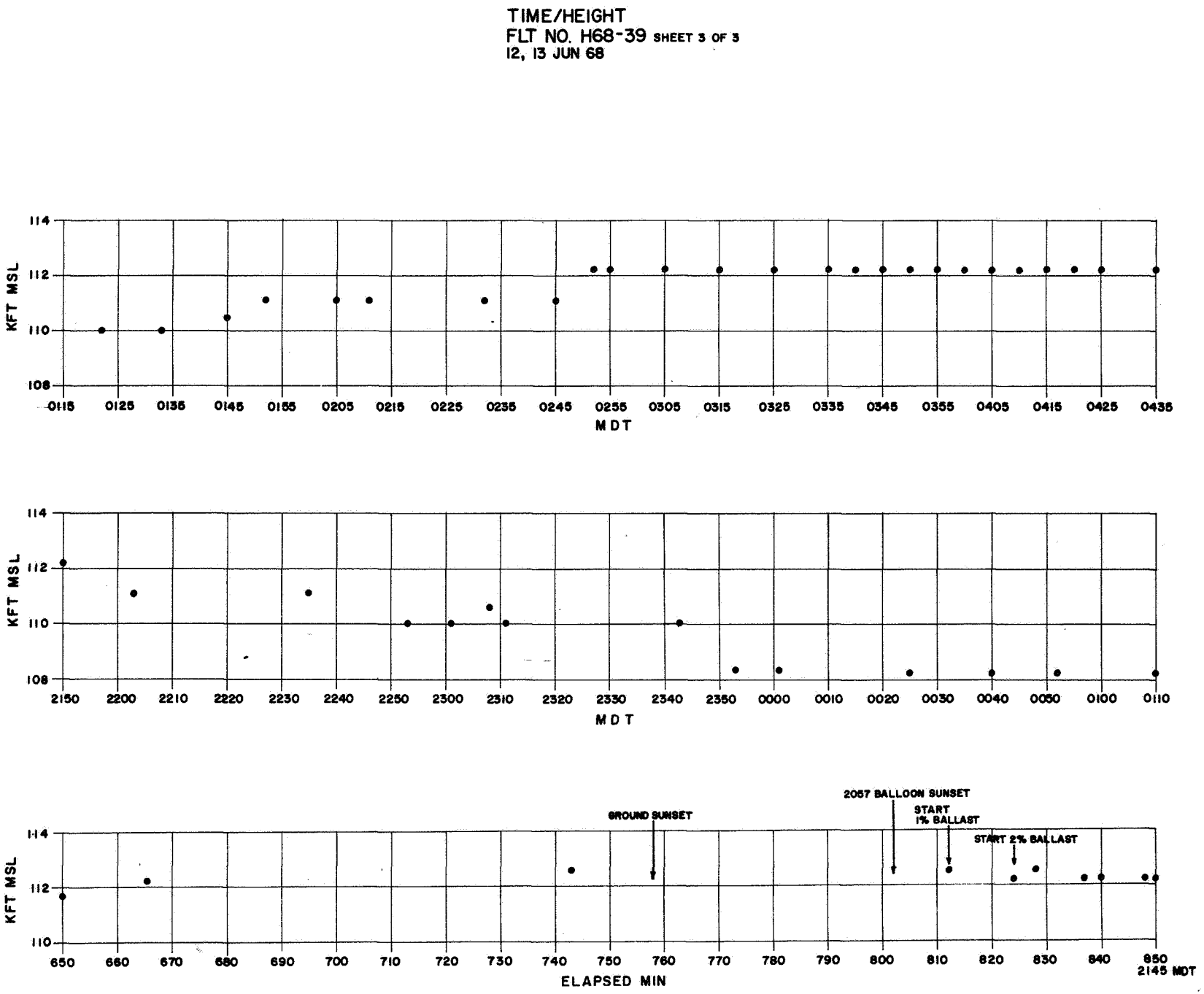

Figure 6. Flight history (650 — 1255 minutes, 04:35 MDT)

E.4 *Biosciences*

4.1 *Studies on Microbiological Replication*

(Dr. Stanley Scher, *et al.*)

Studies of replication at the level of cytoplasmic organelles have been undertaken using the sensitive plastids of *Euglena gracilis* as the experimental object. These studies bear on the hypothesis of informational autonomy of plastids. One aspect of this work is concerned with the localization of information required for plastid replication. One approach to this problem is based on the idea that autonomous replicating units may suffer from genetic defects under one set of environmental conditions (restrictive) but not under another (permissive). The second approach makes use of selective agents, such as antibiotics and analogs of metabolites, that block organelle replication without interfering with other cell functions. To facilitate the analysis of replication, we have developed an alternative to the conventional surface plating procedure in which samples are distributed in one dimension. Sample alignment is achieved using capillary tubes that can be scanned by a photosensitive device coupled with a recorder. The results of recent studies are summarized below:

Decay of photoreactivability in ultraviolet irradiated Euglena plastids at restrictive temperatures. Irradiation of *Euglena gracilis* with sublethal doses of ultraviolet (UV) light blocks the replication of plastids, presumably due to the formation of pyrimidine dimers in plastid localized DNA. Although photoreversal of UV damage can be achieved with efficiencies approaching 100%, the fraction of cells carrying genetic determinants for constructing a normal chloroplast progressively decays with time. The rate of decay of photoreactivable entities per generation is greater than that expected from theoretical dilution. At temperatures that restrict plastid replication but not cell division, the rate of loss of photoreactivation is further increased; however, the efficiency of photoreactivating enzyme is not impaired at restrictive temperatures. Moreover, preincubation at such temperatures does not appreciably alter the rate of photoreactivation. Accordingly, we interpret these observations as evidence that the substrate for photoreactivating enzyme (UV-irradiated DNA) is more rapidly degraded

at restrictive temperatures than in controls at normal temperatures. The accelerated decay of plastid DNA at restrictive temperatures is consistent with the hypothesis that the temperature-sensitive component is a plastid-localized enzyme (e.g. DNA polymerase) intimately associated with the replication process.

Structural requirements for aminoglycoside antibiotic induction of chloroplast-less mutants in Euglena. Exposure of *Euglena gracilis* to streptomycin (SM) or closely related aminoglycoside antibiotics leads to the induction of mutant progeny that lack the genetic determinants for chloroplast formation. In bacteria, these antibiotics bind to ribosomes, modify codon-anticodon pairing, result in misreading of the genetic code, and/or inhibit protein synthesis. Since chloroplast ribosomes resemble bacterial ribosomes in their physical properties and sensitivity to certain antibiotics, we examined some of the structural requirements for induction of chloroplast mutants in *Euglena* and attempted to relate these to the requirements for misreading of the genetic code.

SM was found to be 10 times as effective as the dihydro derivative for chloroplasts of *Euglena*. In contrast, these antibiotics were equally effective as inhibitors of poly-u directed polyphenylalanine synthesis in bacterial extracts. This finding points to the aldehyde group as an important component of the streptose moiety for aminoglycoside activity in *Euglena*, but not for bacteria. The ineffectiveness of didesamidino-dihydro-SM in both bacteria and *Euglena* indicates that one or more amidino groups are required for biological activity.

Spectinomycin, an aminoglycoside that lacks a streptamine residue, inhibits protein synthesis in bacterial systems without causing detectable misreading. When compared with SM, these antibiotics were equally active against *Euglena* chloroplasts. Since SM and other aminoglycosides that induce misreading contain either streptamine or deoxystreptamine, the effectiveness of spectinomycin in *Euglena* provides evidence that the streptamine residue is not required for aminoglycoside action on chloroplasts and argues against misreading of the genetic code as a mechanism of induction of chloroplast-less mutants.

Studies on the informational autonomy of plastids: dependence of plastid replication upon extraplastidic macromolecular synthesis. Although chloroplasts of *Euglena* contain DNA, RNA, and a protein-synthesizing system, recent evidence supports the hypothesis that these organelles are not completely autonomous. During light-induced development of proplastids to chloroplasts, extensive activation of non-plastid RNA is detected. We have attempted to determine if analogous demands upon the cell are made during the process of plastid replication.

Dark grown cells of *Euglena gracilis* Z were preincubated with selective inhibitors to distinguish between plastid and non-plastid synthesis, and the kinetics of chloroplast-less mutant formation by streptomycin was followed as an index of plastid replication. Inhibition of DNA-dependent RNA synthesis by actinomycin D suppressed the rate of mutant formation, whereas 5-fluorouracil, an inhibitor of RNA synthesis, enhanced the mutant yield. Protein synthesis inhibitors such as sparsomycin or streptovitacin strongly reduced the rate of mutant formation. In contrast, the amino acid analog O-methylthreonine markedly enhanced this rate.

These results can be interpreted as follows: Since actinomycin binds to guanine, it is reasonable that this antibiotic would act more strongly upon transcription from nuclear DNA (C + G:A + T ratio = $\sim$ 1:1) than on plastid DNA (C + G:A + T ratio = $\sim$ 1:3). Similarly, there is evidence that 5-fluorouracil selectively inhibits RNA synthesis in chloroplasts.

The inhibition of protein synthesis by sparsomycin also depends strongly upon the base composition of the mRNA. Codons rich in C + G are more susceptible to inhibition than those rich in A + U. Streptovitacin, a glutarimide antibiotic related to cycloheximide, inhibits protein synthesis on ribosomes of eucaryotic cells but not procaryotic cells. The analog O-methylthreonine imposes an isoleucine requirement upon plastid protein synthesis without interfering with non-plastid synthesis.

These results taken together argue in favor of the hypothesis that plastids are dependent upon macromolecular synthesis external to the plastid for their replication. Indeed, the action of analogs such as 5-fluorouracil and O-methylthreonine suggests that plastids depend upon

non-plastid protein synthesis to supply the replicating organelle with metabolites such as uracil and isoleucine. This interpretation is consistent with the view that the plastid is a resident auxotroph within the *Euglena* host cell.

Euglena threonine deaminase: distribution and properties. Threonine deaminase (TD) catalyzes the conversion of L-threonine to α-ketobutyrate. The rate of this conversion is typically under feedback control by the end product isoleucine. However, feedback properties of this enzyme may differ in their sensitivity to isoleucine. We describe here some observations on the distribution of TD in *Euglena* and a mutant strain lacking the ability to form chloroplasts. In addition, we report on some properties of the enzyme from experiments with crude cell extracts.

Log-phase light adapted *Euglena gracilis Z* were grown in a synthetic medium at pH 3.5, broken in a French pressure cell, and chloroplasts were isolated by flotation on sucrose. To assay for TD activity, α-ketobutyrate was determined colorimetrically with 2,4-dinitrophenylhydrazine. When various fractions were compared, virtually all of the TD activity was confined to the cell extract (lacking chloroplasts); little or no TD activity was detected in the chloroplast fraction. The absence of TD activity in chloroplasts is consistent with the distribution of this enzyme in mutant strains. Comparable amounts of TD activity were found in wild-type and mutant cells unable to develop a normal photosynthetic organelle.

O-methylthreonine (OMT) has been reported to induce permanent loss of chloroplast-forming ability in *Euglena*. Since OMT may be considered an analog of both the allosteric inhibitor isoleucine and the substrate threonine, the effect of this compound was examined on TD. Comparison of threonine and OMT as substrates for the enzyme provide evidence that the catalytic site cannot deaminate OMT to the corresponding α-keto acid; hence TD cannot use OMT as a substrate. Experiments with isoleucine and OMT as feedback inhibitors of TD show that the allosteric site is relatively insensitive to either the end product or the analog. Even at high concentrations, TD activity was only slightly depressed.

The results presented here can be interpreted as evidence that TD activity in *Euglena* is under inefficient feedback control. The absence of TD activity in chloroplasts may reflect the lack of end-product control for isoleucine biosynthesis at the organelle level. According to this interpretation, the chloroplast may be dependent upon an extraplastidic control mechanism to regulate the isoleucine pool size. The failure of OMT to influence TD activity strongly suggests that the analog may exert its inhibitory effect on chloroplasts by competing for isoleucine incorporation into plastid proteins.

Participating Personnel:

Dr. Stanley Scher	—	Associate Research Microbiologist
Steven G. Halverson	—	Assistant Development Engineer (Graduate Student)
Patricia L. Haley Sydell Gelber	}	Laboratory Technicians
Wendell Brunner Connie Lynch	}	Graduate Students
Norman Bookstein	—	Laboratory Assistant (Student)
Kay Yatabe	—	Laboratory Helper (Student)

Publications and Lectures:

Linear automated microbiological analysis. Scher, S. *U. S. Government Research and Development Reports 67*, 53 (1967).

Evidence that the mutagenic action of streptomycin is independent of plastid DNA replication. Scher, S., and P. L. Haley. *Third International Congress Cytology* (in press).

Studies on the informational autonomy of plastids: dependence of plastid replication upon extraplastidic macromolecular synthesis. Scher, S. *Sixth International Congress Embryology* (in press).

Euglena threonine deaminase: distribution and properties. Scher, S., and P. L. Haley. *Third International Congress Histochemistry and Cytochemistry* (in press).

Decay of photoreactivability in ultraviolet irradiated *Euglena* plastids at restrictive temperatures. Scher, S. *Fifth International Congress on Photobiology* (in press).

Structural requirements for aminoglycoside antibiotic induction of chloroplast-less mutants in *Euglena*. Scher, S. *Twelfth International Congress of Genetics* (in press).

Dr. Scher presented invited seminars on "Informational autonomy of plastids" at each of the following institutions:

Department of Microbiology, Colorado State University, Fort Collins, Colorado.

Department of Biology, Northwestern University, Evanston, Illinois.

Department of Biology, Smith College, Amherst, Massachusetts.

Department of Microbiology, Miami University, Oxford, Ohio.

Department of Biological Sciences, Purdue University, Lafayette, Indiana.

Dr. Scher participated in the Gordon Research Conference on Biological Regulatory Mechanisms, Andover, New Hampshire.

4.2 *Protein Synthesis in the Germinating Spore of Bacillus subtilis*

(Professor Thomas H. Jukes, Helen Mayoh)

Control of DNA synthesis in *B. subtilis* has been studied by pulse-labeling synchronous cultures of germinating spores with radioactive precursors of DNA and protein. During the first replication, the rates of DNA and protein synthesis changed in a similar fashion; both rose to a peak at approximately 2 hours and dropped to a minimum approximately 20 minutes later. In subsequent replications, however, the rates of DNA and protein formation were not closely allied. After the first replication, the DNA rate rose in a step-wise pattern, which probably indicated the start and finish of each replication of the synchronous culture. The rate of protein synthesis, however, rose approximately linearly.

DNA labeled with thymidine-methyl-H^3 during the first replication "peak" and DNA labeled at a later time were shown to have the same densities in CsCl gradients. The DNA of the "early peak," therefore, appeared to be normal and not an artifact of methyl group metabolism, for example.

Chloramphenicol administration at the beginning of the "early peak" abolished both protein and DNA synthesis. At other times during the "early peak," chloramphenicol caused an immediate decrease in the rate of DNA synthesis, but DNA formation continued for several hours.

Previous studies have shown that inhibition of DNA synthesis by thymidine starvation did not affect the "initial peak" of protein synthesis although this treatment decreased the rate of subsequent protein synthesis. Hence the occurrence of the first replication seems to depend upon the simultaneous synthesis of the "early protein peak." The reverse situation, that the "early protein" synthesis depends on DNA synthesis, is unlikely.

Soluble proteins, pulse-labeled at different times, were compared by gel electrophoresis. The arrangement of radioactive protein bands was constant throughout the "early peak." At later times the pattern changed and more radioactive bands were present. The co-ordinated synthesis of a limited number of proteins in the "early peak" and the dependence of the first replication upon this peak suggested that DNA synthesis was regulated by the turning on and off of a "replication operon."

Several observations, however, argue against such a theory. Extensive gel studies had failed to demonstrate that the banding pattern of the "early protein peak" was repeated and was correlated with later replications. Although the chloramphenicol experiments indicate that some of the proteins of the "early peak" were concerned with DNA synthesis, there is no evidence that all the proteins are involved in replication. Finally, some of the protein bands of the "early peak" were present at earlier and later times. Hence the "early peak" may be an expression of overall control of protein synthesis rather than of a specialized operon.

4.3 *Studies on Isolated Metaphase Chromosomes*

(Professor John E. Hearst, Department of Chemistry)

Molecular weights of homogeneous samples of deoxyribonucleic acid determined from hydrodynamic theories for the wormlike coil (Professor John E. Hearst; Carl W. Schmid and Frank P. Rinehart, Research Assistants). The molecular weights of a number of viral DNA's have been calculated using the hydrodynamic theories for the wormlike coil and the Flory-Mandelkern equation. The theoretical fit to the experimental sedimentation and viscosity data is good. The Kuhn statistical length of DNA has been calculated to be 805 Å in a solution with an ionic strength of 0.2. The ionic strength dependence of $1/\lambda$ is large and has

been calculated. The range of molecular weights calculated for T-2 bacteriophage DNA is 94.4×10^6 through 105×10^6. The range calculated for T-7 bacteriophage DNA is 21.6×10^6 through 24.0×10^6.

Density gradient molecular weights of large homogeneous DNA's (Carl W. Schmid and Professor John E. Hearst). Density gradient sedimentation equilibrium in principle provides a valuable technique for the measurement of molecular weights of large DNA's such as those isolated from bacteriophages or mammalian chromosomes. Several experimental artifacts have prevented the use of density gradients for this purpose. These artifacts have been partially eliminated, and the molecular weight of two viral DNA's has been determined by this technique.

The molecular weight of T-7 NaDNA is 23×10^6 daltons; the molecular weight of T-5 NaDNA is 57×10^6 daltons. These values are in good agreement with other molecular weight determinations of these DNA's by hydrodynamic theory, but they are 20% lower than the values obtained by electron microscopy.

Isolation of Drosophila chromosomes (Laura Kayfetz, Laboratory Technician; David Kafton, NIH Fellow; and Professor John E. Hearst). Metaphase chromosomes (*Figure 1*) have been isolated from 3-hour old Drosophila eggs using the isolation procedures of Cantor and Hearst. Yields are still low, so modifications of the procedure are being tested to improve yields and chromosome purity. The eventual goal of this research is the separation of the four Drosophila chromosomes from one another and the observation of chemical changes associated with cell differentiation.

Magnesium ion binding by metaphase chromosomes (Kenneth Cantor, Research Assistant, and Professor John E. Hearst). It had previously been observed that hydrogen ions were released when $MgCl_2$ was added to a sample of chromosomes that had been exhaustively washed in distilled water. Upon addition of Mg^{++} to a final concentration of 10^{-4} or greater, 3.5×10^{-4} millimoles of hydrogen ion per milligram of chromosomes were released into the aqueous solution. In the present work, we have studied the binding of magnesium to chromosomes to determine the number of Mg^{++}

binding sites. Eriochrome Black T, a dye that undergoes a spectral change upon binding magnesium ion, was used to determine the binding constant (K) and the number of binding sites on chromosomes. Preliminary results are that $K = 1 \times 10^5$, and the number of sites lies between 1.5×10^{-5} and 2.6×10^{-5} sites per mg chromosomes. This means that more than 10 hydrogen ions are released for each magnesium ion bound to the chromosome.

Formation and characterization of a protein-RNA-DNA complex (Leon Borowski, Research Assistant, and Professor John E. Hearst). It has been reported that *in vitro* a protein-RNA-DNA complex is important in regulating the expression of genes. We plan to investigate the physical chemistry of this complex in order to determine the nature of the complex.

The protein-RNA complex has been isolated from crude ascites nucleohistone. When crude nucleohistone is layered on 1.7-M sucrose and centrifuged, the nucleohistone sediments while the protein-RNA remains at the interface between buffer and sucrose. Eight-molar urea is dialyzed into the interfacial material, which is then separated on an A-25 DEAE Sephadex column. The protein-RNA elutes at 0.55-M NaCl.

A RNA test shows that all the O.D. at 260 mμ is RNA. There is a negative DNA test as well as a positive protein test. The protein-RNA complex has a buoyant density of 1.685 g/cc in CsCl, indicating the complex is about 2/3 RNA and 1/3 protein.

We plan to study the binding of the protein-RNA complex to ascites DNA by equilibrium dialysis. If the protein-RNA complex is a repressor, as reported in the literature, it should be possible to demonstrate a strong binding of the protein-RNA complex to DNA.

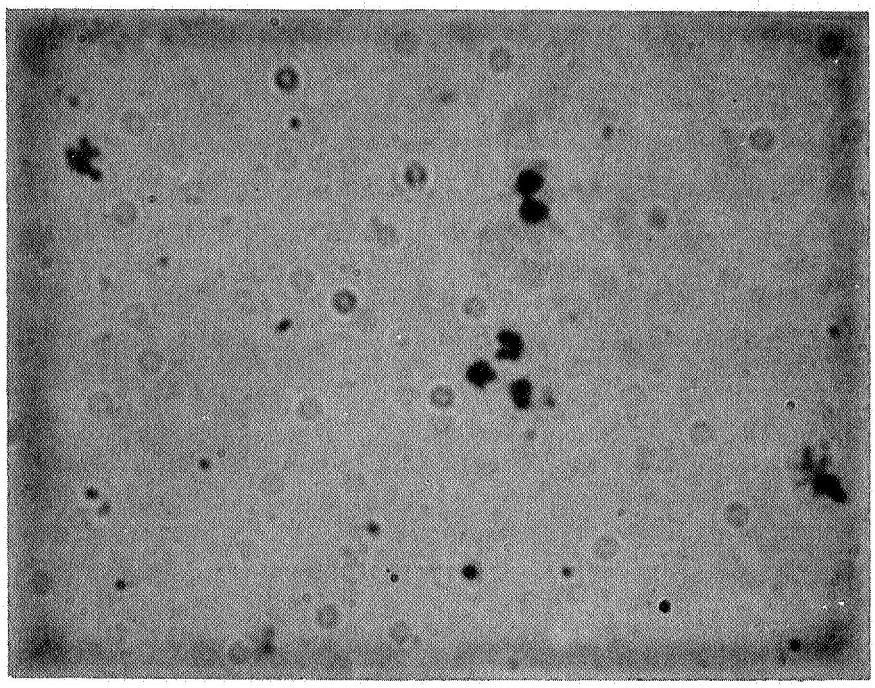

Figure 1. Isolated Drosophila chromosomes.

E.5 *Engineering Science*

5.1 *Interaction of Radiation with Solid Surfaces*

(Professor Harold P. Smith, Jr., Department of Nuclear Engineering)

A comprehensive program has been established to investigate the interaction of radiation with solid surfaces. Much of this work has been supported under related NASA grants.*

The feasibility of obtaining an atomically clean surface in vacuum through use of high power, pulsed LASERs has been demonstrated. In addition to the expected advantages of this technique, unique surface structures such as non-satellite silicon (111) surfaces were created as a result of millisecond quenching following LASER-induced heating. On the other hand, the usual satellite structure was obtained by low temperature annealling of the quenched surface. By using a temperature versus intensity technique, we have measured the free-energy of formation of the satellite structure.

The formation of contaminated (oxide) surfaces has been investigated. In particular, ordered structures of oxygen on aluminum have been determined. These investigations will be extended to include investigation of oxide and metallic structures on silicon.

Use of the LASER to create clean surfaces has demonstrated the need to understand the mechanisms of pulsed, surface vaporization. A radioactive tracer technique, developed for ion bombardment studies under a previous NASA contract, has been adapted to this problem. An extensive computational model, which emphasizes the importance of critical temperature and plasma absorption, has attained moderate agreement with our experimental results.

The Bethe formalism for dynamical diffraction of low energy electron diffraction has been adapted to numerical computation. Intensity-wavelength calculations for aluminum have been compared favorably with experimental measurements in our laboratory. Further improvement will be obtained by increasing the number of Bloch functions in the numerical formulation.

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*NASA Grants NGR 05-003-161 and NGR 05-003-275.

Further work in ion bombardment has continued. Cesium ion implantation profiles at saturation in aluminum have been measured. The velocity distribution of sputtered particles has been measured and favorably compared with a combined momentum transport-local heating model of the interaction. Finally, the feasibility of a proton microprobe for measurement of implantation profiles has been demonstrated. Further work in the last category is planned.

Participating Personnel:

Professor Harold P. Smith, Jr.	—	Department of Nuclear Engineering
Ferdinand Hofmann	—	Assistant Research Engineer
S. M. A. Bedair		Research Assistants
Gary K. Cowell		
F. William Reuter, III		
Wigbert Siekhaus		
Yeong-du Song		
Guilio Varsi		

Publications:

Cesium ion bombardment of aluminum oxide in a controlled oxygen environment. E. H. Hasseltine, F. C. Hurlbut, N. T. Olson, and H. P. Smith, Jr. *J. Appl. Phys. 38,* 4313 (1967).

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A dynamical theory of low energy electron diffraction (LEED). F. Hofmann and H. P. Smith, Jr. *Phys. Rev. Letters 19,* 1472 (1967).

Competition between random and preferential ejection in high-yield mercury sputtering. R. G. Musket and H. P. Smith, Jr. *J. Appl. Phys.* (to be published).

LEED studies of oxygen adsorption on the (100) face of aluminum. S. Bedair, F. Hofmann, and H. P. Smith, Jr. *J. Appl. Phys.* (to be published).

Oxygen surface density measurements based on characteristic x-ray production by 100 keV protons. R. R. Hart, N. T. Olson, J. M. Khan, and H. P. Smith, Jr. *J. Appl. Phys.* (to be published).

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Calculation of low energy electron diffraction intensities using dynamical theory. F. Hofmann and H. P. Smith, Jr. *Fourth International Materials Symposium: Structure and Chemistry of Solid Surfaces*, June 1968, Berkeley, California.

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Impurity profile measurement using proton produced, characteristic x-rays. F. W. Reuter, III and H. P. Smith, Jr. (In preparation.)

Radioactive tracer investigation of surface vaporization by LASER bombardment. G. Varsi and H. P. Smith, Jr. (In preparation.)

Oxygen K x-ray production in thin films of aluminum oxide by 20 to 100 keV protons. R. R. Hart, F. W. Reuter, III, J. M. Khan, and H. P. Smith, Jr. (In preparation.)

E.6 *Public Administration*

The NASA Public Administration Program at Berkeley was initiated in February 1967 with a grant of $25,000, which was used to fund five research assistantships in the general area of public administration. Broadly defined, the goal of the program has been to assist selected faculty members in their efforts to relate developments in science and technology to the understanding and solution of emerging administrative and public policy problems. The reports for the individual projects follow.*

6.1 *Political-Governmental Data Bank*

(Professor William E. Bicker, Lance Widman and Dorothy Clayton, Research Assistants)

The record-keeping and reporting techniques used by the state of California and its many local governmental units and agencies are probably the most automated in the nation. The resulting data are a

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*In addition, Professor Aaron Wildavsky and the "Oakland Project" received a small amount of assistance at the end of fiscal year 1968.

basis for numerous studies for social scientists employing automated data analysis techniques. Both the officials and academicians in the state are primarily concerned with the same types of data. However, information about the existence or availability of these data is widely scattered and difficult, if not impossible, to obtain quickly. This difficulty leads to duplication of effort and expenditure of time and resources that could be used for analysis.

This project involves an inventory of data currently available in machine-readable form regarding California's social, economic, and political, characteristics. Initially, efforts will be concentrated on the location of such data on this campus and then extended to the other University campuses and all other institutions of higher learning in the state. Finally, governmental sources will be examined.

The first tangible result of this project was the acceptance of a proposal to the Regents' Innovative Course Project Fund for the initial cleaning and collection of public opinion poll data specifically directed toward California's problems, issues, and politics over the past ten years (six polls per year, plus a selection of votamatic ballot cards such as those used by sixty percent of the California electorate today, as well as basic city, county, and SMSA census data on California and the nation as a whole). With the funds from this grant it will be possible to have the beginnings of a data library established in the Institute of Governmental Studies that, hopefully, will grow to encompass a broad variety of relevant political and social data.

6.2 *The Impact of Science and Technology Upon the Development Process*

(Professor Robert P. Biller, and Paul Kelly, Research Assistant)

This project inquires into the meaning of political and social development and explores the ways scientific and technological processes, institutions, outcomes, and personnel may contribute to developmental outcomes. Some of the major assumptions that inform public policy decisions in this area may be unduly naive when examined within

the setting of the United States and in error when examined in an international setting, particularly in reference to low-income, "developing" nations. It is hoped that the project may have implications for: the technical assistance policy of the United States; the developmental policy of low-income societies; and the developmental policy of the United States in relation to such questions as urban development.

In 1968-69 we have worked on two tasks. The first involves the development of a model that depicts the major relationships between science and technology, their directionality, and the processes of development and modernization. The major hypothesis being explored is that many such developmental policies and assistance efforts have the effect of transferring *symbols* of modernization (i.e., discrete bits of technology, trained personnel, etc.) rather than contributing to the emergence of self-sustaining adaptation and change processes that may more fundamentally reflect development.

The second task consists of taking several subcomponent policy questions inferred from this model and exploring them in depth. These subquestions include migration, institutional infrastructures, professional societies, educational investment, etc. Most of the effort has been devoted to exploration of the migration and educational investment policy questions relevant to scientists and engineers in low-income societies.

Ten 3-hour informal seminars were held by the principal investigator and five graduate students during the spring quarter 1968. In addition, three draft papers are now being completed. The first addresses the question of technical personnel migration in relation to development policy. The second explores technical education policies in developing societies in terms of their contributions to political and social development. The third defines a research procedure to test one component of the model outlined above. This research would use data on technical assistance efforts to test the relationship between a project's substantive and processurial content and its modernizing or developmental outcomes.

Individual seminar presentations resulting directly or indirectly from this grant during the past year include:

1. Fall Quarter, 1967 — Legislative Interns in Sacramento, "Organizing for Effective Administration in the State of California"
2. Winter Quarter, 1968 — Political Science Undergraduate Course in Science, Technology, and Politics, "Technology and Political Development"
3. Winter Quarter, 1968 — Student-Initiated Course in Public Health on "The Role of the Technical Assistant in Development"
4. Winter Quarter, 1968 — Dr. Derryberry's Seminar in Public Health on Health Education, "Planning Developmental Change"

6.3 *Comparative Analysis of Public Organization*

(Professor Warren Ilchman, and Judith Merkle, Research Assistant)

The research pursued under the NASA Public Administration grant has been the factor analysis of an 800-item bibliography on comparative public organization and subsequent comparison of emerging propositions with those found in organization theory. The major questions are:

1. What accounts for variable political power of public bureaucracies within and between political systems?
2. What accounts for different levels of productivity of public bureaucracies within and between political systems?
3. What accounts for variations in the patterns of organizational authority and form within and between public organizations and between political systems?
4. What accounts for variations in the behavior of public bureaucrats within and between political systems?

5. For what functional requisites do public bureaucracies perform within and between political systems?

The intention of the research is, simply put, to cosmopolize American public administration and organization theory and to determine the cross-national validity of key propositions. The first propositions have been studied in two graduate seminars in Comparative National Administration. A first publication of the research, "The Unproductive Study of Productivity," is being published this summer in the *Comparative Politics Quarterly*. A book already contracted for by Little, Brown and Company will be finished in the autumn by Professors Todd R. LaPorte and Warren Ilchman.

6.4 *Relationships between Technical Professionals and Managerial Personnel*

(Professor Todd LaPorte, and Jim Wood, Research Assistant)

As the federal government has increased its stimulation and support of science and technology, there has been a rapid increase in the number and degree of organizational research directed toward the conversion of scientific findings into technological advances. As these organizations have grown in size and number, one major problem that has emerged is the relationships between technical professionals and managerial personnel. Attitudes of technical professionals who express needs for release from organizational constraints often contrast sharply with the attitudes of managers who are required to control activities and organize professionals in the interests of coordination. Problems stemming from these basic differences are the object of study.

Data have been collected from three different types of government-funded research laboratories, e.g., a military laboratory, an industrial laboratory, and an independent university-related laboratory funded entirely by NASA. The characteristics peculiar to each organization lead to different structures and blends of attitudes among professional and managerial personnel.

Data from three organizations have been analyzed to examine: (1) the attitudes scientists and engineers hold regarding their professional work, the managers, and a number of conditions in each laboratory; (2) attitudes

of managers regarding the kinds of things they expect of professionals; and (3) the structural resolutions each of these organizations has devised to deal with the problem of organizing professionals. In sum, the study is an attempt to examine the mechanisms that tend to reduce the level of tension between technical and managerial personnel.

These data reveal variations among scientists and engineers regarding the degree to which they identify with their organizations, their levels of satisfaction, their attitudes toward managers, etc. Furthermore, the attitudes of managers about what scientists and engineers should do make substantial differences in the degree to which professionals feel they can carry on professional activities, their sense of professional satisfaction, and their intention to remain in these organizations. During 1968-69, analysis has related to those activities that tend to increase the influence a professional has on his immediate work situation.

Our most general hypotheses are as follows: the greater the opportunity professionals have to exert influence over their immediate work environment, the more likely they will have work experiences that they value; and organizational environments vary in the degree to which they provide opportunities for professionals to influence their working situations. More specifically, we have selected two work-influencing activities: (1) the opportunities of professionals to persuade sponsors to support or to fund their research work (entrepreneurial activities), and (2) the opportunities of professionals to engage in work not formally specified in the contract or grant (non-formal research work). Furthermore, a number of professionally and organizationally desirable activities have been selected, on the basis of other studies of professionals and organizations, that are considered to be highly desirable experiences for professionals. These include adequate funds, opportunities to contribute to scientific knowledge, freedom to select research projects, consultation with managers about decisions affecting their work, etc.

In its most elemental form, then, our hypothesis is: Professionals who indicate that they have work-influencing opportunities (a) to engage in non-formal research work, and/or (b) to carry on entrepreneurial activities also indicate that they have opportunities to do or to experience a number of other desirable professionally related activities.

There are two broad categories of activities that have been examined to test this hypothesis: (1) the professional activities noted above; and (2) the more general attitudes and activities related to the organization, such as degree of satisfaction, obligation to organizational goals, opportunities for organizational promotion, etc. Thus, we have two general types of activities and attitudes that are related to the degree of experience in work-influence activities. In summary form, the data show that in two of the three organizations almost three-fourths of the professionally desirable activities were experienced more frequently by scientists and engineers who had opportunities to engage in either one or both of the work-influence activities; and in the third organization over half of these professionally desirable activities were experienced. In some cases, those who had frequent opportunities to engage in *both* were a great deal more likely to experience desirable professional conditions. This was not nearly so much the case for activities and conditions related to organization factors. Generally, at least at this stage of the analysis, opportunities to engage in work-influencing activities seem to have an indeterminant effect on the degree to which organization factors are experienced.

As the foregoing remarks suggest, there has been some variation in the general or gross effects of experiencing opportunities to engage in work-influence activities. Part of the reason for this variation is found in the different organizational situations or contexts of the three laboratories. In an initial attempt to explore in context the effects of variations upon the world of the professional, we have studied the differences between these organizations on the basis of their relationships to their primary sources of financial support. One of the three laboratories is supported and directed solely through a military command in one of the branches of the service. Another, the nonprofit laboratory, is completely supported by an agency from which at least *two* major sources of funds are derived. The third, an industrial laboratory, is funded from a number of government sources and can submit grant and contract proposals to any of the *many* sources within the government. Thus the financial support of these organizations range from single-source to multiple-source in relation to the supporting agencies.

Theoretically, it can be argued that as an organization becomes more and more dependent upon a single source of funds, the effort required to engage in activities that will allow professionals to do the research they want "legally" will become greater and less effective than the effort required for non-formal research. Conversely, in laboratories having multiple sources of funds, entrepreneurial activities have the advantage of enabling the researcher to do more nearly what he wants to do within the formal relationships of the organization. That is, one does not need to carry on activities that fall outside the normally justifiable, legal limits of work specifications.

This relationship has been examined initially using data from these organizations. Thus far, it appears that in the laboratories that have only one or a few sources of funds, the non-formal research activity has a much greater effect on the degree to which researchers experience desirable professional conditions than do entrepreneurial activities. The reverse is true in the laboratories having multiple sources of funds.

Presented papers, resulting directly or indirectly from this grant during the past year, include:

1. "Politics and Inventing the Future — Perspectives in Science and Government," delivered to Particle, University of California, Berkeley.

2. "Science and the City: A Question of Expectation," to Bay Area Chapter of the American Society for Public Administration.

3. "Technology and Politics Implications for Government and Science," Faculty Seminar, School of Business and Public Affairs, Cornell University, Ithaca.

4. "Professionals in Complex Organizations: Effects of Enabling Mechanisms," Science and Public Policy Lecture Series, Cornell University, Ithaca.

5. "Beyond the Bureaucracy Study Seminar," Presbyterian National Seminar Series (with James T. Gustafson, Yale University).

A working paper ("Technical Professionals in Complex Research Organizations") has just been completed that covers about two-thirds of a theoretical statement upon which the study is based.

It is a revised version of earlier papers and presents a major portion of the conceptual section of a monograph that will bring theory and empirical work together. The paper, which will be in two parts, is based on the organizational and social context in which technical professionals and organizational managers interact. Materials are drawn from systems theory, structural-functional theory, bureaucratic theory, and role theory. These are woven together to provide a basis for deriving hypotheses concerning the origins of role strain and conflict between professionals and managers and the accommodation mechanisms found in research organizations that reduce strain to manageable and productive levels.

Plans are to complete the data analysis and to prepare an article dealing with the effects of various "enabling mechanisms" and organizational context noted above. Furthermore, literature review and updating is in progress for the completion of the theoretical paper described above.

6.5 *Professional Education and the Public Service*

(Professor Frederick C. Mosher, and Michael Gould, Research Assistant)

With the help of research assistance financed by NASA Grant NsG 243 a report on "Professional Education and the Public Service" was completed, published, submitted to the Center for Research and Development in Higher Education, and subsequently submitted to the U. S. Office of Education. I am continuing work toward a book on the broader subject of professionals and the public service, which will be published by the Chandler Publishing Company in 1969.

E.7 *Technology and Urban Management*

7.1 *Oakland Budget Project*

(Professor Aaron Wildavsky, Chairman, Department of Political Science, and Jeffrey L. Pressman, Research Assistant, Space Sciences Laboratory)

The Oakland Budget Project, under the direction of Professor Aaron Wildavsky is an action-research program to examine the allocation of resources in the city of Oakland. By focusing initially on the

budget process, participants in the study have gained an understanding of the ways in which allocation decisions are made in the crucial areas of urban policy — police, poverty, taxation, city planning, and so on.

However, the project is not concerned merely with descriptive research; members of the project are also working with various city agencies as policy assistants and researchers. Arnold Meltsner, a graduate student in the Department of Political Science, has worked on revenue and taxation problems for the past two years with the City Manager of Oakland. During the last year, Mr. Meltsner prepared a Fiscal Capability Survey for Oakland, which shows the likely consequences of various forms of taxation. On the basis of Mr. Meltsner's study, the City Manager is recommending to the Council a change in the city's tax policies.

The Oakland City Budget totals approximately $53 million, but annual federal outlays in Oakland (including approximately $400 million in defense expenditures) total over $500 million. Jeffrey Pressman, also a graduate student in political science, has been working in the Mayor's office on the compilation of a comprehensive directory of federal programs in Oakland. Included for each program will be the federal agency and the legislation involved, the amount of money spent, and the ways in which the money is used. Mr. Pressman has also been working on the federal-city task force to bring the Mayor into contact with federal officials in the areas of redevelopment, housing, and poverty.

David Wentworth, a graduate student in political science with a Master's degree in criminology, has prepared a report on decision-making in the Police Department; he is preparing to work this year in Chief Gain's office. Judy May, a graduate student in political science, has been offering technical and writing assistance to the Oakland Economic Development Council, the local Community Action Agency of the Poverty Program. She is also writing a report on budgetary decision-making in the Streets Department.

These four students will write theses about the areas of urban policy they are now studying. In addition, they will collaborate in writing a book on allocation decisions in Oakland. Finally, they will continue to offer assistance to Oakland government as it is needed.

III. SOCIAL SCIENCES

The *Memorandum of Understanding* between the National Aeronautics and Space Administration and the University of California articulated the intent of both organizations to seek ways in which the benefits of a multidisciplinary program of space research could be applied to the social, business, and economic structure of the United States. The Social Sciences Group of the Space Sciences Laboratory carries out its mandate in a number of ways: (1) the group seminar; (2) specific research projects; (3) the working paper series, as well as other publications; and (4) services to the community at large, such as consultative services to civic, state, and national government agencies, and participation in public lectures, seminars, and forums.

During recent weeks, all members of the University community have been called upon by President Charles J. Hitch to mobilize their resources to help deal with America's urban crises. He requested a complete report of the areas of research and public service in which professional knowledge could provide meaningful assistance in the urgent problems of the larger community. Acknowledging its responsibility to respond to the urban crises, the University has called for a comprehensive inventory of its internal resources. In view of President Hitch's expressed intention to mobilize the University's capability for systems research on city problems, many of the research programs of the Social Sciences Group take on special significance because they are directly relevant to the tasks at hand. Assessment of the extent of the contributions to be made would be premature, but it may be anticipated that herein lies another opportunity to fulfill the terms of the *Memorandum of Understanding* — to serve as a medium through which the wider consequences of NASA-sponsored research can have an impact on the total environment — social, economic, and political.

The structure of the research in the social science program consists of a set of studies dealing with the philosophical base of a "systems approach" to science and technology, another set of studies concerned with the specific impact of the systems approach to problems of government agencies, and a further set of studies of related topics of research

management and policy formation. The weekly seminar of the Social Sciences Group cements these various efforts together by a conscious effort to explore their relevance to one another, as well as to the problems of large social systems.

This report begins by describing the three aspects of the program, is followed by a description of the seminar, and concludes with a listing of publications, lectures, and other material that illustrates the way in which the group communicates with the outside world.

It should also be mentioned that the Social Sciences Group has an ongoing relationship with the members of TAUM (Technology and Urban Management), whose efforts are reported in a separate progress report.

A. *Philosophical Base of the Systems Approach to Science and Technology*

Under this heading are the projects concerned with the philosophical meaning of a "systems approach" to R & D effort (or to any effort). In classical texts of scientific method, one reads about the logic of testing hypotheses by observation, but very little is said about how research is initiated, how hypotheses are formulated, what data are relevant, how research is organized, and so on. Still less is said about the relevance of such effort in the larger system, i.e., what the real purposes of research projects are. Finally, few classical texts deal with the management of the R & D process, although this is clearly an important aspect of scientific endeavor.

First, there is the need to describe the "systems approach," both its weaknesses and its strengths. This has resulted in two books by Professor C. West Churchman, *Systems Approach*, Delacorte Press, to appear in the fall of 1968, and *Challenge to Reason*, which was published by McGraw Hill, March, 1968. The main point of both books is that there is no "objective" way to study large systems; the systems scientist must regard himself as a part of the system he studies and must play a political as well as a scientific role. Thus, he cannot assume that his "facts" are universally valid. Furthermore, no one knows any reliable method of understanding the whole system, even though the concept is central to making recommendations for system change. Consequently, the system

scientist operates in a realm of critical uncertainty. None of these points implies a pessimistic philosophy of large social systems. But they do imply that to assume expert competence of either the system scientist or the manager-politician is probably illusory.

A larger work, *The Design of Inquiring Systems*, is now being revised for publication. This book is a serious effort to put forth alternative designs of inquiry, each of which hypothetically satisfies the criteria of a "systems approach." The source of the designs lies in the history of ideas, as does the criticism of each design.

One section of this work, the "Hegelian Inquiring System," proposes that the research process proceeds by a very careful and dramatic attempt to oppose a thesis by an antithesis. The concepts of this chapter of the work have recently been applied in a Ph.D. thesis by Richard Mason to "counterplanning."* Mr. Mason has worked with a firm that conceived a five-year plan, based on its assumptions about what its "real world" is like. Mason then constructed another plausible view of the company's real world that led to a reinterpretation of the evidence and a "counterplan." Both plan and counterplan were displayed to management, and the process clearly strengthened their concept of the future and led to a richer "synthesis" plan.

Another Ph.D. candidate, Charles Portwood, is attempting to apply the concept of design to the selection of project leaders of R & D projects to determine what qualities produce the "best" leaders.

B. *Application of Systems Analysis to Social Problems*

Drawing on case materials from completed and ongoing systems analyses, Dr. Ida R. Hoos, Associate Research Sociologist, is developing an empirical review of the current and growing trend toward utilization of the systems approach and related quantitative techniques, such as cost/benefit measures and program budgeting, in social planning. The earlier phases of the research have been devoted to an examination of the bases for and assumptions underlying the widespread acceptance and application of the systems approach. Taken into account were the relevant factors of

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*See p. 95 of this report (Internal Working Paper No. 87).

association with the defense effort and space missions. Of special significance were the political and economic conditions that have fostered the precedent-setting experience of the State of California. Because substantial sums of public money are being committed to more and more systems studies at all levels of government as a means to alleviating social distress — all on the strength of the "success" of the California experience — it becomes increasingly important that that experience be analyzed and set in proper perspective. This is the objective of Dr. Hoos' research study.

The areas designated originally by Edmund G. Brown when he was Governor of California were information handling, waste management, mass transportation, and criminal justice, with Lockheed Missiles and Space Company, Aerojet General Corporation, North American Aviation Incorporated, and Space-General Corporation the contractors. Subsequently, Space-General received a contract to study welfare operations, Lockheed to study crime information handling, Aerojet General to devise a system for coping with pollution in the Fresno area, and TRW to develop a land use information system. With more than two-thirds of a billion dollars of public funds already committed to contracts (nationally) for non-military systems, the field of contenders now represents a heterogeneity of backgrounds: the aerospace industry; electronics companies; manufacturers of computers; chemicals, and cars; management consultants; and university and other non-profit research organizations, popularly known as "think tanks."

Although there is developing a considerable literature on the application of systems analysis to military planning, its utilization in the civil or social sphere has received plaudits in the face of a persistent lack of substantive evidence for its efficacy. The California experience, reverently cited as a model for emulation, as counties, cities, states, and federal agencies attempt to introduce "rational" techniques into their planning, contains a wealth of material. This, no doubt, is because it represents, in its larger dimensions, a unique demonstration of the dynamics of social change as effected through public administration.

Dr. Hoos' research can be viewed as an on-line real time activity. Her writings and reports are in great demand; in addition to her contributions through the Internal Working Paper Series, she has had articles pub-

lished in international journals. During recent months, *La Scuola in Azione* (Milan) and *Mercurio* (Rome) have included her papers. In the near future, the Institute of Economic Affairs (London) will publish a monograph, *A Critical Review of Systems Analysis*, as an Eaton Paper. A series of her papers is scheduled to appear in *Data*, an American journal, which specializes in defense and civil systems.

If the systems approach is to serve as the medium through which governmental processes are improved, it becomes vitally necessary to identify the social costs and benefits and the applications and misapplications. Dr. Hoos combines scholarly research with empirical observation and translates the results into guidelines directly available to government planners so as to provide better understanding of the social dimensions and implications of the "technical" approach to problem solving and program planning. The ultimate objective of this research project is to point up the areas where there is need for mutations in the state of the art and new dimensions of professional stature in the state of the artists.

At what might be called the micro level of this phase of our effort is a laboratory study recently completed and reported in Dr. Jan Huysmans' thesis.* One of Dr. Huysmans' major theses is that managers whose "cognitive style" is nonanalytic (i.e., "intuitive") tend to resist recommendations containing analytic (mathematical) material, even though the argument is also stated in "plain English." This thesis was confirmed by the experimental evidence, which also indicates that "analytic" managers are not perturbed by the mathematical material. The thesis is important because it shows how cognitive style can be measured so as to predict how managers will respond to technical managerial reports.

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*See p. 94 of this report (Internal Working Paper No. 78).

C. *Specific Projects Dealing with the Research and Development Process*

1. *Conflict and accommodation between scientists, engineers, and managers in complex research organizations*

Professor Todd R. LaPorte, Department of Political Science, is analyzing the findings of his ongoing comparative studies of three different types of research laboratories — government, university-allied, and industrial. In his endeavor to gain a better understanding of the mechanisms that tend to reduce tensions between technical and managerial personnel, Professor LaPorte has examined the bases for strain and the varying structural accommodations that take place in the three divergent environments.

The research points up the likelihood that organizational relationships to sources of funds is a very important factor in both the generation and resolution of such tensions. As patterns of federal spending undergo alteration and as currently-held notions about the value of basic research are subjected to critical scrutiny, these findings take on new and greater significance.

2. *Management of research in a professional school*

Two studies under the general heading of the management of research are in progress by Dr. David H. Stimson, Assistant Research Economist. The first is an investigation of the effects of federal funds on the growth and direction of the research function of a professional school, in this case the School of Public Health at the University of California. The impact of research activity on the teaching and community service functions of the school is being examined, as is the effect on research management when the value placed on a discipline by the federal government differs from the value orientation of the university community. The second concerns itself with the use of sociometric analysis as a tool for research managers; the endeavor in this case is to ascertain the extent to which this methodology serves to bring variables that elude measurement within the scope of the formal analysis of research management problems.

3. *Funds, fragmentation, and the separation of functions in the state university*

This study of the relationship between formal structure and functions in state universities has been completed by Dr. David H. Stimson, Assistant Research Economist, Dr. Frederick W. Betz, Assistant Research Physicist, and Mr. Carlos E. Kruytbosch, Post Graduate Research Sociologist. The research team conducted a historical survey of funding to ascertain the ways in which changed modes and sources of funding have affected the internal organization and administrative concepts of such institutions. They conclude that structural fragmentation and lack of congruence of the contemporary multi-university is due in large part to the imperatives of rapidly changing funding conditions. They foresee the danger of even greater separation between teaching and research functions as cost/effectiveness measures and program budgeting become the accepted means for assessing "performance" in academic circles as they have in business and government.

Dr. Betz and Mr. Kruytbosch will continue their research and teaching careers in the Department of Organizations, State University of New York at Buffalo. Indeed, five former members of the Social Sciences Group will be at Buffalo next year (in addition to Dr. Betz and Mr. Kruytbosch): Richard Hoffman, L. Vaughn Blankenship, and Rollo Handy.

4. *Scientific ideology in the space program*

This recently concluded study by Dr. Uri Hurvitz, Post Graduate Research Sociologist, takes the form of a Ph.D. dissertation. The task accomplished is a sociological analysis of the manner in which scientists take into account organizational constraints when they set goals for experiments in space. Especially important have been the problems encountered by scientists who forsake the academic milieu and pioneer under new sponsorship in areas regarded as unorthodox by their colleagues. Dr. Hurvitz, on completion of his research, will return to Israel to work in planning of scientific policy in the National Council for Research and Development. Hence, he has a concern for the broader issue: how to involve scientists in the planning and direction of social and political enterprises that extend beyond the boundaries of specific disciplines.

5. *Research, development, and science policy*

This research by Mr. Nabil C. M. Faltas, Research Assistant, has as its objective an assessment of the problems generated by the application of cost/benefit measures to research and development. Of special import are the implications for public policy of the economic evaluations as quantitative methodology becomes ever more prevalent in public expenditure planning. The analytic framework includes examination of the limits and prospects for public policy-making at both the micro- and macro-economic levels. At a later stage, the research will be directed to the qualitative, institutional, political, and administrative aspects of science policy as related to these quantitative factors; these will be examined by comparative analysis of different international economic and social systems.

6. *New careers program evaluation*

Although the New Careers Program does not come within the official jurisdiction of the Social Sciences Group,* its intent and dynamics are of sufficient interest to the members to warrant inclusion in this context. Professor Todd R. LaPorte and Dr. Ida R. Hoos of the Social Sciences Group are making their professional experience available to the persons responsible for furthering the program and developing a framework for its analysis and evaluation.

The New Careers Program, designed to provide new occupational avenues for minority group members through a carefully planned combination of classroom and on-the-job training is a pilot operation at present involving only four persons at the Space Sciences Laboratory and five on the Berkeley campus as a whole. Its major objective is to provide concurrent employment and educational opportunities to adult residents of Oakland's poverty areas in order to help them prepare for career jobs at the University and elsewhere. Because it is important to determine if and how the program at the Laboratory can be generalized to the campus community at large, all stages and phases of this important endeavor are being reviewed and reported.

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*A more detailed report may be found under the report on the Core Funding Component of NsG 243.

D. *The Seminar*

The Group Seminar, meeting weekly under the direction of Professor C. West Churchman, is attended by faculty, research staff, and graduate students from varied disciplines — philosophy, psychology, law, business administration, management science, sociology, public administration, economics, and urban planning. The "core" membership of the group has changed considerably during its five-year history; this is reflected in the research topics and emphasis. Continuity has, however, been achieved through the Seminar, which has served as the medium through which interests and problems have been shared, methodologies critically examined, and ideas vigorously debated. The Seminar also serves as a bridge between the "hard" and the "soft" sciences, for it has provided a forum for dialogue and discussion on issues fundamental to both "cultures." Similarly, it has proved to be a useful link among the social science disciplines. The weekly colloquia have attracted a great many guests either on a regular or occasional basis from both the University and the outside community. Some have presented papers, with a view to drawing upon the Group's multidisciplinary background for reactions, responses, and insights. Others have come as experts to participate when a subject of particular interest was under discussion. Still others have attended as observers, sometimes to contribute comments, or merely to listen.

The following are some of the topics discussed during recent months:

"Attitudes Toward a Civilian Police Review Board: Urban Problems in a Nut Shell"

"What should be the Objectives of a Police Force in an Urban Community?"

"The Administration of Criminal Justice as a System"

"The Allocation of Police Force in the City of San Francisco"

"Science and Society," a discussion of relevant problems of science's relation to society's goals, and society's relation to science's goals.

"Science and the Scientist." Professor Samuel Silver, Director of the Space Sciences Laboratory, presented this talk.

"The Experimental City: Large Scale Experiment in Science and Morality? Reflections on a Science of Business and Society." This paper was presented by Dr. Ian Mitroff, formerly associated with the Group as a pre-doctoral student, now Assistant Professor at the University of Pittsburgh.

"Technocratic Approaches to Political Science and International Affairs." This paper was presented by Dr. Sidney Slomich, formerly with Jet Propulsion Laboratory, at present associated with Stanford Research Institute.

"Aspects of Value Inquiry." This paper was presented by Professor Rollo Handy, Department of Philosophy, State University of New York at Buffalo, who participated regularly in the Seminars during a year at Berkeley as a Visiting Scholar.

"The Logic of Wicked Problems" and "Is the Devil a Planner or Scientist?" A discussion of the role of the rational analyst in the very complex social problems. Specifically, the discussion centered on the issue of whether simplifying a complex problem does or does not produce recommendations for change that are worse (more dangerous) than current policies.

"The Role of the Expert on Organizational Design and Change," a discussion of "advice giving" in social systems.

"Technical Professionals in Complex Research Organizations: A Structural Process Perspective."

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"A Study on the Capital Costs in the Japanese Enterprise for Long Range Planning." Mr. Ryuei Shimizu, Associate Professor of Business Administration, Keio University, Tokyo, a regular attendant at the Seminars during his year as Visiting Scholar at Berkeley.

"Implementation of Operations Research," a laboratory study of the relation of a manager's "cognitive style" to his resistance to mathematically based recommendations.

"The Risky Shift: Effect of Decision Consequences and Role on Group Decision Making." The paper was given by Dr. S. W. Becker, Visiting the Berkeley campus on a U. S. Public Health Service Special Research Fellow, from the Graduate School of Business, University of Chicago.

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"Impacts and Benefits of the U. S. Space Program upon the Nation." This paper was given by Dr. John G. Meitner, Manager, Aerospace Systems Program, Stanford Research Institute. Dr. Meitner has been a frequent visitor to the seminars.

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Several sessions of the Seminar have been concerned with the problem of funding research on a university campus. These include:

"Federal Funding: Its Impact on a Professional School"

"Funds, Fragmentation, and the Separation of Functions in the State University"

E. *Relation of Social Science Group to External Environment*

Perhaps of most interest as a new topic in this area is the transportation of the Social Sciences Group's philosophy to two campuses, The University of New York at Buffalo (Kruytbosch, Betz, Blankenship, Hoffman, and Handy) and the University of Pittsburg (Mitroff).

One graduate student, Søren Holm, is reviewing the methods used by groups in other universities to bring the university into closer and more relevant relationship with its environment.

Also to be included under this topic are the working papers and a list of organizations requesting our reports and lectures given by members of the group. It is of interest to note that the first officially approved interdisciplinary course on the Berkeley campus is a direct offshoot of the Social Science Seminars. It is I.D. 175, a nontechnical introduction to operations research, offered to graduate students in the professional schools (Business Administration, Political Science, Public Health, Social Welfare, Criminology, City Planning, Architecture, Librarianship).

1. *New working papers*

   74. NASA and the scientific community: A study on organizational behavior (Chapter IV: *The Tree of Knowledge*, in preparation). L. V. Blankenship (December 1967).

   75. Technical professionals in complex research organizations: A structural process perspective. Todd LaPorte (November 1967).

   76. The ethics of social science research: A discussion of some issues. Barbara Ballis (December 1967).

   77. Systems analysis in government administration: A critical analysis. Ida R. Hoos (January 1968).

   78. The implementation of operations research: A study of some aspects through man-machine simulation. Jan Huysmans (December 1967).

   79. Systems analysis in state government. Ida R. Hoos (January 1968).

   80. The case against planning: The beloved community. C. West Churchman (February 1968).

   81. Studying the future: A new discipline. A. George Schillinger (February 1968).

   82. Funds, fragmentation, and the separation of functions in the American university. Fred Betz, Carlos Kruytbosch, and David H. Stimson (February 1968).

   83. Systems analysis and the technical writer's growing responsibility. Ida R. Hoos (February 1968).

   84. Moral creativity in science and law. T. A. Cowan (July 1968).

85. Research and development for domestic imperatives: A design for decision. Scott J. McCrea (May 1968).

86. Operations research in public health decision making: A case study. David H. Stimson (July 1968).

87. Dialectics in decision-making: A study in the use of counterplanning structured debate in management information systems. Richard O. Mason, Jr. (June 1968).

28a. (Revised) Design and inquiry (Chapter I of *The Design of Inquiring Systems*, in preparation). C. West Churchman (March 1968).

29a. (Revised) Leibnizian inquiring systems (Chapter II of *The Design of Inquiring Systems*, in preparation). C. W. Churchman (March 1968).

31a. (Revised) On whole systems: The anatomy of teleology (Chapter III of *The Design of Inquiring Systems*, in preparation). C. West Churchman (July 1968).

31b. An illustration of a Leibnizian inquirer (Chapter III Supplement of *The Design of Inquiring Systems*, in preparation). C. West Churchman (July 1968).

2. *Requests for Working Papers*

Requests come from government agencies, the business community, various departments on this and all other campuses of the University of California, and other universities, American and foreign. A partial listing suggests the wide distribution:

Government Agencies

City of Burbank, California
Orange County Planning Department
Tri-City Mental Health Authority, Pomona, California
California Assembly Departments and Divisions — Budget, Employment, Planning, Welfare, Program, and Policy, etc.
Federal Bureau of the Budget, Health Education and Welfare, General Accounting Office, Forest Service, National Bureau of Standards, Office of Naval Research, Civil Service Commission, Office of Emergency Planning (Executive Office of the President).

Business Organizations

Boeing
Booz Allen Applied Research
Coca Cola
Dow Chemical
GFI Computer Industries
Hunt Wesson Foods

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Arthur D. Little
McGraw-Hill
McKinsey
Mead Johnson
Frederick Praeger
The RAND Corporation

System Development Corporation
Shell Development
TEMPO (General Electric)

TRW Systems
Unilever (London)
United Steel Companies (London)
Weyerhauser
Ernst and Ernst
Matson Navigation
C & H Sugar
Northwestern Mutual Life Insurance Company

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University of California Departments and Institutes

Business Administration
Center for Research in Management Science
City and Regional Planning
Criminology
Economics
Engineering
Industrial Relations
Institute for Business and Economic Research
Law
Physiology
Political Science
Psychology
Public Health
Real Estate

American Universities

Air Force Institute of Technology (Wright-Patterson Air Force Base, Ohio)
University of Arizona
Carnegie-Mellon Institute of Technology
University of Chicago
University of Cincinnati
Columbia University
Cornell University
University of Colorado
University of Denver
University of Florida

(con't.)

George Washington University (Washington, D. C.)
Harvard University
Harvard Business School
University of Idaho
University of Iowa
University of Kansas
Massachusetts Institute of Technology
Michigan State University
University of Michigan
University of New Mexico
Northwestern University
New York University
University of Notre Dame (Indiana)
Oregon State University
The University of Ohio
University of Pennsylvania
Purdue University
Rutgers University
University of San Francisco
Southern Illinois University
State University of New York at Buffalo
Syracuse University
Stanford University
Temple University
Vanderbilt University
University of Texas
University of Washington (Seattle)
Washington University (St. Louis)
Wayne State University
Western Reserve University
Yale University

Foreign Universities

Bradford University (Yorkshire England)
Centre Francais de Recherche Operationnelle (Paris)
Simon Fraser University (Burnaby, British Columbia)
University of Ghent (Belgium)
Institute for Atomic Physics (Bucharest, Rumania)
Max Planck Institute (Germany)
University of Strathclyde (Glasgow, Scotland)
University of Sussex (England)
University of Technology (Leicestershire, England)
University of Toronto (Canada)
University of Lancaster, England
University of Waterloo, Ontario

3. *Lectures and seminars given by members of the Social Sciences Group*

By C. West Churchman:

Four seminars for civil service employees at the Executive Seminar, Berkeley, on "Managerial Decisions and Operations Research."

"Education in a Technological Age" at a conference on "The University: An Environment for Creativity," at Washington State University, Pullman, and at the "Conference on Education and Communication in a Dynamic Society, co-sponsored by the Center for the Study of Democratic Institutions, Santa Barbara, and Project Public Information, Madison, Wisconsin.

"The Case Against Planning: The Beloved Community" at a dinner meeting on "Long Range Planning," University of Pennsylvania, Philadelphia.

"New Frontiers to Conquer: The Research Challenge" at the "New Deans Conference," Bloomington, Indiana.

Addressed a conference for hospital administrators at Emory University, Atlanta, Georgia, organized by the National Communicable Diseases Center.

Discussed operations research at the seminar for "Introduction to Comprehensive Planning, Phoenix.

Addressed faculty and students at the Graduate School of Business, University of Pittsburgh, and at Penn State on "Whither the Collaboration of Management Science?"

"Program Budgeting and Cost/Benefit Analysis" at the 1968 Annual Forum of the Association for Institutional Research, San Francisco.

Addressed students and faculty at the 13th Annual Management Development Program at McClellan Air Force Base, Sacramento, on "New Frontiers to Conquer: The Academic Challenge."

Conducted a seminar on "Systems Approach" in the Executive Program, Business Administration Extension, University of California, Berkeley.

Participated in program for city officials conducted by the Institute of Governmental Studies, Dunsmuir House, Oakland, California.

Participated in Mental Health Program, San Diego.

Presented the work of the Social Sciences Group, Space Sciences Laboratory, at a NASA Conference, Syracuse University.

By Dr. Ida R. Hoos:

"Technology and Organizations: Some Processes and Trends," Executive Seminar Center, U. S. Civil Service, Berkeley, October 16, 1967.

"The Ghetto Crisis: The Work Training Approach," Social Policies Planning (Faculty) Seminar, University of California, Berkeley, October 31, 1967.

Testimony before Sub-Committee on Electronic Data Processing Applications, Assembly Interior Committee on Social Welfare, Sacramento, December 21, 1967.

"The Welfare Counselor and Social Realities," Vocational Counselors of California, Northern Section, San Mateo, January 22, 1968.

Informal testimony and resource at hearing of California Assembly Interior Committee on Social Welfare, Sacramento, February 7, 1968.

"Technological Advance and the Anomic Society," Three Lectures: (1) The Numerical Imperative; (2) Coinbox Morality; (3) A Nameless, Faceless World. 67th Annual Earl Lectures Pastoral Conference, Pacific School of Religion Seminars, Berkeley, February 20, 21, and 22, 1968.

Series of five talks on various aspects and implications of technological advance: "The Sensate Culture, 1984, and the Year 2,000," Episcopal Church, Diocese of California, March 9, 16, and 30, April 6, and May 11, 1968.

"Poor People, the Protestant Ethic, and Productivity," Insurance Personnel Management Seminar, San Francisco, March 13, 1968.

"The Welfare Worker and the World of Work," Solano and Napa County Welfare staff workshop (lecture and discussion leader), Vallejo, March 14, 1968.

"Our Wasted Workforce," Interview on "University Explorer," Columbia Broadcasting System, March 24, 1968.

"The Technological Imperative plus the Cult of Efficiency Equals Invasion of Privacy," Lecture and discussion leader, Berkeley Center for Human Interaction, April 24, 1968.

"The Hard Core Unemployed — Industry's Hot Potato," The Executive Progam Seminar, University of California Graduate School of Business Administration, Berkeley, May 2, 1968.

"Education — The Preparation of Youth and Adults for the Labor Market and Employment," Lecture and discussion leader, Manpower Research Seminar, sponsored by the U. S. Department of Labor (Manpower Administration), San Francisco, May 3, 1968.

"Systems Analysis and the Technical Writer's Growing Responsibility," 15th International Communications Conference (Society of Technical Writers and Publishers), Los Angeles, May 10, 1968.

"Uses and Misuses of Systems Analysis in Public Administration," Lecture sponsored by the RAND Corporation for middle management in government agencies, graduate students in public administration, et al., under aegis of Public Policy Research Organization, University of California, Irvine, May 15, 1968.

"Science, Technology, and the City," Clergy Summer School, Church Divinity School of the Pacific, Berkeley, July 12, 1968.

"Systems Techniques and Organizations: Impacts and Implications," Executive Seminar Center, U. S. Civil Service, Berkeley, August 27, 1968.

"Technological Advance: Its Implications for Educators," Keynote address, Benicia School District workshop, Aetna Springs, August 28, 1968.

By Professor Todd LaPorte:

"Politics and Inventing the Future — Perspectives in Science and Government." Delivered to Particle, University of California, Berkeley.

"Science and the City: A Question of Expectation." To Bay Area Chapter, American Society for Public Administration.

"Technology and Politics Implications for Government and Science." Faculty Seminar, School of Business and Public Affairs, Cornell University, Ithaca.

"Professionals in Complex Organizations: Effects of Enabling Mechanisms. Science and Public Policy Lecture Series, Cornell University, Ithaca.

"Beyond the Bureaucracy Study Seminar." Presbyterian National Seminar Series (with James T. Gustafson, Yale University).

By Dr. David H. Stimson:

Presented paper, "Funds, Fragmentation, and the Separation of Functions in the State University," at the TIMS-ORSA meetings, San Francisco.

Lectured to an operations research graduate seminar in the School of Public Health, University of California, on "Utility Measurement."

Lectured to a graduate seminar in health planning in the School Of Public Health, University of California, Los Angeles, on "Systems Analysis in Health Planning."

Presented a paper on "The Management of Research in the Professional Schools," at the ORSA meetings in Tokyo.

GRADUATE STUDENTS IN THE SOCIAL SCIENCES GROUP

Nabil C. Faltas: graduate student in business administration; studying international economic planning.

Søren J. Holm: graduate student in business administration; studying the relationship between the university and the community.

Uri Hurvitz: graduate student in sociology; doctoral dissertation topic: "Interpretations of Basic Research in the Social Context of the Space Program"; research focus particularly relevant to his experience in Israel with a government agency responsible for allocations of research and development resources.

Carlos Kruytbosch: part of a group whose topic is "Organized Research at the University of California."

Erik R. Metz: graduate student in business administration; studying the utilization of open space in urban communities.

James L. Wood: graduate student in political science; studying the relation of manager to professionals in R & D organizations.

Charles S. Portwood: graduate student in business administration; attempting to apply the concept of design to the selection of project leaders of R & D projects to determine what qualities produce the "best" leaders.

Richard O. Mason: completed his Ph.D. in business administration. His thesis is Internal Working Paper No. 87, "Dialectics in Decision-Making: A Study in the Use of Counterplanning Structured Debate in Management Information Systems."

Scott J. McCrea: completed his Masters in business administration. His thesis is Internal Working Paper No. 85, "R & D for Domestic Imperatives: A Design for Decision."

IV. NUTRITIONAL SCIENCES

(Professor Sheldon Margen and Professor Doris Howes Calloway, Department of Nutritional Sciences)

NASA funds have been utilized to support an integrated program in space nutrition by providing for payment to technical personnel, purchase of necessary supplies, and payment to volunteers in those instances where human subjects have been required. Additional support for the total program has come from USPHS Grant AM 10202-02, as well as supplementary NASA grants, which have been consolidated with present grants for some of the work during the period of this report. The allocation of sustaining grant funds (NsG 243) to this work was explained earlier in Section II. In view of the fact that the use of human subjects in many of these experiments necessitates tremendous cost and effort, attempts are made to organize the studies in such a manner that many investigators from various disciplines are able to utilize these opportunities for human experimentation.

During the past year, experiments have emphasized the necessity to delineate potential problems of prolonged space flight. It is hoped that the systems proposed for space cabin atmosphere regeneration will also provide food; however, the bioregenerative systems proposed to date will provide foodstuffs having a higher N:C ratio than that found in man's normal diet. During the prior 2 years we have attempted to define individual minimum requirements for high-quality dietary nitrogen in order (1) to define the minimum nitrogen content for foods carried along or (2) to supplement some of the proposed chemical synthesis systems. Currently, the series of experiments is designed to define the maximal tolerance of man for protein.

As the diet is altered (particularly a bioregenerative system diet) nitrogen supply will be not only in the form of protein but also will have a large concentration of nucleic acids. Therefore, knowledge of the handling of these substances by normal individuals and of methods of increasing tolerance to them or altering their metabolic pathways are essential parts of the investigation. In addition to this, these unusual-type diets can be anticipated to have significant effects on the microflora of the

intestinal tract. These effects may be deleterious to the physiology of the organism and may lead to the production or evolution of unusual toxic trace gases; they would certainly be expected to alter concentrations of gases produced by microflora when an individual has consumed a "normal" diet. Various workers in the space-nutrition program have developed specific interests during the course of time. The principal studies instituted during the prior year and the individuals conducting these experiments are the subject of this progress report.

1. *Studies of Maximum Protein Tolerance in Man*

(Professor Sheldon Margen and Professor Doris Howes Calloway)

The purpose of this study is to investigate the maximum protein tolerance for man. Studies in animals have revealed that protein in the diet at approximately 60 to 80% or more of calories leads to apparent adverse effects, as manifested by failure of food intake, some failure of growth, and a general unhealthy appearance of the animal. To our knowledge, comparable levels of protein have not been fed to man for long periods of time. Generally, in those instances where "protein foods," such as meat, were fed, these were considered high protein; even in the more extreme instances the protein represented only about 50% of the total caloric value of the foodstuff. Primarily observational studies of meat intake alone have suggested that at this level of protein intake humans are able to exist and to survive for long periods of time. In order to achieve much higher levels of protein intake, to vary the protein intake, and to be able to keep other constituents with the exception of carbohydrate and fat in this diet constant, it was necessary to devise special, formula-type diets.

In most of our prior investigations we attempted to use one source of protein, namely egg white. However, because of the desire to keep minerals constant, as well as to guard against possible but unknown toxic effects of avidin (even when denatured by heat),it was decided that high levels would be achieved with a mixed protein intake. Therefore, the diet devised was based upon a mixture of casein, lactalbumin, soy protein, and partially decalcified casein. With this mixture of protein it was possible to formulate a diet that could be fed the experimental

subjects at protein levels of approximately 75, 300, and 600 grams per day in various metabolic periods. Carbohydrates were substituted isocalorically for protein, and calories were adjusted with carbohydrate to keep weight constant. Caloric intake varied with different individuals and was between 2800 and 3300 kcal per day. The protein at the 600-gram level contributed 2400 kcal of the total.

One problem did present itself that was insurmountable — how to maintain constant sulfur content in the diet while protein intake is varied. Sulfur in the diet is primarily contained in amino acids in protein, and catabolism results in the formation of sulfate, an anion that is excreted by the kidney. We were unable to supply sulfate at the low protein intake in amounts that would be equivalent to that excreted at the 300- and 600-gram protein level, in spite of repeated attempts. No sulfate salts or compounds that were sufficiently absorbed could be found, and diarrhea resulted at the 75-gram protein level in all instances when adequate supplementation was attempted. Therefore this plan was abandoned, and all minerals were kept constant except for the sulfur, which was supplied at the minimum level to avoid change in bowel habits at the 75-gram protein dietary intake.

The subjects were studied for metabolic periods of 15 days. Some of the results of these investigations follow:

A. All subjects were able to tolerate a diet containing 600 grams of protein in a formula for a metabolic period of 15 days.

B. Urinary volume increased to approximately 4 — 5 liters per day to accommodate the increased solute load. Even at these high urinary volumes the osmolarity of the urine was quite high. At the lower levels of protein intake, fluid intake had been programmed to anticipate the necessary higher fluid intake and urinary output; in spite of this programming, in some subjects it was impossible to force fluids that correspond to the high levels seen with the high protein intake. In addition to the increased urinary output, a small but definite fall in urinary pH was observed at the high protein intake levels.

C. Blood urea was markedly elevated at the high protein levels. At the 100-gram level, blood urea nitrogen averaged about 15 mg%, increasing at the 300-gram level; and at the 600-gram level it averaged about 40 to 45 mg%. Levels as high as 53 mg per 100 ml of blood were noted.

D. With increasing protein levels of the purine-pyrimidine free diet, marked increases in urinary uric acid were noted. These increases were of the order of magnitude of 4 to 5 times the baseline values observed on the 75-gram protein diet. The values on a daily basis were far in excess of normal urate pools and most likely represent increased synthesis of purines, the uric acid precursors, induced by high protein intake. In spite of these high levels of uric acid excretion, there was an actual fall in serum uric acid levels as the protein level of the diet increased.

E. The intestinal tract was able to tolerate the enormous doses of protein. The fecal losses of protein expressed on a percentage of intake basis remained relatively constant at all levels of protein intake. That percent of the protein lost in the feces above endogenous losses remained at about 10% of the ingested material.

The effects of increasing protein on mineral metabolism are described below.

F. Changes in integumentary losses. With increasing protein intake there is increased integumentary loss of nitrogen. The increases noted on the 600-gram protein diet were about 3 times that of control values. Since our prior work had shown a relationship between integumentary loss and protein intake on a low range, this was not surprising. It would appear that this correlation is related to blood urea nitrogen since a close correlation is found between integumentary losses and blood urea nitrogen level.

G. Effect on nitrogen balance. Since our studies are performed extremely carefully and all possible losses (including that from skin, hair, and residue on dishes and toilet paper) are estimated, we believe that our balance studies have as high validity as those undertaken by any other investigators. We found that at the 75- and 300-gram levels the subjects appeared to be essentially in balance. However at the 600-gram protein level there was a negative nitrogen balance of about 1 to 2 grams per day. This negative nitrogen balance is apparently quite real. In fact, it is probably of greater magnitude than observed. One of the reasons for this is that the retention of urea represents a significant apparent positive nitrogen balance. Therefore the presence of the negative nitrogen balance on high protein intakes we believe is significant and indicates an adverse effect of very high protein feeding.

H. The direct relationship between dietary protein and urinary calcium excretion was again noted. It was found that as protein in the diet from 75 to 300 to 600 grams increased there was a marked increase in urinary calcium. At 300 grams the increased urinary calcium was approximately 200% of the value at the 75-gram protein (control) intake and was over 400% greater than the control values at the 600-gram protein intake. This observation extends the observed relationship between ingested protein and urinary calcium from zero protein intake up to 600 grams per day. Over this entire range there is a direct effect of protein intake on urinary calcium excretion.

At the end of the 15-day study of 600-gram nitrogen intake utilizing formula, an attempt was made to match the protein intake utilizing "natural foods." A feeding schedule was instituted that consisted of four feedings per day: One consisted of a quarter of the day's allotment of formula; another consisted of approximately 500 grams of dry baker's cottage cheese; the third meal was 500 grams of cooked

shrimp; and the last meal was 500 grams of cooked white turkey meat. Carbohydrate and fat were kept similar to that in the formula diet, but with this feeding schedule the mineral intake no longer matched that of the prior dietary periods.

The subjects were able to tolerate this high protein intake in the form of natural foods. Most of the phenomena observed with the formula feeding were again observed. However, there was a further increase in uric acid excretion, probably because the diet contained purines. In spite of this, the serum uric acid did not rise. At the termination of this feeding, for a period of about 3 days after the 75-gram feeding was resumed, glycosuria was observed in some subjects without any elevation in blood sugar levels. This was interpreted to indicate an effect on renal tubular handling of glucose and probably represents an adverse effect upon renal function. Upon return to the control diet the subjects rapidly returned to nitrogen balance, blood urea nitrogen levels fell, and the subjects upon discharge were immediately able to resume a normal food intake.

During this entire study, as has been typical of all of our studies, two subjects remained on the control (75-gram protein) diet. These controls allow for internal checks on non-nutritional effects, the total environmental situation, and the overall methodology and expected variations. No adverse physiological or psychological effects were observed.

2. *Other Activities in the Consolidated Project*

Among the many other coordinated studies are the following:

A. Effects of high protein feeding upon energy metabolism. This work, under the direction of Dr. Robert B. Bradfield (Department of Nutritional Sciences), was reviewed briefly in the report of the prior year. These studies are being continued and observations are being extended to other dietary constituents besides protein.

B. Effects of various dietary constituents upon lipid metabolism. This work, primarily under the direction of Dr. Amy C. Odell (Department of Nutritional Sciences), was reported in part at the Federation Meetings, April 1968. As part of these studies Dr. Odell has demonstrated that there is no effect of protein ingestion upon cholesterol levels in the blood. In our series of experiments this lack of an effect was noted at all levels of protein intake, from zero through 600 grams. Furthermore, Dr. Odell reported a negative effect on cholesterol levels of alterations in exercise at constant dietary intakes.

C. Studies in environmental aspects of confinement. Currently, through the Social Sciences Group of the Space Sciences Laboratory, Dr. Richard W. Seaton (of the College of Environmental Design), is engaged in studies of the effect of confinement upon various attitudes and emotional responses of subjects and the best manner for minimizing these responses. In conjunction with various members of the Department of Architecture, he is studying alterations in space and other aspects of the physical environment upon the attitudes and comforts of experimental subjects.

Participating Personnel:

Doris Howes Calloway Sheldon Margen	Co-Principal Investigators
Robert B. Bradfield	— Assistant Clinical Professor of Human Nutrition
Amy C. Odell	— Assistant Research Nutritionist
Naomi F. Goldsmith	— Assistant Research Physiologist
Diane Curtis Patricia Huntzincker Carol Waslien J. Y. Chu	Research Assistants
Francoise Costa Melinda Buchanan	Assistant Specialists
Edison Meissner Dorothy Davis Eppie Sheng	Laboratory Technicians
Majorie York	— Junior Statistician
Cresencia Flores	— Laboratory Helper
Marjorie Teach	— Secretary

Publications:

Sirbu, E. R., S. Margen, and D. H. Calloway. Effect of reduced protein intake on nitrogen loss from the human integument. *Am. J. Clin. Nutr., 20*(11): 1158-1165 (1967).

Waslien, C. I., D. H. Calloway, and S. Margen. Uric acid production of men fed graded amounts of egg protein and yeast nucleic acid. *Am. J. Clin. Nutr.* (Sept. 1968, in press).

Theses:

Curtis, Diane Eaton. Energy balance study of obese women. M. S. Thesis, University of California, Berkeley (1967).

Huntzincker, Patricia Beard. Parameters of energy expenditure: Heart rate and ventilation volume. M. S. Thesis, University of California, Berkeley (1968).

Abstracts:

Calloway, D. H., and S. Margen. Human response to diets very high in protein. *Fed. Proc., 27:* 725 (1968).

Waslien, C. I., and D. H. Calloway. The effect of dietary nucleic acid and protein on blood and urine uric acid levels in normal men. *Fed. Proc., 27:* 486 (1968).

Margen, S., and D. H. Calloway. Effect of high protein intake on urinary calcium, magnesium, and phosphorus. *Fed. Proc., 27:* 726 (1968).

Bradfield, R. B., D. E. Curtis, and S. Margen. The effect of exercise on caloric response of obese women. *Fed. Proc., 27:* 559 (1968).

Odell, A. C., D. H. Calloway, and S. Margen. Serum cholesterol levels related to dietary protein and exercise, and effect of egg-simulated lipids. *Fed. Proc., 27:* 726 (1968).

Margen, S., N. F. Goldsmith, and G. P. Vose. The effects of dietary protein on urinary calcium and bone density. Eleventh Plenary Meeting, *COSPAR*, Tokyo (1968).