SCIENTIFIC EXPERIMENTS FOR A MANNED ORBITING LABORATORY

Submitted to:
National Aeronautics and Space Administration
Washington, D. C.

THE UNIVERSITY OF MICHIGAN

December 1963

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THE UNIVERSITY OF MICHIGAN
Ann Arbor, Michigan

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December 2, 1963

Dr. Peter C. Badgley
Chairman
MOL Science Studies
National Aeronautics and Space Administration
Washington 25, D. C.

Dear Dr. Badgley:

This document is being submitted in response to NASA queries as to the interest of The University of Michigan in participating in the scientific aspects of the Manned Orbiting Laboratory program.

We are pleased indeed to report a widespread interest among our research, teaching, and administrative staffs in an active participation in the MOL program. The breadth and depth of this interest is not at all surprising, in view of the large current participation of the University in space and space-related programs of NASA and other agencies. A view of this current participation is provided in the issue of our Research News, "Space Research at the University," included as Appendix A of this document.

A number of experiments proposed for the MOL program by various staff members and research units of the University are presented in Section IV. The experiments should be regarded only as representative, and not inclusive of the full scope of interest within the University. The short time available for preparation of this document has made it impossible for all interested individuals and units to contribute at this time as they would wish to. For the same reason, the level of detail of the various proposed experiments varies widely and estimates of experiment costs have not been included.

All of us would welcome an opportunity to develop a more detailed, comprehensive, and integrated program.

The discussions and deliberations which have accompanied the preparation of this document have made it clear to us that a manned earth-orbiting laboratory would be of inestimable value to a wide variety of scientific activities basic to civilian and defense matters of major national significance. We believe very strongly that the presence of men in the orbiting laboratory will be necessary to exploit properly its many exciting potentials. Section II of this document presents a resume of some of the many considerations which have brought us to this position.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

Dr. Peter C. Badgley

December 2, 1963

Section V of this document presents a brief description of the research capabilities of The University of Michigan. You are perhaps aware of the magnitude and scope of our research program. During the last fiscal year, our research activities sponsored by government, industry, foundations, and the State of Michigan were funded at approximately $36,000,000. The program ranges broadly over nearly all disciplines, and covers the spectrum from the small, highly individualistic project of a single faculty man with one or two graduate students to large and complex interdisciplinary projects involving large numbers of staff members, extensive field operations, and major subcontracting. We would like very much to bring this capability to bear upon the highly promising and exciting Manned Orbiting Laboratory program.

Please keep us informed of your progress, and call upon us for whatever assistance the University can provide.

Very truly yours,

Ralph A. Sawyer

Ralph A. Sawyer
Vice-President for Research

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*Separate enclosures

I

INTRODUCTION

The concept of a Manned Orbiting Laboratory, presently under consideration by the National Aeronautics and Space Administration, opens up the possibility of conducting a large number of novel and effective scientific experiments to provide a greatly increased understanding of many physical and biological phenomena and to realize practical applications of this knowledge. Members of the teaching and research faculty of The University of Michigan have considered the implications of this new medium for scientific investigation and have suggested a number of specific experimental programs which they believe would add significantly to the fund of knowledge in their own scientific disciplines. Descriptions of these experiments are collected in this document as a means of providing a broad view of the many possibilities of space experimentation and as an indication of the substantial interest of the University's faculty in participating in this new direction of research.

In examining the operational requirements for successfully performing sophisticated types of space experiments, the staff members who have proposed the experiments described in this report considered the requirements for stationing men aboard the space vehicle to conduct the experiments. Their conclusions concerning the increased capabilities of manned experiments have been summarized in Section II.

The experiments which have been suggested cover a very broad range of topics, but do not represent the complete interest of the University's staff. Because of the limited time available for review and analysis, many of the staff could not study the research possibilities in sufficient depth and therefore chose to consider the matter further, with the intention of proposing experimental programs at a later date. A summary view of the experiments which have been suggested in time for inclusion in this report is presented in Section III, which describes the essential nature of each experiment in the form of an abstract. A detailed description of each of the experiments is given in Section IV. A number of these experiments, for example, those on radio astronomy, and studies of the characteristics of the ionosphere, are direct outgrowths of current University space research programs of considerable magnitude and duration, and therefore represent directions for new experimentation in which the University has unusual interest and capabilities. Other proposed experiments, such as the observation of environmental constraints on fish behavior,represent decidedly new approaches to the acquisition of knowledge and can therefore be presented at this time only in general terms, since they will require some preliminary experimental results to define their areas of usefulness.

The discussion of item 2 , dealing with the subject of comparative multispectral sensing, is somewhat broader in scope than the other experiments, since it deals with a range of sensing instrumentation which would be useful for many types of individual investigations, particularly those which rely on the observation of the earth and its atmosphere by means of photographic, infrared, radar, and passive microwave imaging devices. Thus, the presentation in multispectral remote sensing proposes system and conceptual aspects as well as scientific experiments involving the joint participation of a large number of departments of the University. A research program of substantial magnitude which has been conducted at the University for some years has been devoted to research in remote sensing of the environment. On the basis of this experience, we are convinced that a single system of comparative multispectral sensing instrumentation can be developed which will serve many of the important experiments for the various earth science disciplines. An operational system for use in such investigations can be achieved after a minimum of preliminary experimentation. In order to provide such equipment and to coordinate the collection and analysis of results for a variety of experimenters, a Comparative Multispectral Sensing Center is proposed in item 2.1.

The projects described in item 7 are not experiments in themselves but are intended to lead to the establishment of special facilities, in the areas of data processing and library-like functions, which would furnish valuable assistance to the experimental staff in the MOL.

A further indication of interest on the part of the University staff in the Manned Orbiting Laboratory program is provided in Section VI, which contains the biographical summaries of many of the teaching and research staff who have evidenced an interest in the program. As in the case of the experiments, this list is by no means an exhaustive one.

General information on the broad range of research activities of The University of Michigan is presented in Section V. Appendix A supplements this general information with a discussion of the past and present participation of the University in the various aspects of space research.

II

THE NEED FOR HUMAN BEINGS ON BOARD GENERAL PURPOSE ORBITING EXPERIMENTAL STATIONS

Introduction

Serious contemplation of the construction and operation of a Manned Orbiting Laboratory entails, at the outset, judgments regarding two fundamental questions: do the benefits likely to be derived from the rapid and thorough exploitation of the space about the earth warrant the required commitment of a significant fraction of the nation's resources, human and other, and does achievement of those benefits require the presence of human beings on board the orbiting laboratory?

Concerning the first question, the staff of The University of Michigan believes generally the anticipated benefits to be worth the costs. With regard to the second question, it is the consensus of the University staff that the presence of human beings on board the orbiting laboratory is for some purposes a sine qua non and for many others highly desirable. It is believed that not all experiments can be performed automatically or by remote control, that many experiments can be performed more satisfactorily and more expeditiously by human beings than they can be done automatically or by remote control, and finally, that for equivalent results the cost of experimentation in orbit would be much greater when done automatically or by remote control than when done by humans in an orbiting laboratory. The arguments leading to these conclusions are sufficiently diverse and general that it has been deemed useful to assemble them in one place rather than discussing them in the context of specific experiments.

The factors relevant to the need for humans in the orbiting laboratory appear to fall into groups concerned with the five general subjects: (1) man as a subject of experiments, (2) the nature of experimental activity, (3) the present state of the art of automatic and remote operations as compared to direct human participation, (4) equipment reliability in an incompletely specified environment, and (5) comparative costs of human and automatic experimental systems.

Man as a Subject of Experimentation

Assuming it has been decided that man must go into space for reasons other than experimentation (e.g., for military purposes) his responses to that environment must be learned. This cannot be accomplished without studying his physiological and psychological behavior over extended periods in that environment. Little more needs to be said on this subject. The remainder of the discussion will be concerned with activities not requiring man as a subject of the experimentation.

The Nature of Experimental Activities

There have been many splendid achievements in space to date, using automatic and/or remote control, TIROS, the communication satellites, a number of measurement programs of solar and cosmic emanations and influences, to mention a few. In general these have been engineering triumphs, in which man has capitalized on what he could predict with confidence and a capability for putting objects into orbit with reasonable precision. There are, of course, a number of other essentially engineering programs which could be handled similarly to advantage. It is in learning more about the less well understood or discovering the presently unknown phenomena that it becomes most desirable to use man, with his peculiar capabilities for using judgment, exercising imagination, and making decisions, in space.

The course of increase in fundamental knowledge is never predictable by definition. Experiment nominally progresses from a few predictable steps to a branch point requiring a decision, based on the results of the operations up to that point, to proceed along one of two or more possible paths. Whichever subsequent sequence is selected will involve additional branch points, not all of which can be anticipated. Hence an experiment of any complexity will involve unanticipated occurrences requiring changes in the parameters of the equipment or operation, improvisation on the part of the investigator, and, on occasion, changes in the basic nature of the experiment because partial completion reveals some unforeseen goal of far greater importance than the original objective. Thus experimentation is a typically human activity resembling other human activities, such as politics, in that it requires great flexibility in accommodating the activities of each step to continuously changing circumstances.

Capabilities of Automatic and Remote Controlled Operations as Contrasted With Direct Human Participation

Automation is currently much discussed and not too well understood. It is popularly supposed, because of the extent of technological unemployment and the resultant publicity, that automation is a highly developed art. The truth of the matter is that people displaced by automatic machinery were engaged in repetitive tasks that exercised only a minuscule portion of their capabilities. In fact, the tasks which can now be performed by devices are restricted to fairly routine operations. The most sophisticated automatic machinery, the modern digital computer, can make some simple types of decisions <u>but only when all the steps in all the sequences of operations following the decision are completely specified in advance</u>. The fact that such machinery can perform a great many tasks with great rapidity tends to obscure the simple nature of the tasks. A theory of adaptive, self-learning and self-repairing mechanisms is beginning to be formulated, but has not yet produced any results indicating significantly greater capability than the large computers. Therefore it is safe to say that automation has not advanced to the point where it can play a dominant role in experimental activities.

Direct participation of humans in experimental activities permits significantly greater experimental complexity because the man can make value judgments, employ pattern recognition, change the goals of the experiment and improvise based on a lifetime of accumulated experience and training. These capabilities, as yet unattainable in devices, permit the human to refine an experiment at each step based on results of prior steps, select and change subject material (e.g., aim pictorial sensing devices), edit data for transmission over band-limited data links, and in fact perform any feasible act requiring judgment.

In the foregoing it is not apparent that the human could not function as well remotely connected to the experiment by a data link capable of transmitting pictorial and numerical data. He cannot. A human being senses and interprets his immediate environment in a complex fashion, not too well understood, integrating inputs from his senses of sight, hearing, smell, taste, tactile sense, kinesthetic sense and possibly others with his memory. The use of device sensors and a data link to put a human in contact with his experiment fails to provide for a large portion of the inputs he would employ were he located at the site of the experiment. Humans are not normally aware of the diversity of sensory sources they customarily employ until deprived of them. As one example: the military services have on occasion attempted to improve the visual performance of troops by developing glasses or binoculars of various special types which give magnification, increased light gathering power, or some other desirable feature. In all cases to date these devices, although useful in restricted special situations, have been found to degrade over-all visual performance when general use was attempted. The reason appears to be that the eye-brain combination is an extremely flexible combination of a number of different capabilities. The use of binoculars forces a reduction in total usable viewing angle cutting off peripheral vision. Peripheral vision, although not having great geometrical resolution does provide high light sensitivity and even higher sensitivity to moving targets. Thus, for general application, no matter what improvement in foveal vision is achieved by devices, net performance is degraded by abandoning use of foveal and peripheral vision integrated by the brain. A human operating at the end of a data link is crippled by loss of the peripheral aspects of most of his senses. This is borne out by the fact that, in astronomy, more details of Mars' surface can be discerned by direct observation of a telescopic image than by observation of photographs of that image. The image motion compensation of the eye-brain combination appears to be better than any machine built to date.

Equipment Reliability in a Not Completely Known Environment

Until recently equipment reliability was not studied as a recognized discipline. Neither failure processes themselves nor the environmental factors causing them received much attention. That is now beginning to change but the attainment of reliability is still more of an art than a science. Prior to World War II machines and structures were relatively not very complex and in most cases satisfactory reliability could be assured by overdesign.

In building equipment to be placed in orbit, weight and power restrictions limit opportunity to ensure reliability by overdesign. At the same time cost of equipment failure is increased manyfold. Attempts to improve reliability result in building expensive installations simulating the space environment to test equipment to be orbited. Despite size and cost these installations give only partial information. There are two prominent reasons for this: first, the precise nature of the space environment is unknown and second, earth-bound test facilities cannot simulate faithfully all the known aspects of the space environment. Zero gravity cannot be simulated for any length of time. Vacuum conditions can be simulated well but not all the way down to space pressures. Simulation of thermal radiation exchange can be accomplished less satisfactorily and that of the high energy particle environment not at all. As a result many of the equipments lofted into space fail partially or completely, some for reasons which are later understood and others for reasons not as yet determined. What is known about failures in orbit indicates that, for the most part, they represent easily repairable component breakdowns rather than catastrophic failures. That is, they would be corrected easily if a human being were there to observe the nature of the failure and take corrective action or to initiate an alternative mode of operation to compensate for an uncorrectable failure of some component. The occasions on which Mercury astronauts took just that type of action are illustrative. When experimental apparatus more complex than that carried on the Mercury flights is lofted into orbit, there seems little doubt that the attendance of humans will be required to correct or compensate for minor breakdowns, and to describe more adequately the nature of failures and the environmental factors causing them so that future generations of apparatus more appropriate to the environment can be designed.

Comparative Costs of Human and Automatic Experimental Systems

In view of the factors discussed thus far, there can be little doubt that the total cost of obtaining extensive results from orbital experimentation will in the long run be far less with manned systems than with unmanned systems. A high initial cost is involved to provide a viable environment for man in the orbiting laboratory. After that, however, man's flexibility will, over a number of experiments, save much more than the cost of placing him in the laboratory. He can repair minor breakdowns and avoid the necessity of lofting a replacement apparatus. He can deactivate equipment at the first sign of malfunction and minimize the extent of the damage, increasing the likelihood of successful repair, i.e., he can act as a very sophisticated protective fuse. When experimental equipment is designed for human operation it can, after its original function has been served, be adapted to other experimental uses. Some equipment can, in fact, be designed to function as a component common to a number of experiments. If the estimate of $1,500 per pound to place objects in orbit is approximately correct, the re-use of apparatus and the employment of multipurpose apparatus could, as time goes on and orbital experimentation increases, more than compensate for placing humans in orbit.

Conclusion

To support the preceding conclusion, consider a number of surface activities similar to orbital experimentation. Experimental work is presently being carried on in the Antarctic, in atomic energy "hot" laboratories and at great depths under the sea. In all these circumstances it is expensive to provide for the presence of humans. The costs for these purposes are not radically different from the costs of maintaining man in orbit. Nevertheless men are supported in those places because no more satisfactory way has been found to obtain equivalent information for the same cost. Therefore it is believed that the desired extensive orbital experimentation cannot all be accomplished without man in space and even though the goals of the experimentation were reduced to those achievable without man in space, even those restricted goals can be reached faster and with less cost with man's presence in the orbiting laboratory.

III

ABSTRACTS OF EXPERIMENTS

In this section, an abstract is given for each of the proposed experiments or related projects. A more complete description of each experiment is contained in Section IV.

The individual experiments are grouped into the following categories:

1. Astronomy
2. Comparative Multispectral Sensing
3. Meteorology - Aeronomy
4. Geology and Mineralogy
5. Physics
6. Biosciences
7. Special Facilities

1. ASTRONOMY

1.1. Astronomical Observations

1.1.1. Reflecting Telescope

A one to two-and-one-half meter reflecting telescope is proposed in a multi-purpose configuration. This telescope is to be used for direct photography of planets, stars, clusters, and galaxies of high-resolution periods. Photographic and photoelectric planetary, stellar and nebular spectroscopy can be conducted, both in and beyond the focal plane of the telescope.

1.1.2. Refractive Telescope

A refracting instrument is proposed directed primarily to the study of transit events in the solar corona associated with solar flares, coronal condensations and long enduring particle streams in space.

1.2. Experiments in Radio Astronomy

An exploratory program in radio astronomy is to be conducted using an extremely flexible, simple radiometer, manually tunable by the observer from 50 Kc/s to 10 Mc/s and capable of operation in several modes so that various experiments may be performed. The experiments include the following:

Spectrum of excess radio noise from 200 to 600 km. above earth.

Radiation from earth's surface and lower atmosphere.

Radiation originating in ionosphere and exosphere.

Investigation of plasma in vicinity of satellites.

Radiation from extraterrestrial sources.

2. COMPARATIVE MULTISPECTRAL SENSING

2.1. Comparative Multispectral Sensing Center

Electromagnetic sensing techniques now available are capable of producing imagery over a very wide spectral range, including ultraviolet, visible, infrared and microwave wavelengths. Important applications of these techniques exist for scientific studies in such fields as geology, geography, meteorology, oceanography, and atmospheric physics and for the collection of data useful for such economic activities as agriculture, fishing, and shipping.

The operation of presently available types of electromagnetic sensing systems from orbiting platforms will provide a many-fold increase in the ability to sense the meaningful characteristics of the earth and its environment. This can best be accomplished by designing an integrated comparative multispectral sensing system and conducting a preliminary earth-based experimental program to determine the proper methods of operating the system and interpreting the results. It is proposed that a Center be established to coordinate the efforts devoted to designing equipment, obtaining data, and interpreting results.

2.2. Illustrative Multispectral Sensing System

The multispectral sensing system described in this item is illustrative of equipment which could be designed for use in a MOL based on present knowledge and experience. The system would contain equipment for obtaining photographic, thermal (infrared), and radar imagery. A passive microwave imaging system is also a possible component of the system, although this type of system has so far been operated only on a trial scale. Technical requirements of photographic and thermal imaging equipment are discussed in detail.

2.3. Radar

Radar equipment for use in a MOL is described in the Classified Supplement to this document.

2.4. Measurement of Atmospheric Transmission

This experiment will measure the transmission characteristics of the earth's atmosphere. Signal attenuation by the atmosphere arises primarily from absorption and scattering. In the infrared spectrum, the primary cause of attenuation is absorption by water vapor and CO_2. In the experiment, a spectrometer aboard the MOL is aimed either at the sun or at a strong, calibrated source of infrared radiation located at a point 60,000 ft. above the earth's surface.

3. METEOROLOGY AND AERONOMY

3.1. Observation of Cloud Systems and Air Pollution Processes

3.1.1. Thermal Effects on Cloud Processes

A coordinated program in which observations are made simultaneously of cloud systems, from the earth looking outward and from a satellite location looking earthward, is expected to appreciably aid the process of evaluating cloud processes as a result of the seasonal thermal effects in the regions of large bodies of water such as the Great Lakes. The end result will contribute to basic knowledge of the rain-producing processes and will bear upon the question of weather control.

3.1.2. Effects of Air Pollution

Measurements of the radiation characteristics of a cloud-free atmosphere will be useful in evaluating the effects of air pollution; for example, to determine how the urban plumes of air pollution from Milwaukee and Chicago are affected as they traverse lower Michigan.

3.2. Study of Earth's Heat Balance

The primary objective of the proposed experiment is to obtain data, not available by other means, which will make possible accurate computations of the earth's heat balance. The spectral radiance of typical meteorological targets will be measured as a function of viewing angle and angle of incidence. Measurements will be made by means of an interference spectrometer with two spectral bands, 0.3-3.0μ, and 3.0-30.0μ. The resulting data are to be used to establish a functional relationship between radiation measurements as taken by the TIROS or NIMBUS satellites and total hemispherical radiation.

3.3 Auroral Photography

Auroral displays are to be recorded by means of high resolution color photography. These are to be supplemented by time and geographic identification and a verbal description of the phenomena. Photography of auroras from above offers the possibility of obtaining pictures of some displays in their entirety and should thus permit synthesis of an over-all view.

3.4 Plasma and Sheath Studies

A series of experiments is proposed to investigate the characteristics of the sheath (especially the wake) which surrounds a body moving in a plasma such as the ionosphere. These experiments will contribute to an increased knowledge of plasma physics in general and will have value for many technical applications. Three types of experiments are of interest:

3.4.1. Sheath Probing

The sheath surrounding a variety of geometrically simple bodies and around the MOL vehicle itself can be mapped point by point using movable probes to measure local electron and ion density and energy distribution. An exhaustive theoretical study should be carried out in conjunction with this experiment.

3.4.2. Electromagnetic Wave Propagation in the Plasma

Further information on plasma properties and the importance of collisions may be obtained through wave propagation experiments in the ionosphere. Such experiments should study the propagation of artificial noise through the plasma and examine the received signal spectrum at multiple points remote from the MOL.

3.4.3 Electron and Ion Beam Interactions

This experiment consists of introducing modulated electron and ion beams into the plasma. The modulation frequencies are to be varied from below to above the plasma characteristic frequencies. Information can be obtained in this manner on the magnitude of energy exchange between charges and fields.

3.5. Mass Spectrometer Experiments

A quadrapole mass spectrometer (massenfilter) would be used to measure neutral particle and positive ion composition of the ionosphere.

These experiments would result in a more realistic model of the atmosphere, clarify the effects of ambient thermodynamic and ionic non-equilibrium, and determine the nature and effects of the plasma sheath surrounding the MOL. The increased knowledge of the mass spectrometer characteristics would contribute to its usefulness in subsequent planetary studies.

4. GEOLOGY AND MINERALOGY

4.1. Collection of Micrometeoritic Material

A suitable apparatus is to be attached to the exterior of the MOL to collect micrometeorites and space dust for detailed mineralogical and chemical studies. It would also be desirable to obtain comparisons between impact densities and collection densities. Types of material expected include both magnetic and non-magnetic particles, probably ranging from appreciably smaller than one micron up to perhaps 0.5 mm.

4.2 X-Ray Analysis of Members of the Solar System

This proposal is concerned with determining chemical compositions of objects in the solar system. The basic principle involved is that radiation from the sun will cause the secondary emission of characteristic x-rays from objects so irradiated. By analyzing the wavelength and intensity of these secondary x-rays, information relating to the chemical composition of the object can be obtained.

4.3 Tectonic Interpretations

It is suggested that high-level high-resolution photographs in both visible and infrared spectra be obtained of continental areas so that tectonic interpretations can be made.

5. PHYSICS

5.1. Experiments in Liquid Transport Phenomena

5.1.1. Performance of Boiling Systems

The performance of thermal equipment in zero-gravity environments will be significantly influenced by the configuration and disposition of vapor relative to the heating surface in such systems. A zero-gravity boiling heat transfer experiment is proposed in which quantitative measurements can be made of heat flux, surface temperatures and liquid-vapor configuration.

5.1.2. Liquid-Vapor Configurations and Convection Patterns

The objective of this experiment is to obtain information concerning the positioning of liquid and vapor in closed containers at low gravity and subjected to unsteady solar heat flux. A knowledge of this and the heat and mass transport phenomena across the liquid-gas interface will permit the reliable design of vent systems giving optimum (i.e., minimum) propellant loss.

6. BIOSCIENCES

6.1. Physiological Effects of Weightlessness

6.1.1. Changes in Vestibular Nerve Activity at Prolonged Zero g

The proposed experiment is to determine if zero g effect upon the otolithic apparatus of the inner ear is the cause of g-sickness. Correlation of vestibular nerve activity with behavior is to provide basic information. The experiment is to be carried out by implanting electrodes in the ganglionic portion of the vestibular nerve in a cat, squirrel monkey, or macaque monkey.

6.1.2 Vestibulometry at Fractional g Loads

This experiment is to study the interdependency between two portions of the inner ear sensor mechanism, the semi-circular canal system and the otolithic system. The experiment is to be carried out by cold air actuated nystagmus (involuntary oscillation of the eyeballs) recorded by electronystagmography at incremental g loads.

6.1.3. Effects of Prolonged Zero g on Bone Architecture and Calcium Metabolism

The effect of prolonged zero g on bone and calcium metabolism is to be studied. It is suggested that loss of calcium will weaken the bone structure. The experimental subjects are to be humans and macaque monkeys. Periodic chemical analyses are to be made.

6.1.4 The Effect of Zero g on Musculoskeletal System Growth

This would be a morphologic study using newborn Kangaroo rats.

6.1.5 Determination of Cause of Post-Zero g Hypotension

Maintenance of peripheral vascular tonus by rotating pressure cuffs on proximal portions of limbs, with alternation of subjects between 0 and 1 g modules. Pituitary hormonal studies should be included.

6.1.6. Electromylographic Studies of Weight-Bearing Muscle During Prolonged Zero g

6.1.7. Muscle Metabolism Studies During Prolonged Zero g

These studies will include electrical studies and creatine determinations.

6.2 Manual Performance Prediction Methods for Space Laboratory

In order to schedule activity properly and to design future space stations in the most effective manner, it is important to be able to predict the time and learning curves for those manual operations which will have to be performed in space. Tests to measure basic motor ability, basic decision ability, and intelligence will be conducted in both simulated and actual space environments.

6.3 Environmental Constraints on Fish Behavior Patterns

If reflection and radiation characteristics of large bodies of water can be measured successfully with satellite instruments, significant contributions can be made to the understanding of fish behavior patterns and the existence of environmental constraints which affect some of these patterns.

7. SPECIAL MOL FACILITIES

7.1. Development of Optical Data-Processing Equipment

Data-processing methods based on the use of optical diffraction techniques are especially adaptable to certain types of computing processes, such as filtering, correlation, and Fourier analysis. It is proposed to develop and construct a compact optical computing system to be carried aboard the MOL for rapid and efficient reduction and analysis of experimental data.

7.2. Automatic Library for the Manned Orbiting Laboratory

This project is intended to develop equipment and methods for providing scientists on the MOL with an information storage and retrieval facility. The equipment will feature automatic methods of information storage and retrieval, with the ability to accept additional information as needed. This flexible library will be designed to fit the special requirements of the scientists and the experiments currently being conducted.

IV

DESCRIPTION OF EXPERIMENTS

1 ASTRONOMY

1.1 ASTRONOMICAL OBSERVATIONS

Submitted by: Orren C. Mohler, Professor of Astronomy and Chairman, Department of Astronomy, College of Literature, Science and the Arts; and Director of University Observatories.

Two telescopes are proposed:

1. A one to two-and-one-half meter aperture multi-purpose configuration. It is suggested that this telescope be designed so that it can be used for direct photography and for photography of slit-less spectra. It may be pointed out that a slit spectrograph will be of little value outside the earth's atmosphere since there will be no seeing disturbances and telescopic images of stars should have diameters determined by diffraction.
2. A refracting telescope somewhat similar in design to existing coronographs. The aperture of this instrument should be approximately three-quarters of a meter. It should be carefully constructed for absolute symmetry about the optical axis so that instrumental polarization is a minimum. An equally carefully constructed and designed spectroscope should be included with this instrument.

Telescope mounting:

It is desirable that both instruments be mounted independently. The one to two-and-one-half meter aperture reflecting telescope would be used primarily for stellar observations. The refracting telescope would be used for solar observations. Both telescopes should be mounted with motions in altitude and azimuth with respect to the principal moments of inertia of the manned orbital laboratory. The refractor must be provided with a rotational motion about the optical axis of the objective so that polarization effects can be easily and accurately evaluated.

Telescope guiding:

It is assumed that suitable photoelectric devices will provide a lock-on type of guiding with rapid setting motions that can be manually controlled. The accuracy of guiding should be significantly better than one second of arc with visual supervision. The resolving power of these telescopes should be one-tenth of a second of arc or better, and focal lengths should be chosen that will make possible photographic recording of such fine structure.

Scientific objectives:

1. The one to two-and-one-half meter reflecting telescope.

   A. Direct photography of planets, stars, clusters and galaxies of high resolution. Faint (ultraviolet visual and infrared) magnitudes. The small image size and the dark sky that can be attained in a manned orbiting laboratory should make this equipment more effective for direct photography than any planned terrestrial telescope. Astrometric work of all kinds should be far more accurate than from any terrestrial site.

   B. Photographic and photoelectric planetary, stellar and nebular spectroscopy both in and beyond the focal plane of the telescope. With accurate guiding, there will be no need of a slit except for extended objects. Initial spectroscopic survey should cover moderately large areas of the sky, perhaps five degrees in diameter.

Astronomers still remain almost totally ignorant of the ultraviolet spectrum of any object other than the sun. One attractive prospect is the possibility of studying atomic and molecular hydrogen in the interstellar medium.

2. The refracting telescope.

   This instrument would be directed primarily to the study of transit events in the solar corona associated with solar flares, coronal condensations and long enduring particle streams in space. The coronal structures and the extent of these features should be observed in detail. Their intensities should be measured as functions of the wavelength and radial distance from the sun. Spectra of solar prominences will merit detailed study at wavelengths short of 3000 A.

Supporting Investigations:

Dispersing media, such as spectroscopes, interferometers and polarizing interference filters will need considerable development for use in the analysis of monochromatic spectrum lines originating in astronomical objects, for example, the solar corona.

It is probable that an expensive investigation will be required into the proper methods of figuring large telescope mirrors and preserving this figure under the conditions obtaining in an orbiting laboratory. If the laboratory is alternately illuminated by the sun and then shaded from it by the earth, or if the conditions of illumination change as the telescope is pointed to different celestial objects, it may be difficult to attain optical stability of the order of a tenth of a second of arc.

Supporting Efforts:

Earth based observations in support of solar ultraviolet photography will require direct telephone links with the McMath-Hulbert Observatory so that observations of transient solar phenomena can be rapidly coordinated. It is anticipated that photographic records of all observations made in the manned orbiting laboratory can be returned to earth for detailed study and reduction.

1.2 EXPERIMENTS IN RADIO ASTRONOMY

Submitted by: Frederick T. Haddock, Prof. of Astronomy, Dept. of Astronomy, College of Literature, Science and the Arts; Prof. of Electrical Engineering, Dept. of Electrical Engineering, College of Engineering; and Director, Radio Astronomy Observatory.

I. Introduction

The University of Michigan Radio Astronomy Observatory (UM/RAO) proposes an exploratory program in radio astronomy as a part of the Manned Orbiting Laboratory. The experiment instrumentation package proposed is an extremely flexible, simple radiometer, manually tunable by the observer and capable of operation in several modes so that various experiments may be performed based upon the conditions and environment encountered.

II. Scientific Considerations

A. Background Discussion

The UM/RAO successfully launched a cosmic background experiment in September, 1962. The results of this experiment are summarized in the attached COSPAR paper.[1] A second experiment in this series with additional refinements to the instrumentation is now in preparation. Launch is expected by the third quarter of 1964.

The RAO is also an experimenter on both the Eccentric Orbiting Geophysical Observatory and the Polar Orbiting Geophysical Observatory, scheduled for launch in 1964. In addition, considerable work has been underway for the last two years for advanced instrumentation for future planetary probes, probably in the Mariner series.

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[1] Cosmic Radio Intensities at 1.225 and 2.0 Megacycles/sec. Measured up to an Altitude of 1700 Kilometers, D. Walsh, F. T. Haddock, and H. F. Schulte, presented at the COSPAR 6th Plenary Meeting and 4th International Space Symposium, Warsaw, Poland, June, 1963.

B. Tentative List of Experiments for MOL

Spectrum of excess radio noise from 200 to 600 km. above earth.

Radiation from extra terrestial sources.

Radiation from earth's surface and lower atmosphere.

Radiation originating in ionosphere and exosphere.

Investigation of plasma in vicinity of satellite.

III. Advantages of MOL as Contrasted to an Unmanned System for this Scientific Activity

It is desirable to perform this experiment in a manned satellite, for several reasons. Firstly, an observer can monitor the received signal, and thus obtain a first-hand observation of the characteristics of it — white noise, impulsive or partially so, static, corona discharge, small scale spectral variation, breakthrough from the earth, whistler mode propagation from below the ionosphere, etc. Secondly, an observer can select the mode or program of operation of the receiver, based on observation of what, where and when the most interesting signals are received. Thirdly, the observer can make minor adjustments and even replace a faulty part if necessary; this cannot be done on an unmanned satellite without extremely complex equipment. In other words, the equipment can really be made simple and consequently more reliable. For example, an extremely wide dynamic range may not have to be built into the receiver, since the observer may adjust the gain for optimum on the spot. And fourthly, there will be no necessity for complex, power-consuming telemetry, for at least two reasons;

the observer can act as a filter, to record only pertinent and non-redundant data, and this recording can be in the form of, say, taped samples of the signals, observer comments, and frequency, time and intensity of the signal taken directly from the receiver output.

IV. Engineering Considerations

A. Characteristics of the Proposed Equipment

a. Variable bandwidth (10 Kc/s to 2 Mc/s) electrically controllable

b. Self calibrating

c. Manually tunable (50 Kc/s to 10 Mc/s)

d. Envelope and product detection system

e. Conventional, delayed and pulse type AGC

f. Capable of handling electric and magnetic antenna inputs

g. Antenna systems

long wire dipole (preferably up to a mile long)

20-foot 1-turn loop

h. Antenna impedance measuring capability

i. Estimated weight — 10 lbs.

j. Estimated power consumption — 5 watts

k. Estimated volume — 1 ft^3

2 COMPARATIVE MULTISPECTRAL SENSING

2.1 COMPARATIVE MULTISPECTRAL SENSING CENTER

Submitted by: Marvin R. Holter, Research Engineer and Head, Sensory Systems Group, Infrared Laboratory, Institute of Science and Technology.

Introduction

Many of The University of Michigan staff believe that present electromagnetic sensing technology and the ability to operate from orbiting platforms will permit the development of systems providing a many-fold increase in ability to sense the meaningful characteristics of the earth and its environment. This can be accomplished by designing an integrated comparative multispectral sensing system and conducting experiments to determine the proper methods of operating it and interpreting the results. It is proposed that a Center be established to do this. Although the Center would be concerned with both pictorial and non-pictorial sensor outputs, it is presently felt that, for many important applications, pictorial data will be most useful.

To understand the need for such sensing and the reasons for believing that significant improvements can be made, consider briefly the history and some of the deficiencies of aerial photography. Starting with World War I aerial photography was applied to a steadily increasing variety of tasks. At the close of World War II, with the release of many trained and experienced interpreters as well as a great quantity of applicable equipment, the employment of aerial photography suddenly accelerated in quantity and scope. In addition to its military uses, it has been found virtually indispensable in political, economic and scientific applications. Just a partial list of the disciplines in which it is a valuable tool may be inferred by scanning the chapter headings of the "Manual of Photographic Interpretation".[1] Extensive application is indicated in geology, soils mapping, wild life, range and watershed management, agriculture, urban analysis and planning, archaeology, geography and so forth. Also plans are currently being made to extend the techniques to the observation of other planets on fly-by missions.

In spite of this extensive and increasing utilization of aerial photography, many of its techniques remain relatively modest extensions of the capabilities of the human eye. Although numerous methods of analysis and inference have been developed and the use of fast high speed aircraft has become common, the range of practical usefulness for aerial photography remains more restricted than is desirable. The principal restrictions are (1) inability to sense some very important parameters such as temperature, (2) relative slowness of interpretation as compared to the rate at which information is desired and can be photographed, (3) costs of acquiring imagery over large areas, and (4) altitudes attainable in aircraft and balloons. It is asserted that the development of integrated systems making use of modern techniques will remove or alleviate these restrictions.

Advantages of Multispectral Sensing Techniques

Techniques now available are capable of producing imagery over a very wide spectral range including ultraviolet, visible, long and short infrared and microwave wavelengths. Imagery made in spectral bands heretofore little used and comparison of simultaneous imagery made in a variety of spectral bands promises to increase the utility and applicability of pictorial sensing by

[1] Published in 1960 by the American Society of Photogrammetry.

two means. First, new types of information, not obtainable with conventional photography, can be provided. For instance the use of infrared can furnish indications of the operation of artificial power sources and produce thermal maps. Furthermore comparison of imagery in the ultraviolet, visible, infrared and microwave bands may make it possible to discriminate among objects which exhibit no discernible differences in the photographic region. Second, the employment of a wide variety of spectral regions may permit much increased use of pictorial tone differences and lessen the need for strong reliance on the use of the fine details of shape information, which is one of the principal reasons for the slowness of the normal interpretive process.

For a number of years the University has been engaged in experimental and theoretical sensing studies in the ultraviolet, visible, infrared and microwave regions. It has been demonstrated that useful new information can be obtained in spectral bands other than the visible. It has also been demonstrated that simultaneous examination of imagery in more than one spectral band can produce information not deducible from a single band. Thermal maps of Yellowstone National Park and Kilauea volcano in Hawaii have been made in the infrared. These indicate that, providing global coverage can be acquired, direct information concerning the available geothermal resources of the world can be obtained. Other infrared imagery produced by the University has shown it to be useful for the protection and conservation of forested areas, indicating the composition, growth, and decay of sea ice, indicating mixing and current patterns in streams, rivers and oceans, indicating cloud temperatures and so forth. Recently produced ultraviolet imagery has exhibited differing tones between healthy and diseased fruit trees. Microwave imagery is becoming recognized as a valuable source of information in the field of structural geology and it is immediately clear upon inspection of preliminary data that much information of importance in this field can be obtained only from satellite altitudes where large areal coverage preserves the continuity of surface manifestations of geographically large structures. An account of the conclusions and recommendations of some of the recent work of this nature carried on at The University of Michigan is contained in the attached report "Remote Sensing of Environment".[2] Additional discussions and examples of multiband sensing are given in References 3, 4, and 5. The physical reasons that tonal differences may be expected to occur in the infrared are discussed in Reference 6.

Advantages of Orbital Operation

There are many reasons, economic, political, military and scientific, which make imagery of the entire earth or major parts of it desirable. Such

[2] Report 4864-6-F, published 1963 by The University of Michigan, IST, and supported by ONR, AFCRL, ARO and NAS.

[3] Report 4864-3-X, "Proceedings of the Second Symposium on Remote Sensing of Environment, 15, 16, 17 October 1963", published February 1963 by The University of Michigan, IST, and supported by ONR, AFCRL, ARO and NAS. (30 copies were sent to NASA in October 1963 as part of a proposed Gemini experiment.)

[4] "Some Practical Applications of Multiband Spectral Reconnaissance", by R. N. Colwell, American Scientist, Vol. 49, No. 1, March 1961.

[5] "Basic Matter and Energy Relationships Involved in Remote Reconnaissance", by R. N. Colwell, et al, Photogrammetric Engineering, Vol. XXIX, No. 5, September 1963.

[6] "The Energy Environment in Which We Live", by D. M. Gates, American Scientist, Vol. 51, No. 3, September 1963.

wide coverage cannot be obtained from aircraft or balloons but could be obtained from an orbiting satellite. In some large areas balloon and aircraft access is not permitted by the local governments, but satellites are not subject to these prohibitions. For some purposes nearly simultaneous (synoptic) imagery of the entire earth is desirable. This is not possible with airborne craft. Global coverage can be generated in times as short as 26 hours by satellites. Such synoptic coverage would be extremely useful for mapping crop distributions, ocean temperatures, weather and other things in times short compared to the intervals during which large changes can occur in those phenomena.

Placing a sensing system at satellite altitudes does prevent obtaining the finest ground resolutions, but many of the reasons for mapping very large portions of the earth do not require very fine ground resolution. In fact for the recognition of major geologic features and mapping ocean temperatures, the desired information tends to be obscured by a wealth of detailed structure if the resolution is too fine. Because the lack of perfect matching between the edges of mosaic elements is a serious handicap, it is desirable to obtain as wide a coverage as possible in each image. Therefore, in a number of important applications it is desirable to exchange fine resolution for width of coverage. Obviously at too high an altitude ground resolution can become too coarse. At low altitudes the width of strip over which ground resolution is fine enough is severely restricted. (See Reference 7 for calculations.)

[7] "Optical Mechanical Scanning Techniques", by M. R. Holter and W. L. Wolfe, Proc. IRE, Vol. 47, No. 9, September 1959, pp. 1540-1550; or "Fundamentals of Infrared Technology", by Holter, et al, Macmillan, 1962, p. 345.

Calculations indicate that for optical collecting apertures between 6 and 30 inches in diameter and desired ground resolution of a few tens or hundreds of feet, the optimum altitude to maximize the width of coverage is approximately 200 miles.

Not the least attractive feature of an orbiting platform for the earth mapping function is that the cost appears to compare favorably with airborne platforms. The current cost for aerial photo coverage is between \$2.50 and \$4.00 per square mile (see Reference 1, p. 27). To map the entire earth the higher figure is probably applicable since there are a number of large areas such as the arctic where the costs will be higher. There are approximately 2×10^8 square miles on the earth's surface. Hence the cost of one complete, synoptic coverage would be approximately 800 million dollars, assuming sufficient aircraft were available. Since a large percentage of the cost undoubtedly represents aircraft operation there appears to be little hope of reducing this. One anticipated result of multispectral sensing experimentation on a MOL is information making it possible to design an orbiting, unmanned operational multispectral mapping system capable of global mapping much more economically than is possible by any other means. It seems a fair assumption that the cost of putting an operational unmanned mapping satellite in orbit will not differ radically from the cost of firing an Atlas missile, which is estimated at 4 million dollars. If a like amount is assumed for sensing equipment capable of one year's operation, a very large number of synoptic global maps could be made operationally for a total cost of approximately 8 million dollars. This is less by a factor of one hundred than the cost of a single airborne synoptic global coverage.

Conclusions and Recommendations

In conclusion, it appears that the expansion of the earth's population requires an ever increasing knowledge of the earth environment and efficiency in the use of its resources. World-wide pictorial coverage is an indispensable tool in achieving this. Ordinary aerial photography cannot achieve this because it does not produce all the needed information, takes too long to interpret and is prohibitively expensive to employ for world-wide coverage.

There are under development pictorial comparative multispectral techniques which may be capable of providing the needed information in useful form when the systems are operated in orbiting platforms. Many of the sensing techniques are in hand but have not been assembled into systems adequate for these purposes. The sensors which do exist have not yet been operated to produce the data needed by the earth scientists in order to determine the extent of their utility in those applications. Scattered radiometric and spectrometric measurements of the earth's features exist but not in sufficient quantity nor quality to provide the needed guidance in designing multispectral sensing systems.

There exists an urgent need for a concentrated and coordinated program of ground and airborne measurements which will be adequately interpreted and a need for a series of orbiting experiments based on those measurements to determine the desired nature of an operational orbiting sensing system. This program must be carried out as an integrated effort by a single organization. Since an integrated system such as this is more than a simple sum of its parts, neither the desired information nor a workable system is likely to result if an attempt is made to assemble parts developed by separate groups, each responsible for a different spectral region or technique.

The economic value of such an operational orbiting system is incalculable when employed to map the surface of the earth and its atmosphere. Such a system will also have scientific uses in studying the earth and in building up the experience and techniques required for lunar and planetary fly-by observations.

Should such a Center be established, those other individual experiments concerned with related matters appearing in this document would become part of the integrated Center program and the funding requested for them would be added to the Center funding statement.

Proposed Technical Program

The University of Michigan proposes the establishment of a Comparative Multispectral Sensing Center to capitalize on the anticipated Manned Orbital Laboratory (MOL) capability of the United States. Such a Center, established in the immediate future, would provide for the orderly attainment of a capability, concurrent with the MOL, to observe the earth and its environment simultaneously in the ultraviolet, visible, infrared and microwave regions with resolution adequate for most earth sciences as well as socio-economic and military purposes.

The program to attain this goal, concurrent with the MOL vehicle development, will accomplish the following tasks:

1. Develop an integrated system of multispectral sensing devices and techniques suitable for orbital operation. Fabricate several such systems for operation in the MOL.

2. Improve techniques of interpretation. Imagery interpretation techniques, other than photographic, have received remarkably limited study to date. This should be accomplished through cooperation with interested scientists of government agencies, and those with university, foundation, and industrial affiliations, but could be separately funded.

3. Establish and prosecute an airborne experimental program. This will supply information for (1) and (2) above. It will consist of a program of airborne data gathering over instrumented sites serving to calibrate instruments and the data obtained therefrom for refinement of interpretation techniques. It will also provide the instrumented sites for use in the MOL experiments <u>per se</u>.

4. Conduct the MOL multispectral sensing experiments in cooperation with those responsible for MOL vehicle operations and those scientists and organizations cooperating in the program. This task will culminate in coordinated sets of multispectral data, simultaneously obtained from the MOL and the instrumented ground sites.

5. Reduce and analyze the data obtained in (4) above and submit a report of the findings. This will be done in cooperation with the many earth scientists whose scientific disciplines will be involved. This task will result in recommendations for operational earth sensing systems and will attempt assessment of their economic, political and military value.

The program will be primarily concerned with pictorial comparative multispectral information and the related radiometric and spectrometric data necessary to utilization of the imagery. The ultraviolet, visible, infrared and microwave regions will be investigated. Sensing of both the earth and its atmosphere will be done. Where meaningful in conjunction with the above data, magnetic and gravimetric sensing may be included in the program.

The unique experience of The University of Michigan in the generation and utilization of comparative multispectral data will be applied to this program. Contributions to the solution of problems of generating the data and to the conduct of the experimentation will be made by members of departments concerned with engineering and the physical sciences, and by the Institute of Science and Technology. Contributions to the tasks of analyzing and utilizing the data will be made by many departments in need of and experienced in the employment of such data, e.g., the School of Natural Resources, the Departments of Botany, Geography, and Geology and Mineralogy. Although not financed as part of this Center, it is anticipated that very extensive cooperation will be established with other organizations having experience with and interest in such data. Among those organizations are the Military Services, the U. S. Geological Survey, U. S. Department of Agriculture, U. S. State Department, U. S. Department of Commerce, Bureau of Fisheries, the Office of Naval Research, committees of the National Academy of Sciences, scientists in many universities and other organizations.

It is proposed that the Center be composed of approximately 25 professional personnel with approximately an equal number of non-professional supporting technicians. The effort would be initially divided in the ratios 2/5, 1/5, 1/5 and 1/5 among the tasks of obtaining aerial and ground multispectral data, data interpretation, optical system development (including ultraviolet, visible and infrared), and microwave system development, respectively. As the program progresses toward MOL launching, increasing efforts would be shifted to site preparation and detailed experiment design. Two DC-6 class aircraft* will be required to gather aerial data over surface sites having the required variety of characteristics and to survey the sites to be used in conjunction with the orbiting systems.

The preceding section contains a discussion of multispectral sensing which touches on the capabilities and needs for multispectral sensing, the reasons for believing orbiting platforms to be required, and comments on the value, economic and otherwise. The comments relative to the need for human operators given in Section I applies to this experiment and will not be repeated here.

*DC-6 aircraft appear to be available; the U. S. Air Force currently has a surplus because of its change-over to jets.

2.2 ILLUSTRATIVE MULTISPECTRAL SENSING SYSTEM

Submitted by: Joseph O. Morgan, Research Physicist, and Head, Special Applications Group, Infrared Laboratory, Institute of Science and Technology

To make the nature of an orbiting multispectral system more concrete, the proposed experiment presented in this section describes a possible system based on present knowledge and experience. It could be implemented and operated in space. It would obviously be preferable, however, to defer final decisions regarding the details of orbital experimentation until additional ground and aerial experimentation has been completed. Furthermore The University of Michigan has already proposed a limited multispectral sensing experiment for the Gemini program. If it is carried out, the results will aid materially in optimizing the form of the MOL experiments.

Characteristics of Remote Sensing Techniques

A comprehensive remote sensing experiment for acquisition of pictorial data over a broad spectral range must include three basic imaging techniques: photography, for the region from the ultraviolet at 300 millimicrons to the near infrared at 1 micron, optical-mechanical scanning for the infrared region between 1 micron and 40 microns (and, for some of the work, between .3 and 1 microns), and passive microwave or radar for discrete regions between 1 millimeter and several centimeters or meters in wavelength. The state-of-the-art is such that all three regions can be adequately instrumented.

Photographic imagery will yield data concerning the amount of solar energy reflected from the earth and its cloud cover as a function of wavelength, in selected narrow spectral regions. Further study, based on work currently in progress at the Institute of Science and Technology, may prove that electro-optical or optical-mechanical scanning techniques should be employed in this spectral region in order to acquire data of optimum usefulness. These methods, since they produce data in the form of an electrical video output, permit special processing before final recording on film or tape; thus the information from one spectral region may be combined additively with that from another region, for example, and a single picture produced which may represent an optimum image for certain studies.

Infrared imaging devices will produce recordings of the thermal structure and behavior of the terrestrial and meteorological environment. Since experience has shown that terrestrial data in at least two spectral regions (e.g., 4.5 - 5.5μ and 8.5 - 13.5μ) are often much more useful than either one alone, several infrared channels will be provided. Other wavelengths should be used for cloud and wind studies (wavelengths corresponding to absorption regions in the atmosphere).

Radar imagery provides a comparative measure of the reflection from various components of the earth or of clouds. Reflected intensity (radar return) is affected by the aspect of the terrain relative to the beam direction, by the dielectric properties (at the radar frequency) of the material, and, for elements smaller than the resolution limit, by element size. Small angle (near grazing incidence) scanning yields intensity variations which are a sensitive function of the local slope of complex landforms; it is therefore a singularly powerful technique for topographic mapping. Extensive research may be required to determine optimum frequencies, scan angles, and power requirements.

Passive microwave scanning radiometers have not been developed as extensively as the other sensors under consideration here, but new techniques for improving thermal sensitivity and speed of operation are available, and serious consideration should be given to the inclusion of passive microwave instrumentation. Although comparatively few informative pictures have been produced, polarization effects and the fact that radiation in the passive microwave region originates from beneath the surface of certain terrestrial materials (e.g., ice and snow) offer promising possibilities for geological and arctic exploration.

Purpose of Measurements

As was pointed out previously in this section, the multispectral remote sensing experiments proposed herein will serve a great many purposes. The numbered paragraphs describe a few of the promising possibilities. In all cases enumerated here, data acquired from aircraft have already proven the validity of the experiments.

(1) Snow and Ice Studies

Documentation of the growth and decay of polar pack ice, glaciers, snow fields and icecaps, for use by:

a. Climatologists, for prediction of the total annual growth and decay of ice and determination of the long-range weather effects. Existing methods of data collection are so limited in scope that only a very sketchy picture of the dynamic behavior of the major ice systems of the world is obtained annually. The lack of definitive information makes it difficult to formulate and test predictions or to compute the heat exchange parameters of the world weather picture.

b. Glaciologists, for studies of growth and recession of glaciers and ice and snow cover. Glacier formations are notably inaccessible, especially during periods of polar darkness, and many gaps exist in the information necessary for computation of the total annual snow accumulation, rate of glacier motion, and useful information concerning large-scale growth and recession in various areas of the world.

c. The maritime services, for iceberg assessment and prediction, mapping of coastlines, and the course of the gulf stream, etc. These problems are of major importance to the shipping and fishing industries, among others. Infrared and radar techniques have been established as extremely useful for determination of arctic coastlines, detection of icebergs under adverse conditions, and determination of the course of major ocean current patterns.

(2) Tectonic and Geology Studies

Imagery acquired with electromagnetic sensing equipment aboard an MOL could be used in compiling maps showing the world-wide distribution of geomorphological features and in particular tectonic landforms such as folds, faults, and eroded or exhumed igneous masses. Some of the big problems in basic research in the geological sciences include determining the mechanisms responsible for localized deformation of the earth's crust and those responsible for triggering global orogenies, and understanding the extent to which these diastrophic forces displace the land masses relative to one another (continental drift).

Much of the present knowledge surrounding the cause and effect of crustal deformation has been derived from localized studies in certain classic areas. With the advent of aerial photographic mapping techniques it became possible to expand outward from these areas and gather aerial data relative to the surface expressions of tectonic activity in the more remote regions of the earth.

Through the use of aerial photography, it has been possible to project more accurately the trends of some of the major fault systems of the earth. Since these fault systems present some of the basic clues to the direction and magnitude of past and present forces and the extent of their influence on the structure of a region, a complete world-wide picture of all primary, secondary, and tertiary fault systems apparent at the earth's surface would be an invaluable aid in unravelling some of the basic geological problems. Present-day, high resolution, side-looking radars can highlight lineations in the earth's surface representing alignment of structures, fault scarps, parallelism of drainage, etc., and can do this without the detailed "noise" of photography and the requirement for cloud-free atmosphere. This makes radar particularly suited to the task of world-wide tectonic mapping. The capability of radar to delineate physiographic features and offer something quantitative in the way of surface material classification has been adequately demonstrated on a local scale by existing systems in aircraft.

The MOL in polar orbit would be the ideal platform for performing the task of acquiring data to be used in the compilation of a global tectonic map because the entire land masses of the earth would be surveyed on successive orbits aboard this vehicle. It would also be possible, on a demand basis, to change the antenna train angle so as to change the aspect angle of data acquired over a given point. This would compensate for data drop-outs, caused by shadow areas on the backside of landforms when viewed from only one direction, and thus increase the probability of detecting important lineations. Furthermore, it would make it possible to operate the equipment only when the vehicle was passing over the land masses and thus reduce the amount of data storage space required.

Visible and thermal sensing devices on board the MOL would be used to augment the structural mapping capability of the radar system. The infrared scanning system would be operated over areas of active faulting, volcanism, and hydrothermal activity, on a demand basis and over any other areas where knowledge of the thermal environment might provide a more clear picture of the state of tectonic activity. Likewise, aerial photography could be acquired any time it was deemed necessary.

The benefits that would accrue from this proposed use of electromagnetic sensors aboard a MOL are manifold. First of all is the acquisition of new knowledge relating to tectonic processes. The ability to preserve continuity of surface tectonic features over entire continental masses and an anticipated ability to more accurately project these manifestations from one continent to another will provide geologists with data toward a better understanding of the nature of terrestrial deformation mechanisms. Aside from the purely basic scientific merit of this data acquisition program there is an attendant capability that has economic and social aspects that are of immediate interest to persons occupying the geologically unstable areas of the world. Through a combination of thermal, radar, and photographic data acquired over areas of active faulting and volcanism, it may be possible to derive criteria for predicting crustal movements or volcanic eruptions. If such criteria can be established the savings in human life and property through adequate alerting could be considerable.

(3) Vegetation Studies

While considerable development remains to be done, both theoretical conclusions and limited-scope empirical efforts indicate that detection and recognition of vegetative material, e.g., forests, crops, pastureland, etc., is possible through remote sensing of the broad spectral reflectance and emission characteristics of such material. In addition, research has shown that remotely sensed spectral differences may be used to identify members of specific vegetative classes, e.g., corn crops versus wheat crops, and for a given member, condition of the vegetation, e.g., healthy versus diseased, mature versus seedling.

In the experiment proposed, signatures in the visible through infrared spectral bands associated with vegetative type and condition will be obtained on a world-wide, seasonal basis. To calibrate the spectral signatures interpretation and to assure validity of signature interpretation in unknown regions, control areas will be established on the surface in which known vegetative type and condition are measured and monitored using ground party and low-altitude remote sensing techniques. The data expected from analysis of the multi-band, orbiting laboratory sensor outputs will permit mapping on a world-wide scale the identity, location and status of major areas of vegetation as a function of season.

The uses of such data are several, both for immediate application and for advancement of scientific knowledge. Agriculturists and foresters will benefit from the currentness and scope of the data in preparing surplusdeficit predictions, conservation measures, plans for storage and distribution of surplus and plans for future land use. Similarly, economists may provide more valid estimates of crop and forest product futurities on national and international scales. For scientific purposes, broad-scale data on vegetation characteristics may be used to establish the interactions between vegetation and climatological conditions, between vegetation and urbanization trends, and between vegetation and major geologic/geophysical characteristics of the earth surface.

Such activities are, of course, currently on-going. However, such efforts are dependent on the limited-area, time-consuming sampling of vegetation parameters permitted by surface and airborne techniques. With such techniques, not only does the sampling process introduce inaccuracy, but the time-consuming process of integrating samples to form a composite picture of national and international vegetation status serves to compromise the timeliness of predictions from such samples. In addition, current techniques require much manpower and equipment, both for sampling and sample integration, resulting in very high recurring costs. The rapid, complete measures obtainable from a single configuration of equipment aboard an orbiting laboratory should overcome such inadequacies of existing techniques.

(4) Oceanography Studies

Electromagnetic sensors aboard a manned orbiting laboratory offer the opportunity of acquiring detailed thermal characteristics of the earth's ocean surfaces. This information has particular significance in the fields of physical oceanography, meteorology, and climatology and to naval and maritime interests.

Use of the MOL to gather these data will permit all of the earth's water covered areas to be completely thermally surveyed at a tremendous saving in effort and cost over conventional aerial mapping techniques. Admittedly, the resolution at the earth's surface obtained by the systems aboard the MOL will not match that obtained in low altitude flights. However, the MOL's more complete data will enable subsequent low altitude flights to make concentrated high resolution studies of areas exhibiting particularly unusual or significant thermal characteristics.

The analysis of these world data will permit thermal maps to be prepared which may be used to deduce ocean current flow patterns and current velocities. The existence of diurnal variations in the currents may be expected to assist weather predictions, while annual variations or long term trends will be of assistance to climatologists in deducing and explaining climatic changes. Further, since ocean current circulation in the polar regions has a great influence on the climate of these regions, the tendency toward the accumulation or reduction of continental icecaps may be inferred from changes in flow of polar currents. The steady-state aspect and the seasonal variation of the ocean's thermal character used in conjunction with marine biological information should prove valuable to fishing interests in locating and tracking potential catches.

Of particular interest to navy and physical oceanographic groups is the determination of ocean thermal profiles given the surface thermal conditions. Since an indication of subsurface conditions can be determined through thermal features such as rifts and upwellings at the surface, a simultaneous program of detecting these thermal features from the MOL and investigating them in detail from the surface should provide a much better understanding of the relation between the surface and subsurface thermal conditions.

(5) Atmospheric Physics

Some of the basic problems of meteorology and climatology can best be studied above the earth's atmosphere from an earth orbiting platform such as the MOL. Furthermore, such problems as determining variations in earth albedo and studying the mechanism responsible for the birth and perpetuation of severe storms, can most economically be studied using data acquired simultaneously in many different spectral regions and over large areas of the earth's surface. Thermal characteristics of the earth's surface that affect weather are of particular interest to the meteorologists and world-wide observation of these effects have both scientific and economic aspects. Such a method of surveying the atmosphere and the earth-atmosphere interface would promote a better understanding of fundamental physical phenomena as well as increase the capability for forecasting weather. Since heat exchange has a big influence upon the weather, the study of the heat budget over various earth surface materials such as polar packs and snow fields, oceans, bare soil, vegetated areas, and inland rivers and lakes, on a daily and seasonal basis would provide a better understanding of the forces that contribute to the various weather phenomena. Again, it is the accessibility to large areas of the surficial regimes outlined above that make an earth orbiting vehicle particularly suited to this study.

(6) Exploratory Studies

Scientific observations from new vantage points or with new equipment frequently result in findings which have not been predicted or expected. The fields of archaeology and cultural anthropology, for example, have in several instances benefited quite accidentally from aerial photography flown for quite different purposes. Since the proposed MOL remote sensing venture presents both a new vantage point and new equipment applications, unexpected findings can be anticipated.

It is not inconceivable, for example, that some significant correlation between population density and MOL-obtained thermal maps might be established, thus providing the foundation for a more efficient census and/or population migration measurement technique. More timely earth population data, particularly in those regions seldom if ever polled, would form the basis for more effective socio-economic planning.

Another area in which the MOL remote sensing studies will have application is in the interpretation of imagery of planets other than Earth obtained by unmanned fly-by vehicles. The MOL data on image characteristics of a variety of measured earth-surface characteristics will provide the keys and signatures information required as comparison sources in identifying the imaged surface features of other planets.

Thus, while not a necessary condition in experiment planning and conduct, attention will be given in the remote sensing data reduction phase to opportunities for non-programmed exploitation of the data.

Measurement Equipment and Operation

(1) Current capabilities

Remote sensing of the earth environment has been actively pursued with equipment suitable for obtaining photographic, thermal (infrared), and radar imagery. Passive microwave imaging systems have been operated only on a trial scale. Currently available equipment is tailored largely for use in fixed wing aircraft, and specifically for military operations involving a wide range of altitude, speed, and resolution requirements. In general, equipment is optimized for acquisition of data at very much higher rates than would be required in the case of a manned orbiting laboratory.

Photographic mapping and reconnaissance capabilities are fairly well known. Film formats ranging from 35 mm to 9 x 14 inches, lens focal lengths from less than one inch to more than 36 inches, and framing and continuous strip modes of operation are all in frequent use and have been thoroughly developed. Existing multilens framing cameras could be adapted to MOL. World coverage in seven spectral regions could be obtained with a reasonable amount of film.

An instrument such as the Itek VELA UNIFORM nine-lens camera, or a battery of Sonne strip cameras, both of which are currently available, would be adequate, with special selection of lenses, filters, and photographic emulsions, for narrow band photography throughout the photographic region, with adequate resolution. Scales of the order of 1:1,000,000 to 1:5,000,000 would be obtained. Such data would be of particular usefulness in areas involving vegetation and soil studies, as elaborated below. Other techniques for producing imagery in this spectral region which may have important advantages are discussed below.

Infrared imaging technology has been developed for the military services to a high degree of sophistication. Although the performance characteristics of military infrared scanners are presently classified, it is sufficient to state that speed of data acquisition, resolution capability, and thermal sensitivity are adequate at the present state-of-the-art for immediate application to the MOL requirement. The small velocity/height ratio of an orbiting platform allows considerable time for data acquisition at resolution values considered to be appropriate, and the operational concept would include nearly continuous operation in three or four spectral regions, special circuitry for internal calibration against a reference standard, and on-board processing of at least a fraction of the recording film.

It is now possible, with reliable techniques, to secure thermal imagery of good quality in all regions of atmospheric transmission between 1 micron and 15 microns in the infrared. (The latter figure represents the long wavelength transmission limit of the atmosphere.) Wavelengths beyond 15 microns may prove extremely useful for upper atmosphere phenomenological studies such as the thermodynamics of clouds and moving air masses. Excellent detector sensitivity is available out to 25 microns and perhaps to 40 microns in the far infrared.

Whereas the camera measures relative amounts of reflected energy in the photographic region, the infrared scanner records relative amounts of naturally-emitted (thermal) radiation, which is dependent upon the distribution of surface temperature, the power of emission of surface materials, and the atmospheric transmission.

High resolution radar techniques have evolved rapidly since World War II, and thanks to heavy support by military agencies, current radars exhibit very impressive performance characteristics. Radar parameters can be varied to permit acquisition of very high resolution data over a limited area or wide angle coverage at reduced resolution. A number of frequencies should be considered for optimum imaging of terrain and atmospheric phenomena.

Passive microwave radiometric or scanning techniques have not been exploited very fully. Theoretical studies have indicated that passive microwave radiation, especially because it originates in some media (e.g., snow and ice) from some distance beneath the surface, may reveal important data not otherwise obtainable. Instrumentation is not so highly developed in this area, and careful consideration may indicate that active radar techniques are more generally useful. Radar systems have been intensively developed for airborne use, and it is anticipated that pictorial imagery of excellent resolution may be obtainable.

(2) Equipment Requirements

General

Equipment considerations in this proposal are based on assumption of a circular polar orbit, 250 nautical miles altitude, and a period of 96 to 100 minutes, corresponding to completion of approximately 15 orbits per day. Orbital paths over the earth's surface are spaced approximately 1660 miles apart at the equator, and the speed is approximately 4.4 miles per second. The parameters of existing photographic, infrared, and radar imaging systems suitable for use under these conditions are discussed below. The parameters have, in general, been optimized for practical attainment of whole earth coverage, at some sacrifice in other performance criteria.

Photography

It is entirely possible that some of the imagery in the 0.3μ to 1μ spectral region might best be acquired with scanning techniques. The output from two or more spectral channels can be processed prior to recording on film. Advantages might include optimization of data, final recording of data from fewer channels, and improved sensitivity.

Assuming use of state-of-the-art multispectral instrumentation, photographic parameters might be approximately as follows:

Film: 3 rolls, 70 mm width x 100 to 500 foot length

Lenses: 9 separate, individually selected and focussed for optimum performance in narrow spectral regions between 0.3μ and 1μ. Focal length is approximately 3 inches.

Spectral separation: approximately 0.1μ bandwidth filters, .3, .5, .7, .9, 1μ, 2 unfiltered panchromatic channels, 1 unfiltered infrared channel.

Scale: 1:6,000,000

Ground resolution: 200-800 feet, depending on contrast.

Coverage per frame: 187 miles or 35,000 square miles.

Photos per orbit for full coverage (10% overlap): approximately 150.

Minimum photographs for world coverage: approximately 2000.

Number of orbits for full coverage: approximately 70.

This configuration would yield photographic coverage on a scale compatible with that of the infrared scanner proposed below, and the choice of film-filter combinations is sufficient for adequate separation of spectral characteristics of vegetation, soils, etc. The camera would be programmed for optimum acquisition of redundant coverage, which would be affected by such things as cloud cover and movement, increased sidelap near the poles, etc.

Developmental work would be carried out on problems of automatic adaptation to illumination conditions for optimum exposure in each spectral channel, selection of film-filter combinations, and determination of a suitable window material of good optical quality. Existing data on narrow band photography will be of material assistance in spectral band selection.

Choice of continuous strip cameras or optical scanning techniques rather than multi-lens framing cameras would have certain advantages. Spare strip cameras could be provided for substitution in the event of malfunctions, and the continuous strips would match other imagery more closely and would, for most purposes, be considerably more convenient to work with. Excellent cameras of this type are available, and only minor modification would be required.

Infrared

The state of the art in image acquisition with single detector object plane scanning devices is such that one can envision employing an existing instrument with minor modifications aboard a manned orbiting laboratory. However, the combination of altitude and speed implicit in the orbiting configuration result in a small ratio of velocity to height, which permits operation at lower data acquisition rates, even with good (1 milliradian) resolution. This has the advantage of decreasing the bandwidth requirement for amplifier and tape recording devices. The scanning system should be carefully optimized for the work of particular interest under the prevailing circumstances.

Assuming a 1 milliradian instantaneous field of view, which is attained with state-of-the-art detectors and optics of modest dimensions, the area viewed instantaneously at the earth's surface would be approximately one-quarter mile square. This number is related to the resolution capability, and high contrast objects of even smaller size, especially those having linear or one dimensional characteristics, such as highways and rivers, would be expected to show clearly at certain times of day. Assuming an instrument with a total field of view of 60^{o} to 120^{o}, possible scanning and imaging parameters are approximately as summed up below:

Optics: 4-inch to 6-inch diameter, 6-inch or 12-inch focal length.

Scan rate: 35 lines per second for 50% overlap.

Coverage: 860 mile wide strip for 120^{o} instrument, 500-mile wide strip for 60^{o} instrument.

Number of resolution elements per line: 2,020 (120^{o} scanner)

Recording bandwidth requirements: approximately 70 to 100 kilocycles.

Scale: 1:20 million for 120^{o} scan, 1:9.5 million for 90^{o} scan, 1:6.5 million for 60^{o} scan.

A minimum of two interlaced sets of 24-hour orbits are required for full earth coverage. Approximately 1000 feet of film would be involved. It is anticipated that coverage should ultimately be obtained in three or four spectral regions, including the 4.5 - 5.5μ atmospheric window, the 8.5 - 14μ window, and possibly in two absorption regions, i.e., around 6μ and in the region between 15 and 40μ. Much of this detail can be determined definitely only from early experiments and evaluation of data.

Although larger scale formats may be obtained by printing out a narrow portion of the total field of view of the instrument, it is felt that little would be gained, and that the approximate one-quarter mile resolution attained as described above will permit identification of most features of geological, meteorological, and oceanographic interest.

Engineering studies should be carried out to determine optimum operational parameters under orbiting conditions. This work would include:

(1) consideration of instantaneous fields of view of less than 1 milliradian and down to one tenth milliradian, for attainment of ground resolution of approximately 150 feet.

(2) developmental work on miniaturization of detectors, and packaging of several detectors together, which would lead to more compact instrumentation.

(3) over-all system reliability improvement.

(4) continued developmental work on closed cycle cooling techniques, possibly utilizing the easy availability of high vacuum conditions in the space environment.

(5) selection of window materials for maximum transmission in the region between 1μ and 40μ.

(6) calibration, stability, and linearity studies leading to realization of a quantitative relationship between the grey scale of the photographic image and the infrared radiation levels.

Some of the more important equipment specifications are shown in the accompanying table. Radar equipment is proposed in item 2.3.

EQUIPMENT SPECIFICATIONS

Infrared

Item	Weight	Volume	Power
Scanner	45 lbs	4 ft^3	400 watts
Film Recorder	25 lbs	6 ft^3	120 watts
Tape Recorder	200 lbs	6 ft^3	175 watts
CRT Power Supply	10 lbs	1 ft^3	350 watts

Ultraviolet and Visible

Item	Weight	Volume	Power
Camera or Scanner System	50 lbs	4 ft^3	200 watts
Recorder	150 lbs	5 ft^3	150 watts

Proposed Technical Program

An experimental program, utilizing presently available instrumentation, for the attainment of data on the earth and its environment simultaneously in the ultraviolet, visible, infrared, and microwave regions would consist of the following steps:

1. Fabrication of the required system on the basis of current knowledge.
2. Conduct of a MOL multispectral sensing experiment in conjunction with those responsible for MOL vehicle operations and those scientists and organizations cooperating in the program. This task will culminate in coordinated sets of multispectral data, simultaneously obtained from the MOL and the instrumented ground sites.
3. Reduction and analysis of the data.

2.3 RADAR

Submitted by William M. Brown, Professor of Electrical Engineering, Department of Electrical Engineering, College of Engineering; Research Engineer, and Head, Radar Laboratory, Institute of Science and Technology.

Radar equipment is proposed in a classified supplement to this document.

2.4 MEASUREMENT OF ATMOSPHERIC TRANSMISSION

Submitted by: Richard R. Legault, Research Mathematician, Computation Department, Institute of Science and Technology; and Lecturer, Industrial Engineering Department, College of Engineering.

Of considerable interest for military and civilian application of sensors operating in the visible and infrared regions are the transmission characteristics of the earth's atmosphere. Signal attenuation by the atmosphere arises primarily from absorption and scattering. In the infrared spectrum the primary cause of signal attenuation is absorption of the signal power by water vapor and CO_2. Attenuation due to water vapor and CO_2 has been investigated theoretically in considerable detail and recent calculations by D. M. Gates reflect the physical factors involved. It is known that temperature-pressure variations cause variations in the absorption bands for both water vapor and CO_2 and since both temperature and pressure of the earth's atmosphere vary, variations in the signal attenuation may also be expected. Transmission measurements of the earth's atmosphere by Yates and others tend to support the theoretical calculations.

The measurements of atmospheric transmission have to date been done at or near the earth's surface. Both water vapor and CO_2 achieve their greatest concentration at low altitudes. Consequently, these measurements primarily reflect the absorption characteristics of water vapor and CO_2 that is, the attenuation effects of other atmospheric constituents are masked. Therefore, transmission models for paths at or near the earth's surface cannot easily be extrapolated to paths at very high altitudes.

The transmission characteristics of high altitude paths have not been measured. While it is theoretically possible to derive high altitude atmospheric attenuation characteristics from information about the composition of the atmosphere at these altitudes, measurements are required to support the calculations. There are many paths of interest to equipment designers and it is not possible nor practical to measure all such paths. What is needed are measurements which support a theoretically derived model of the atmosphere.

Transmission measurements require a known source of radiation. Since the path lengths should be long in order to obtain measurable attenuation values for the weaker atmospheric constituents, the source must be fairly intense. The spectrum of the radiant source must be stable and known precisely or must be measured during the experiment. Two paths for which the source can be reasonably well calibrated and over which measurements can be made are as follows:

(1) Consider the path which extends from an orbiting vehicle to the sun through the atmosphere (see Figure 1). As the vehicle moves, the length of the path through the atmosphere varies and can be determined. Therefore, theoretical attenuation calculations can be made and compared for various paths.

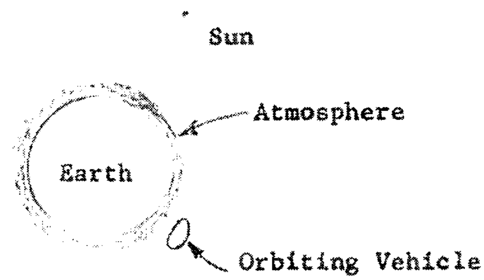


Figure 1

(2) A calibrated source located at altitude (at say 60,000 feet) and the instrument aboard the orbiting vehicle aimed at the source.

The measuring instrument should have a narrow field of view so that as little radiation as possible from sources other than the known source is measured. The instrument should have high spectral resolution so that the transmission spectra may be measured to the fineness usable by equipment designers.

The requirement for a narrow field of view demands that the instrument be aimed at the known source. An auxiliary sensor and computer for performing the aiming task is a man.

The following tasks should be performed:

(1) Development of an instrument for the MOL with the spatial and spectral resolution required.

(2) Development of a calibrated source.

(3) Detailing a plan for the transmission experiments.

3.1 OBSERVATION OF CLOUD SYSTEMS AND AIR POLLUTION PROCESSES

Submitted by: A. Nelson Dingle, Prof. of Meteorology, Dept. of Meteorology and Oceanology, College of Engineering.

Two experiments which would provide important information in the study of meteorology are:

1. Systematic observations of cloud systems as they approach, traverse, and leave the Great Lakes area with a view toward evaluating amplification and suppression of cloud processes as a result of the Great Lakes thermal effects in each season.
2. Systematic observations of the radiative characteristics of the cloud-free atmosphere in the Great Lakes Area with a view toward evaluating the effect of the urban plumes of air pollution from Milwaukee and Chicago, for example, as they traverse Lake Michigan.

Both of these observational programs require the use of remote-sensing devices of the highest possible resolution in both the visible and infrared regions, and both might be enhanced by the use of transmissometry techniques using carefully located ground based laser beacons. The desired data are to be evaluated in terms of the (1) thickness and extent of clouds, and their changes with time and location, and (2) the distribution of airborne contamination and its rate of dispersion under varied clear-weather conditions.

The advantages of a Manned Orbiting Laboratory in making these observations are numerous. Principal among them are (a) the ability to use high-resolution devices for the purpose of determining details of cloud systems, (b) the ability of a man to observe and note especially any peculiarities or special features of the observed situation, (c) flexibility of the experiment in terms of ground to satellite communication to optimize or otherwise improve observations for scientific ends.

A coordinated program of earth-bound observations is proposed:

3. Land- and ship-based observations of rain-producing weather systems at meso-scale as they traverse the Great Lakes area, particularly Lake Michigan. The rain-production of the satellite-observed cloud systems will be monitored in detail both by conventional rain gauges and by such special devices as weather radar, raindrop-size spectrometers, and rain samplers. The objective of these studies is to document as clearly as possible the rain-generating process and its end product in such a way as to evaluate the effects of the Great Lakes heat and moisture reservoirs upon the respective weather systems. The end result will contribute to basic knowledge of the rain-producing processes and will bear upon the question of weather control. Work in these areas has been carried forward at this University and is reported in publications by Hardy and Dingle (1962), Gatz and Dingle (1963), Hardy (1963), and in several reports.

4. Airplane and ground-based sampling of the air throughout the haze layer from the large city complexes downstream. The objective of this program, coordinated with satellite clear-sky data, is to determine the sinks to which major air pollution is carried through the air. Because of the acid chemistry of industrial contamination and the alkalinity of the Great Lakes, a chemical gradient over the lakes is

anticipated. It is not yet clear how effective this chemical situation is in removing contamination from the air. Samples of air at various levels and of surface water, in addition to the rain samples (3 above) are to be collected both over Lake Michigan and the adjacent land areas following the Chicago and Milwaukee plumes of urban air pollution.

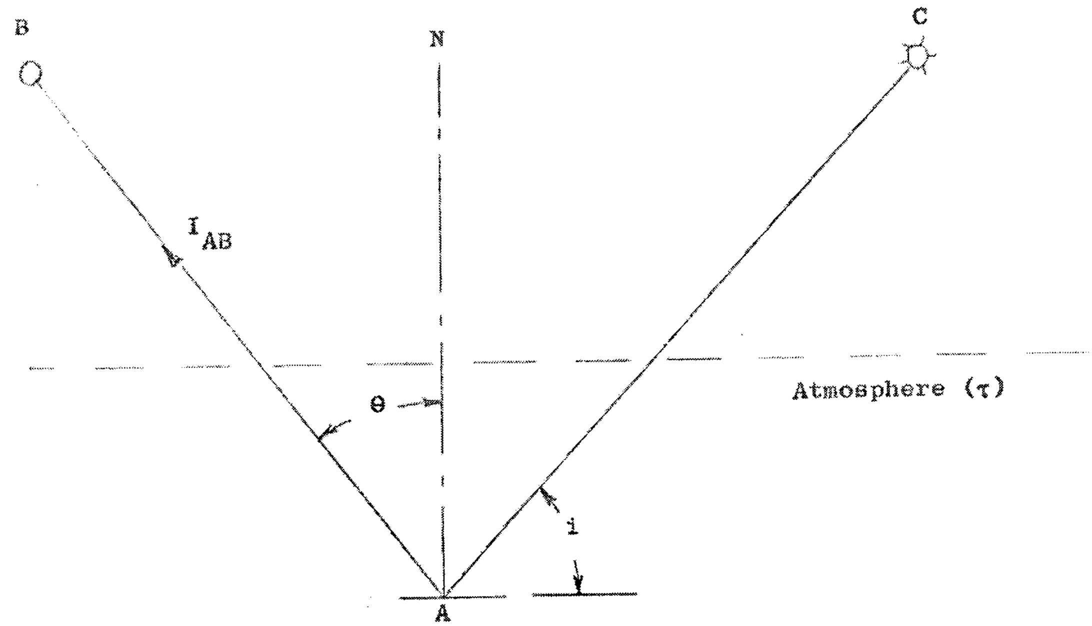
3.2 STUDY OF EARTH'S HEAT BALANCE

Submitted by: Leslie M. Jones, Professor of Aeronautical and Astronautical Engineering, Department of Aeronautical and Astronautical Engineering, College of Engineering; and Head, High Altitude Engineering Laboratory.

Scientific objective

The primary objective of the proposed experiment is to obtain data which will make accurate heat balance computations possible. The earth's heat balance has been the subject of scientific investigation over a period of many years. Scientists have measured the earth's radiation field from mountain tops, aircraft, balloons, rockets, and satellites. The introduction of each new observation platform has advanced our knowledge and understanding of the heat balance. But, in spite of this great effort, the picture is not yet complete, nor is it at all satisfactory.

The latest and most ambitious effort in this field has been the TIROS radiation measurements. These measurements have given us the first real global look at the heat balance problem. This is, of course, a step forward, but at the same time it has been very frustrating. We are frustrated by our inability to interpret the available data. We do not know the functional relationship which exists between the measured radiation and the total hemispherical radiation. The proposed MOL experiment offers the opportunity to solve this problem. Specifically, the spectral radiance of typical meteorological targets will be measured as a function of viewing angle and angle of incidence.



The measurement situation can best be understood by referring to the diagram shown above. A is a meteorological target, B is a satellite containing a radiation measuring device, and C is the sun which is irradiating the target. The radiance, I_{AB}, of A along the path AB is measured at B. The basic problem is to relate the measured radiance, I_{AB}, to the total radiance which exists over the entire hemisphere above the target.

Scientific benefits

The MOL satellite offers the possibility of measuring I_{AB} as a function of θ. This data would then be used to derive the desired function for the single plane case. The assumption would then be made that the hemispherical distribution could be represented by the function generated by revolving the plane function. Using this information the functional relation between I_{AB} and I would be computed for all types of meteorological targets. The functions would then be applied to the TIROS or NIMBUS data to make heat balance calculations. This would represent a big step forward which could possibly form the basis for an understandable theory of atmospheric circulation. At a later date these calculations could be further refined by using two MOL satellites flying intersecting orbits to make simultaneous measurements on given meteorological targets.

Other methods

1. TIROS satellite

The TIROS radiometer normally makes only one measurement on any given target. Hence, the only method available for measuring I_{AB} as a function of θ is by statistical methods. Statistical methods have been applied to the TIROS data, but with very little success. The reason for the lack of success can best be understood by considering how I_{AB} is functionally related to the total radiance. First, I_{AB} has a definite spectral characteristic such that $I_{AB} = \sum_{\lambda_1}^{\lambda_2} I_{AB}(\lambda)\, d\lambda$. Theoretically, $\lambda_1 = 0$ and $\lambda_2 = \infty$ but in practice if $\lambda_1 = 0.3\mu$ and $\lambda_2 = 30\mu$ all the significant radiation will be included.

If we consider that each $I_{AB}(\lambda)$ is functionally related to each $I(\lambda)$ as follows: $I(\lambda) = I_{AB}(\lambda) \cdot f(\theta, i, T, \epsilon_A, \epsilon_S, T_A, T_S)$

where θ = the observation angle

i = sun's angle of incidence

T = atmospheric transmissivity

ϵ_A = atmospheric emissivity

ϵ_S = meteorological surface emissivity

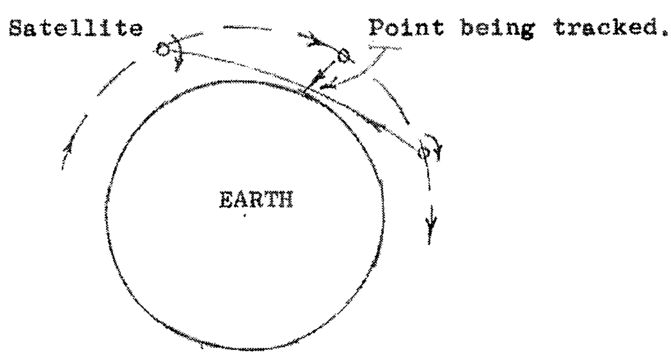
T_A = atmospheric temperature

T_S = meteorological target temperature

and furthermore the values of ϵ_A and F_S are functionally dependent upon the value of Θ. This serves to point out the advantage of measuring $I_{AB}(\lambda)$ as a function of Θ directly.

2. Rotating spectral radiometer

Another possible satellite technique would be to equip a satellite with a radiation measuring device whose field of view rotated in the plane of the satellite's orbit. If the satellite were earth-oriented, such as the NIMBUS, and the rotation had the proper non-linear rotation, then the radiation device would track given spots on the earth's surface.



The difficulty with this experiment is that there would be no pre-selection of the targets being tracked. The data would have to be carefully examined and all cases of multiple targets removed before the classification of the targets tracked could be determined. This would be a long and laborious process. The amount of data which would have to be collected in order to obtain the desired data would be quite large and be the subject of a separate study.

3. High flying aircraft

It is obvious that measurements from an aircraft will be deteriorated somewhat by not being completely above the atmosphere. However, for some meteorological targets the effect may be negligible. Furthermore, there is the definite advantage that targets could be examined along more than one path. Some measurements of this kind have been made on various cloud types, and more should be made. It is strongly suggested that a measurement program utilizing high flying aircraft be instigated as a preliminary to an MOL experiment.

Description of experiment

There are many possible meteorological targets, but in order to organize the experiment all targets will be classified according to a finite classification system. The proposed system is shown in the accompanying table.

This classification is subject to modification and would be re-examined as more data become available. This simply represents a system by which meteorological targets could be classified. The operator in the MOL would be trained to recognize the targets by class. He would pick a target as far ahead as possible and track the target as long as possible. The only information which would be stored and transmitted to the ground would be that obtained during the tracking sequence. The preselection of data would be a tremendous advantage during the data reduction process.

Measuring equipment

The basic measurements could be made with any of several types of devices. The High Altitude Laboratory has had experience in the use of filter radiometers,

Arctic Winter	Arctic Summer	Temperate Winter	Temperate Summer	Tropic
Snow fields	Snow fields	Snow fields	Ocean	Ocean
Ocean	Ocean	Ocean	Forest	Forest
Cirrus clouds	Tundra	Forest	Fields	Fields
	Cirrus clouds	Fields	Pasture	Pasture
	Cumulo-cirrus	Desert	Desert	Desert
		Mountain	Mountain	Mountain
		Cirrus	Cirrus	Cirrus
		Cumulo-cirrus	Cumulus	Cumulus
		Cumulo-stratus	Cumulo-cirrus	Cumulo-cirrus
			Cumulo-stratus	Cumulo-stratus

prism spectrometers, diffraction grating spectrometers, and interference spectrometers. Based on our experience and the requirements of the experiment, we believe the interference spectrometer represents the best choice for this experiment. This instrument has the advantage that it observes all wave lengths simultaneously; hence, the relative spectral response of a changing target will be more accurately determined than, for instance, a grating spectrometer. The proposed instrument would have two spectral bands: one band would measure the reflected radiation from 0.3 to 3.0 μ, and the other band would measure the emitted radiation from 3.0 to 30.0 μ.

The instrument specifications are as follows:

Band 1	Wave number span	30,000 cm^{-1} to 2,500 cm^{-1}
	Resolution	40 cm^{-1}
Band 2	Wave number span	2,500 cm^{-1} to 160 cm^{-1}
	Resolution	10 cm^{-1}
Field of view		Variable from 2° to 0.2° solid angle
Basic data period		2 sec.
Minimum detectable signal per resolution element		1 erg cm^{-2} sec^{-1} $STRD^{-1}$
Physical size		6"x6"x6" = 216 cu. in.
	weight	10 pounds
	power	5 watts

The following information would be stored and transmitted over the MOL telemetering link:

1. Radiation intensity (2 bands)
2. Scan mirror position (2 bands)
3. Mount position (3 axes)

4. Aperture setting

5. Data set identification

6. Television picture of target

It is assumed that the following facilities would be basic to the MOL and available to this experiment:

1. A tracking mount with a sighting telescope

2. An accurate means of measuring the mount position

3. A television camera slaved to the tracking mount

4. A high resolution (aircraft type) movie camera slaved to the tracking mount.

5. An infrared window extending to 30μ or an outside slaved mount for the spectrometer.

Time Requirements — in orbit

Estimated time per data set	5 minutes
Target selection and lock-on time	3 minutes
Number of data sets per orbit	5
Data sets per day	50
Minimum classes of targets	35
Minimum data sets per target type	5
Minimum data sets required	185
Minimum data days in orbit	4
Desired data days in orbit (minimum x 4)	16

State of the art capabilities

The current state of the art is such that with the exception of the scanning mirror drive a straightforward design of a satisfactory instrument is possible. We believe that a rather modest development effort would produce a satisfactory drive mechanism. The estimated effort is as follows:

Engineering man months	8
Technician man months	10
Machinist man months	12

The estimated effort to design and construct a satisfactory instrument including a prototype would be as follows:

Engineering man months	36
Technician man months	40
Machinist man months	40

3.3 AURORAL PHOTOGRAPHY

An experiment proposed by Professor Sydney Chapman who provided the information for this outline.

Submitted by: Leslie M. Jones, Professor of Aeronautical and Astronautical Engineering, Department of Aeronautical and Astronautical Engineering, College of Engineering; and Head, High Altitude Engineering Laboratory.

1. Description of experiment

High resolution color photography of auroral displays; time and geographic identifications; recorded verbal description.

2. Scientific significance

Auroral morphology* signifies the description and study of the changing distribution and characteristics of the aurora. There are countless narrations concerning particular auroras seen from individual places, and also measurements of the changing situation in the local sky, and of their color and spectra. From this enormous wealth of facts one must select the main features to be explained. As the aurora is a planetary and not merely a local phenomenon, a synoptic world picture should be sought; but even now, despite the expansion of observing effort during the IGY, such a picture is difficult to attain. Recent studies made with this object are not in complete agreement.

Photography of auroras from above provide the possibility of obtaining pictures of some displays in their entirety. Auroras are now photographed with all-sky cameras at a few widely scattered ground stations. These observations are not sufficient to permit synthesis of an over-all view. Photographs, spectrograms and magnetograms are the principal tools used in

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* See Appendix 3.3A

studying the entire auroral phenomenon of which the visual morphology is a crucial part.

3. Advantages of photographing Auroras from an MOL

   a. More complete view can be obtained from MOL as compared with ground view.*

   b. Recoverability of high resolution photographs.

   c. Evaluation and choice of displays to be photographed.

   d. Manipulation of camera setting and film for optimum results.

4. Equipment

Successful auroral photographs are possible with modern equipment and emulsions, the choice of which remains to be made.

5. Preparation

It is estimated that the auroral photography experiment could be prepared by 2 or 3 men in 6 months time.

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* See Appendix 3.3B

APPENDIX 3.3A

Auroral morphology*

Recent studies made to obtain a synoptic world picture of auroral morphology indicate some differences of conclusion. (Davis 1962; Akasofu 1963; 1, 2). Observed details, however, will serve as a basis for understanding the nature of the photographic problem.

> "During magnetic calm, and sometimes even in a magnetic storm – for short intervals – the aurora may consist of faint diffuse quiet arcs extending along the part of the auroral zone or other isochasm that is in darkness. With the onset of a polar magnetic substorm (DP) the aurora becomes active over a wide range of longitude, but especially in the post-midnight sector; the kind of activity varies along the zone, partly depending on the local time, which measures the azimuth of the local meridian relative to the noon meridian half-plane in which the sun is situated. The duration of the DP and the active aurora is usually brief – from one to two or three hours; during the greatest storms and auroral displays there is a succession of such periods of activity.
>
> "It is specially instructive to study the outstanding cases, though the more average events, and also those of low intensity, must be borne in mind. Storm activity is sometimes (very rarely) so great that the aurora

* Excerpted, with permission, from the forthcoming book: Space Physics, a collective work edited by Donald P. LeGalley and Alan Rosen, to be published in 1964 by John Wiley and Sons, New York.

comes within sight of places in the tropics (Chapman 1953-3, p. 610). For example, from Mexico City (19^{o}N), the aurora was seen on November 14, 1789, and again on September 1, 1859, and February 4, 1872 – this last aurora was seen also from Bombay (9.5^{o}N). Thereafter the aurora was not visible from Mexico City until during the IGY, on February 11, 1958. Two other great IGY auroral displays, of September 13 and 23, 1957, were visible from northern Mexico (4,5). For Russian observations of the aurora of February 10/11, 1958 see Mironov et al (1959-3, p. 643).

"During the DP substorms, when the auroral strip is broad in latitude, the sky shows many and complicated arcs in violent movement. At times during the expansions of the auroral strip the aurora shows strong surges along their direction of horizontal extension; the aurora is so bright, and moves so rapidly over the sky, that the camera films are over-exposed, and failed to indicate the changing form of the aurora, such as a visual observer could see; in future there is need to make the photography more sophisticated, by controlling the duration and frequency of the exposures, according to the degree of brightness of the aurora.

"Akasofu (2) has made a detailed study of the dynamical morphology of the aurora during a variety of conditions, ranging from magnetically quiet to highly disturbed times. As seen from one station, for example from one slightly to the south of the (arctic) auroral zone, on a night of some auroral activity, there may be one or more cycles of auroral display. Each cycle coincides with the growth and decline of a DP substorm, and has three phases. In the first, a quiet arc rises slowly from the northern horizon, moving southward, and it may be followed by other arcs from further north.

They may or may not cross the zenith into the southern half of the observer's sky. Then, at what is called the break-up, there is a change, which may be sudden, occupying only one or a few minutes. The (arc or) arcs become thinner and better defined; rays appear in them; and they move about over the sky, like waving and sweeping curtains or draperies. Also they may become folded into great loops (not closed), which may move along them. In the last phase the arcs and curtains may disappear, and luminous patches may be strewn over part or all of the sky. These may pulsate or drift over the sky, often eastward. Sometimes a moving changing patch can be identified and followed for as long as ten minutes.

"As seen from a station near the auroral zone, but on its poleward side, arcs and bands may move rapidly poleward from the zone; later some may return to the zone.

"During the active phase the arcs may become very complicated, by the formation of folds along them – sometimes folds within folds. The folds appear always to lie on the poleward side of the arc; they may fold back on themselves, and the exact form may be difficult to recognize on an all-sky film, because the scale of the large folds is so great that it may nearly fill the sky of one observing station. The great folds travel westward, with speeds that may exceed 300 m/sec.

"Davis (1962; 1) finds that at normal times the peak latitude of auroral occurence shows a daily variation, and moves from about 70° magnetic axis latitude, in the early evening, to about 66° near midnight; later the distribution becomes broader in latitude, and the latitude of maximum occurrence is less well defined. In general the number of arcs moving south (in the arctic auroral zone) exceeds the number moving north, apparently because of the disappearance of arcs to the south of the zone.

"In the auroral cap there are two daily epochs of maximum frequency, one at midnight and one in the early morning. The former is due to auroras that advance from the zone during the breakup phase; such arcs are usually bright. The early morning displays are usually very quiet and diffuse; sometimes they show faint rays; their brightness changes only slowly. The hour of the midnight maximum becomes earlier as one moves poleward (Malville 1959a-3, p. 638). Feldstein (1960, 6, p. 61) showed that the hour of the morning maximum becomes later as one moves poleward. These latitude variations of the peak hour have been related to Stormer's spiral precipitation pattern (Nikolski 1947; 7, Meek 1955-3, p. 641; Thomas and Piggott 1960; 8); but this may be a misinterpretation of Stormer's result (Agy 1962; 9).

"Elvey (1957; 10) recognized a type of auroral change which he called the pseudo-breakup, in which an arc near the center line of the auroral zone is disrupted or deformed, during a period of small magnetic activity. It is probably due to a well-developed fold travelling westward along the arc from the morning side. In such a case radio waves are only slightly absorbed, whereas in the true breakup, echoes of radio waves directed vertically upwards cease to return.

"One feature of the aurora, in both the quiet and active phase, is so remarkable that it specially calls for theoretical explanation. This is the thinness of the luminous surfaces. These have a range in height — from about 100 km, the usual height of the lower border — of about one or a few hundred km; the horizontal extent, in the east-west direction, may be some thousands of km. But the thickness of quiet arcs is only a few km, e.g., 3, and during the active phase it becomes reduced by a factor of ten, to about 300 meters."

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APPENDIX 3.3B

Photography of the aurora from above*

"As the aurora lies above all clouds, photography from above is free from the limitations that clouds impose on photography from the ground. But the main advantage of photography from above over that from below is the greater sky area open to more direct view.

"The auroral light when most suitable for photography is disposed in thin sheets inclined to the vertical along the geomagnetic field lines. But the brightness is usually greatest near the lower edge, at a height h of order 100 km. The length of the bright portion along the field direction is much less than its horizontal extension, and often decidedly less than the horizontal dimension of the great auroral folds. To understand the large-scale geographical distribution of the aurora we need to know how the lower edges of the auroral sheets are disposed over the spherical surface S at height h; its radius is a+h, where a denotes the earth's radius (here taken to be 6370 km). Hence it is convenient to consider the appearance of this distribution on S, as seen from a viewpoint O. This point may be on the ground, or above the surface S, at a height H ($H > h$) above the ground. The distance of O from the earth's center C will be denoted by R; if O is on the ground, R = a, if it is above S, R = a + H.

"Consider the part of S lying within a cone with vertex C, axis CO and angular radius θ; let α denote its angular radius as seen from O, and e the

* Excerpted, with permission, from the forthcoming book: __Space Physics__, a collective work edited by Donald P. LeGalley and Alan Rosen, to be published earily in 1964 by John Wiley and Sons, New York.

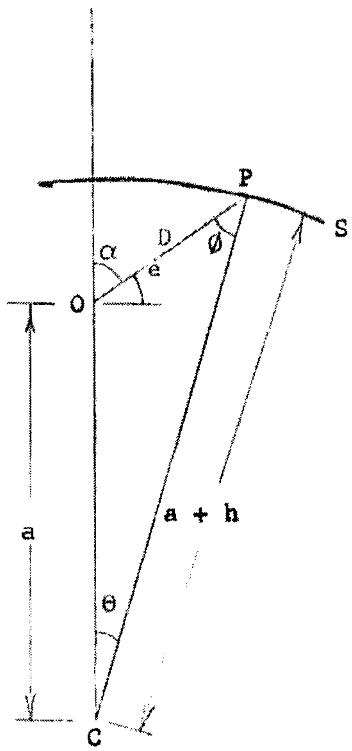

FIG. A

Viewpoint O on the ground

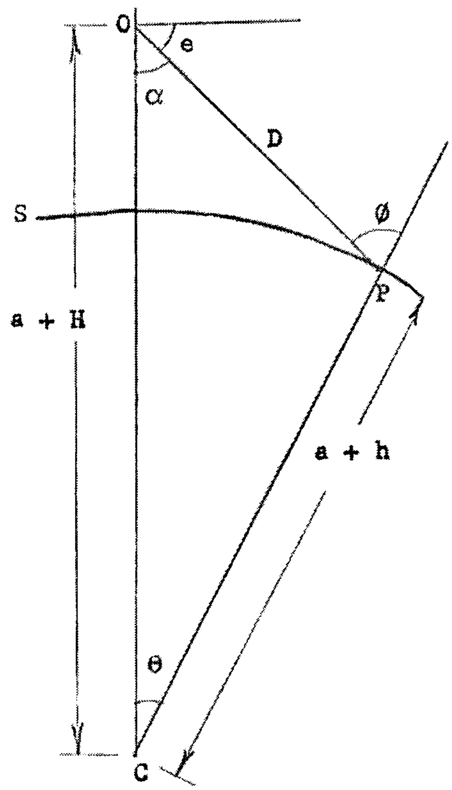

FIG. B

Viewpoint O above the ground

angle of elevation or depression, above or below the horizontal at O, of the line of sight from O to any point P on the border of this spherical cap (Figures A and B); in either case, e is reckoned as positive, and $e = 90° - \alpha$. From O the center of this cap is viewed directly ("full face"); elsewhere the view is oblique, and the greatest obliquity is at the border of the cap; it is measured by ϕ, the angle between the line OP and the normal at P to S; we take $\phi < 90^\circ$. Clearly

if O is below S, $\alpha = \phi + \theta$ if O is above S, $\alpha = \phi - \theta$ (1)

Let D denote the length OP, the greatest distance from O to any point on the spherical cap. By the geometry of the triangle CPO, we have:

$$\frac{a + h}{\sin \alpha} = \frac{R}{\sin \phi} = \frac{D}{\sin \theta} \tag{2}$$

"For an all-sky camera on the ground, the greatest possible camera aperture α is 90°, corresponding to zero elevation of the limiting line of sight OP. The value of ϕ is arcsin $a/(a+h)$; with the values a = 6370 km, h = 100 km, R = a, $\phi = 79.9^\circ$, and $\theta = 10.1^\circ$; in this case $D^2 = (a + h)^2 - a^2$, hence D = 1138 km. Thus, the view near the edge of the sky area photographed is very oblique, and it is difficult to recognize the distribution of the lower edges of the auroral arcs at low elevations. Even a small reduction of the limiting obliquity of view, for example from 79.9° to 75°, greatly reduces the corresponding sky area, of which θ is the simplest measure; for $\phi = 75^\circ$, $\theta = 3.85^\circ$, little more than a third of the full angular radius θ of the whole sky as seen from the ground; the area viewed is of course proportional to θ^2, and the reduction of area is therefore by a factor 6.9.

"The equation (2) are most easily solved by taking θ and ϕ as known, and computing α and H and D. Results thus obtained are given in Table A for O on the ground, and in Table B of O above S.

"If the desired maximum obliquity of view were 65°, the sky area viewed from the ground would have an angular radius of 2° (subtended at the center C of the earth); whereas from a height of 788 km above ground, θ for the same obliquity ϕ would be 10°, giving an area of view 25 times as great, with a somewhat smaller camera aperture; the nearest point on S in this case is 688 km from the camera, and the farthest point in the field of view is at a distance of 1372 km. The value $\theta = 10^\circ$, corresponding to an angular diameter of 20° for the field of view, would enable more than a fifth of the whole auroral cap to be photographed at once, and photographs taken from a satellite crossing this cap would give a good (though not quite complete) synoptic picture of the distribution of the aurora along and within the auroral zone.

"The exposure time would have to be set according to the height above ground and the brightness of the aurora, taking account also of the blurring of the picture because of the motion of the satellite."

Table A

Viewpoint on the ground

Angular radius of sky area viewed, θ	4°	3°	2°	1°
Limiting obliquity of view, ϕ	75.4	71.4	64.9	47.7
Limiting distance D, km	459.	352.	245.	150.
Camera aperture, α	79.4	74.4	66.9	48.7
Minimum angle of elevation	10.6	15.6	22.1	41.3

Table B

Viewpoint at height H km above the ground

This table shows at what height a camera must be, above the ground, in order to photograph (with camera aperture α) a sky area of angular radius θ (subtended at the center of the earth) with a limiting obliquity of view ϕ.

	$\theta=4^\circ$			$\theta=6^\circ$			$\theta=8^\circ$			$\theta=10^\circ$			$\theta=12^\circ$			$\theta=15^\circ$		
ϕ	α	H	D	α	H	D	α	H	D	α	H	D	α	H	D	α	H	D
o	o	km	km	o	km	km	o	km	km	o	km	km	o	km	km	o	km	km
65	61	335	516	59	471	771	57	622	1074	55	788	1372	53	973	1685	50	1284	2186
60	56	384	544	54	554	817	52	741	1143	50	943	1467	48	1169	1810	45	1553	2368
55	51	451	581	49	653	876	47	877	1231	45	1126	1589	43	1401	1972	40	1875	2605
50	46	522	628	44	766	951	42	1038	1346	40	1341	1748	38	1682	2183	35	2272	2919
45	41	604	688	39	899	1050	37	1232	1496	35	1607	1959	33	2031	2470	30	2779	3349

3.4 PLASMA AND SHEATH STUDIES

Submitted by: George R. Carignan, Lecturer, Department of Electrical Engineering, College of Engineering; and Director, Space Physics Research Laboratory.

Joseph E. Rowe, Professor of Electrical Engineering, Department of Electrical Engineering, College of Engineering; and Director, Electron Physics Laboratory.

The availability of a streaming low density unbounded plasma affords a unique opportunity to perform a variety of experiments. The problem of the sheath (especially the wake) which surrounds a body moving in a plasma such as the ionosphere has been of great interest to researchers in a wide variety of fields. Due to the extreme complexity of this problem, however, no satisfactory theoretical results have yet been obtained. The absence of any meaningful data on the sheath characteristics has added to the general lack of understanding. Thus the theories given so far have been based on mathematical models the physical justification for which is in most cases rather questionable.

The importance of an investigation of the sheath is twofold. Firstly, it will contribute to an increased understanding of plasma physics in general. Secondly, a thorough knowledge of the sheath is highly desirable in many technical applications which are critically affected by the presence of the sheath (such as the perturbation of the ambient plasma by an instrument supposed to measure the unperturbed plasma or the disturbance introduced into the ionosphere by a hypervelocity body such as a missile).

It is also of great interest to study the effects both on the sheath and the plasma itself of artificially introduced disturbances, such as the introduction of an electron beam, or coherent and incoherent radiation.

An electron beam experiment is of particular interest for an investigation of plasma stability against longitudinal oscillations. One of the proposed experimenters (E.G.F.) is presently engaged in a theoretical study under a NASA grant of the effect of the plasma stability conditions on the electron temperature in the ionosphere. By complementing this theoretical effort an experimental investigation of the effect of artificially induced instabilities would, therefore, also be of significant geophysical importance.

Description of experiments

In order to carry out the above mentioned investigations the following experiments are proposed:

1. Sheath probing

   (a) A complete point by point mapping of the sheath surrounding a variety of geometrically simple bodies (such as sphere, cylinder, cone, etc.) which are to be extended some distance away from the main vehicle. The mapping is to be done by movable probes which will measure local electron and ion density and energy distribution. In addition we propose to carry out a complete and continuous mapping of the sheath around the MOL vehicle itself. Aside from its scientific aspect we expect such a mapping to be of great value to many other experimenters whose data may be affected by the presence of the sheath and its changing configuration as a function of altitude, latitude, relative position of the sun, and solar activity.

   (b) In conjunction with the experiment described in part (1a), an exhaustive theoretical study is to be carried out using both analytical and numerical methods. Since the plasma remote from the MOL is unbounded, a rigorous one-dimensional theory can be developed and evaluated by comparison with experimental data. The applicability and appropriateness of various theoretical collision models and stability conditions can be studied with the experiments to be performed.

2. Electromagnetic wave propagation in the plasma

Further information on plasma properties and the importance of collisions may be obtained through wave propagation experiments. It is proposed to map the complete $\omega - \beta$ diagram for wave propagation in the ionosphere covering a frequency range extending from below to above the cyclotron and plasma frequencies. The experimental results are to be correlated with wave theories.

Other important and interesting experiments involve the propagation of artificial noise through the plasma and the examination of the received signal spectrum at multiple points to determine amplification or attenuation and phase shift. Multiple probe measurements should be made remote from the MOL and correlation techniques used to interpret the received data. The theoretical analysis of expected results should be made before the experiments are designed.

3. Electron and ion beam interactions

Noise generation (Whistlers) and instabilities in the ionosphere are allegedly due to charge-wave interactions and give rise to space-charge waves, cyclotron waves and magnetoionic waves. It is proposed to carry out experiments in which both modulated electron and ion beams are shot through the plasma. The modulation frequencies will be varied from below to above the plasma characteristic frequencies $\omega_c \sim \omega_p$. The importance of these experiments is that information can be obtained on the magnitude of energy exchange between charges and fields.

These proposed experiments will be analyzed using both nonlinear ballistic type analyses and by solving the nonlinear Boltzmann equation including collision effects.

Suitability of proposed experiments for MOL

A manned laboratory is ideally suited for such a series of experiments since the type of measurements to be taken must be flexible and of a large variety. Equipment will have to be moved, adjusted (e.g., collimation of electron beams), replaced by different equipment for different experiments, etc. Furthermore, it would be practically impossible to program all desirable experiments in advance since the necessity for certain measurements may arise only as a consequence of previous measurements.

Equipment aspects

A Langmuir probe would be used to map the sheath about the various geometric configurations employed. The bodies about which the sheath would be studied would have major dimensions in the order of several feet but could be made collapsible to minimize storage volume. The probes would be small (e.g., a 1mm diameter sphere) and would be mounted on the end of a telescoping boom.

Electronic equipment required to implement the proposed studies would include principally the probe voltage source and current detector, an electron beam generator (neutralized to prevent charge build up), noise signal generator, a spectrum analyzer, and a multiple probe detection and signal correlation system. The following table shows gross estimates of weight, volume, and power requirements.

Table I

Item	Weight	Volume	Power
Langmuir Probe	4 lbs.	250 in^3	4 watts
Electron Beam Generator	16 lbs.	500 in^3	12 watts
Noise Generator	5 lbs.	400 in^3	15 watts
Spectrum Analyzer	12 lbs.	500 in^3	10 watts
Detection and Correlation Equipment	10 lbs.	600 in^3	10 watts
Geometric Models	5 lbs.	500 in^3	
Miscellaneous	10 lbs.	500 in^3	10 watts
TOTALS	62 lbs.	3,250 in^3	61 watts

3.5 MASS SPECTROMETER EXPERIMENTS

Submitted by: Leslie M. Jones, Professor of Aeronautical and Astronautical Engineering, Department of Aeronautical and Astronautical Engineering, College of Engineering; and Head, High Altitude Engineering Laboratory.

Background

The adaptation of a quadrapole mass spectrometer (massenfilter) to measure atmospheric constituents has been performed successfully by the High Altitude Engineering Laboratory using sounding rocket techniques. At the present time, a massenfilter which will have sufficient sensitivity — without loss of resolution — to make neutral particle and positive ion composition measurements up to altitudes of 900 km is being developed for installation aboard POGO, an unmanned satellite. It has become apparent during the course of this work that the use of a manned vehicle would assure the attainment of accurate quantitative results with this instrument. In-flight calibrations — impossible aboard an unmanned vehicle — could be performed; the present need for requirements for state-of-the-art electronic equipment, owing to remote operation, could practically be eliminated; precise measurement of trace constituents could be made by suitable in situ instrument modification and manual control; and, finally, the operation of the massenfilter could be altered to meet existing environmental conditions since the operator can edit the data as he obtains them and recognize data patterns which would indicate the nature of succeeding experiments.

Unique advantages of MOL

Operation of a massenfilter aboard an MOL provides unique advantages which will ultimately provide aeronomy data having previously unattainable scope and accuracy as well as a more complete understanding of the operation of the spectrometer itself. Among these advantages are the following:

1. Fully recoverable data

The operator can edit data as they are received, compare it with previous data in order to recognize developing trends, adjust his instrumentation to investigate apparent anomalies or questionable data, and screen the data in order that only pertinent data are transmitted. Performing a preliminary analysis of the raw data prior to subjecting it to the filtering action of a limited bandwidth data link provides data which have practically no degradation.

2. Space environment

In order to develop a massenfilter for planetary work, facilities for the production of extremely high vacuums are necessary, i.e., systems capable of maintaining a pressure of 10^{-12} mm Hg with an operating instrument inside. Earth-bound experiments would require vacuum systems of great magnitude and of state-of-the-art development or beyond. A vacuum system of modest capability, placed aboard an MOL, would more than satisfy any vacuum requirements.

Refinement of the positive-ion massenfilter requires a simultaneous simulation of environmental mean-free path and Debye length, the latter being the characteristic dimension of the plasma sheath that is produced as a result of the hypersonic motion of the vehicle. Since such simulation cannot be performed in a ground based facility, any definitive data pertaining to the nature of the plasma sheath, particularly with respect to its influence on measurements, and the use of compensating devices, such as guard rings, must await MOL experiments.

3. More sophisticated experiments

More elaborate and sophisticated spectrometer experiments can be performed on an MOL than is possible with an unmanned vehicle. For example, the scope of the basic experiment can be extended to include the following (listed in order of increasing complexity):

a. Manual variation of instrument of resolution, sensitivity and operating point to optimize instrument capabilities with respect to existing environmental conditions.

b. Selection of massenfilter radio frequency best suited to analysis of particular group of gases under study.

c. In-flight calibration procedure.

d. Optimization of resolution vs sensitivity by proper selection of massenfilter inlet port that is best suited to gases being analyzed.

e. Investigation of plasma sheath effects on ion spectroscopy

   i) various simple-geometry devices (guard rings, grids, tubes, etc.) would be placed over the entrance aperture of the spectrometer and their influence noted.

f. Investigation of the effects of the ion source upon ambient composition

   i) interchangeable ion sources fabricated from different materials and having various surface finishes would be used to study accommodation coefficients, recombination processes and contamination.

   ii) interchangeable ion sources of various geometrical configurations would be used to study the focussing effects of their associated fields.

iii) the angle-of-attack of incident particles would be varied with respect to the axis of the instrument to detect possible introduction of surface contaminants.

4. Judgment and adaptability of man

Present state-of-the-art limitations make impossible the construction of remotely operated equipment having a degree of sophistication sufficient to perform the more elaborate experiments outlined in (3) above. Man would be necessary to carry out many of the operations. Even for some of the less elaborate extensions proposed above, the degree of data redundancy would be high resulting in an extremely inefficient use of the instrument and data transmitting link. Man's judgment would allow him to edit the data and modify the experimental procedure in accordance with his observations. In addition, man has the capability of correlating his results with other simultaneously-received data and performing related experiments on the basis of intelligent evaluations of these correlations. Finally, he has the ability to react properly to special or unique events of importance for the aims of his experiments. All of these capabilities can be attained only by an MOL.

Two other important benefits as regards this experiment are derived from the presence of man. First, a greater zero drift of the d-c electrometer associated with the spectrometer can be tolerated without degradation of data since on-the-spot corrections are possible, thereby resulting in a greater effective electrometer sensitivity — at least an order of magnitude greater than that to be used in an unmanned vehicle — without loss of speed of response. Second, at all times the spectrometer can be adjusted for optimum resolution. A "conservative" setting of the instrument resolution is required for remote operation to prevent complete loss of data in the event of power supply voltage drift.

Activity outline

Massenfilter

1. Description of scientific activities

Measure neutral particle and positive ion composition of the ionosphere; measure effects of plasma sheath upon instrument; measure effects of ion source upon ambient; develop operational characteristics of massenfilter beyond that possible through earth-bound experimentation. Run number, time, orbital position, MOL orientation with respect to flight path, calibration data, verbal description and comments should be recorded in addition to spectral data.

2. Scientific benefits and potential uses expected

   a) Obtain more realistic model atmosphere by incorporation of latitude and magnetic influences. (Inclination of approximately 85° would be desirable)

   b) Clarify presence, persistence and influence of ambient thermodynamic and ionic non-equilibrium especially in vicinity of magnetic poles and edge of earth's shadow. (Reported negative saturation of electrometers near southern magnetic anomaly.)

   c) Determine the nature of plasma sheath on MOL and its influence on ion spectrometry.

   d) Development of a mass spectrometer whose behavior over a wide range of conditions is precisely known; subsequent use of this instrument in planetary studies.

3. Advantages provided by MOL as contrasted with an unmanned system for this scientific activity

   a. Recoverability

   Since man will be the observer, spectra and related data will be available in the following forms: photographs, recordings with comments, notes which contain questions, judgments, correlations, and conclusions based upon his on-the-spot observations of essentially unfiltered data and events. His instruments will introduce the only bandwidth limitations in the system.

   b. Selectivity

   Man will edit data as received; compare it with previous spectra; recognize data patterns related to time, position, special events, etc., and vary instrument parameters and configuration to attain optimum capabilities. Faulty equipment can be replaced or repaired immediately thereby minimizing loss of data and maximizing utilization of equipment.

4. Equipment requirements

To insure flexibility a number of massenfilters having appropriate ranges of capability would be produced within the High Altitude Engineering Laboratory in a manner similar to that used in the development of the rocket and unmanned satellite massenfilters. Appropriate back-up units and ancillary test and calibration equipment would also be supplied.

5. Requirement studies needed to improve our capabilities in this scientific field

   a) Investigate improvement of resolution, sensitivity, and large mass number operation of massenfilter

   b) Study of results from unmanned satellites to aid in experiment design for MOL

c) Attain better theoretical understanding of plasma sheath and surface accommodation coefficients

d) Investigate operation of ion source to develop improved operational characteristics

6. Potential experimenters

a) Requirement studies - utilize present in-house personnel.

b) In-flight missions - not yet determined.

Equipment aspects

1. Weight: 200#

2. Volume 40 cu ft

3. Power 150 watts avg.
250 watts peak

4. Man time/day 10%

5. 3 access ports to ambient

6. Orient experiment with respect to flight path.

4. GEOLOGY AND MINERALOGY

4.1 COLLECTION OF MICROMETEORITIC MATERIAL

Submitted by: E. Wm. Heinrich, Professor of Mineralogy, Department of Geology and Mineralogy, College of Literature, Science, and the Arts; Curator of Mineralogical Collections.

William C. Kelly, Associate Professor of Geology, Department of Geology and Mineralogy, College of Literature, Science, and the Arts.

It is proposed that a suitable apparatus be devised and attached to the exterior of the MOL for the purpose of collecting micrometeorites and space dust for detailed mineralogical and chemical studies.

The requirements for such a device and its operation include:

1. Panels coated with vacuum-resistant greases.
2. Apparatus for exposing successively, for timed intervals, a series of such panels.
3. Successive removal of exposed panels, at designated times.
4. Storage of exposed panels in sealed containers.

It would also be desirable to be able to obtain comparisons between impact densities (via microphone system) and collection densities. Expectable types of materials include both magnetic and non-magnetic particles, probably in the size range of appreciably smaller than one micron to perhaps 0.5 mm.

Previous sources of possible micrometeoritic material and alleged cosmic dust include:

1. Adhesive plates exposed to the atmosphere in regions of low industrial activity.
2. Rain water.

3. Deep-sea deposits and their fossil equivalents.

4. Polar ice.

5. Sedimentary evaporite formations.

6. Upper atmosphere samples.

All are subject to an enormous degree of terrestrial contamination, which not only produces dilution, but casts suspicion on the origin of any presumed extraterrestrial particles that do not, in either composition or texture, show affinities to larger meteorites.

Our estimate of the weight and size requirements for such an apparatus are:

1. 10 10 x 10" coated plates, plastic backing, aluminum frames, @ no more than 1 lb. each.

subtotal — 10 lbs.

2. One air-lock return chamber of square cross section 12 x 12" and 3/4" depth, which could be evacuated and supplied with a filter to prevent dust contamination upon repressuring.

10 lbs. — estimated weight

3. A sample holder casette for storage of unused and subsequently exposed plates under MOL pressure. Estimated dimensions 10 x 12 x 12".

5 lbs. — estimated weight

Total —— 25 lbs.

One of the principal advantages of the collection of such material from an MOL would lie in the ability of the investigators to check periodically the nature and quantity of materials obtained and therefrom to direct the operators in MOL to vary exposure times, procedures, and directions.

It is anticipated that any particles collected would be investigated by means of the following general techniques:

1. Chemical analysis, principally by means of the electron microprobe.
2. Shape studies by means of the electron microscope.
3. Mineralogical and textural studies under optical microscopes, with both transmitted and reflected light.
4. Analyses for various isotopes, both radiogenic and non-radiogenic.

4.2 X-RAY ANALYSIS OF MEMBERS OF THE SOLAR SYSTEM

Submitted by: Paul L. Cloke, Assistant Professor of Geology, Department of Geology and Mineralogy, College of Literature, Science, and the Arts.

It is proposed that consideration be given to X-ray analysis of suitable objects in the solar system by instruments in a manned satellite. The basic principle involved is that radiation from the sun will cause the secondary emission of characteristic X-rays from objects so irradiated. By analyzing the wavelength and intensity of these secondary X-rays, information relative to the chemical composition of the object can be obtained. The proponent is aware that a similar project is underway, under the aegis of Philips Electronic Instruments Company, for analysis by instruments in unmanned satellites. Several advantages accrue from the use of manned equipment, so that the results would complement and extend the studies from unmanned satellites.

Advantages of performing this type of study from a manned vehicle include:

1. Better aiming, so that small parts of the moon could be analyzed independently. If the X-ray source is intense enough, it might be possible to analyze asteroids, Mercury, or other planetary satellites without atmospheres.
2. Analysis for all elements heavier than and including sodium. As I understand the Philips Plan, one analyzing crystal and one detector will be present for each element selected for analysis. With a manned instrument a complete scan of wavelengths seems feasible.

3. Greater choice of analyzing crystals to permit more versatility in eliminating interferences and achieving greater sensitivity than otherwise possible. Some of these interferences may not be evident in advance of the start of measurements.
4. Greater versatility because of the possibility of inserting absorbing foils to increase selectivity of elements analyzed in difficult cases of interference.
5. Perhaps greater versatility in setting or choosing cut-off limits in pulse height selection.
6. One instrument for all elements, rather than a separate instrument for each element (as I interpret the Philips proposal).

A suitable instrument for this study, at present located in this department, weighs about 500 lbs., requires about 500 watts of power, and occupies a total space of about 2 ft. x 2 ft. x 6 1/2 ft. No doubt this could be miniaturized to a great extent, but I have no experience with miniaturization and can give no estimates as to the reductions possible. Presumably this could be determined easily by inquiring of Philips Electronics Instrument Company.

4.3 TECTONIC INTERPRETATIONS

Submitted by: Edwin N. Goddard, Professor of Geology, Department of Geology and Mineralogy, College of Literature, Science, and the Arts.

It would be of considerable interest to be able to receive copies of any high-level, high-resolution photographs, both visible and infra-red, of continental areas that would become available through MOL operations for:

1. Tectonic interpretation of lineaments and other large scale structural features.
2. Tectonic interpretation of such features accompanied by analysis of data on anomalous radioactivity (possible ?) and magnetism.

5 PHYSICS

5.1 EXPERIMENTS IN LIQUID TRANSPORT PHENOMENA

Submitted by: John A. Clark, Prof. of Mechanical Engineering, Dept. of Mechanical Engineering, College of Engineering.

Experiments are proposed which involve the steady and transient convection of liquids in closed containers in force fields ranging from 20 to essentially zero times normal gravity. Owing to the short duration of terrestrial zero-gravity experiments, it is desirable to perform such experiments over a longer period of time. Measurements of this kind can best be obtained in a vehicle which itself is in the low gravity environment of orbital flight. For meaningful observations to be obtained in a controllable experiment, it is furthermore desirable that an experienced human observer be present. This set of conditions would be ideally achieved in a manned orbital laboratory.

The aforementioned short duration zero-gravity measurements have indicated that nucleate boiling heat transfer is relatively uninfluenced by gravity while maximum heat flux and film boiling are significantly gravity-sensitive. These results have been qualitatively substantiated by theoretical studies. However, of prime concern to most space operation is the performance of boiling systems over extended periods. In zero-gravity environments, the problem arises as to the configuration and disposition of vapor relative to the heating surface in these systems. The performance of thermal equipment in space will be significantly influenced by this factor. Hence, it is proposed that a zero-gravity boiling heat transfer experiment be conducted in an orbiting laboratory in which quantitative measurements can be made of heat flux, surface temperatures and liquid-vapor configuration. This latter would be obtained by high speed motion and still photography. From data such as these, additional information concerning bubble mechanics at low gravity, the influence of pressure, velocity and sub-cooling could be gathered. This kind of long-time measurement is impossible to obtain on the earth.

A second problem of great current interest, which is ideally suited to study in an orbiting laboratory, is that of liquid-vapor configurations in closed containers and convection patterns in both phases. This problem is associated with the storage and transport of liquid propellants in space. Presently very little is known concerning the positioning of liquid and vapor in closed containers at low gravity and subjected to unsteady solar heat flux. A knowledge of this and the heat and mass transport phenomena across the liquid-gas interface will permit the reliable design of vent systems giving optimum (minimum) propellant loss.

To obtain this information it is proposed that partially filled models of liquid containers be introduced into the sunlight from an orbiting laboratory and measurement be made of surface temperatures and internal pressure. Sufficient viewing ports should be provided on the models to permit a photographic study of the vapor-liquid configuration.

Power requirement for these two experiments is estimated to be 1 kw.

6 BIOSCIENCES

6.1 PHYSIOLOGICAL EFFECTS OF WEIGHTLESSNESS

Submitted by: Brian F. McCabe, M.D., Asst. Prof. of Otorhinolargngology, Dept. of Otorhinolargngology, Medical School.

1. Changes in Vestibular Nerve Activity at Prolonged Zero G

Background: It is known that an impulse pattern change is generated over the vestibular nerve in response to zero g effect upon the otolithic apparatus of the inner ear, as well as to a changing g. The brain, receiving these impulses, acts on the information, relaying it to other centers in a sometimes deleterious distribution. It is believed, for example, that sickness resulting from weightless parabolas is due to abnormal otolithic stimulation. Whereas continuous weightlessness has seldom caused sickness (cosmonaut Titov) the periods of exposure have been relatively short and this reaction may be a matter of individual susceptibility. If prolonged continuous weightlessness can cause g-sickness, otolithic origin is more likely than confusional information resulting from ears, eyes and muscle. Correlation of vestibular nerve activity with behavior will provide basic information in this regard.

Animal: The cat, squirrel monkey or macaque monkey.

Method: Implantation of electrodes in the ganglionic portion of the vestibular nerve, amplified through a self contained unit buried surgically within the animal. Signals may be amplified by a second unit within the MOL for telemetering to earth or tape recorded in the MOL. Information is processed by computer.

2. Vestibulometry at Fractional G Loads

Background: The degree of interdependency between the two portions of the inner ear sensor mechanism, the semi-circular canal system and the otolithic system, is not known but their proximity and common boundaries as well as their cellular similarity certainly suggests an interdependency. The MOL would be an ideal environment for the determination of the degree of augmentation or facilitation of the semi-circular canal apparatus by the otolithic apparatus. This study would be in the basic category.

Method: Cold air actuated nystagmus (involuntary oscillation of the eyeballs) recorded by electronystagmography at incremental g loads, from 0 to 1 using non-rotating and rotating modules. (This could as well be done in the Gemini capsule, using 0 and 1 g, without increment.)

3. Effects of Prolonged Zero G on Bone Architecture and Calcium Metabolism

Background: The arrangement of bony lamellae are such as to retain the integrity of the skeletal system under a relatively constant force acting along definite vectors. Ablation may materially interfere with the structural integrity of bone because bone metabolism is a dynamic process. That bone and calcium metabolism may be affected has already been suggested by the finding of excessive urinary calcium in one cosmonaut. It is not inconceivable that after six months of weightlessness an astronaut may step from his capsule, stumble, and break both legs.

Animal: Human and macaque monkey.

Method: Periodic determination of serum and urinary calcium and phosphorus, and alkaline phosphatase, over three to six months. Pre and post exposure radiographic detail of proximal femur architecture by special techniques.

Method: (Animal) The same biochemical analyses, including bimonthly autoradiographs of long bones after tagging bone calcium and/or phosphorus with radioisotopes. Periodic sacrifice of a series of animals, with determination of total calcium and phosphorus, total bone mass, analysis of bone protein, and microanalysis of architecture by light and electron microscopy, and microautoradiography.

4. The Effect of Zero G on Musculoskeletal System Growth

This would be a morphologic study using newborn Kangaroo rats (3 – 6 months).

5. Determination of Cause of Post-Zero G Hypotension (Lowered Blood Pressure)

Maintenance of peripheral vascular tonus by rotating pressure cuffs on proximal portions of limbs, with alternation of subjects between 0 and 1 g modules. Pituitary hormonal studies should be included.

6. Electromylographic Studies of Weight-bearing Muscle During Prolonged Zero G

7. Muscle Metabolism Studies During Prolonged Zero G

To include electrical studies and creatine determinations.

6.2 MANUAL PERFORMANCE PREDICTION METHODS FOR SPACE LABORATORY

Submitted by: Walton M. Hancock, Professor of Industrial Engineering; Chairman, Department of Industrial Engineering, College of Engineering.

The Industrial Engineering Department of The University of Michigan, for the past ten years, has been conducting research on methods of predicting the performance of humans on manual operations such as those found in industrial processes. This work has been primarily supported by the Methods-Time Measurement Association which is an association established for the development of these types of prediction techniques.

During the last two and one-half years, we have been interested in developing learning curves from manual operations. However, the contemporary methods of developing learning curves have not, in our opinion, been found to be completely satisfactory primarily because the curves have been developed empirically and very little insight has been gained into the reasons why they behave the way they do. Consequently, we have been running experiments in the laboratory and also in industrial firms to attempt to obtain prediction techniques which can be generally applied. With a specially built computer, we have been able to develop learning curves for the basic elemental motions that the people use. This work has resulted in prediction equations for these elemental motions, which can then be combined to predict the rate at which a subject will learn a manual operation as a function of the complexity, the length of time, initial performance level, and the elemental mix of the operation.

We have also been investigating the types of dexterity tests that have been administered to various types of industrial employees which would enable us to predict initial and final performance on the subjects used in our experiments. Our basic interest in the testing procedures has been twofold; (1) in order to predict the rate of learning of an individual in a manual operation, it is necessary to know at what level he starts, and (2) the tests should reveal, if at all possible, the basic characteristics of people that are necessary to the attainment of high final performance levels.

Our results with the Purdue Manual Dexterity Test, in conjunction with our experiments on learning curves, have revealed the following information which is preliminary at the present time, but which will be published in the next year:

A. The correlation using a multiple regression analysis of the various methods of running the Purdue Manual Dexterity Test and the performance on the manual operations is very high with initial levels of performance. (.90 and above)

B. The correlation with final performance, after all learning has ceased, is very low. (.19 or below)

Another observation which has come from the learning curve research is that subjects learn the various elements such as the Reach, Grasp, Move, and Position at entirely different rates. In general, the learning rates are negative exponential with exception of the higher skilled elements, such as position, which appear to be linear and which occur over much longer periods of time.

The above observations have led us to conclude that there are no developed and/or widely used basic measures of the true potential of a person to perform manual operations. As a consequence of this conclusion, we have been very interested in developing very simple tests which will provide these basic measures and give a much more reliable prediction of potential performance. We feel that these basic measures are as follows:

A. Basic motor ability where sensory input is zero.

B. Basic decision ability up to 16 alternatives with consideration of error rates.

C. Some measure of intelligence.

Proposal

Manual operations will, of course, have to be performed in space. It is important to be able to predict the time and learning curves of these operations in order to schedule activity properly and to design future space stations in the most effective manner. In addition, the most efficient use can be made of time actually spent aloft.

The basic objective of the study would be to develop measures of change in performance as a function of the different environmental conditions encountered in space. At the present time we feel that we do not have the reliable predictors of an individual's true potential performance even on the ground. It is felt that if these basic criteria could be well developed, where potential performance under many types of conditions on earth would be thoroughly investigated, we would have a very good basis for attempting to predict space performance. The environmental conditions found in space could be simulated in certain cases where the equipment would be available to reduce the effects of gravity and change in atmospheric conditions according to those that are being considered for the space laboratory. These tests would provide certain information which could be used to modify the predictors for operations in space. However, the prolonged effects of reduced gravity or change in atmospheric conditions may effect different results than can be found under simulated short term conditions. Because of this factor, it would be necessary to develop and design simple operations which could be performed in the space capsule in order to finally validate the predictors.

6.3 ENVIRONMENTAL CONSTRAINTS ON FISH BEHAVIOR PATTERNS

Submitted by: Karl F. Lagler, Prof. of Fisheries and Chairman, Dept. of Fisheries, School of Natural Resources; and Prof. of Zoology, Dept. of Zoology, College of Literature, Science and the Arts.

If reflection and radiation characteristics of large bodies of water can be measured successfully with satellite instruments, significant contributions can be made to the understanding of fish behavior patterns and the existence of environmental constraints which affect some of these patterns. There are listed below some questions which might be answered by the proposed project:

(1) Can the high-seas locations of schools of certain animals be detected? Among the fishes, tunas have body temperatures some degrees above the water, as of course do whales, porpoises and dolphins all three groups of which are mammals hence warmblooded. Location would be of value in the study of migration (routes, factors) and of exploitation through harvesting the animals.

(2) Can areas of upwelling in coastal and offshore areas be detected in the oceans and in freshwater bodies such as the Great Lakes? Upwelling brings cool, nutrient-laden waters to the surface and may serve to concentrate exploitable organisms. If locations are known, fishing effort may be directed there.

(3) Can offshore water temperatures be related to inshore ones, including detection of currents which may affect this relationship? This relationship is relatively unexplored yet, and must also be related to the distribution and abundance of certain organisms.

(4) Can oceanic surface temperatures and currents be related to plankton abundance and distribution? Plankton is the microscopic plant and animal life that composes the first link in the food chains of higher animals of use as food or raw material for industry (e.g., herring).

(5) Relative to basic productivity by plant plankton, can the differences in reflected versus absorbed solar energy be measured by space vehicular instruments?

7.1 DEVELOPMENT OF OPTICAL DATA-PROCESSING EQUIPMENT

Submitted by: John M. DeNoyer, Assistant Professor of Geology, Department of Geology and Mineralogy, College of Literature, Science and the Arts; Associate Research Physicist; and Acting Head, Acoustics and Seismics Laboratory, Institute of Science and Technology.

Philip L. Jackson, Associate Research Engineer, Acoustics and Seismics Laboratory, Institute of Science and Technology.

George W. Stroke, Professor of Electrical Engineering, Department of Electrical Engineering, College of Engineering; Research Engineer; and Head, Electro-Optical Sciences Laboratory, Institute of Science and Technology.

Nature and purpose

It is assumed that man is not a specialist in all experimental areas on MOL. Therefore, he will require assistance to analyze even the simplest experimental data, for purposes of further experimentation, decision, transmission, etc.

The classes of possible data which may arise from MOL experiments will undoubtedly include

1. Data available in optical form (i.e., pictures from astronomical, meteorological, infrared, radar, and similar origin, as well as of course optical spectra).
2. Data in electrical signal form (i.e., counters, magnetometers, etc.).
3. Other data, i.e., mechanical, pressure, etc.

All of the data of electrical and other character can be easily reduced to permanent film records or to non-permanent light-sensitive transducers (such as thermoplastic media, etc.) when applicable. Sound-recording techniques on photographic film form a typical example.

Advantages of optical diffraction computing method

A dramatic two-dimensional information storage capability is a singular characteristic of optical images. It is basic to the compactness and speed of optical image computing, as compared to digital or non-optical analogue computers. For example, 1 million or so bits per square inch can be stored and used for immediate correlation with some reference standard, at the speed of light.

Scientific benefits

Several different scientific benefits should result from the use of the proposed optical data (or signal) processing equipment on MOL. Among those, one could single out the following:

1. New experimental information (optical, magnetic, electro-magnetic, meteorological, etc.) that needs to be immediately correlated or compared to some reference "standard"; correlation or comparison can be most easily achieved by optical correlation and optical matched filtering techniques.
2. Time-varying experimental information that must be correlated; again optical correlation provides practically instantaneous result.
3. Signal selection and signal-to-noise improvement in experimental information can be most effectively carried out by optical filtering and signal processing techniques, and helps considerably in any storage, telemetering bandwidth, and so on.

The same optical equipment as used in the correlation computing under Paragraphs 1 and 2 is used for the signal selection and noise reduction.

Conclusion

Optical filtering and computing has been shown to have considerably greater computing capability where applicable (that is in the MOL experimental data processing cases discussed) than any comparable electronic processing. Moreover, optical computing has been successfully used to solve problems not yet solved on any electronic computers (i.e., dispersion filters), because of the immediate simplicity of optical computers.

Equipment characteristics

Size: (Complete optical computing system, including electro-optical converter of electrical to optical data) About 1 cubic foot.

Power: About 2 watts.

Weight: About 10 lbs.

Equipment Development Schedule: 2 to 3 years

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7.2 AUTOMATIC LIBRARY FOR THE MANNED ORBITING LABORATORY

Submitted by: Dean H. Wilson, Research Engineer; Head, Industrial Systems Research Laboratory, Institute of Science and Technology; and Lecturer, Department of Industrial Engineering, College of Engineering.

During an experiment, the scientist must often refer to previous results in order to help understand the phenomena which he has observed. In addition he may need standard analysis tools such as tables and charts. The experimenter in space is no exception: in fact, due to the uniqueness of the experimental environment and the relatively extended time period, this need for supporting information becomes particularly important. It may be that the results of one experiment will trigger a whole set of new experiments barely considered before the trip. Thus, it is proposed here to build a flexible library designed to fit the personal characteristics of the scientist and the experiments currently being conducted. Upon request, or possibly in anticipation of a request, the system would automatically search, retrieve and send the information to the scientist. In this way the scientist would have at his disposal both sources of information - personal communication via radio as well as library facilities.

In general the library material (reports, tables, graphs, technical documents) will be stored at a ground station. The space laboratory will contain only the inquiry console. Although several mechanizations will be investigated, a likely candidate is an inquiry console which consists of a cathode ray tube and associated console. The console would be one of the ways in which the experimenter could request information. For example, to retrieve a report, author and subject would be keyed or dialed into the console, the request transmitted to a ground station, the report retrieved, transmitted and displayed on the CRT.

The general approach for developing the automatic library system is described in the following paragraphs.

A. Initially, the contents of the libraries needed to support the experiments to be performed in the MOL will be determined. A system will be designed so that the appropriate information in the libraries can be retrieved rapidly on request. In addition, a method for adding recent information to the libraries for the duration of the flight will be devised. This information storage and retrieval system will be implemented by a digital computer.

B. Preliminary testing will be done by substituting the automatic library for the personal library of a researcher at The University of Michigan who is running experiments similar to some of those which will be performed on the MOL. At this time the adequacy of the library contents, the design of the retrieval system, and the effect of the personal characteristics of the scientists will be evaluated and the system redesigned.

C. The results of this preliminary testing on different scientists and experiments will be generalized and the system parameters developed.

D. Final testing will simulate remote conditions of the MOL. Scientists removed from the normal scientific environment, such as occurs on expeditions to the Antartica, will be serviced by the automatic library. Experimenters participating in the Gemini flight should be included in this final testing phase.

E. Two prototypes of the system hardware will be built and tested.

F. Finally the automatic library will service the scientists planning to participate in the MOL for a period of time before they go aloft. This will give the scientists experience with the automatic library while at the same time allowing the library system to adapt to the particular characteristics of the scientists.

V

RESEARCH CAPABILITY OF THE UNIVERSITY OF MICHIGAN

The University engages in an unusually extensive and varied program of basic and applied research, through its seventeen schools and colleges and its many research institutes, centers, and bureaus. This program totalling nearly $36,000,000 during the past fiscal year, came from the federal government, industry, foundations, the State of Michigan, and endowment and other University funds. The program ranges broadly over nearly all disciplines, and varies from studies in specific disciplines carried on by individual members of the teaching or research staff to complex interdisciplinary projects involving the coordination of a number of interrelated tasks of substantial magnitude.

The University has had a continuing interest and involvement in space research since World War II. Its current program in space and space-related research is large and varied, representing many scientific fields. The program includes projects for the collection of scientific data on the upper atmosphere, studies of space navigation, guidance, and communications, ballistic missile radiation analysis, remote sensing of the terrain and of aerospace objects by multispectral imaging techniques, space radio astronomy, solar astronomy, and space vehicle design. Some measure of this program is provided in the issue of Research News, "Space Research at the University", which is presented as Appendix A of this document.

The efficient management of large-scale projects is effected by means of organized research units within the University having the administrative and technical capabilities to handle the major responsibilities involved. Each of these research units conducts an extensive research program, carried out in most cases by its own full-time staff, with active participation by members of the teaching faculty and graduate and undergraduate students. The research staff has available to it extensive facilities and equipment and is aided by every type of supporting service necessary to the performance of its tasks.

The work of the University's professional personnel is aided by a large staff who provide assistance of all types necessary for the support of research projects. Direct technical assistance is provided by fully organized operating staffs for equipment design and construction, analog and digital computation, photography, report preparation, library activities, and aircraft and automotive operation. The Sponsored Research Business Office performs all necessary business services, including accounting, purchasing, property control, travel, contracting and subcontracting functions.

The University's continued competence and interest in space and space-related research is ensured by the extent of its current participation in the nation's space program. It is in a position to contribute additional support to this program over a broad range of disciplines and at any required level of effort ranging from individual studies to projects of considerable magnitude and complexity.

VI

BIOGRAPHIES

In this section, biographical summaries are presented for members of the teaching and research faculty of The University of Michigan who have proposed experiments contained in this document or have otherwise indicated an interest in the Manned Orbiting Laboratory program.

Name: BARTMAN, Frederick Lester

Born: July 22, 1919, in Milwaukee, Wisconsin
Married (four children)

Education and Experience

BS, (E.E.), University of Wisconsin, 1941
MS, (E.E.), Stevens Institute of Technology, 1945
MA, (Math.), University of Michigan, 1951
Graduate Studies, Princeton University, 1945-48

7/41-12/41, Student Engineer, Westinghouse Electric and Manufacturing Company
1942-45, Junior Engineer and Design Engineer, Westinghouse, Lamp Division
2/42-8/42, Instructor (night school), Rutgers University
1945-48, Assistant Physicist, Palmer Physical Laboratory, Princeton University
1948-present, Research Engineer, University of Michigan Research Institute
1956-present, Lecturer, in Aeronautical Engineering, University of Michigan

Professional and Honorary Societies:

American Physical Society	1947-present	Member
Institute of Radio Engineers	1943-present	Member
Mathematical Association of America	1951-present	Member
American Rocket Society	1959-present	Member
Eta Kappa Nu	1940-present	Member
Sigma Xi	1947-present	Member

Professional Publications and Books:

"Falling Sphere Method for Upper Air Density and Temperature" (with others), J. Atmos. Terr. Phys., Spec. Suppl. 1, 1954.

"Upper-Air Density and Temperature by the Falling-Sphere Method" (with L. W. Chaney, L. M. Jones, and V. C. Liu). J. App. Phys. Vol. 27, No. 7, pp 706-712, July, 1956.

"Satellite Drag and Air-Density Measurements" (with L. M. Jones) Scientific Uses of Earth Satellites, J. A. VanAllen, ed., Univ. of Michigan Press, Ann Arbor, p. 85, 1956.

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"Rocket-Grenade Measurements of Temperatures and Winds in the Mesosphere over Churchill, Canada" (with W. G. Stroud, W. Nordberg, W. R. Bandeen and P. Titus) Jour. Geoph. Res. Vol. 65, No. 8, pp 2307-2323, Aug. 1960. Reprinted in Space Research, H. K. Kallman Bijl (ed.), North-Holland Publishing Co., Amsterdam, pp 117-143, 1960.

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"An Aerodynamic Method of Measuring the Ambient Temperature of Air at High Altitudes" (with V. C. Liu, E. J. Schaefer) UMRI Report on Contract DA-36-039-SC-32307, July 1950.

"A Simplified Falling-Sphere Method for Upper-Air Density" (with L. M. Jones) UMRI Report #2215-10-T, Contract AFCRC-TN-56-497, June 1956.

Conference Reports

"D. C. Analog Computer Survey of Trajectories of Spheres Falling Through the Upper Atmosphere", Ann Arbor Meeting of Association of Computing Machinery, June, 1954.

"The Grenade Technique for Stratospheric Temperature Soundings", 15th Annual Conference of the Instrument Society of America, New York City, September, 1960

Listed in:

American Men of Science

Member of:

Rocket and Satellite Research Panel.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

NAME: William P. Bidelman

TITLE: Professor of Astronomy

DATE OF BIRTH: September 25, 1918

EDUCATION:

S.B., Harvard, 1940
Ph.D., University of Chicago, 1943

EXPERIENCE:

Professor of Astronomy, The University of Michigan, 1962 to the present
Associate Astronomer, Lick Observatory, University of California, 1957-62
Assistant Astronomer, Lick Observatory, University of California, 1953-57
Assistant Professor of Astrophysics, University of Chicago, 1948-53
Instructor in Astronomy, University of Chicago, 1945-48
Physicist, Ballistic Research Laboratory, Aberdeen Proving Ground, 1943-45
Assistant at Yerkes Observatory, University of Chicago, 1941-43

PUBLICATIONS:

(Somewhat incomplete; joint papers sometimes not included, nor very short notes and abstracts when a later paper covering the same material is listed)

"A Discussion of the Presence of KH Lines in the Spectrum of the Solar Disk," Ap. J. 96, 157, 1942.

"Hd 15963, A New Shell Star," Ap. J., 97, 452, 1943.

"A spectroscopic study of the Region of the Double Cluster in Perseus," Ap. J. 98, 61, 1943.

(a considerable number of classified reports were written while at the Ballistics Research Laboratory during the interval 1943-45)

"On the Interstellar Reddening in the Region of the North Polar Sequence and the Normal Color Indices of A-type Stars," Ap. J., 104, 245, 1946 (with W. W. Morgan).

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"Emission-Line Stars near h and χ Persei," A. J. 52, 121, 1947.

"Two High-Velocity Stars of Early Type," P.A.S.P. 60, 264, 1948.

"Note of the Peculiar Spectrum of HD 25878," Ap. J. 107, 413, 1948.

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"The Spectrum of GP Orionis," Ap. J. 112, 219, 1950.

"Spectral Classification of Stars Listed in Miss Payne's Catalog of c Stars," Ap. J. 113, 304, 1951.

"The Ba II Stars," (with P. C. Keenan), Ap. J. 114, 473, 1951.

"Hd 160641, a Hydrogen-Deficient O-type Star," Ap. J. 116, 227, 1952.

"The Ultraviolet Spectrum of U Cygni," P.A.S.P. 64, 133, 1952.

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"Spectral Classification of Some Peculiar A Stars," P.A.S.P. 67, 179, 1955, (with K. H. Bohm).

"The Peculiar Spectrum of the Variable Star FR Scuti," (with C. B. Stephenson), P.A.S.P. 68, 152, 1956.

"Spectral Classification of the Brighter Stars of the Praesepe Cluster," P.A.S.P. 68, 318, 1956.

"A Late-type Star of Very Large Radial Velocity," P.A.S.P. 68, 533, 1956, (with G. Preston).

"Double Lines in the Spectrum of ρ Cassiopeiae," (with A. McKellar) P.A.S.P. 69, 31, 1957.

"Spectral Classification of Stars Noted on Case Objective-Prism Plates. I." P.A.S.P. 69, 147, 1957.

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"Report of the I.A.U. Sub-Commission on Stellar Classification (29c)," Trans. I.A.U., Vol. 11A, 333, 1962.

"Atmosphere of 53 Tauri," (with L. H. Aller) A. J. 67, 571, 1962. (Abstract)

"Iron-Rich Star HR 6870," (with L. H. Aller) A. J. 68, 273, 1963. (Abstract)

HUGH E. BRADLEY

ASSISTANT PROFESSOR OF
INDUSTRIAL ENGINEERING

EDUCATION:

1957 S.B. and A.M. in E.E. received from M.I.T. in June,

1963 Ph. D. expected from The Johns Hopkins University in June; major: operations research; minors: statistics, electrical engineering.

EXPERIENCE:

Student engineer in Research Division and Computer Division of the Philco Corporation for one and one-half years (cooperative program with M.I.T.).

Electrical engineer in Systems Research Department of Aeronautical Equipment Division of the Sperry Gyroscope company for three years.

Research Assistant in Diagnostic and Evaluation Center for Handicapped Children of the Johns Hopkins Hospital for two years.

Junior Instructor in the Industrial Engineering Department of The Johns Hopkins University for two years.

Assistant Professor of Industrial Engineering, The University of Michigan

HONORS:

M.I.T.:
Honorary freshman scholarship.
Election to Eta Kappa Nu.

Johns Hopkins:
University Fellowship, 1960-61
Daniel Coit Gilman Teaching Fellowship, 1961-62
National Science Foundation Cooperative Graduate Fellowship, 1962-63.
American Statistical Association award in statistics, 1961.

RESEARCH INTERESTS:

Adaptive processes, stochastic processes, dynamic programming.

TEACHING INTERESTS:

Linear and dynamic programming, queueing theory; stochastic processes, mathematics. statistics, applied mathematics.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

BROWN, WILLIAM M.

RESEARCH ENGINEER;
HEAD, RADAR LABORATORY; &
PROFESSOR OF
ELECTRICAL ENGINEERING

EDUCATION

BS	Electrical Engineering	West Virginia University, 1952
MS	Engineering	Johns Hopkins University, 1955
Dr. Engr.		Johns Hopkins University, 1957

EMPLOYMENT

Assistant Instructor, Physics Department, West Virginia University, 1950-52
Engineer, Air Arm Division, Westinghouse Electric Corporation, Baltimore, Maryland, 1952-54
Lecturer, Johns Hopkins University, 1954-57
Project Supervisor, Countermeasures Group, Radiation Laboratory, Johns Hopkins University, 1954-57
Associate Professorial Lecturer, George Washington University, 1957
Member of Technical Staff, Institute for Defense Analysis, Weapons Systems Evaluation Group, Pentagon, Washington, D.C., 1957-58
On Administrative Leave from Institute of Defense Analysis in summer of 1958 while consulting for Summer Study of Project MICHIGAN
Assistant Professor, Electrical Engineering Department, The University of Michigan, 1958
Consultant, Sensory Subsystems Group, The University of Michigan, IST, 1958-60
Associate Professor, Electrical Engineering, The University of Michigan, 1960
Course Chairman, Intensive Course on Random Processes, The University of Michigan, short summer course, 1961,1962
Research Engineer (Head, Radar Laboratory), The University of Michigan, IST, 1960-
Consultant, Institute for Defense Analyses
Special Adviser, Aeronautical Systems Division, WPAFB
Professor, Electrical Engineering, The University of Michigan, 1963-

EXPERIENCE

Teaching. Research in countermeasures, radar analysis, noise theory, and system analysis. Analytical studies of sensory subsystems. Development of transistor circuits. Study of nonlinear dielectrics and coordination of engineering and fabrication of autopilots. Study of electronic warfare and battlefield surveillance in tactical military operations.

PROFESSIONAL AND HONORARY SOCIETIES

Member, Institute of Radio Engineers
Member, Societv for Industrial and Applied Mathematics
Member, Sigma Xi
Member, Tau Beta Pi
Member, Eta Kappa Nu
Member, Sigma Pi Sigma
Registered Professional Engineer in the State of Michigan

PUBLICATIONS

"Noise Statistics After Transformations Commonlv Found in Circuits," Office of Technical Services, Dept. of Commerce, O.T.S., No. PB 12 15 15, 1955

"Noise Jamming of Tracking Radar," co-author, National Symposium on Electronic Countermeasures, The University of Michigan, 1957

"Analysis of Discrete Linear Systems," Journal of the Society for Industrial and Applied Mathematics, December 1957

"Analysis of Range Tracking Radar in the Presence of Interference," 2nd National Convention on Military Electronics, Institute of Radio Engineers, 1958

"Time Statistics of Noise," IRE Transactions on Information Theory, December 1958

"Some Results on Noise Through Circuits," Transactions of the International Svmposium on Circuit and Information Theorv, IRE, 1959 2900-17-R

"Foundations of Circuit Analysis," Proceedings of the Fourth Midwest Symposium on Circuit Theorv, IRE, 1959

"Theory of Coherent Systems," IRE Transactions on Military Electronics, April 1962

"Analvsis and Optimization of Coherent High-Resolution Radars bv Circuit Theory Concepts," 2900-144-T and 2831-19-T

"Effects of Phase Errors on High Resolution Radars," co-author, 2831-34-T/2900-225-T

"Area Transforms," IRE Transactions of the Professional Group on Circuit Theory, June 1962

"System Performance in Presence of Stochastic Delavs," Transactions of the 1962 International Symposium on Information Theory, with C.J. Palermo, September 1962

Analysis of Linear Time Invariant Systems, Book in production, McGraw-Hill

"Optimum PreFiltering of Sampled Data," IRE Transactions on Information Theory, October 1961.

"One and Two Dimensional Processing of Line Scanned Data," Journal of Applied Optics, (of the American Optical Society), co-author, April 1963.

BURKHALTER, BARTON R.

EDUCATION:

BS, Engineering Mathematics, The University of Michigan, 1961.
BS, Engineering Mechanics, The University of Michigan, 1961.
MS, Industrial Engineering, The University of Michigan, 1962.
(Currently working towards Ph.D. in Industrial Engineering at
The University of Michigan.)

EMPLOYMENT:

Draftsman, E. W. Bliss Company, Toledo, Ohio, 1957.
Engineer, Chelsea Products, Chelsea, Michigan, 1958.
Engineer, U. S. Forest Service, Anchorage, Alaska, 1959.
Engineer, Sanzenbacher, Miller, & Brigham, Toledo, Ohio, 1960.
Teaching Fellow, Ford Foundation Project on Computers, The University of Michigan, 1961.
Research Assistant, MTM Association, 1961.
Teaching Assistant, Department of Industrial Engineering, The University of Michigan, 1960-61.
Lecturer in Industrial Engineering, The University of Michigan, 1962.
Research Assistant, Industrial Development Program, Institute of Science and Technology, The University of Michigan, 1962.
Lecturer in Industrial Engineering, Extension, Wayne State University, 1962--.

EXPERIENCE:

Mr. Burkhalter obtained his undergraduate training in mathematics and applied mechanics at The University of Michigan during the years 1956-1961. During this period, he worked part-time and summers as a draftsman and engineer.

Since 1960, he has been studying in the Department of Industrial Engineering at The University of Michigan, doing research and teaching. During 1961, he worked on an MTM Association research project studying learning in elemental motions. During the summer, he also taught computer programming for the Ford Foundation Project on Computers.

The following year, Mr. Burkhalter worked on an Institute of Science and Technology research project studying marketing strategies of business firms in Michigan. His work here also led into statistical prediction techniques and simulations of natural resource systems.

Since 1962, Mr. Burkhalter has been employed by the Adult Education Program of The University of Michigan and Wayne State University teaching a course in the Introduction to Management Sciences.

PROFESSIONAL AND HONORARY SOCIETIES:

Operations Research Society of America
Technical Institute of Management Science
American Institute of Industrial Engineers
Association for Computing Machinery
Society for General Systems Research
Alpha Pi Mu

PUBLICATIONS:

1. "An Application of Search Techniques to an Irrigation-Reservoir System," Periodic Report of Industrial Engineering Research, The University of Michigan, October, 1962.

2. "Foreign Trade in the Electronics Industry," paper given at the Michigan Electronics Industry Conference, Institute of Science and Technology, The University of Michigan, 1962.

3. "The Redeployment of Land, Water, and Human Resources (in Southeastern Michigan," contributor, Regional Development Studies II, Department of Conservation, The University of Michigan, 1962.

4. "A Mobile Queue Server in a Source-Sink System," unpublished report, Department of Industrial Engineering, The University of Michigan, 1962.

5. "Applying Artificaial Intelligence to the Pattern-Cutter's Problem," (abstract) ORSA Bulletin, Vol. 11, No. 1, 1963.

CARIGNAN, GEORGE R. — Director, Space Physics Research Laboratory, Electrical Engineering Department

Education: B.S.

Positions Held: Academic

University of Michigan: Associate Research Engineer, 1959-63; Research Engineer, 1963- ; Lecturer in Electrical Engineering; Director, Space Physics Research Laboratory, 1962-

Other Professional

U. S. Navy: Electronic Technician, 1947-49; 1950-54. Philco Corp: Field Engineer, 1954-56; Ballistics Research Labs, Instrumentation Engineer, 1956-59

Experience:

Telemetry signal-reception station; probe instrumentation; preparation and countdown of rocket firings; instrumentation and telemetry supervision for Space Physics Research Laboratory.

Publications:

"Ionosphere Electron Temperature Measurements and Their Implications," Journal of Geophysical Research Vol. 68, October 1, 1963

"Electron Temperature Evidence for Non-Thermal Equilibrium in the Ionosphere," Journal of Geophysical Research Vol. 67, December, 1962

Name: CHANEY, Lucian W.

Born: January 21, 1921, in Rochester, Minnesota
Married (three children)

Education and Experience

BA (Physics), Carleton College, 1941

1941-44, Design Engineer, Physicists Research Company. Design of precision gaging equipment.

1944-46, Electronic Technician, United States Navy.

1946-47, Design Engineer, Physicists Research Company.

1947-50, Research Engineer, Willow Run Laboratories, University of Michigan. Design and study of radar systems.

1950-53, Research Engineer, High Altitude Engineering Laboratory, Department of Aeronautical and Astronautical Engineering, University of Michigan. Design of rocket-borne instrumentation for upper atmosphere measurements.

1953-57, Chief Engineer, Micrometrical Development Corporation. Design of gaging, vibration and noise-measuring instrumentation.

1957-61, Design Engineer, Strand Engineering Company. Designed instrument transformer test facility, antenna system for AN/TPD-2 radar, and oil well logging instrumentation.

1961-present, Research Engineer, High Altitude Engineering Laboratory, Department of Aeronautical and Astronautical Engineering, University of Michigan. Evaluation and test of radiation measuring devices for meteorological satellites.

Professional and Honorary Society

Institute of Electrical and Electronic Engineers 1947-present Member

Professional Publications

"The Anderometer" (with E. A. Abbott and E. Bragg), Mech. Eng., July, 1944.

"Upper Air Temperature and Density by the Falling-Sphere Method" (with F. L. Bartman, V. C. Liu, and L. M. Jones). J. App. Phys. Vol. 27, No. 7, pp 706-712, July, 1956.

University of Michigan Research Institute Publications

"Survey of Early Warning and Tracking Radar" (with Rowland McLaughlin) UMM-68, December 1950.

"An Infra-Red Interference Spectrometer" (with Leslie T. Loh). ORA Report No. 05863-3-T, August 1963.

CLARK, JOHN ALDEN   Professor

Education: Univ. of Mich.: B.S.E. (M.E.), 1948. Mass. Inst. of Tech.: S.M., 1949; Sc.D., 1953.

Employment: Academic
Mass. Inst. of Tech.: Instr. of Mechanical Engineering, 1949-52; Asst. Prof. of Mechanical Engineering, 1952-57. Univ. of Mich.: Prof., 1957--.

Other Professional
H.E. Farmer Engineering Co., Detroit: Machine Designer, 1941-43. U.S. Air Force: Pilot, 1943-45. Michigan National Guard: Pilot, 1946-48. Eng. Res. Inst.: Res. Engineer, 1946-48. United Aircraft Corp., East Hartford, Conn.: Res. Engineer, 1948. Mass. Inst. of Tech.: Project Leader, Boiling Research Project, 1949-52; Assoc. Director, Heat Transfer Laboratory, and Project Supervisor, Unsteady-Convective Heat Transfer Project, 1954-57. Consultant to: DuPont Polychemicals Division; Westinghouse Atomic Power Division; Commonwealth Assoc., Jackson, Mich.; General Electric Knolls Atomic Power Laboratory.

Experience: Heat transfer; high velocity gas streams; heat exchangers; thermal transient conditions.

Publications: Articles--8 (5 with coauthors) on the mechanism of boiling heat heat transfer, determining the static temperature of high velocity gas streams, heat transfer and pressure drop data for high heat flux densities to water at high subcritical pressures, local boiling heat transfer to water at low Reynolds numbers and high pressures, thermal transient conditions, high temperature.

Professional and Honorary Societies: Am. Soc. of Mechanical Engineers; Phi Kappa Phi; Pi Tau Sigma; Sigma Xi; Tau Beta Pi (Received Pi Tau Sigma Gold Medal in 1956 for "outstanding achievement in mechanical engineering within 10 years of graduation," presented by ASME.)

THE UNIVERSITY OF MICHIGAN / Ann Arbor

CLOKE, PAUL L. Assistant Professor

Education: Harvard Univ.: A.B., 1951. Mass. Inst. of Technology: Ph.D., 1954.

Positions Held: Academic
Mass. Inst. of Technology: Teaching Assistant, 1951-52, spring of 1954.
Univ. of Mich.: Asst. Prof., 1959- .

Other Professional
Maine Geological Survey: summers of 1945-46-47. U. S. Geological Survey: summers of 1948-49-50-51-52, Anaconda Co., Butte, Mont.: Research Geologist, 1954-57. Harvard Univ.: Res. Fellow, 1957-59.

Experience: Geologic mapping; geologic reconnaissance; high pressure and high temperature solubility studies in the system $KOH-H_2O-SiO_2$; alter-artion and sulfide paragenesis studies of copper orebodies; Eh-pH and solubility studies in polysulfide solutions.

Publications: Articles-- one in fields of "Experience."

Professional and Honorary Societies: Am. Inst. of Mining, Metallurgical and Petroleum Engineers; Geochemical Soc.; Sigma Xi.

NAME: George S. Cohen
TITLE: Associate Research Engineer
DATE OF BIRTH: January 10, 1925

PRESENT RESPONSIBILITIES:

Electronic Engineer working on Advanced Technical Development of Radiometers.

EDUCATION:

B.E.E., University of Dayton, 1953
M.S.E. (E.E.), University of Michigan, 1955
Ph.D. (E.E.), University of Michigan, 1962

EXPERIENCE:

Academic:
Lecturer, Electrical Engineering, University of Michigan, 1958-1959
Instructor, Electrical Engineering, University of Kansas, 1955-1956

Non-Academic:
Associate Research Engineer, Radio Astronomy, University of Michigan, November 1961 to present
Staff Engineer, Bendix Systems Division, March 1959-November 1961
Research Associate, Electronic Defense Group, University of Michigan, June 1956-March 1959
Project Engineer, University of Kansas, September 1955-June 1956
Graduate Research Assistant, University of Michigan, Electronic Defense Group, June 1953-September 1955
Project Engineer, Commonwealth Engineering Company, Dayton, Ohio, June 1952-June 1953 (part-time)

SUMMARY OF TECHNICAL EXPERIENCE:

General electronic circuit design, e.g., pulse, generators, switching circuits, and rf amplifiers; synthesis of passive networks; analysis of nonlinear systems. Design and development of EGO satellite ground support equipment for Radio Astronomy Experiment.

SOCIETIES, ETC.:

Member, IRE
Member, Sigma Xi
Science Research Club

PUBLICATIONS:

"Evaluation of Susceptibility of Conical Scan Radars," Tech. Rept. 92, Electronic Defense Group, University of Michigan, 1959.

"Analysis of a Class of Nonlinear Sampled-Data Systems with a Gaussian Input Signal," Dissertation, 1962.

DENOYER, JOHN M.

RESEARCH GEOPHYSICIST
ACTING HEAD, ACOUSTICS
AND SEISMICS LABORATORY

EDUCATION

AB	Mathematics	Chico State College, Chico, California, 1953
MA	Geophysics	University of California (Berkeley), 1955
PhD	Geophysics	University of California (Berkeley), 1958

EMPLOYMENT

U.S. Army, 1950-51
Research Assistant (Seismology), Department of Geology, University of California, 1954-57
Instructor, Geology Department, The University of Michigan, 1957-59
Assistant Professor, Geology Department, The University of Michigan, 1959-
Associate Research Geophysicist, The University of Michigan, IST, 1961-63
(Leave of Absence 9-1-62 to 8-31-63)
Staff Member, Research and Engineering Support Division, Institute for Defense Analyses, Washington, D.C. (during leave of absence)
Research Geophysicist and Acting Head, Acoustics and Seismics Laboratory, The University of Michigan, IST, 1963-

EXPERIENCE

Seismology - research involving nuclear detection and identification.

PROFESSIONAL AND HONORARY SOCIETIES

Seismological Society of America
Geological Society of America
American Geophysical Union
Sigma Xi
Acoustical Society of America

PUBLICATIONS

Articles:

"Determination of the Energy in Body and Surface Waves (Part I)," Bulletin of the Seismological Society of America, Vol. 48, October 1958

"Energy in Earthquakes as Computed from Geodetic Observations," Contributions in Geophysics (Earth Sciences Series), Pergamon Press, Inc., coauthor, 1958.

"Determination of the Energy in Body and Surface Waves (Part II)," Bulletin of the Seismological Society of America, Vol. 49, January 1959.

"Crustal Structure of the North Pacific from Love Wave Dispersion," Bulletin of the Seismological Society of America, Vol. 49, October 1959.

"A Heating Micro-coil for the Study of Mineral Fragments and Heat-Etching of Polished Sections," American Mineralogist, Vol. 45, 1960, co-author.

"The Effect of Variations in Layer Thickness on Love Waves," Bulletin of the Seismological Society of America, Vol. 51, April 1961.

"Depth of Faulting," Bulletin of the Geological Society of America, Vol. 67, No. 12, December 1956, coauthor.

"Energy in Earthquakes Determined by Field Observations," Bulletin of the Geological Society of America, Vol. 68, No. 13, Part 2, December 1957, co-author.

"Determination of the Energy in Body and Surface Waves," Bulletin of the Geological Society of America, Vol. 69, No. 12, Part 2, December 1958 co-author.

"Crustal Structure in the North Pacific from Love-Wave Dispersion," Bulletin of the Geological Society of America, Vol. 70, No. 12, Part 2, December 1959.

"The Effect of Variations in Crustal Thickness on Love-Wave Dispersion," Bulletin of the Geological Society of America, Vol. 71, No. 12, Part 2, December 1960.

"Gravity Profiles Across the Sangre De Cristo Range, Colorado," Bulletin of the Geological Society of America, Vol. 71, No. 12, Part 2, December 1960.

"Azimuthal Asymmetry of a Point Source in a Two-Dimensional Low-Velocity Medium," Bulletin of the Geological Society of America, Vol. 72, No. 12, Part 2, December 1961, co-author.

"Measurements of the Velocity of Crack Propogation in Glass Plates," Bulletin of Seismological Society of America, Vol. 53, No. 1, co-author.

"Differentiation of Earthquakes and Underground Nuclear Explosions on the Basis of Amplitude Characteristics," Bulletin of the Seismological Society of America, Vol. 53, No. 5, co-author.

"Observed Asymmetry of Amplitudes from A High Explosive Source," Bulletin of the Seismological Society of America, Vol. 52, No. 1, co-author.

"Azimutal Asymmetry of a Point Source in a Cylindrical Low Velocity Medium," Bulletin of the Seismological Society of America, Vol. 52, No. 1, co-author.

Bulletins

Bulletin of the Seismographic Stations (Univ. of Calif.) Vol.24, No.2, pp49-92

DOLPH, CHARLES L. Professor

Education: B.A., University of Michigan, 1939
M.A., Princeton University, 1941
Ph.D., Brown University, 1944

Employment:
Academic - Princeton University, Instructor, 1940-42
U. of Michigan, Lecturer and Research Mathematician, 1946-47
U. of Michigan, Asst. Prof., 1947-54; Assoc. Prof., 1954-60; Professor, 1960-
Technische Hochschule, Guest Professor, 1957-58 and Guggenheim Fellowship, 1957-58

Nonacademic - Naval Research Lab., Physicist, 1943-44
U.S. Navy, Ensign, 1944-45
Bell Telephone Labs., member technical staff, 1945-46
Ramo-Wooldridge Corp. and Inst. of Numerical Analysis, UCLA (part time), 1955-56

Bibliography:

Non-Linear Integral Equations of the Hammerstein Type. Proc. Nat. Acad. Sci., 31 (1945): 60-65.

A Current Distribution for Broadside Arrays Which Optimizes the Relationship Between Beam Width and Side-Lobe Level. Proc. Instit. Radio Eng., 34 (1946): 335-48. (Browder Thompson award paper, 1947.)

The Transient Behavior of a Large Number of Four Terminal Unilateral Linear Networks Connected in Tandem (with C. E. Shannon). Bell Telephone Lab. Tech. Memo. 46-110-49 (1946): 1-34.

Discussion on: A Current Distribution for Broadside Arrays which Optimizes the Relationship Between Beam Width and Side-Lobe Level (with H. J. Riblet). Proc. Instit. Radio Eng., 35 (1947): 489-92.

Three Dimensional Flows of Supersonic Compressible Fluids (with N. Coburn). Willow Run Res. Center IMF-25 (1947): 1-13.

The Three Dimensional Stationary Supersonic Flow of a Compressible Gas (with N. Coburn). Ibid., IMF-27, pp. 1-14 (1947).

An Approximate Method of Solution to the General Equations of Compressible Flow. Ibid., IMF-51 (1948): 1-12.

The Method of Characteristics for Three Dimensional Supersonic Flow (with N. Coburn). Proc. Symposia Appl. Math. New York: Amer. Math. Soc., 1 (1949): 55-66.

Non-Linear Equations of the Hammerstein Type. Pt.II. Trans. Amer. Math. Soc., 66, No. 2 (1949): 289-307.

Normal Modes of Oscillation of Beams. External Rpt. UMM-79, Proj. MX-794, Willow Run Res. Center, October, 1950. Pp. 18.

Review of Advances in Applied Mechanics, ed. R. von Mises and T. von Karman (with N. Coburn). I. Amer. Math. No., 57, No. 4 (1950): 274-77.

Representation Theory and Prediction of Stochastic Processes (with M. A. Woodbury). Willow Run Res, Center EMF-11 (1950): 1-69.

Dynamics of a Ship's Structure (with J. Ormondroyd and others). Final Rpt., Eng. Res. Instit. Proj. M-670-4, Off. Res. and Invention, June, 1951.

On the Integral Equation Formulation of Transmission and Reflection Problems for the Scalar and Vector Wave Equations. Willow Run Res. Center EMF-26 (1951): 1-89.

On the Relationship Between Green's Functions and Covariances of Certain Stochastic Processes and Its Application to Unbiased Linear Prediction (with M. A. Woodbury). Trans. Amer. Math. Soc., 72 (1952): 519-50

Review of the Status of the Mathematical Theory (Sec. 1.4) in Propagation of Underwater Sound in a Bilinear Velocity Gradient. Final Rpt., Eng. Res. Instit. Proj. 2002, Off. Naval Res. Contract UNR 23223 (1953): 6-9.

Unclassified technical memoranda available on request.

Inverse Transforms of Products of Legendre Transforms (with R. V. Churchill). Proc. Amer. Math. Soc., 5 (1954): 93-100.

On the Timoshenko Theory of Transverse Beam Vibrations. Quart. Appl. Math., 12 (1954): 175-87.

On a Three-Dimensional Transmission Problem of Electromagnetic Theory (with R. B. Barrar). Journ. Rat. Mech., 3 (1954): 725-43.

Symmetric Linear Transformations and Complex Quadratic Forms (with J. E. McLaughlin and I. Marx). Comm. Pure and Appl. Math., 7 (1954): 621-32.

Numerical Methods in Axially Symmetric Inviscid Compressible Flow (with J. M. Richardson) and is the GMRD Report RW-26-30-105, dated 5 March 1956 of the Ramo-Wooldridge Corporation. 24 pages.

Formulation of Approximate Hypersonic Flow Field Behind Detached Shocks by the Variational Method (with J. M. Richardson). This GM-TM-71 (GM-51-5) of GMRD of the Ramo-Wooldridge Corporation. March, 1956. Pp. 1-27.

The Mathematician Grapples with Linear Problems Associated with the Radiation Condition. Trans. Inst. Radio. Engr., Prof. Group on Antenna and Propagation, Ap-4, 3 (1956): 302-11.

The Schwinger Variational Principles for One-Dimensional Quantum Scattering (with R. Ritt). Math. Zeit., 65(1956): 309-26.

Classified paper with J. M. Richardson which appeared in the First Classified Ballistic Missile Symposium held at the Ramo-Wooldridge Corp. in June 1956.

Variational Principles for the Wave Function in Scattering Theory (with Saul Altshuler), GM-42-386 of GMRD of the Ramo-Wooldridge Corp., October 14, 1957, pp. 1-20. Also printed in PHYSICAL REVIEW in March, 1958, pp. 1830-36.

A Saddle Point Characterization of the Schwinger Stationary Points in Exterior Scattering Problems. Journ. Soc. Ind. Applied Math., Vol. 5, No. 3, 1957, pp. 89-104.

On the Application of Infinite Systems of Ordinary Differential Equations to Perturbations of Plane Poiseuille Flow (with D. C. Lewis). Quart. Appl. Math., Vol. 16, No. 2 (1958), pp. 97-110.

On the Theory of a Class of Non-Self-Adjoint Operators and Its Applications to Quantum Scattering Theory (with F. Penzlin). Presented to a joint seminar of the University and ETH of Zurich, Switzerland on February 8, 1958. 48 pages.

Annales Academiar Scientiarum Fennicae Sines A, No. 263 pp. 1-36, May, 1959.

Recent Developments in Some Non-Self-Adjoint Problems of Mathematical Physics. Bull. Amer. Math. Soc., Vol. 16, No. 1 (1961), pp. 1-69.

DRAKE, WILLIAM D.

EDUCATION:

BSE, Industrial Engineering, The University of Michigan, 1959.
MBA, Graduate School of Business Administration, The University of Michigan, 1960.
Ph.D., Industrial Engineering, The University of Michigan, 1964 (expected June, 1964).

EMPLOYMENT:

Laboratory Technicain, Ford Motor Company Scientific Laboratories, Ford Motor Company, Dearborn, Michigan, Summer, 1955.
Junior Engineer, Ford Motor Company Scientific Laboratories, Ford Motor Company, Dearborn, Michigan, Summer, 1956.
Junior Engineer, Chrysler Corporation, Central Engineering, Highland Park, Michigan, Summer, 1957.
Staff Member, A. T. Kearney & Company--management consultants, Chicago, Illinois, 1959 (one-half time).
Teaching Fellow, Regents, The University of Michigan, Department of Industrial Engineering, Ann Arbor, Michigan, 1959 (one-quarter time).
Staff Member, A. T. Kearney & Company--management consultants, Chicago, Illinois, 1960, 1961, 1962 (one-quarter time).
Teaching Fellow, Regents, The University of Michigan, Department of Industrial Engineering, 1960, 1961, 1962, 1963 (one-third time).
Independent Researcher, Project on the Use of Computers in Engineering Education, Ford Foundation, Ann Arbor, Michigan, 1961.
Lecturer, Board of Governors, Wayne State University, Dearborn, Michigan, 1962, 1963.
Independent Researcher, Center for Research on Learning and Teaching, The University of Michigan, Ann Arbor, Michigan, 1963.

EXPERIENCE:

Mr. Drake has had a good deal of experience in a broad range of specialized fields. In addition to operations research and data processing, he has had some experience in designing and implementing real management systems. He also has a capability in the field of mechanical engineering and in particular, the automotive industry.

While at the Ford Motor Company, Mr. Drake conducted laboratory evaluations of an experimental gas turbine automotive engine. In addition, he designed a complete external lubrication, cooling and monitoring system for the gas turbine engine which was subsequently used in laboratory tests. He also assisted in the evaluation of experimental cab-over-engine trucks. At Chrysler Corporation, he assisted in design and evaluation of suspension systems for experimental automobiles.

While working with A. T. Kearney & Company, he planned and implemented the relocation of an entire corporate division to a new geographic area. This relocation involved almost all industrial engineering phases, including the new plant layout, building construction, methods, standards, cost accounting systems, production and inventory control systems and the actual movement of the machinery and labor force to the new location. This job was not completed until the new plant was running smoothly.

Several projects with A. T. Kearney & Company have involved the extensive use of work sampling techniques. The use of this measurement technique has been only a portion of his total effort on these system modification projects.

While performing independent research sponsored by the Ford Foundation, Mr. Drake designed a stochastic decision simulation model. This decision simulation model has been used extensively by other universities, as well as The University of Michigan, over the last two years. He originally programmed it on the small electronic computer, LGP-30. Presently, the decision simulation is being re-programmed for the IBM 7090.

During the last four years, Mr. Drake has been actively teaching on a part-time appointment. He has taught such courses in the past as Fundamentals of Industrial Engineering and Management Control. Presently he is teaching a Data Processing Systems course. In an effort to facilitate the teaching of computer programming, Mr. Drake is currently in the process of writing an auto-instructional programmed text. This work is being implemented by his association with the Center for Research on Learning and Teaching.

PROFESSIONAL AND HONORARY SOCIETIES:

Phi Kappa Phi
Phi Eta Sigma
Alpha Pi Mu
American Institute of Industrial Engineers
National Society of Professional Engineers
Michigan Society of Professional Engineers
Operations Research Society of America
The Institute of Management Sciences

PUBLICATIONS:

1. Management Decision Simulations. "Periodic Report of Industrial Engineering Research," Department of Industrial Engineering, The University of Michigan, Ann Arbor, Michigan, October, 1962.

2. An Analysis and Comparison of Three Management Decision Simulations, Industry Program, Engineering Summer Conference, June, 1962.

3. The Design of a Stochastic Decision Simulation, paper presented at the National [illegible] Institute of Industrial Engineers, [illegible]

4. [illegible] of the United States, Industrial Development Research Program, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, March 1962.

5. Management Decision Simulation for the LGP-30 Digital Computer, Ford Foundation Project on the Use of Computers in Engineering Education, The University of Michigan, Ann Arbor, Michigan, January, 1962.

6. Model III--Relationships Among the Competitive Situation, Product Strategy, and Capabilities within a Firm, Industrial Development Research Program, Institute of Science and Technology, The University of Michigan, Ann Arbor, Michigan, September, 1961.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

PERSONAL HISTORY

Merrill M. Flood

Education

AB	(Math.)	University of Nebraska	1929
AM	(Math.)	University of Nebraska	1930
PhD	(Math.)	Princeton University	1935

Scientific and Professional Experience

Professor of Mathematical Biology, Department of Psychiatry, The University of Michigan, 1960-Present
Senior Research Mathematician, Mental Health Research Institute, The University of Michigan, 1959-Present
Professor of Industrial Engineering, The University of Michigan, 1956-Present
Associate Director, Engineering Research Institute, The University of Michigan, 1956-1958
Professor of Industrial and Management Engineering, Columbia University, 1953-1956
Director, Institute for Research in the Management of Industrial Production, Columbia University, 1954-56
Director, Behavioral Models Project, Columbia University, 1953
Project Officer for Logistics, The RAND Corporation, 1949-1952
Executive Director, The American Statistical Association, 1948-1949
Assistant Deputy Director of Research and Development, Department of the Army, 1947-1948
Expert Consultant to the Secretary of War, 1946-1947
Director, Applied Mathematics Group, Princeton University, 1944-1945
Field Service Consultant, Office of Scientific Research and Development, 1944
Owner, Merrill Flood and Associates, 1942-1949
Director, Princeton Branch, Fire Control Design Division, Frankford Arsenal, 1943-1944
Director, Fire Control Research Office, Princeton University, 1940-1945
Administrative Consultant, Graduate School of Education, Harvard University, 1940
Technical Advisor to the Governor of West Virginia, 1937-1940
Public Finance Consultant, Social Science Research Council, 1937-1940
Director of Statistics, State and Local Government Section, Princeton University, 1936-1940
Research Supervisor, New Jersey Department of Institutions and Agencies, 1935
Instructor in Mathematics, Princeton University, 1932-1936
Research Assistant, Princeton University, 1931-32
Instructor in Mathematics, University of Nebraska, 1929-1931

Fields of Research

Operations research, management science, system engineering and logistics
Applied mathematics, public administration, and business forecasting
Warfare theory, fire-control instruments, optical devices, photogrammetric instruments, and rocket propellants
Decision-making, organization theory, game theory, and learning theory
Algebra of matrices, combinatorial algebra, and mathematical programming theory

Professional and Honorary Organizations

Fellow, American Association for the Advancement of Science (Council, 1958-Present)
Fellow, Royal Economic Society
Fellow, New York Academy of Sciences
Senior Member, American Society of Tool and Manufacturing Engineers
Member, American Mathematical Society
Member, Society for Industrial and Applied Mathematics (Council, 1955-1958)
Member, The Institute of Management Sciences (President, 1955; Council, 1954-1956)
Member, Operations Research Society of America (President, 1961; Council, 1956-1959, 1961-1964)
Member, Society for General Systems Research
Member, American Institute of Industrial Engineers
Member, Association for Computing Machinery
Member, Sigma Xi
Member, Pi Mu Epsilon
Honorary Member, Alpha Pi Mu

Listed In:

American Men of Science
Who's Who in the East
Who's Who in the Middle West
Who's Who in American Education
Who Knows and What

TECHNICAL PUBLICATIONS AND OTHER PAPERS

Merrill M. Flood

I. Scientific Publications

A. Papers Published in Scientific Journals and Proceedings

1. "Division by Non-Singular Matric Polynomials," Annals of Mathematics (2), Vol. 36, No. 4, October 1935, pp. 859-869.

2. "On the Highest Common Factor of Two Polynomials," American Mathematical Monthly, Vol. 43, No. 9, November 1936, pp. 562-563.

3. "Column Normal Matric Polynomials," Annals of Mathematics (2), Vol. 38, No. 2, April 1937, pp. 465-468.

4. "The Resultant Matrix of Two Polynomials," American Mathematical Monthly, Vol. 44, No. 5, May 1937, pp. 309-312.

5. "The Resultant Matrix of Two Polynomials," Bulletin of the American Mathematical Society, Vol. 43, No. 10, October 1937, pp. 724-729.

6. "Equivalence of Pairs of Matrices," Transactions of the American Mathematical Society, Vol. 44, No. 1, July 1938, pp. 8-17.

7. "Reallocating Our Property Tax Levies," West Virginia School Journal, Vol. 67, No. 3, November 1938, pp. 5-6.

8. "Foundation School Program," West Virginia School Journal, Vol 67, No. 8, April 1939, pp. 11-12.

9. "Sharing Our School Costs," West Virginia School Journal, Vol. 67, No. 8, April 1939, pp. 22-24.

10. "A Computational Procedure for the Method of Principal Components," Psychometrika, Vol. 5, No. 2, June 1940, pp. 169-172.

11. "Recursive Methods in Business-Cycle Analysis," Econometrica, Vol. 8, No. 4, October 1940, pp. 333-353.

12. "Road Costs in New Jersey," Traffic Engineering, January 1941, pp. 172-175.

13. "Tumbler Mortality," Journal of the American Statistical Association, Vol. 42, December 1947, pp. 562-574. (With George W. Brown.)

14. "On the Hitchcock Distribution Problem." In: Alex Orden and Leon Goldstein (Eds.), Proceedings of Symposium on Linear Inequalities and Programming, Washington, D. C., June 14-16, 1951. Comptroller, Headquarters, U. S. Air Force, 1 April 1952, pp. 74-99.

15. "On the Hitchcock Distribution Problem," Pacific Journal of Mathematics, Vol. 3, No. 2, June 1953, pp. 369-386. (Revision of IA14.)

16. "A Stochastic Model for Social Interaction," Transactions of the New York Academy of Sciences, Ser. II, Vol. 16, No. 4, February 1954, pp. 202-205.

17. "Application of Transportation Theory to Scheduling a Military Tanker Fleet," Journal of the Operations Research Society of America, Vol. 2, No. 2, May 1954, pp. 150-162.

18. "On Game-Learning Theory and Some Decision Making Experiments." In: R. M. Thrall, C. H. Coombs, R. L. Davis (Eds.), Decision Processes. John Wiley & Co., New York, 1954, pp. 139-158.

19. "The Influence of Environmental Non-Stationarity in a Sequential Decision-Making Experiment." In: R. M. Thrall, C. H. Coombs, R. L. Davis (Eds.), Decision Processes. John Wiley & Co., New York, 1954, pp. 287-299.

20. "A Group Preference Experiment." In: Mathematical Models of Human Behavior - Proceedings of a Symposium, Rye, New York, February 26-27, 1954. Dunlap Associates, Inc., Stamford Connecticut, pp. 1-21.

21. "Operations Research and Logistics." In: Proceedings of the First Ordnance Conference on Operations Research, Frankford Arsenal, May 14, 1954. Office of Ordnance Research, Ordnance Corps, U. S. Army, January 1955, pp. 3-32.

22. "Research Project Evaluation." In: Albert H. Rubenstein (Ed.), Coordination, Control, and Financing of Industrial Research. Presented at Arden House in June, 1954. King's Crown Press, Columbia University, New York, 1955, pp. 287-294.

23. "Decision Making," Management Science, Vol. 1, No. 2, January 1955, pp. 167-169.

24. "The Objectives of TIMS," Management Science, Vol. 2, No. 2, January 1956, pp. 178-184.

25. "The Traveling Salesman Problem," Journal of the Operations Research Society of America, Vol. 4, No. 1, February 1956, pp. 61-75.

26. "This is Operations Research," Petroleum Refiner, Vol. 35, No. 2, February 1956, pp. 100-102.

27. "The Traveling Salesman Problem." In: J. F. McCloskey and J. M. Coppinger (Eds.), Operations Research for Management. Johns Hopkins Press, Baltimore, 1956, Vol. II, pp. 340-357. (Reprinting of IA25.)

28. "New Mathematical Tools for Decision Making," Industrial Laboratories, September 1956, pp. 50-55.

29. "Management Science and Operations Research," Journal of Engineering Education, Vol. 47, No. 2, October 1956, pp. 106-112.

30. "Management Science Techniques for Research Administration." In: Proceedings of 10th National Conference on the Administration of Research. Pennsylvania State University Press, University Park, 1957, pp. 9-13.

31. "New Formula for Magazine Selection," Tide, November 9, 1956, pp. 22-24. (With C. T. Jaeger.)

32. "Distribution and Scheduling Problems." In: Operations Research - Record of the 1955-1957 Operations Research Seminar and "Operations Research in Industry," Symposium. The University of Michigan, June 1957, IP-227, pp. 77-94.

33. "Operations Research and Automation Science." In: Proceedings of the Third Ordnance Conference on Operations Research, Rock Island Arsenal, May 24-25, 1956. Office of Ordnance Research, Ordnance Corps, U. S. Army, pp. 5-27.

34. "Problemes de Repartition et d'Ordonnancement," Journees de Recherche Operationnelle, Paris, September 1957, 28 pages. (Translation, by M. Dufaure, of IA32.)

35. "Operations Research and Automation Science," Journal of Industrial Engineering, Vol. 9, No. 4, July-August, 1958, pp. 239-242. (Revision of IA33.)

36. "Some Experimental Games," Management Science, Vol. 5, No. 1, October 1958, pp. 5-26.

37. "Linear Programming." In: Max Davies and Michel Verhulst (Eds.), Operational Research in Practice. Pergamon Press Ltd., London, 1958.

38. "Operations Research and Logistics," Naval Research Logistics Quarterly, Vol. 5, No. 4, December 1958, pp. 323-325. (Revision of IA21.)

39. "A Transportation Code." In: Philip Wolfe (Ed.), Proceedings of the RAND Symposium on Mathematical Programming. The RAND Corporation, Santa Monica, 1959, pp. 79-80.

40. "An Alternative Proof of a Theorem of König as an Algorithm for the Hitchcock Distribution Problem." In: Richard Bellman and Marshall Hall, Jr. (Eds.), Combinatorial Analysis: Proceedings of Symposia in Applied Mathematics. American Mathematical Society, Providence, R. I., 1960, Vol. X, pp. 299-307.

41. "System Engineering." In: C. W. Churchman and Roger Crane (Eds.), Management Technology. The Institute of Management Sciences, White Plains, N. Y., 1960, Monograph 1, pp. 21-35.

42. "Sequential Decisioning." In: Robert E. Machol (Ed.), Information and Decision Processes. McGraw Hill, New York, 1960, pp. 34-52. (Revision of IA28.)

43. "Adaptive System Models." In: J. Banbury and J. Maitland (Eds.), Proceedings of the Second International Conference on Operational Research. English Universities Press Ltd., London, 1961, pp. 11-20.

44. "Stochastic Learning in Rats with Hypothalamic Implants," Annals of the New York Academy of Sciences, Vol. 89, Art. 5, 28 January 1961, pp. 795-822.

45. "Summary Address." In: Proceedings of 2nd IBM Medical Symposium. International Business Machines Corporation, Yorktown Heights, N. Y., 1960, pp. 417-425.

46. "Adaptive Economic Control Systems." In: L. E. Slater (Ed.), Proceedings of the Pilot Clinic on the Impact of Feedback Control Concepts in the Study of Economic and Business Systems. Foundation for Instrumentation Education and Research, New York, 1960, pp. 28-31.

47. "Digital Computer Simulation of Learning Behavior." In: L. E. Slater (Ed.), Proceedings of the Interdisciplinary Clinic on the Instrumentation Requirements for Psychophysiological Research. Foundation for Instrumentation Education and Research, New York, 1961, pp. 97-101.

48. "Simulation of Stochastic Learning in Rats." In: Proceedings of 3rd IBM Medical Symposium. International Business Machines Corporation, Yorktown Heights, N. Y., 1961.

49. "A Transportation Algorithm and Code," Naval Research Logistics Quarterly, Vol. 8, No. 3, September 1961, pp. 257-276.

FONTHEIM, ERNEST GUENTHER — Lecturer, Associate Research Physicist

Education:
Southwest Missouri State College: A.B., B.S., 1950.
Lehigh University: M.S. (Physics), 1952; Ph.D. (Physics), 1960.

Positions Held: Academic
Lehigh University: Teaching Assistant, 1950-57; Research Assistant, 1957-60.
Moravian College, Bethlehem, Pa.: Instructor, 1952-53.
University of Michigan: Lecturer and Associate Research Physicist, 1960-.

Experience:
Quantum field theory, electromagnetics, plasma theory, interaction of electromagnetic waves with plasmas, physics of the ionosphere, theoretical aspects of free-free absorption, stimulated emission effect.

Publications: Books, Bulletins, etc.
"Interpretation of Tracks in Nuclear Emulsions," Tech. Memo No. 91, White Sands Proving Ground, 1953. "Effect of Multiple Scattering in Coincidence Counter Experiments," Report, Brookhaven National Laboratory, 1954. "Space Charge Waves in the Ionosphere and their Effect on the Heating of the Atmosphere," Second Western National Meeting of the American Geophysical Union, Palo Alto, Calif., December 1962 (with others).

Professional and Honorary Societies:
American Physical Society, Sigma Xi.

HERBERT P. GALLIHER, JR.

EDUCATION:

1940	B.A., Yale (mathematics)
1950	M.A., Yale
1952	Ph.D., Yale. Dissertation in mathematical logic: A Theory of Lebesgue Measure in an Extension of Basic Logic

POSITIONS:

1941-1946	Army, terminal rank of Captain
1946-1949	Assistant in Instruction, Mathematics Department, Yale University
1949-1953	Assistant Professor, Mathematics, New Haven State Teachers College, New Haven, Connecticut
1953-1954	Operations Research Group, Arthur D. Little, Inc., Cambridge, Massachusetts
1954-1957	Research Staff, Mathematics Dept. M.I.T.
1957-1963	Operations Research Center, M.I.T. Assistant Director, 1956-1959 Associate Director, 1959-1963
1963-	Professor of Industrial Engineering, The University of Michigan

PROFESSIONAL OFFICES:

Associate Editor, Operations Research, 1958-1962
Editor, International Abstracts in Operations Research
Chairman, Education Committee, Operations Research Society of America, 1959-1961
Member, National Academy of Sciences Committee on Theory of Traffic Flow, 1960-date

MEMBERSHIPS:

Phi Beta Kappa
Sigma Xi (associate)

American Mathematical Society
American Association for the Advancement of Science (Fellow)
Operations Research Society of America (member)
Association for Symbolic Logic
Institute of Mathematical Statistics
Institute of Management Sciences

TEACHING EXPERIENCE:

1946-1949	Freshman mathematics, including special Directed Studies courses, Mathematics Department, Yale
1949-1953	Mathematics and Statistics courses, freshman and sophomore, New Haven State Teachers College
1954-1957	Statistics, Mathematics Dept., M.I.T.
1961	Operations research, Mathematics Department, M.I.T.
1961-1963	Laboratory in operations research, Physics Department, M.I.T.

GRADUATE SUPERVISION:

Since 1955 have supervised 19 masters theses and have served as the principal technical supervisor of 4 doctoral dissertations. Presently on doctoral committees of 2 candidates. The above have been distributed among the following departments: Aeronautical Engineering, Civil Engineering, Electrical Engineering, Industrial Management (masters only), Mathematics and Physics.

RESEARCH ACCOMPLISHMENTS:

Devised the inventory control procedure now being used by the U. S. Army Munitions Command for national supply, including the original mathematical solution on which it is based and a new method for forecasting the variance of demand.

Devised the stochastic model of aircraft traffic at airports being put into use by the Federal Aviation Agency to evaluate airport designs.

Developed the use of compound probability distributions for demand-type processes [cf. "Le Processus de Galliher (Poisson par 'grappes')" by A. Kaufmann and R. Cruon, Revüe Francaise de Recherche Operationelle. 12 (1959) pp. 137-144.]

Principal investigator or technical supervisor of about one million dollars of staff research since 1955, covering inventory, automobile traffic, airport traffic, message traffic, hospital patient traffic, library traffic and use, methods of indexing literature, urban firefighting, methods of simulation, steel-making, learning on production lines, mathematics of queuing.

PUBLICATIONS:

1. with G. C. Bush and P. M. Morse, "Attendance and Use of the Science Library at M.I.T.," American Documentation, Vol. VII, No. 2, pp. 87-109.
2. with R. C. Wheeler, "Calculation of Non-Stationary Queuing Probabilities for Landing Congestion of Aircraft," Operations Research, Vol. 6, No. 2, March-April, 1958.
3. with R. B. Fetter, "Waiting-Line Models in Materials Handling," Journal of Industrial Engineering, Vol. ix, No. 3, May-June, 1958.
4. with P. M. Morse and M. Simond, "Dynamics of Two Classes of Continuous-Review Inventory Systems," Operations Research, Vol. 7, No. 3, June, 1959.
5. with P. M. Morse, G. P. Wadsworth, B. O. Koopman, R. A. Howard, and G. E. Kimball, "Notes on Operations Research 1959," The Technology Press, M.I.T. Author of chapters on Queuing, Production Scheduling, Simulation of Random Processes.
6. Various reports of the M.I.T. Operations Research Center.
7. in progress:
   (i) Airport Runway Design, Traffic and Delays (presented at ASCE meeting October, 1962)
   (ii) Tables of Poisson Queuing Functions

TECHNICAL CONSULTING:

Have been retained for several years by one of the ten largest companies in the country on inventory control and applications generally of probability. Devised and supervised over 2 years the installation of a very profitable computer-based production and inventory distribution system for a large Boston manufacturer. Spot consulting includes the Executive Office of the President, the National Academy of Sciences-National Research Council, NATO, numerous manufacturers, large and small, mostly on production, demand, inventory and associated traffic processes, most involving some essential application of random processes, and most including experimental testing of predictions.

HARVEY L. GARNER

Education:

BS Physics, University of Denver, 1946
MS Physics, University of Denver, 1949
PhD Electrical Engineering, The University of Michigan, 1958

Scientific Experience:

Research Associate, Cosmic Ray Research Program, University of Denver, and the Inter-University High Altitude Research Lab. at Echo Lake, Colorado, 1949-1951.

Chief Engineer, Engineering Research Institute, The University of Michigan, (Associated with the development and operation of the MIDSAC and MIDAC computers), 1951-1955.

Instructor, Electrical Engineering, The University of Michigan, 1955-1958.

Chairman, Intensive Summer Computer Courses, 1955 to present.

Consultant, electronic and computer forms (IBM; Lockheed Missile Systems Division; Lear, Inc.; Bell Telephone Laboratories; Ford Instr. Co.; Strand Engineering; Holley Carburetor Co.), 1955 to present.

Assistant Professor, Electrical Engineering, The University of Michigan, 1958-1960.

Associate Professor, Electrical Engineering, The University of Michigan, 1960-1963.

Director, Information Systems Laboratory, Electrical Engineering Department, The University of Michigan, 1960 to present.

Consultant, USAF, 1961 to present.

Professor, Electrical Engineering, The University of Michigan, 1963 to present.

Fellowships or Grants:

Ford Faculty Development Grant for independent study of biological systems, 1961-1962.

Honors:

Eta Kappa Nu
Sigma Pi Sigma
Sigma Xi

Professional Societies:

Association for Computing Machinery
Institute of Electrical and Electronics Engineers

Publications:

Articles:

"A Multi-channel Analyzer for Time of Flight Measurements," IRE Convention Proceedings, 1956.

"Generalized Parity Checking," IRE Trans. on Electr. Computers, EC-7, 3, 207-13, September 1958.

"A Ring Model for the Study of Multiplication for Complement Codes," IRE Trans. on Electr. Computers, EC-8, 1, March 1959.

"The Residue Number System," IRE Trans. on Electr. Computers, EC-8, 2, June 1959.

Book Chapters:

"Analog to Digital and Digital to Analog Conversion Techniques," Notes on Digital Computers and Data Processors, (with J. W. Carr and N. R. Scott), Ann Arbor, The University of Michigan Press, 1-16 (1956).

Reports:

"The MIDSAC Computer," Engineering Research Institute Report 1947-3-T, The University of Michigan (1954).

"Basic Circuitry of the MIDAC and MIDSAC," Engineering Research Institute Report 1937-2-T, The University of Michigan (1954).

"Computer Components Development: Phase One," Engineering Research Institute Report 2452-1-P, The University of Michigan (1956).

"Computer Components Development: Phase Three" Engineering Research Institute Report 2452-3-P, The University of Michigan (1957).

"Computer Components Development: Phase Four," Engineering Research Institute Report 2452-4-P, The University of Michigan (1957).

"Computer Components Development," Industry Program of the College of Engineering IP-248, The University of Michigan (1957).

"Residue Number Systems for Computers," for contract AF 33(616)-7540, ORA Report, The University of Michigan, August 1961.

"Finite, Non-Redundant Number System Weights," for contract AF 33(657)-7811, ORA Report, The University of Michigan, May 1962.

Invited Paper Presentations:

"Machine Number Systems," presented at Harvard-USAF Symposium, August 1961.

"The Communication Sciences Program at The University of Michigan," presented at IBM Research Laboratories, September 1961.

"Parallel Computation and Associative Storage," presented at the AEC Workshop on Computers, Brookhaven Laboratory, Upton, New York, July 1962.

"Iterative Circuit Computers," USAF-Westinghouse Workshop on Parallel Computers, Baltimore, Maryland, October 1962; Proceedings of the Workshop on Computer Organization, Spartan Books, (1963).

Published Reviews:

"The Use of Index Calculus and Mersenne Primes for the Design of a High-Speed Digital Multiplier," by A. S. Fraenkel, IRE Trans. on Electr. Computers, EC-10,1, March 1961.

"Reducing Computing Time for Synchronous Binary Division," by R. G. Saltman, IRE Trans. on Electr. Computers, EC-11, 6, December 1962.

"Parity as an Operation Checking Code," by R. E. Seidell, IEEE Trans. on Electr. Computers, June 1963.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

GODDARD, EDWIN N.

Professor
Chairman of Department

Education: Univ. of Mich.: A.B., 1927; M.S., 1928; Ph.D., 1936.

Employment: Academic
Univ. of Mich.: Inst., 1928-30; Prof. and Director of Geological Field Work, 1949- ; Chairman, Dept. of Geology, 1952-.
Other Professional
U.S. Geological Survey: Junior Geologist, 1930-34; Asst. Geologist, 1934-39; Assoc. Geologist, 1939-43; Geologist, 1943-45; Senior Geologist and Geological Map Editor, 1945-49. Chairman, Map Symbol Committee, U.S. Geological Survey; Chairman, Rock Color Chart Committee, Natl. Res. Council; Chairman, North American Geologic Map Committee, Geological Soc. of Am.; Chairman, Screening panel for earth-science fellowships, Natl. Science Foundation.

Experience: 20 years' research on geology and ore deposits of mining districts in Colorado, Montana, New Mexico, Haiti, and southeastern Alaska.

Publications: Books, Bulletins, etc.--Geology and ore deposits of the Front Range, Colorado (with coauthor), U.S. Geol. Survey, Prof. Paper 223, 1950.
Articles--26 (some with coauthors) on mineral and ore deposits in the Rocky Mountain States, especially Colorado, and in Haiti.

Professional and Honorary Societies: Am. Assn. of Petroleum Geologists; Am. Geophysical Union; Geological Soc. of Am.; Geological Soc. of Washington; Mich. Acad. of Science, Arts, and Letters; Mich. Geological Soc.; Mineralogical Soc. of Am.; Soc. of Economic Geologists; Sigma Xi.

Listed in: American Men of Science; Who Knows - And What; Who's Who in America; Who's Who in the East.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

NAME: Fred T. Haddock

TITLE: Professor of Astronomy, College of Literature, Science and Arts
Professor of Electrical Engineering, College of Engineering
Director of The University of Michigan Radio Astronomy Observatory

ADDRESS: The Observatory
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OFFICE PHONE: NO(rmandy) 3-1511
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RESIDENCE: 800 Avon Road
Ann Arbor, Michigan

PHONE: NO(rmandy) 3-8333

BIRTH: Independence, Missouri; May 31, 1919

EDUCATION:

S.B. (Physics), Massachusetts Institute of Technology, 1941
M.S. (Physics), University of Maryland, 1950

EXPERIENCE:

From 1941 to 1946 at the U. S. Naval Research Laboratory conducted research in microwave radar components which led to the design and development of the first (in 1944) submarine periscope radar antenna. It was extensively used in the Pacific Submarine Fleet during World War II. Awarded a Letter of Commendation by the Secretary of the Navy in 1945 for originating this antenna system and for directing the project.

At the same laboratory from 1946 to 1956 conducted research in microwave radio astronomy. This was one of the first groups in radio astronomy in the world. Participated in the procurement of the NRL 50-foot radio telescope; the highest gain antenna of its type. Led the group that detected discrete thermal type radio sources and measured the intensity of the bright radio sources for the first time at 10 cm and 3 cm wavelength, an extension of radio source spectra by sevenfold.

Since February 1956 has taught in the Astronomy and in the Electrical Engineering Departments at The University of Michigan, first as Associate Professor and since 1959 as Professor. Appointed Director of the Radio Astronomy Observatory in 1961 by the Regents. At the University was responsible for the design and construction of a dynamic radio spectrograph for recording solar burst transients over the band 100 to 600 Mc/sec and 2000 to 4000 Mc/sec using a 28-foot radio telescope and for a precision 85-foot telescope with associated low-noise microwave radiometers using traveling-wave-tubes, ruby solid-state masers, etc. The 85-foot telescope was used to make the first radio detection of the planet Mercury and the first measurement of the planet Saturn and of a new class of radio sources, the planetary nebulae. In 1959 initiated a research program in low-frequency (0.1 to 10 Mc/sec) radio astronomical studies of the galaxy, sun, and planets with the development of instrumentation for very high altitude rockets, satellites and space probes. Experimenter on the first OGO, Orbiting Geophysical Observatory, Satellite scheduled for 1964 and the second OGO, Polar Orbiting Geophysical Observatory also scheduled for 1964.

MEMBERSHIP:

National Academy of Science Panel on Astronomy Facilities, 1963-

National Aeronautics and Space Administration Solar Physics Committee, 1963-

National Science Foundation, Ad Hoc Advisory Committee on IQSY, 1963-

National Aeronautics and Space Administration, Goddard Space Flight Center, Space Radio Astronomy Committee, 1963-

The President's Science Advisory Committee Ad Hoc Panel on the U. S. Navy 600-foot Radio Telescope, 1962-63

U. S. Naval Research Laboratory Scientific Advisory Committee on the 600-foot Radio Telescope, Sugar Grove, 1962-63

The Chief of Naval Research Ad Hoc Committee on Technology and Instrumentation for the U. S. Navy 600-foot Radio Telescope, 1960-61

Air Force, Office of Scientific Research, Arecibo Observatory 1000-foot Radio Telescope Advisory Committee, 1962-

National Aeronautics and Space Administration Office of Space Science Ad Hoc Working Group on Apollo Scientific Experiments and Training, 1962-63

National Aeronautics and Space Administration Advisory Committee on Astronomy and Radio Astronomy, 1958-62

MEMBERSHIP (Cont'd):

National Academy of Sciences Subcommittee on Frequency Allocations for Radio Astronomy, 1962-

National Aeronautics and Space Administration Advisory Committee on Planetary and Interplanetary Sciences, 1961-62

Senior Consultant to the National Radio Astronomy Observatory, Green Bank, 1960-61

National Science Foundation Advisory Panel on Astronomy, 1957-60

Delegate to international scientific unions: 1955, 1957, 1958, 1960, and 1961

PROFESSIONAL AFFILIATIONS:

Vice-President American Astronomical Society, 1962-64
Fellow of Royal Astronomical Society
Fellow of the Institute of Radio Engineers
International Astronomical Union
American Geophysical Union
American Institute of Physics
Sigma Xi

LISTED IN:

American Men of Science, 9th and 10th Editions
Leaders in American Science, 4th and 5th Editions
Registered Professional Engineer - Washington, D. C.

PUBLICATIONS:

"Observation of a Solar Noise Burst at 9500 Mc/s and a Coincident Solar Flare," with Schulkin, Decker, Mayer and Hagen, Phys. Rev., 74, 840, 1948.

"NRL Aleutian Radio Eclipse Expedition," Sky and Telescope, X, No. 5, 1951, with Hagen and Reber.

"The Measurement of 3 and 10 Centimeter Radiation during the Total Solar Eclipse of September 12, 1950," with Mayer, McCullough, White and Sloanaker, Astron. J., 56, 38, 1951.

"Radio Emission from the Orion Nebula and Other Sources at λ 9.4 Centimeters," Astrophys. J., 119, 456, 1954, with Mayer and Sloanaker.

"Radiation at 10 cm from Discrete Sources and the Orion Nebula," with Mayer and Sloanaker, J. Geophys. Res., 59, 155, 1954.

"Eclipse Measurements at Centimeter Wavelengths and their Interpretation," J. Geophys. Res., 59, 174, March 1954.

"Radio Observations of Ionized Hydrogen Nebulae and Other Discrete Sources at a Wavelength of 9.4 cm," with Mayer and Sloanaker, Nature, 174, 176, 1954.

"Extension of Radio Source Spectra to a Wavelength of 3 Centimeters," with McCullough, Astron. J., July 1955.

"The Radial Brightness Distribution of the Sun at 9.4 cm," Proc. of the IAU Symposium on Radio Astronomy, Manchester, England, August 1955.

"Hydrogen Emission Nebulae as Radio Sources," Proc. of the IAU Symposium on Radio Astronomy, Manchester, England, August 1955.

"Radio Sources," Proc. of the National Electronics Conf., XI, 496, October 1955.

"A Model for Non-Thermal Radio Source Spectra," Astrophys. J., 124, 35-42, 1956, with N. Roman.

"Introduction to Radio Astronomy," Proc. IRE, 46, 3-12, 1958.

"Some Characteristics of Dynamic Spectra of Solar Bursts," International Astronomical Union, International Scientific Radio Union, Paris Symposium on Radio Astronomy, 188-192, 1959, ed. R. N. Bracewell, Stanford Press.

"Radio Telescope," McGraw-Hill Encyclopedia of Science and Technology, Book 10, 539-540, 1960.

"Radio Astronomy," McGraw-Hill Encyclopedia of Science and Technology, Book 11, 467-470, 1960.

"Radio Astronomy Observation in Space," American Rocket Society July 1960, 30, 598-602.

"A Relation Between Solar Radio Emission and Polar Cap Absorption of Cosmic Noise," Nature, London, with M. R. Kundu, 1960.

"Spectrum of 1957 November 4 Solar Outburst," Annales d'Astrophysique, Tome 23, No. 3, 1960, 478-479, with A. Boischot and A. Maxwell.

"Measurements of Microwave Radiation from the Planet Mercury," Astronomical J., 66, 287, 1961.

"Measurement of Microwave Radiation from the Planet Mercury," with Howard, W. E., III, Barrett, A. H., Astrophy. J., 136, 3, pp. 995-1004, November 1962.

"Thermal Radio Emissions from Celestial Bodies," Physical Sciences Some Recent Advances in France and the United States, Chap. 6, pp. 64-74, New York University Press, Edited by Kallmann, H. P., Korff, S. A., Roth, S. G., 1962.

"The Plane Polarized Component of Several Radio Sources Measured at 8000 Megacycles/sec," with Hobbs, R. W., Astronomical J., March 1963.

"Cosmic Radio Intensities at 1.2 and 2.0 Megacycles/sec Measured at an Altitude of 1700 Kilometers," with Schulte, H. F., Walsh, D., Astronomical J., March 1963.

REPORTS:

"An Experimental X-Band Radar Antenna for Submarine Periscope," with Davenport and Mayer, NRL Rept. R-3045, February 20, 1947.

"Extraterrestrial Radiation Research at NRL," with Hagen, Report of NRL Progress, 1-9, May 1950.

"The Discovery of Microwave Celestial Sources," Report of NRL Progress, 1-10, March 1954, with Mayer and Sloanaker.

"Astronomical Experiments Proposed for Earth Satellites," UMRI Rept. 2783-1-F, 87 pp., 1958, with L. Aller, L. Goldberg, and W. Liller.

"An Attempt to Measure Gamma Ray Energies with 180° Focussing Magnetic Spectrograph," Bachelor's Thesis, M.I.T., 1941.

"Radio Wave Emission from the Quiet Sun," Master of Science Thesis, University of Maryland, 81 pp., 1950.

HANCOCK, WALTON MILTON

CHAIRMAN OF THE DEPARTMENT OF INDUSTRIAL ENGINEERING AND PROFESSOR OF INDUSTRIAL ENGINEERING

EDUCATION

BE	Industrial Engineering, Johns Hopkins University, 1951
MS	Industrial Engineering, Johns Hopkins University, 1952
Dr. of Eng.	Industrial Engineering, Johns Hopkins University, 1954

EMPLOYMENT

Academic

Professor and Chairman, Department of Industrial Engineering, The University of Michigan, 1963-present
Professor, The University of Michigan, 1962
Associate Professor, The University of Michigan, 1960
Associate Research Engineer, Operations Research Department, The University of Michigan, 1959-1960
Lecturer in Industrial Engineering, The University of Michigan, 1959
Assistant Professor in Production Engineering, Industrial Administration Department, Air Force Institute of Technology, 1954-1956 (1st Lieutenant)
Instructor, Johns Hopkins University, 1956-1959
Instructor, Wittenberg College, 1954-1956

Industrial

Director of Industrial Engineering, Lord Baltimore Press, Baltimore, Maryland, 1956-1959

PROFESSIONAL SOCIETIES

Institute of Management Sciences (Tres. Detroit Chapter)
Professional Engineer, State of Ohio
Methods-Time Measurement Association (Research Director)
American Institute of Industrial Engineers

HONORARY SOCIETIES

Tau Beta Pi
Epsilon Delta Sigma
Pi Epsilon Gamma
Sigma Xi
Alpha Pi Mu

PUBLICATIONS, PAPERS AND MAJOR REPORTS

"Maintenance and Lubrication of High Speed Printing Equipment," Master's Thesis, The Johns Hopkins University June, 1952

"The Capabilities of Printing Processes to Print Uniform Color," Doctor's Thesis, The Johns Hopkins University, June, 1954

"A Study of Moisture Content of Paperboard," Technical Association of the Pulp and Paper Industry, September, 1955, (Co-author)

"Color Variation in Paperboard," Technical Association of the Pulp and Paper Industry, January, 1958 (Co-author)

"Report on the Survey of National Guard Units Regarding Regional Maintenance Representative Services," Willow Run Laboratories, July, 1960, Confidential, (Co-author)

"A Mail Survey of Ordnance Corps Maintenance Technicians Concerning The Ordnance Corps Technical Assistance Program," Willow Run Laboratories, July, 1960, Confidential (Co-author)

"A Mail Survey of Regional Maintenance representatives Concerning the Ordnance Corps Technical Assistance Program," Willow Run Laboratories July 1960, (Co-author)

"An Approach to Development Policies Concerning Scheduled and Unscheduled Maintenance," presented at the U. S. Army Fifth Conference on Design of Experiments in Research, Development and Testing, Fort Detrick, Maryland and published in the Proceedingss, (Co-author), November, 1959.

"Industrial Research on the MTM Element Apply Pressure," Methods-Time Measurement Association, Ann Arbor, May, 1961

"New Research Techniques in Work Measurement," presented at the 12th Annual National Conference and Convention of the American Institute of Industrial Engineers and published in the Proceedings, May, 1961 reprinted in the Journal of Methods-time Measurement, Vol. 8, Nos. 1 and 2, 1961

"An Experiment in the Use of Management Games in Teaching," published in the Proceedings of the Conference on Business Games as Teaching Devices, Tulane University, April, 1961 (Co-author)

"A Description of the Electronic Data Collector and the Methods of its Application to Work Measurement," the Jornal of Industrial Engineering, Vol. 13, No. 4, July-August, 1962, (Co-author)

"Effects of Learning on Short-Cycle Operations," Research Information Paper, No. 2, published by the Methods-Time Measurement Association, 1961 (Co-author)

"A Laboratory Study of Learning," presented at the 11th Annual Methods-Time Measurement Conference and published in the Proceedings, pp. 113-119.

"Learning Curve Research on Short Cycle Operations-Phase I," Laboratory Experiments, with James A. Foulke. (To be published in monograph form by the MTM Assn. April, 1963)

"Production Control Simulations for use in Teaching Production and Inventory Control in Industrial Engineering," to be published as a monograph by the Ford Foundation Project on Computers, May, 1963.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

HEINRICH, E. WILLIAM

Professor
Curator
of Mineralogical Collections

Education: Iowa State College: B.S., 1940. Harvard Univ.: M.S., 1942; Ph.D., 1947.

Positions Held: Academic
Mont. School of Mines: Instr. in Geology, 1946-47. Univ. of Mich.: Asst. Prof. of Mineralogy, 1947-50; Assoc. Prof., 1950-56; Prof., 1956- .

Other Professional
Harvard Mineralogical Museum: Asst. Curator, 1940-42. U.S. Geological Survey: Geologist, 1942-47. Mont. Bureau of Mines and Geology: Geologist, summers, 1947-50. Consulting geologist and mineralogist for various mining, refractory, and technical companies, 1947- . Editor of The Geochemical News, 1957- . Assoc. Editor of The American Mineralogist, 1957- .

Experience: Optical mineralogy; optical crystallography; pegmatite minerals; non-metallic mineral deposits; radioactive mineral deposits; mineral paragenesis; general petrography and economic geology; field work in general geology and mineralogy carried on throughout U.S. and in Canada, Scandinavia, Germany, Switzerland, and Brazil.

Publications: Books, Bulletins, etc.--Deposits of the Sillimanite Group of Minerals. South of Ennis, Madison County, with Notes on Other Occurrences in Montana, Mont. Bur. Mines and Geol., Misc. Contrib., No. 10, 1948. Pegmatite Mineral Deposits in Montana, Mont. Bur. Mines and Geol., Memoir 28, 1949. Sillimanite Deposits of the Dillon Region, Montana, Mont. Bur. Mines and Geol., Memoir 30, 1950. Pegmatite Investigations in Colorado, Wyoming, and Utah, 1942-44 (with coauthors), U.S. Geological Survey, Prof. Paper 227, 1950. The Camp Creek Corundum Deposit, near Dillon, Beaverhead County, Montana, Mont. Bur. Mines and Geol., Misc. Contrib. 11, 1950. Microscopic Petrography, McGraw-Hill Book Co., 1956. Mica Deposits of the Southeastern Piedmont, Part 1: General Features, (with coauthors), U.S. Geol. Survey Prof. Paper 248-A, 1952. Mica Deposits of the Southeastern Piedmont, Part 9: Thomaston-Barnesville District, Georgia (with coauthors), U.S. Geol. Survey Prof. Paper 248-F, 1953. Mica Deposits of the Southeastern Piedmont, Part 10: Outlying Deposits in Georgia (with coauthors), U.S. Geol. Survey Prof. Paper 248-F, 1953. Mica Deposits of the Southeastern Piedmont, Part 11: Alabama District (with coauthors), U.S. Geol. Survey Prof. Paper 248-G, 1953.

Articles--35 on deposits of various minerals, especially mica and pegmatites, chiefly in the Rocky Mountains.

Professional and Honorary Societies: Am. Geophysical Union; Am. Institute of Mining Engineers; Geochemical Soc.; Geological Soc. of America; Mineralogical Soc. of America; Mineralogical Soc. of England; Mineralogical Soc. of Germany; Mich. Acad. of Science, Arts, and Letters; Mich. Geological Soc.; Sigma Xi.

Listed in: American Men of Science.

HOK, GUNNAR Professor

Education: E.E., Royal Inst. of Tech., Stockholm, Sweden, 1926; graduate work at Harvard Univ., 1931-32.

Employment: Academic
Inst. in Electrical Engineering (part time), Royal Inst. of Tech., Stockholm, Sweden, 1929-31, 1932-37; Inst. in Electrical Engineering, New York Univ., 1941-43. Univ. of Mich.: Lecturer, 1948-1953; Prof., 1953-.
Other Professional
Asst. Engineer, Radio Bureau, Swedish Telegraph Board, 1927-33; Development Engineer, Svenska Radio A.B., Stockholm, 1933-37; Development Engineer, Gray Manufacturing Co., Hartford, Conn., 1939-40; Res. Assoc., Radio Res. Laboratory, Harvard Univ., 1943-46; Res. Physicist, Wesleyan Univ., Middletown, Conn., 1946-48; Res. Engineer, Eng. Res. Inst., 1948-53.

Experience: Design of radio communication equipment; research in the fields of acoustics, crystals for frequency control, microwave circuits and generators, particularly magnetrons, and applications of information theory to communication.

Publications: Articles--About 17 (6 with coauthors) on linear and nonlinear circuits, communication equipment, microwave measurements, theory of magnetrons, vibrations of crystals, and Langmuir-probe measurements in the ionosphere.

Professional and Henorary Societies: Am. Institute of Electrical Engineers; Am. Physical Soc.; Institute of Radio Engineers; Sigma Xi.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

JOHN H. HOLLAND — Assistant Professor

Education

BS, Physics, Massachusetts Institute of Technology, 1950
MA, Mathematics, The University of Michigan, 1954
Ph.D., Communication Sciences, The University of Michigan, 1959

Scientific Experience

Previously with IBM, he was a member of the planning group for the IBM 701 computer from 1950 to 1952. From 1952 to 1956, while doing graduate work at The University of Michigan, he was a consultant to IBM on problems of "concept-forming machines." From 1956 to 1958 he was a Research Associate with the Engineering Research Institute, The University of Michigan, and from 1959 to 1961 an Associate Research Mathematician for the University of Michigan Institute of Science and Technology while holding a lectureship first in Psychology and then in Philosophy and in the Communication Sciences. During the academic year 1962-63, Dr. Holland served as acting director of the Logic of Computers Group; he is at present Assistant Professor of Communication Sciences and a Research Associate of the Carnegie Institution of Washington, D.C.

Publications

1. "Information Processing in Adaptive Systems" to be published in Information Processing in the Central Nervous System, a symposium held at the 22nd International Congress of Physiological Sciences.

2. "Concerning Efficient Adaptive Systems," Self-organizing Systems-1962, Washington D.C.; Spartan Books, pp. 215-230.

3. (With M. R. Finley) "The Communication Sciences," Data Processing 1, 8, August 1962, pp. 15-17.

4. "Outline for a Logical Theory of Adaptive Systems," Journal of the Association for Computing Machinery, 9, 3, July 1962, p. 297-314.

5. "Iterative Circuit Computers," Proc. 1960 West. Joint Computer Conf., 259-265, 1960.

6. "A Universal Computer Capable of Executing an Arbitrary Number of Sub-Programs Simultaneously," Proc. 1959 Eastern Joint Computer Conf., 108-113, 1959.

7. "Cycles in Logical Nets," Journal of the Franklin Institute, 270, 3, 202-226, 1960.

8. "Survey of Automata Theory," Willow Run Laboratories Report 2900-52-R, The University of Michigan, 24 pages, 1959.

9. (With R. Bellman and R. Kalaba) "On an Application of Dynamic Programming to the Synthesis of Logical Systems," Journal of the Association for Computing Machinery, 6, 4, 386-493, 1959.

10. (With J. W. Crichton), "A New Method of Simulating the Central Nervous System," Willow Run Laboratories Report 2144-1195-M, The University of Michigan, 37 pages, 1959.

11. (With other members of the Logic of Computers Group), "Review of 'Automata Studies,'" MTAC, 12, 94-99, 1958.

12. (With N. Rochester, L. H. Haibt, and W. L. Duda) "Tests on a Cell Assembly Theory of the Action of the Brain," IRE Trans, Information Theory, September 1956, 80-93, 1956.

Professional Societies

Member, American Mathematical Society
Member, Association for Symbolic Logic
Affiliate, IRE Prof. Group on Electronic Computers
Member, American Assoc. for the Advancement of Science
Member, Association for Computing Machinery

Honors

Levy Medal of the Franklin Institute; Society of Sigma Xi.

HOLTER, MARVIN R. RESEARCH ENGINEER

EDUCATION

BS	Physics	The University of Michigan, 1949
MS	Mathematics	The University of Michigan, 1951
MS	Physics	The University of Michigan, 1958

EMPLOYMENT

Draftsman, St. Regis Paper Co., Oswego, N.Y., 1940-41
Draftsman and Trouble Shooter, Ford Motor Company, Willow Run Plant Aircraft, 1942
Designer Fluid Agitating Equipment, Mixing Equipment Company, Rochester, New York, 1944-45
Supervisor and Designer Industrial Conveyors, Palmer Bee Company, Hamtramck, Michigan, 1945-46
Assistant in Research, The University of Michigan, IST, 1947-50
Research Associate, The University of Michigan, IST, 1950
Research Engineer, The University of Michigan, IST, 1950-56
Associate Professor, Engineering Mechanics, University of Toledo, 1956-57
Research Engineer, The University of Michigan, IST, 1957-

EXPERIENCE

Limited warfare studies. Infrared airborne target detection and discrimination. Infrared strip map scanning system measurements and design. Design and analysis of optical communications systems. Engineering mechanics teaching. All aspects of design of defense systems against ballistic missiles, radar cross-section measurements. Air defense ground system design. Data processor and digital computer logical design and application. Aircraft design. Industrial conveyor design. Fluid agitation equipment design. Design of automatic machinery to fabricate and fill 100 lb. paper bags.

PROFESSIONAL AND HONORARY SOCIETIES

Industrial Math. Society of Detroit
American Association of Computing Machinery
Science Research Club, The University of Michigan
National Academy of Sciences
  National Research Council
    Committee on the Use of Aerial Survey Methods in Agriculture
Sigma Xi

PUBLICATIONS

"Preliminary Study of a Missile Defense System," June 1950 (C)
"Cost and Development Time Estimates for Joint AA00-GCI Storages and Communications Systems. A Comparison of Analog and Digital Systems." April 1952 (S)
"Michigan Air Defense System," September 1952 (S)
"Defense Against Ballistic Targets or the V-2 Class," December 1953 (S)
"Studies in Radar Cross-Sections XIII - Description of a Dynamic Measurement Program," May 1954 (C)
"Defense Against Ballistic Targets of the Intercontinental Class," June 1954 (S)
"Airborne Infrared Exercise 14-18 November 1955," 1956 (C)
"Observation of a Moving Military Convoy with the Project MICHIGAN AN/AAS-4(XA-1)"
"The Project MICHIGAN Infrared Wide Angle Scanner," presented as a paper at the IRIS Symposium in June 1959 and published in the Proceedings of that conference, October 1959, Vol. 4, No. 4.
"A Method of Obtaining Resolution Finer than the Instantaneous Field of View of an Optical Scanning Device," with G. Suits, presented as a paper at the IRIS Symposium in June 1959 and published in the Proceedings of that conference, October 1959
"Optical Mechanical Scanning Techniques," with W. Wolfe, The University of Michigan, Report No. 2900-154-R, April 1960, and published in Proceedings of IRE, September 1959
"Fundamentals of Infrared Technology," with S. Nudelman, G. Suits, and W. Wolfe, and G. Zissis, MacMillan Co., 1962
"Corrections of Compression Effects in Strip Map Scanners," with A.K. Parker, and G. H. Suits, published in the Proceedings of IRIS, May 1961, Vol. 6, No. 2
"Maximum Range and Search Capability Comparisons for Passive Infrared Pulsed Laser and Pulsed Radar Detection Systems," 4479-20-J, with D. Carmer, to be published in the Proceedings of IRIS
"General Range Equation for Optical Communication in Space," with K. Morris, 4968-3-J, to be published in the Proceedings of IRIS

JACKSON, PHILIP L. ASSOCIATE RESEARCH ENGINEER

EDUCATION -

BS	Music	University of Oregon, 1950
AM	Music	The University of Michigan, 1952
MS	Instrumentation Engineering	The University of Michigan, 1957

EMPLOYMENT

Micrometrical Manufacturing Company, Ann Arbor, Michigan, 1951-53
Research Assistant, The University of Michigan, 1953-58
Engineer, Bendix Systems Division, Ann Arbor, Michigan, 1958-1960
Research Associate, The University of Michigan, IST, 1960-1962
Associate Research Engineer, The University of Michigan, IST, 1962-

EXPERIENCE

Investigation of special problems in surface contour and roughness. Experimental research in air temperature control, glass strength and optical distortion, detonation waves, and cryogenic measurements. Analytical and experimental development in measurement and control. Development and simulation of a correlator for range finding. Analysis of, specification for, and flight testing of a measurement system for airborne turbulence. Analysis, design, and testing of a three-axis motor for satellite control.

Research and development on equipment and techniques for the acquisition and analysis of acoustic background noise due to atmospheric turbulence at high altitudes. Analysis of thermal noise in instruments. Optical processing of seismic data.

PROFESSIONAL AND HONORARY SOCIETIES

Member, Phi Mu Alpha
Member, Delta Phi Alpha
Member, Seismological Society of America, Eastern Section
Member, Optical Society of America

PUBLICATIONS

"Analysis of a Large Heat Exchanger," with co-author, Am. Chem. Soc. Fl. Dyn. Symposium, July 1958

"Upper Altitude Acoustic Measurements," with co-author, presented to Acoustical Society of America meeting, October 1960

"Use of a Large Thermocouple Junction to Locate Temperature Distrubances," Project MICHIGAN Report No. 2900-218-R, January 1961

"Envelope Coincidence Method to Extract Weak Seismic Signals in Noise," paper presented to Eastern Section of Seismological Society of America, November 1961

"Optical Analysis Techniques Applied to Seismic Data," U of M Report 4596-4-P

"Instrument Noise in Electrodynamic Seismometers," Earthquake Notes, bulletin of the Eastern Section of the Seismological Society of America

"Use of a Large Thermocouple Junction to Locate Temperature Distrubances." Review of Scientific Instruments, Vol. 33, No. 3, p. 334, March 1962

"Signal Enhancement Through an Ensemble Presentation," paper presented to Seismological Society of America annual meeting, April 18, 1962

"Signal Enhancement Through an Ensemble Presentation," to be published in Bulletin of the Seismological Society of America, accepted September 1962.

"Horizontal Subsystem Turbulence, Air Weather Reconnaissance," Final Report, Bendix Systems Division, October 1959

"Time-varying Spectra and Dispersion Measurement Through Optical Diffraction Scanning," paper submitted to Bulletin of the Seismological Society of America, October 1963

"Analysis of Variable-Density Seismograms Through Optical Diffraction," paper presented to the Annual Meeting of the Society of Exploration Geophysicists, October 1963.

"Optical Diffraction Techniques Applied to Variable-Density Seismograms," paper presented to Eastern Section of the Seismological Society of America, October 1963.

PATENTS

Mechanical-Electrical Transducer, U.S. Patent No. 3,096,656, July, 1963.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

Name: JONES, Leslie M.

Born: December 22, 1917 in Yonkers, New York
Married (three children)

Education and Experience:

B. S. (Eng. Physics), University of Michigan, 1940

1940-41, Sound Engineer, Woodall Industries, Detroit Michigan
Acoustical treatment of automobiles and appliances

1941-42, Production Engineer, Western Electric, Kearney, New Jersey, Filters for multiplex long line telephone carrier systems.

1942-46, Industrial Electronics Instrument Engineer, Physicist Research Company, Ann Arbor, Michigan. Development of electronic instruments for measuring surface finishes, aircraft engine performance and computing gunsight performance.

1947-present, Research Engineer, University of Michigan Research Institute

1949-present, Director, High Altitude Engineering Laboratory, Dept. of Aeronautical and Astronautical Engineering, University of Michigan. Development of techniques and instrumentation for balloon, rocket and satellite experiments for measuring aeronomical and high altitude meteorological parameters. Also, data reduction, geophysical interpretation as well as development of sounding rockets for such experiments.

1957-63, Lecturer in Aeronautical and Astronautical Engineering, University of Michigan.

1963-present, Professor, Aeronautical Engineering, University of Michigan.

Professional and Honorary Societies:

American Institute of Aeronautics and Astronautics	1958-present	Senior Member
Sigma Xi	1954-present	Member
American Geophysical Union	1961-present	Member

Committees:

Committee on Physics of Atmosphere and Space, American Institute of Aeronautics and Astronautics	1960-present	Member
Committee on Extension to the Standard Atmosphere	1960-present	Member
Committee on Upper Atmosphere Rocket Research, Space Science Board	1962-present	Member
Working Group II for the IQSY, COSPAR	1963-present	Member

Listed in:

American Men of Science

Professional Publications and Books:

"Diffusive Separation in the Upper Atmosphere", (with L. T. Loh, W. H. Neil, M. H. Nichols, and E. A. Wenzel). Physical Review, 84, No. 4, 846-847, 1951.

"The Measurement of Diffusive Separation in the Upper Atmosphere", Jour. of Atmospheric and Terrestrial Physics, Spec. Suppl. I, 1954.

"Satellite Drag and Air-Density Measurements", (with F. L. Bartman) Chapt. 10, p. 85, Scientific Uses of Earth Satellites, edited by James A. Van Allen, University of Michigan Press, Ann Arbor, 1956.

"Transit-Time Accelerometer", The Review of Scientific Instruments, 27, No. 6, 374-377, June 1956.

"Upper Air Density and Temperature by the Falling-Sphere Method", (with F. L. Bartman, L. W. Chaney and V. C. Liu) Journ. of Applied Physics, 27, No. 7, 706-712, July 1956.

"The Nike-Cajun Sounding Rocket", (with W. W. Berning, W. H. Hansen, N. W. Spencer and W. G. Stroud) Jet Propulsion, March 1957.

"Seasonal and Latitude Variations in Upper-Air Density", (with F. F. Fischbach and J. W. Peterson), IGY Rocket Report Series, No. 1, July 1958, Nat. Acad. Sci.

"The Measurement of Diffusive Separation in the Upper Atmosphere", (with L. T. Loh, M. H. Nichols, and E. A. Wenzel), Nat. Acad. Sci., IGY Rocket Report Series, No. 1, July 1958, (Moscow).

"Upper Air Density and Temperature: Some Variations and an Abrupt Warming in the Mesosphere", (with J. W. Peterson, E. J. Schaefer and H. F. Schulte). Journ. Geoph. Research, Vol. 64, No. 12, 1959.

"Measuring Upper Air Structure" Astronautics, Vol. 4, No. 7, Page 26, July 1959.

"Upper Air Densities and Temperatures from Eight IGY Rocket Flights by the Falling Sphere Method", (with J. W. Peterson, H. F. Schulte and E. J. Schaefer) Nat. Acad. Sci., IGY Rocket Report Series, December 1959)

"Nike-Cajun and Nike-Deacon", (with W. H. Hansen and F. F. Fischbach) Chapt. 11, Sounding Rockets, ed. by H. E. Newell, McGraw-Hill, N. Y., 1959.

"Satellite Measurements of Atmospheric Structure by Refraction", (with F. F. Fischbach and J. W. Peterson), Planet. Space Sci., Vol. 9, pp. 351 to 352, 1962.

"The Atmosphere," Chapter in Systems Engineering Handbook, ed. by R. E. Machol, McGraw-Hill, N. Y., (in press).

JONES, Leslie M.

Professional Publications and Books (cont'd)

"Upper Air Structure Measurements With Small Rockets", Space Research II, Proceedings of the Second International Space Science Symposium, Florence, Italy, eds., H. C. Van de Hulst, C. De Jager and A. F. Moore, North-Holland Publishing Co., Amsterdam, 1961.

Conference Reports:

"The Measurement of Diffusive Separation in the Upper Atmosphere", (with others). Presented at the Oxford Conference on Upper Atmosphere Rocket Exploration, Oxford, England, August 1953.

"Satellite Drag and Density Measurements", (with F. L. Bartman) Proceedings of the Symposium on Scientific Merits of a Satellite Vehicle, Ann Arbor, Jan. 1956.

"The Nike-Cajun Rocket in the IGY", Proceedings of the CSAGI Rocket and Satellite Conference, Washington, D.C., September 30, 1957. (Published by Pergamon.)

"Rocket Measurements of Temperatures and Winds Above Ft. Churchill, Canada", (with F. L. Bartman, W. Bandeen, W. Nordberg W. G. Stroud). Proceedings of the CSAGI Rocket and Satellite Conference, Washington, D.C., Sept. 30-Oct. 5, 1957.

"Instrumentation for Measuring the Structural Parameters of the Upper Atmosphere", Proceedings of the 14th Annual Meeting and Astronautical Exposition, American Rocket Society, Nov. 16-20, 1959.

"Upper Air Structure Measurements with Small Rockets", Symposium on Scientific Research by Means of Small Sounding Rockets, COSPAR, Florence, Italy, April 10-14, 1961.

University of Michigan Research Institute Reports:

"The Nike-Deacon Sounding Rocket", (with W. H. Hansen) Dept. of Aero. and Astro. Eng., Univ. of Mich., ERI Memo Report, May 1955.

"Density and Temperature of the Upper Atmosphere as Measured by the Falling Sphere Method", (with F. L. Bartman) ERI Report 2299-1-F, Univ. of Mich., Ann Arbor, Sept. 1955.

"A Simplified Falling-Sphere Method for Upper-Air Density", (with F. L. Bartman) ERI Report 2215-10-T, Univ. of M ch., Ann Arbor, June 1956.

"Upper Air Densities and Temperatures Measures by the Falling Sphere Method, 1961 Review", (with J. W. Peterson ORA Report 03558-5-T, Univ. of Mich., Ann Arbor, Feb. 1961.

"Atmospheric Measurements from Satellite Observations of Stellar Refraction" (with F. F. Fischbach and J. W. Peterson) ORA Report 40963-1-T, Univ. of Mich., Ann Arbor, Jan. 1962.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

KELLY, WILLIAM C. — Assistant Professor

Education: Columbia Univ.: A.B., 1951; M.A., 1953; Ph.D. (Geology), 1954.

Positions Held: Academic
Columbia Univ.: Asst. in Economic Geology, 1951-53; Teaching Asst., 1954. Hunter College: Instructor, 1954. Univ. of Mich.: Instructor, 1956-58; Asst. Prof., 1958-

Other Professional
Operations Analyst, Operations Research Office, Chevy Chase, Md., 1954-56.

Experience: Mineralogy of oxidized lead-zinc ores; thermal analysis of natural iron oxides; time, motion, and cost effectiveness studies in transportation systems.

Publications: Books, Bulletins, etc.--Topical Study of Lead-Zinc Gossans, Bulletin No. 46, New Mexico Bureau of Mines and Mineral Resources, 1958. Analysis of Means for Logistic Ship to Shore Transfer of Cargo (with coauthors), Technical Manual, Operations Research Office, Chevy Chase, Md.

Articles--10 (4 with coauthors) on mineralogy of metallic ore deposits, Antarctic rock weathering, thermal analysis of natural iron oxides, chromatographic analysis of ore minerals. Abstracts, Reviews, etc.--4 .

Professional and Honorary Societies: Am. Mineralogical Soc.; Geochemical Soc.; Geological Soc. of Am.; Michigan Academy Arts, Sciences, and Letters; Sigma Gamma Epsilon (Honorary Member); Sigma Xi.

Special Distinctions:

Listed in: American Men of Science.

LAGLER, KARL F.

Professor of Zoology
Professor of Fisheries
Chairman, Department of Fisheries

Education: Univ. of Rochester: A.B., 1934. Cornell Univ.: M.S., 1936. Univ. of Mich.: Ph.D., 1940.

Positions Held: Academic
Univ. of Rochester: Teaching Assistant, 1934-35. Univ. of Mich.: Teaching Fellow, 1939; Instr., 1939-44; Asst. Prof., 1944-50; Assoc. Prof., 1950-55; Prof., 1955- ; Chairman, Dept. of Fisheries, 1950- .

Other Professional
Univ. of Mich.: Investigator of fish management, 1937-39; Res. Associate, Laboratory of Vertebrate Biology, 1945-49. Am. Wildlife Inst.: Leader of Mich. Cooperative fish research unit, 1937-40. Mich. Dept. of Conservation: Res. Associate, Institute of Fish Research, 1939- ; Indiana Lake and Stream Survey, 1942- . Cranbrook Inst. of Science: 1940-41; 1944-48; 1954- . U.S. Fish and Wildlife Service: Biologist, part-time, 1940-42. Am. Fish Tackle Manufacturers: Consultant, 1948-54. Great Lakes Res. Inst.: Sec., 1948-54. U.S. Bureau of Commercial Fisheries, Alaska: Consultant, summer, 1958. Expeditions: Upper Great Lakes, 1945-49; Western Europe, 1958-59.

Experience: Ichthyology; fishery biology; ecology; distribution and taxonomy of Great Lakes fishes; natural history of cold-blooded vertebrates; educational television.

Publications: Books, Bulletins, etc.--Keys for the Identification of the Fishes of the Great Lakes and Tributary Waters (with coauthor), Edwards Bros., 1939. Guide to the Fishes of the Great Lakes and Tributary Waters (with coauthor), Bulletin of Cranbrook Inst. Sci., 1941. Field and Laboratory Studies in Freshwater Fishery Biology, Univ. of Mich., 1947. Fishes of the Great Lakes Region (with coauthor), Bulletin of Cranbrook Inst. Sci., 1947. Fish and Fishing in Michigan, Edwards Bros., 1948. Freshwater Fishery Biology, Wm. C. Brown Co., 1952.

Articles--100 (some with coauthors) on biology of fishes, fishery management, education.

Professional and Honorary Societies: Am. Assn. for the Advancement of Science (Fellow); Am. Fisheries Soc. (Life Member); Am. Inst. of Biological Sciences; Am. Inst. of Fishery Research Biologists (Fellow); Am. Soc. of Ichthyologists and Herpetologists (Life Member); Am. Soc. of Limnology and Oceanography; Assn. of College Honor Soc. (Council Member); Gamma Alpha; Mich. Academy; Phi Sigma (Pres., 1953-); Sigma Xi; Soc. for the Study of Evolution; Univ. of Mich. Research Club; Wilson Ornithological Soc.

Special Distinctions: Billington Lecturer, Cranbrook Institute of Science, 1947. Guggenheim Fellow, 1957-58.

Listed in: American Men of Science; Who's Who in Education.

LEGAULT, RICHARD R. RESEARCH MATHEMATICIAN

EDUCATION

BS	Business Administration	University of California, 1950
MA	Mathematical Statistics & Economics	University of Chicago, 1952

EMPLOYMENT

Graduate Teaching Assistant, The University of California, 1949
Research Assistant, University of Chicago,1950-52
Student, University of Chicago, 1950-52
Buyer, Procter & Gamble, 1953
Sgt., U.S. Army, 1953-55
Graduate Research Assistant, The University of Michigan, IST, 1955-56
Research Associate, The University of Michigan, IST, 1956-59
Associate Research Statistician, The University of Michigan, IST, 1959-60
Research Mathematician, The University of Michigan, IST, 1960-

EXPERIENCE

The design and analysis of engineering field tests. Development of experimental designs for the field testing of large-scale systems. Development and application of statistical estimation and hypothesis testing techniques. Construction of mathematical models representing large-scale systems. Application of digital computer to perform model computations. Test data handling. Air defense. Air traffic control. Battlefield surveillance. Electronic interference. Infrared noise computation. Teaching in industrial engineering.

PROFESSIONAL AND HONORARY SOCIETIES

Member, Phi Kappa Phi
Member, Sigma Xi
Member, American Mathematical Society
Member, Institute of Mathematical Statistics

"An Evaluation and Comparison of an AN/GSG-2 Antiaircraft Defense System and a Zone of Interior Aircraft Systems", (2354-4-T), (co-author).
"An Evaluation of an AN/GSG-2 Antiaircraft Defense System with NIKE", Vol. I, II and III (2354-5-T, 2354-6-T and 2354-7-T), (co-author).
"The Evaluation Program for the AN/FSG-1 Antiaircraft Defense System", Vol. I and II (2354-8-T and 2354-9-T), (co-author).
"Implication for Field Tests of the Modeling Approach", presented at the Symposium on the Prediction of Performance of Large-Scale Systems, (co-author), The University of Michigan, September 1958 (2354-11-S).
"A Classification of Mathematical Models", abstract presented at the May 1958 meeting of the Operations Research Society of America, in Boston, Massachusetts.
Notes for a Short Course "Modeling and Simulation in Operations Research", The University of Michigan, 1960.
"Estimation of Average Values in a Stochastic Model", Proceedings of the Symposium of Digital Simulation Techniques for Predicting the Performance of Large-Scale Systems.
"Battle Field Surveillance Simulation", (2900-158-T), The University of Michigan (co-author) in publication.
"Terminal Operations Model of the Control of Air Traffic", March 1960, The University of Michigan, (co-author).
"Analysis of Electronic Interference (04095-1-T)The University of Michigan, September 1960, (co-author).
"Four Papers Concerning the Modeling of the Communications Systems", (U), June 1961, (co-author).
"Noise Infrarimetry Coefficients," The University of Michigan, 4479-148-Vol. 4.
"Optimal Spectral Filter," IRIS, Vol. 8, No. 4, co-author, September 1963
"Optimal Statistical Spectral Discrimination," The University of Michigan, 5237-14-T
"The Statistics of Spectral Distribution for Sky Backgrounds,", The University of Michigan, 5237-14-T
"State of the Art Report on Spatial Filtering," IRIS, Vol. 9, Nol, co-author, November 1963.
"Topics in Spectral Discrimination," notes for a short course "Special topics in Infrared, The University of Michigan, 1963.

Name: LEITE, Richard J.

Born: Fremont, Ohio, March 8, 1923
Married (2 children)

Education and Experience:

B.N.S., 1945, University of Notre Dame
B.S. (Aero. Eng.), 1947, University of Notre Dame
M.S. (Aero. Eng.), 1948, University of Michigan
PhD. (Aero. Eng.), 1956, University of Michigan

1948-56, Research Associate, Dept. of Aero. Engineering, University of Michigan. Aerodynamicist in Upper Atmosphere Research Laboratory. Project Engineer on program for development of analog computer for automatic reduction of wind tunnel data. Sole investigation in experimental program concerning the stability of fully developed laminar flow in a pipe.

1956-58, Senior Engineer with Booz-Allen Applied Research Inc. Established a program for efficient and timely processing and analyzing of electronic intelligence data and was responsible for a project concerned with a theoretical and experimental analysis of an explosion gas turbine.

1958-62, Research Engineer at the Radiation Laboratory, Dept. of Electrical Engineering, the University of Michigan. Evaluated the fluid dynamic aspects of flow fields of orbiting satellites and the entire flight of ballistic missiles in conjunction with investigations concerning the associated radar cross-section and microwave emission characteristics. Assisted in an analysis of the electromagnetic characteristics of explosions. Project Engineer on a program concerned with passive microwave detection of ballistic missiles during the launch, mid-course, and re-entry phases of flight. Conducted various studies of the influence of plasmas generated by bow shockwaves on blunt re-entry vehicles and boundary layers on high performance re-entry vehicles, upon the propagation of microwaves through these plasmas.

1962-present, Project Engineer, High Altitude Engineering Laboratory, Dept. of Aero. and Astro. Engineering, the University of Michigan. Is directing a program concerned with the adapting a Paul-type RF mass spectrometer to analyze atmospheric constituents while aboard an earth satellite.

Professional and Honorary Societies:

Institute of the Aerospace Sciences	1947-present	Member
American Association for the Advancement of Science	1949-present	Member
Sigma Xi	1949-present	Member
Phi Kappa Phi	1950-present	Member
American Rocket Society	1959-present	Member

Professional Publications and Books:

"Automatic Reduction of Wind Tunnel Data," Aero. Eng. Rev., 12, 42-47, 1953, (with L. L. Rauch, V. S. Haneman, and U. A. Cotecchia).

"A Low-frequency Oscillator," Rev. Sci. Instr., 24, 901-903, 1953, (with R. M. Howe).

"Automatic Reduction of Wind Tunnel Data" Trans. IRE-PGI., PGI-2, 39-47, 1953, (with L. L. Rauch, V. S. Haneman, and U. A. Cotecchia).

"An Experimental Investigation of the Stability of Poiseuille Flow," J. Fluid Mech., 5, 81-96, 1959.

"Critical Frequencies in the Stagnation Region of a Shock Layer," J. Aero. Sci., 28, 820-821, 1961, (with N. Hawk).

"An Experimental Investigation of the Stability of Poiseuille Flow," American Physical Society, New York, January 1956.

University of Michigan Research Institute Reports:

"Detection of Missile Exhausts and Ionization," Summary Progress Report, with M. L. Barasch, H. Brysk, W. E. Burdick, S. T. Harmon, K. M. Siegel, W. E. Vivian, and P. F. Zweifel, Report No. 2764-1-P, DA 36-039 SC-75041, Confidential, March 1959.

"Radiation From Rocket Exhausts; 1 to 10^7 Kc/s," with M. L. Barasch, C. K. Goberdhan, R. F. Goodrich, and H. Weil, Report No. 4259-1-F, General Electric PO 214-46079, Secret, January 1961.

"Study of Microwave Radiometry Detection Techniques," Final Report, with B. A. Harrison, Report No. 2764-13-F, DA 36-039 SC-75041, Secret, August 1961.

"Investigation of Physical Model for Satellite Detection," Final Report, No. 2764-15-F, DA 36-039 SC-75041, Unclassified, May 1962.

Listed in:

American Men of Science

NAME: Wilbur J. Lindsay

TITLE: Associate Research Engineer

DATE OF BIRTH: October 28, 1925

EDUCATION:

B.S.(E.E.), Texas A and M College, 1948
M.S.(E.E.), Texas A and M College, 1954

EXPERIENCE:

Non-Academic:

EGO Satellite Managing Engineers for Radio Astronomy Experiment, November 1961 to the present
Associate Research Engineer, Radio Astronomy, University of Michigan, July 1961 - November 1961
Associate Research Engineer, Cooley Electronics Laboratory, July 1960-July 1961
Research Associate, Cooley Electronics Laboratory, 1954-1960.
Engineer, Texas A and M Research Foundation, 1952-54
Project Research Engineer, Halliburton Oil Weel Cem. Co., 1951-52
Assistant Engineer, Humble Oil and Refining Company, 1948-51
Recorders Assistant, The Texas Company, 1947, summer

SOCIETIES, ETC.:

Member, Institute of Radio Engineers
Tau Beta Pi
Phi Kappa Phi
Sigma Xi

PUBLICATIONS:

"Proceedings of the Institute of Radio Engineers," "The Application of Dielectric Tuning to Panoramic Receiver Design," with T. Butler, L. Orr, September 1955.

"Applications of the Mitron," with Boyd, Proc. of the National Electronics Components Conference, 1955.

"Design for Automatic Spinning Goniometer Radio Direction Finding," with Heim, NBS J. Res., Sec. D, June 1961

Numerous classified technical reports.

NAME: John M. Malville

TITLE: Assistant Professor of Astronomy

DATE OF BIRTH: April 24, 1934

PRESENT RESPONSIBILITIES:

EGO experiment and ground based radio astronomy. Conducting research in the area of solar radio noise bursts. Theoretical studies of the mechanism of solar bursts and assisting in the planning of scientific instrumentation for observing and measuring solar radio bursts.

EDUCATION:

B.S., California Institute of Technology, 1956
Ph.D., University of Colorado, 1961.

EXPERIENCE:

Non-Academic:

Scientist, Arctic Institute of North America and Air Force Cambridge Research Center, Geophysics Research Directorate, Ellsworth Station, Antarctica, 1956-58.

Research Assistant, Yerkes Observatory, University of Chicago, 1958

Research Scientist, Basic Science Laboratory, Lockheed California Company, Burbank, California, 1961-62

Associate Research Physicist, Radio Astronomy, University of Michigan, February 1962-February 1, 1963.

Academic:

Assistant Professor of Astronomy, University of Michigan, February 1, 1963 to present.

SUMMARY OF TECHNICAL EXPERIENCE:

In charge of auroral and airglow program at Ellsworth Station, Antarctica; research scientist at Lockheed working in solar physics.

SOCIETIES, ETC.:

American Astronomical Society
American Geophysical Union
Sigma Xi
Astronomical Society of the Pacific

PUBLICATIONS:

"Antarctic Auroral Observations, Ellsworth Station, 1957," J. G. R., 64, 1389, 1959.

"Type B Aurora in the Antarctic," J. A. T. P., 16, 59, 1959.

"The Effect of the Initial Phase of a Magnetic Storm upon the Outer Van Allen Belt," J. G. R., 65, 3008, 1960.

"Excitation of Helium in the Aurora," J. A. T. P., 21, 54, 1961.

"Narrow Hydrogen Emission in the Aurora," Planetary and Space Science, 2, 130, 1960.

"Artificial Auroras Resulting from the 1958 Johnston Island Nuclear Explosions," J. G. R., 64, 2267, 1959.

"The Trajectories of Chromospheric Disk Sources," with G. E. Moreton, Nature, June 10, 1961.

"The Association of Type III Bursts and Solar Flares," Ap. J., 135, 834, 1962.

"Characteristics of Type III Bursts," Ap. J., 136, 266, 1962.

"Type IV Radiation from Flares Covering Sunspots" with S.F. Smith, J. G. R. in press.

"The Expansion of Flare Filaments," P.A.S.P., in press.

"Spectrum of Coherent Electron Waves in the Solar Corona," A. J., 67, 580, 1962.

"Association of Type IV Radio Bursts with Flares Covering Sunspot Umbrae," with S. F. Smith, P. A. S. P., 74, 406, 1962.

Name: MASON, Conrad J.

Born: January 12, 1932, Detroit, Michigan
Married

Education and Experience:

B.S. (Physics) with distinction, 1953, University of Michigan
M.A. (Physics), 1955, University of California (Berkeley)
PhD. (Physics), 1960, University of California (Berkeley)

1952-53, Research Assistant at the University of Michigan.
1953-55, Teaching Assistant at the University of California.
1955-60, Research Assistant at the University of California Radiation Laboratory.
1960-63, Associate Research Physicist in the Radiation Laboratory of the University of Michigan.
1963-present, Associate Research Physicist in the High Altitude Engineering Laboratory, Dept. of Aero. and Astro. Engineering, of the University of Michigan.

Professional and Honorary Societies:

The American Physical Society	1959-present	Member
Sigma Xi	1957-present	Member

Professional Publications and Books:

"Results From an Enriched Negative K-meson Beam," Phys. Rev., 105, 1417, 1957, (with others).

"Hyperon and Negative K-meson Masses," Proc. Int. Conf. Mesons and Recently Discovered Particles e 43° Congresso Nazionale Di Fisica, IV-41, 1957, (with others).

"Negative K-meson Reactions with Protons: Masses of Charged Sigma Hyperons and the Negative K-meson," Phys. Rev., 112, 622-623, 1953, (with others).

"Decay Measurements in Emulsion on Particles of Negative Strangeness," Phys. Rev., 124, 1209-1223, 1961.

Papers Given at Professional Meetings:

"Hyperons and Hyperfragments from K-interactions in Emulsion," Bull. Am. Phys. Soc. II, 1, 336, 1956, (with others).

"Interaction and Decay of Negative K-mesons," Bull. Am. Phys. Soc. II, 1, 336, 1956, (with others).

"Enriched K-meson Beams From the Bevatron," Bull. Am. Phys. Soc. II, 1, 336, 1956, (with others).

"Σ^- Nuclear Reactions," Bull. Am. Phys. Soc. II, 2, 235, 1957, (with others).

"Lifetime and Decay Modes of Negative K-mesons," Bull. Am. Phys. Soc. II, 4, 443, 1959, (with others).

"The Λ-Hyperon Mass and Production Spectrum From Negative K-meson Reactions With Emulsion Nuclei," Bull. Am. Phys. Soc. II, 5, 224, 1960, (with others).

"$\Sigma^{\pm}$ Hyperon Production and Decay Energetics: Apparent Anomaly in the Reaction $K^- + p \rightarrow \Sigma + \pi$," Bull. Am. Phys. Soc. II, 5, 224, 1960, (with others).

University of Michigan Research Institute Reports:

"Electromagnetic Radiation From Shock Waves in a Low-Density Weakly-Ionized Medium," Department of Electrical Engineering Radiation Laboratory Report No. 2764-11-T, The University of Michigan, April 1962.

THE UNIVERSITY OF MICHIGAN / Ann Arbor

RICHARD L. MEIER

BORN:	Kendallville, Indiana, 1920.
EDUCATION:	Northern Illinois State Teachers College, 1936-39, (Chemistry, Physics, and Mathematics). University of Illinois, 1939-40, BS(Chemistry) UCLA, 1940-44, MA(Chemistry), Ph.D. (Organic Chemistry).
LABORATORY RESEARCH:	California Research Corp., Richmond, California, 1943-47. Petrocarbon, Ltd., Manchester, U. K., 1949-50.
ORGANIZATIONS WORK:	Northern Calif. Assoc. of Scientists, Chairman, 1946-47. Federation of American Scientists, Ext. Secy., 1947-49. Society for General Systems Research, Sec.-Treas., 1957-61.
ACADEMIC:	Fulbright Scholar, Manchester School, UK 1949-50. Assistant Prof. of Planning, University of Chicago, 1950-56. Research Social Scientist, Mental Health Research Institute, University of Michigan, 1957---- Visiting Lecturer, Harvard University, 1959-60. Associate Prof. of Conservation, School of Natural Resources, 1960----
RELEVANT STUDIES:	Science and Economic Development, Technology Press and John Wiley, 1956. A Communications Theory of Urban Growth, M.I.T. Press, 1962. "Efficiency Criteria for the Operation of Lange Libraries", Library Quarterly 31, 215-34, 1961. "Communications Overload: Proposals from the study of a University Library", Administrative Science Quarterly 7, 521-55, 1963. "Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs" (with Donald Michael et al) for Committee on Long Range Studies of NASA by Brookings, 1960. (also various studies on the social organization of science, long range planning, and organization theory)

THE UNIVERSITY OF MICHIGAN / Ann Arbor

NAME: Orren C. Mohler

TITLE: Professor of Astronomy

DATE OF BIRTH: July 29, 1908

EDUCATION:

A.B., Michigan Normal College, 1929
M.A., University of Michigan, 1930
Ph.D., University of Michigan, 1933

EXPERIENCE:

Professor of Astronomy, Chairman of the Department of Astronomy, and Director of The University of Michigan Observatories, 1962 to the present
Professor of Astronomy and Director of the McMath-Hulbert Observatory, 1961-62
Professor of Astronomy and Assistant Director of the McMath-Hulbert Observatory, 1956-61
Associate Professor of Astronomy and Assistant Director of the McMath-Hulbert Observatory, 1946-56
Assistant Professor of Astronomy and Assistant Astronomer at the McMath-Hulbert Observatory, 1945-46
Assistant Astronomer, McMath-Hulbert Observatory, 1940-45
Observer, McMath-Hulbert Observatory, July-August 1939
Instructor in Astronomy, Astronomer at the Cook Observatory, Swarthmore College, 1933-40
Observer, McMath-Hulbert Observatory, The University of Michigan, September 1933

PUBLICATIONS:

"Helium Lines in Three B_e Spectra," (with Helen W. Dodson). Publ. Amer. Astron. Soc. 7 (1932): 182 (Abstract).

"A Determination of the Temperatures of B_e Stars," Publ. Amer. Astron. Soc. 7 (1933): 224. (Abstract).

"The Radial Velocity of the Eclipsing Variable 49 Leonis," Publ. Amer. Astron. Soc. 7 (1933): 234. (Abstract).

"A Determination of the Temperatures of B_e Stars." Publ. Obs. Univ. Mich. 5 (1933): 43-66.

"The Spectrum of a Nova," Publ. Cook Obs. Univ. Pa. 1 (1935): 1-6.

"An Account of the Roslyn House (Cook) Observatory." Pop. Astron. 43 (1935): 1-9.

"A Spectroscopic Orbit for 49 Leonis," Astron. Journ. 45 (1935): 40.

"The Spectroscopic Orbit of TX Leonis," Pub. Cook Obs., No. 2 (1936): 1-11.

"Application of Photoelectric Geiger-Muller Counters to Measurement of Ultra-Violet Radiation." Publ. Amer. Astron. Soc. 8 (1936): 250. (Abstract)

"A New Photoelectric Device for Stellar Photometry." Publ. Amer. Astron. Soc. 9 (1936): 14.

"Measurement of the Intensity of Sunlight in the Extreme Ultra-Violet." Astron. Journ. 46 (1937): 33-36.

"An Application of Coarse Gratings and Wide-Angle Lenses to the Determination of Spectral Classes," Publ. Amer. Astron. Soc. 9 (1937): 129. (Abstract)

"Measures of Effective Wave-Length with Wide-Angle Lenses." Publ. Cook Obs. No. 3 (1938): 1-25.

"Some Changes in the Spectra of the Pleiades," Astrophys. Journ. 88 (1938): 623.

"Cook Observatory Program," The Sky 2 (1938): 3-5.

"Two Bright Line Stars," Harvard Announc. Card, 507 (1939).

"Six New B_e Stars," Astrophys. Journ. 92 (1940): 315.

"Report on the Solar Prominence Radial Velocity Program of the Mc-Math-Hulbert Observatory," (with R. R. McMath, H. E. Sawyer, and J. Brodie). Publ. Amer. Astron. Soc. 10 (1940): 59. (Abstract).

"A Method of Measuring Radial Velocities in Solar Prominences," (with R. R. McMath, H. E. Sawyer, and J. Brodie). Pub. Obs. Univ. Mich., 8 (1940): 57-59.

"The Cook Observatory B Star Spectrographic Survey (with R. K. Marshall). Publ. Amer. Astron. Soc. 10 (1940): 141.

"The Space Motions of Some Typical Prominences," (with H. E. Sawyer and J. T. Brodie). Publ. Amer. Astron. Soc. 10 (1940): 143.

"The Measurement of Space Motions of Solar Prominences," (with R. R. McMath and H. E. Sawyer). Publ. Obs. Univ. Mich. 8 (1941): 123-132.

"The McGregor Spectrograph of the McMath-Hulbert Observatory," Journ. Opt. Soc. Amer., 34 (1944): 121-25.

"Evidence for Coronal Absorption on the Solar Disk" (with R. R. McMath and L. Goldbert) Astron. Journ. 52 (1947): 156. (Abstract)

"The Atmosphere of the Sun." School Sci. and Math. 47 (1947): 156. (Abstract)

"Review of Edward Ford, David Rittenhouse: Astronomer-Patriot 1732-1796." N. Y. Hist. Soc. Quart., 31 (1947): 175-76.

"New Atomic Lines in the Infrared Solar Spectrum" (with R. R. McMath, A. Adel and L. Goldberg). Phys. Rev. 72 (1947): 644-45.

"Photometry of a Solar Flare." Publ. Astron. Soc. Pac. 59 (1947): 266-67.

"High Dispersion Solar Spectrum in the 10,000Å to 20,000Å Region," (with R. R. McMath). Publ. Astron. Soc. Pac. 59 (1947): 267-69.

"The Use of a High-Dispersion Spectrograph in the Wave Length Region 1.0 to 2.0 Microns," (with R. R. McMath). Astron. Journ. 53 (1948): 115. (Abstract)

"Resolution of the Carbon Dioxide Bands at 1.6 Microns," (with A. Adel). Astron. Journ. 58 (1948): 115. (Abstract)

"A Solar Infrared Reflecting Spectrometer," (with R. R. McMath). Sky and Telescope, 7 (1948): 143-44.

"Telluric Bands of Methane in the Fraunhofer Spectrum," (with R. R. McMath and L. Goldberg). Phys. Rev., 73 (1948): 1203-04.

"Simultaneous Observations of Solar Flares, Surges and High-Speed Dark Flocculi", (with R. R. McMath). Observatory 68 (1948): 110-11.

"A Reflecting Spectrometer for the Solar Infrared," (with R. R. McMath), Astron. Journ. 53 (1948): 200-01. (Abstract)

"Spectroscopic Evidence for Ammonia in the Earth's Atmosphere," (with L. Goldberg and R. R. McMath). Phys. Rev. 74 (1948): 352-53.

"The Abundance and Temperature of Methane in the Earth's Atmosphere" (with R. R. McMath and L. Goldberg). Phys. Rev. 74 (1948): 623-24.

"Atmospheric Absorption of Water Vapor between 1.42μ and 2.50μ," (with W. S. Benedict). Phys. Rev. 74 (1948): 702-03.

"New Bands in the Telluric Spectrum," (with R. R. McMath). Publ. Astron. Soc. Pac. 60 (1948): 119-20.

"Recent Developments in Infrared Solar Spectroscopy," (with R. R. McMath and L. Goldberg). Astron. Journ. 54 (1948): 44. (Abstract)

"Isotopes of Carbon and Oxygen in the Earth's Atmosphere," (with L. Goldberg and R. R. McMath). Phys. Rev. 74 (1948): 1881-82.

"Excited-State Bands of Atmospheric CO_2," (with R. R. McMath and L. Goldberg). Phys. Rev. 75 (1949): 520-21.

"Telluric Bands of CH_4 in the Solar Spectrum," (with R. R. McMath and L. Goldberg). Astrophys. Journ. 109 (1949): 17-27.

"New Solar Lines in the Spectral Region 1.52μ-1.75μ," (with R. R. McMath and L. Goldberg). Astrophys. Journ. 109 (1949): 28-41.

"Solar Spectroscopy with a Cashman Cell," (with R. R. McMath). Journ. Opt. Soc. Amer. 39 (1949): 903-07.

"Some Newly Found Gases in the Air We Breathe." Cranbrook Inst. Sci. News Letter, 18 (1949): 78-82.

"Carbon Dioxide in the Infrared Solar Spectrum," (with L. Goldberg, R. R. McMath and A. Keith Pierce). Phys. Rev. 76 (1949): 1848-58.

"An Improved Tracing of the Solar Spectrum between 2.9 and 3.6 Microns," (with A. K. Pierce). Publ. Astron. Soc. Pac. 61 (1949): 221-22.

"Note on Methane in the Infrared Solar Spectrum," (with R. R. McMath, A. K. Pierce and L. Goldberg). Phys. Rev. 76 (1949): 1533-34.

"N_2O Bands in the Solar Spectrum," (with R. R. McMath, A. K. Pierce, L. Goldberg and R. A. Donovan). Phys. Rev. 78 (1950): 65.

"The $3\nu_3$ Band of Telluric CO_2 in the Solar Spectrum," (with L. Goldberg, A. K. Pierce and R. R. McMath). Phys. Rev. 78 (1950): 74.

"New Solar Lines in the Spectral Region 1.97-2.49μ," (with L. Goldberg, A. K. Pierce, and R. R. McMath). Astrophys. Journ. 111 (1950): 565-71.

"Observations of Solar Limb Darkening between 0.5 and 11.2μ," (with A. K. Pierce, R. R. McMath and L. Goldberg). Astrophys. Journ. 112 (1950): 289-98.

"Photometric Atlas of the Near Infrared Solar Spectrum from λ8465 to λ25,242," (with R. R. McMath, L. Goldberg, and A. K. Pierce). Ann Arbor: Univ. of Mich. Press (1950): 7 pp, 234 tracings.

"Solar Atomic Lines in the 3μ region." Phys. Rev. 83 (1951): 464-65.

"Solar Spectroscopy with Echelles," (with A. K. Pierce and R. R. McMath). Astron. Journ. 56 (1951): 137.

"Some Recent Observations of Helium Lines in the Infrared Solar Spectrum." Astrophys. Journ. 115 (1953): 323-25.

"Abundance of CO in the Sun and in the Earth's Atmosphere," (with L. Goldberg, R. R. McMath and A. K. Pierce). Phys. Rev. 85 (1952): 481-82.

"Eclipse Observations of the Structure of the Chromosphere." Mo. Notices Roy. Astron. Soc. 111 (1951): 630-33.

"Identification of Co in the Solar Atmosphere," (with R. R. McMath, A. K. Pierce, and L. Goldberg). Phys. Rev. 85 (1952): 140.

"Experimental determination of Absolute f-Values for Methane," (with L. Goldberg and R. E. Donovan). Journ. Opt. Soc. Amer. 42 (1952): 1-6.

"Table of Infrared Solar Lines 1.4-2.5μ," (with A. K. Pierce, R. R. McMath, and L. Goldberg). Astrophs. Journ. 117 (1953): 41-65.

"Spectroheliographic Observations, 1952, February 25," (with H. W. Dodson). Observatory 73 (1953): 116-119.

"The 50-foot Focal Length Vacuum Spectrograph for Solar Research," (with R. R. McMath and A. K. Pierce). Astron. Journ. 59 (1954): 328.

"Observations of the K line in the Solar Spectrum." Astrophys. Journ. 60, (1955): 173. (Abstract)

"Doppler Shifts in Solar Granules," (with R. R. McMath and A. K. Pierce). Astrophys. Journ. 122 (1955): 565-66, 2 pls.

"A Table of Solar Spectrum Wave Lengths 11984Å to 25578Å." Ann Arbor: Univ. Mich. Press (1955): 83 pp.

"Preliminary Results with a Vacuum Solar Spectrograph," (with R. R. McMath, A. K. Pierce, and L. Goldberg). Astrophys. Journ. 124 (1956): 1-12.

"The Width of the Infrared Helium Line in the Solar Spectrum," (with L. Goldberg). Astrophys. Journ. 124 (1956): 13-19.

"A High-Resolution Isophotometer," (with A. K. Pierce). Astrophys. Journ. 125 (1957): 285-86, 3 pls.

"A Connection between the Granulation and the Structure of the Low Chromosphere," (with L. Goldberg and J. B. Brown). Nature (london) 179 (1957): 369-370.

"The Profile of H during the limb flare of February 10,1956," (with L. Goldberg and E. A. Müller). Astrophys. Journ. 127 (1958): 302-307.

"Solar Spectroscopy," Science, 128 (1958): 505-510.

"Observation of Solar 'Points'" (with H. W. Dodson) Astron. Journ. 63 (1958): 309-310. Abs.

"Solar Research Reported at Moscow," Sky and Telescope 18, (1958): 77-80.

"The double reversal in the cores of the Fraunhofer H and K lines," (with L. Goldberg and E. A. Müller). Astrophys. Journ. 129 (1959): 119-133.

"Solar features associated with Ellerman's 'Solar Hydrogen Bombs'," (with H. W. Dodson and R. R. McMath). Proc. Nat. Ac. Sci. 46 (1960): 165-169.

"Radio Astronomy: A general review of its third decade," Yale Scientific Magazine 34 (1960): 21-23 and 50-51.

"Measurements of the K-line in Spectra of Sunspots," Astron. Journ. 65 (1960): 55. (Abstracts)

"The measurement of the local Doppler shift of Fraunhofer Lines," (with L. Goldberg, W. Unno and J. Brown). Astrophys. Journ. 132 (1960): 184-192.

Book review: "The Sun" by Donald H. Menzel. Sky and Tel. 19 (1960): 301-303.

"Fraunhofer Lines and Heights in the Sun's Atmosphere," Sky and Tel. 20 (1960): 124-127.

"Solar Spectroscopy." - Ency. of Spectroscopy - 1960, p. 684-693.

"Telescope Driving Mechanisms," (with R. R. McMath). Stars and Stellar Systems (ed. by Kuiper and Middlehurst) Vol. 1, Chapter 5, p. 62-79.

"Solar Instruments," (with R. R. McMath). Handbuch der Physik/Encyclopedia of Physics, 54, Astrophysics 5: Miscellaneous (Springer-Verlag, Berlin, 1962).

"Robert Raynolds McMath." QJRAS, 3, 130, 1962.

"Astronomical Telescopes." McGraw-Hill Encyclopedia of Science and Technology - Year Book 1962, 497.

MORGAN, JOSEPH O. RESEARCH PHYSICIST

EDUCATION

BS	Physics	Purdue University, 1949
MS	Physics	Purdue University, 1951

EMPLOYMENT

Research Assistant, Purdue University, Physics Department, 1949-53
Principal Physicist, Battelle Memorial Institute, Columbus, Ohio, 1953-56
Research Associate, The University of Michigan, IST, 1956-58
Associate Research Engineer, The University of Michigan, IST, 1958-1959
Associate Research Physicist, The University of Michigan, IST, 1959-1962
Research Physicist, The University of Michigan, IST, 1962-

EXPERIENCE

Mr. Morgan has been academically connected with Purdue University, where he did teaching and research in spectroscopy, engineering, and in high energy physics. He has also done work on the construction of synchrotron and cloud chamber components, as well as the development of atomic beam light sources and techniques of high-resolution spectroscopy. Other research at Purdue included work on thin semi-conducting films, and the arc spectrum of germanium, and diffraction grating ghosts.

Mr. Morgan did research at Battelle Memorial Institute. Work at Battelle involved the development of thin semi-conducting films, photosensitive surfaces, high temperature precision electrical components, photo-diodes and high frequency transistors. He also developed static and dynamic high vacuum techniques and electrical component reliability, as well as doing environmental tests.

At the Institute, Mr. Morgan has been in charge of field research programs involving airborne infrared mapping, measuring, and interpretation techniques; tactical combat surveillance; and target and background characteristics. He has also conducted investigations of infrared radiation from aircraft, ballistic missiles, and other military targets; and has done research on techniques for calibration and thermal imaging.

PROFESSIONAL AND HONORARY SOCIETIES

Member, Optical Society of America
Member, Sigma Xi
Member, Science Research Club
Member, Sigma Pi Sigma
Member, American Institute of Physics

PUBLICATIONS

"Infrared Measurements of Ballistic Missiles During IRMP 1958," co-author, 2144-410-J and 2144-410-T, Proc. IRIS, Vol. 4, No. 4, October 1959
"Infrared Detection of a Water-Borne Aluminum Sea Marker," Proc. IRIS, Vol. 5, No. 1, p. 505, January 1960
"IR Data-Acquisition Program," co-author, 15 Sept. 1958-30 November 1959, 2825-13-R and 2900-150-R, January 1960
"IR Data Acquisition Program," co-author, Final Report, 2825-16-F, October 1960
"IR Measurements on Missiles During the Launch Phase - IRMP 59/60," co-author, 2900-145-T, December 1960
"Report of Visual, Thermal, and Radar Imagery for Detection of Surface and Subsurface Features in Greenland," co-author, 1961
"An Infrared Data Acquisition Program in Greenland," Proc. IRIS, 1961

NAGY, ANDREW F. Research Engineer

Education: Sydney Tech. College: A.S.T.C. (Radio Engineering), 1955.
University of N.S.W., Australia: B.E. (Electrical Engineering), 1957.
University of Nebraska: M.Sc. (Electrical Engineering), 1959.
University of Michigan: M.S.E. (Electrical Engineering), 1960.

Positions Held: Academic
University of N.S.W.: Lecturer (part time), 1956; University of Nebraska: Instructor, 1957-58; University of Michigan: Teaching Fellow and Lecturer, 1959-.

Professional
Technical Officer, University of N.S.W., 1954-55. Design Engineer, Electrical Control and Eng. Ltd., 1956-57.

Experience: Design and testing of A.M. receivers; design of automatic control apparatus for industrial and educational purposes; vacuum systems work; instrumentation development and theoretical work for upper atmosphere research.

Publications—"An Electronic Stepping Switch Function Generator," CP 61-4 AIEE Winter General Meeting, New York, 1961. "Measurements of Atmospheric Pressure, Temperature, and Density at Very High Altitudes," Final Scientific Report 02804-7-F, Univ. of Mich., ORA Report (August 1961)(with others). "Switching On-off Type Filament Emission Regulator," The Proc. of the IEE 108 Part B, 665 (1961)(with others). "Direct F-Region Measurement of Electron and Ion Temperatures Using an Ejectable Ion Trap-Electrostatic Probe Instrument Package," Second Western National Meeting of the American Geophysical Union, Palo Alto, December 1962 (with others). "Space Charge Waves in the Ionosphere and their Effect on the Heating of the Atmosphere," Second Western National Meeting of the American Geophysical Union, Palo Alto, December 1962 (with others). "Theoretical Investigation of Sounding Rocket and Satellite Born Ion Traps," Scientific Report, Univ. of Mich., ORA, December 1962.

Professional and Honorary Societies: Institute of Electrical Engineers; Electrical Eng. Society of the University of N.S.W.; Eta Kappa Nu; Sigma Xi; American Geophysical Union.

NAME: Lyman W. Orr

TITLE: Research Engineer

DATE OF BIRTH: December 27, 1915

PRESENT RESPONSIBILITIES:

Technical Consultant on Instrumentation for Space Radio Astronomy program.

EDUCATION:

B.A.Sc. (E.E.), University of Toronto, 1943
M.S. (E.E.), University of Michigan, 1946
Ph.D. (E.E.), University of Michigan, 1949

EXPERIENCE:

Academic:

Instructor, Electrical Engineering, University of Michigan, 1952

Non-Academic:

Research Engineer, University of Michigan, 1951 to present.
Research Engineer, Burroughs Research Division, 1950-1951.
Research Engineer, Engineering Research Institute, University of Michigan, 1946-1950.

SUMMARY OF TECHNICAL EXPERIENCE:

Electronics circuit engineering, ferromagnetic and ferroelectric tuning techniques for rf circuits, investigations of transistors, high-speed printing techniques for computing machines, magnetic research for computing machines, electronic-defense work, investigation of the spectrographic spark source.
Secure Voice Communication System Development
Automatic Direction Finder System
Sweep-Frequency EGO Satellite Receiver Development

SOCIETIES, ETC.:

Institute of Radio Engineers
Science Research Club
Sigma Xi

PUBLICATIONS:

Articles:

"A Study of the High Frequency Structure of Spectral Light Intensity Produced by Spark Excitation Using Electron Multiplier Phototubes," Doctoral Thesis, University of Michigan, 1949.

"Reversible Susceptibility in Ferromagnetic Materials," with D. M. Grimes and M. H. Winsnes, Phys. Rev., 91, 1953, p. 435.

"Wide-Band Amplitude Distribution Analysis of Voltage Sources," Rev. Sci. Insts., 25, p. 894, September 1954. Also, IRE National Convention Record, 2, Pt. 10, pp. 92-96, March 1954.

"Subminiature Nonlinear Capacitors for Application to VHF Wide Range Tuning Devices," with H. Diamond and T. W. Butler, Jr., Proc. National Electronics Conference, 11, pp. 839-847, 1955.

"Application of Dielectric Tuning to Panoramic Receiver Design," with T. W. Butler, Jr., and W. J. Lindsay, Proc. IRE, 43, p. 1091, September, 1955.

"A Nuclear Reactor Simulator for Teaching Purposes," with W. Kerr and H. J. Gomberg, Proc. Nuclear Engineering and Science Congress, Cleveland, Ohio, December 12-16, 1955. Also published in Elec. Eng., 56, pp. 364-367, April 1956.

"Nonlinear DC Tuned Capacitors," with T. W. Butler, Jr., and H. Diamond, Teletech and Electronic Industries, 15, No. 5, p. 68, May 1956.

"Compensating Voltage Dividers for Frequency," Electronics, 29, No. 8, p. 194, August 1956.

"A Portable Neon Multivibrator Demonstrator," Electronics, 30, No. 6, pp. 198-202, June 1957.

"A Target Simulator for Conical Scan Radars," Proc. National Electronics Conference, 13, pp. 728-737, October 1957. Also published in Electronic Equipment Engineering, 6, No. 2, pp. 38-41, February 1958.

Reports:

"Transistor Properties and Applications in Digital Computer Service," ERI Proj. M731A (Burroughs Corporation), January 1950, 44 pp.

"High Speed Printing by Spark and Evaporative Techniques," with R. R. White and H. C. Early, ERI Proj. M741 (Burroughs Corporation), January 1951, 45 pp.

"Permeability Measurements in Magnetic Ferrites," EDG Tech. Rept. 9, September 1952.

"Wideband Amplitude Distribution Analysis of Voltage Sources," EDG Tech. Rept. 22, October 1953.

"Interim Report on Ferroelectric Materials and their Applications," with H. Diamond, EDG Tech. Rept. 31, July 1954.

"Ferromagnetic and Ferroelectric Tuning," EDG Tech. Rept. 32, September 1954.

"Magnetic Modulator Design Employing MU Surfaces for Ferrites," EDG Tech. Rept. 37, September 1954.

"ϵ-T-E Surfaces of Ferroelectric Ceramics," EDG Tech. Rept. 53, October 1955.

"A Butterfly Loop Automatic Recorder for Ferroelectric and Ferromagnetic Materials," with M. H. Winsnes, EDG Tech. Rept. 61, March 1956.

"Research and Development of Improved Ignition Systems," Prog. Rept. 1, with G. A. Roberts, H. F. Schulte, T. W. Butler, and J. Otterman, ERI Proj. 2370-2 (Chrysler Corporation), May 1956.

"The Conical Scan Radar Target Simulator," with R. C. Webber, EDG Tech. Rept. 73, August 1957.

"Antenna Studies for the Mark I Continuous Monitor Jamming System," with J. F. Cline and C. E. Lindahl, EDG Tech. Rept. 74, August 1957. SECRET.

"Secure Communications Systems Using the CMJS," Tech. Rept. 78, February 1958, SECRET.

"A Two-Frequency Beacon for High-Altitude Ionosphere Rocket Research," with P. G. Cath and B. R. Darnall, Final Rept., Proj. 2816:3, Electronic Defense Group, December 1959.

PATENTS:

Patent No. 2,698,399, December 28, 1954, Magnetic Deflection Means for Electron Discharge Devices (Filed July 11, 1951).

Patent No. 2,737,882, March 13, 1956, High Speed Printing and Perforating Machine (Filed May 16, 1952).

Patent No. 2,779,652, January 29, 1957, Filing Apparatus (Filed July 8, 1952).

NAME: Robert G. Peltzer

TITLE: Assistant Research Engineer

DATE OF BIRTH: November 20, 1931

PRESENT RESPONSIBILITIES:

Technically responsible for the EGO radiometer development, test and integration into the S-49 Satellite.

EDUCATION:

B.S.E., University of Connecticut, 1957
M.S.E., University of Michigan, 1961

EXPERIENCE:

Non-Academic:

Assistant Research Engineer, Radio Astronomy, University of Michigan, February 1962-present
Assistant Engineer, Electronic Engineering, Bendix Systems Division, Ann Arbor, 1957-1962
Senior Electronics Technician, Electronics Department, United Aircraft Company, CANEL Division, 1956
Gauge Inspector, Gauge Standards Department, United Aircraft Company, Pratt & Whitney Division, 1953-54
Instrument Mechanic, Experimental Test Lab., United Aircraft Company, Pratt & Whitney Division, 1953
Electronics Technician, U. S. Navy, 1949-1953

SUMMARY OF TECHNICAL EXPERIENCE:

Bendix Systems Division: Responsible for development, field test and evaluation of a Doppler detection system for aircraft. Conducted research on the electrostatic suspension of a reaction sphere. Conducted a study of the problems involved in accurately determining wind velocity from a high performance aircraft. Participated in the system design of an airborne radar to be used for meteorological research and weather synopsis. Participated in the solution of multitudinous problems involving radar and acoustics.
United Aircraft Company, CANEL Labs.: Designed electronically regulated power supplies and an X-Y recorder.
United Aircraft Company, Gauge Standards: Tested and repaired standard and inspection gauges, both mechanical and electrical.
United Aircraft Company, Experimental Test: Repair, maintenance and test of aircraft engine test equipment.
U. S. Navy: Responsible for repair and maintenance of all electronic equipment aboard a destroyer.

SOCIETIES, ETC.:

Sigma Xi
Tau Beta Pi
Eta Kappa Nu
Phi Kappa Phi
Institute of Radio Engineers

PUBLICATIONS:

"An Airborne Radar for Weather Reconnaissance," presented to the 8th Weather Radar Symposium of the American Meteorological Society.

PATENTS:

None

ROWE, JOSEPH E. Associate Professor

Education: Univ. of Mich.: B.S.E. (E.E.), 1951; B.S.E. (Math.), 1951; M.S.E. (E.E.), 1952; Ph.D. (E.E.), 1955.

Positions Held: Academic
Univ. of Mich.: Teaching Fellow, 1949-51; Lecturer, 1952-55; Asst. Prof., 1955-57; Assoc. Prof., 1957- .

Other Professional
Eng. Res. Inst.: Res. Assistant, 1951-53; Res. Assoc., 1953-55. Univ. of Mich.: Head, Electron Physics Lab., 1958- .

Experience: Microwave circuitry and measurements, microwave vacuum tubes, radar circuitry, and high-vacuum tubes, plasmas, solid-state masers.

Publications: Articles--12 on traveling-wave amplifiers, backward wave oscillators, electron injection systems.

Professional and Honorary Societies: Am. Institute of Electrical Engineers; Am. Mathematical Soc.; Institute of Radio Engineers; Eta Kappa Nu; Phi Kappa Phi; Sigma Xi; Tau Beta Pi.

Name: SCHAEFER, Edward J.

Born: November 26, 1919, in New York

Education and Experience:

B.E.E., Cooper Union, New York (1943)

M.S., University of Michigan, (1948)

1941-42, Lab. Assistant, H.O. Boehme, New York, N. Y., Test communication terminal equipment.

1942-43, Assistant Electrical Engineer, H.O. Boehme, N.Y., Supervise and devise acceptance tests.

1943-45, Assistant Electrical Engineer, Princeton University, Princeton, N.J., Design, construct and maintain electronic equipment.

1945-46, Project Engineer, Princeton University, Design, install Lark Telemetering equipment. Record and analyze flight data.

1946-present, Research Engineer, Dept. of Aero. and Astro. Eng., Sponsored Research, University of Michigan, Supervisor, research program in composition of the upper atmosphere by mass spectrometry.

Projects at Univ. of Michigan

1. Develop alphatron for impact and side cone measurements aboard V-2's.
2. Develop Pirani wire circuitry for above measurements.
3. Develop inflatable falling sphere experiment for use aboard Aerobee's.
4. Develop timing and actuating circuitry for sample bottle experiments aboard V-2's and Aerobee's.
5. Direct field operations for all above.
6. Direct work on development of multiplexed multiplier.
7. Instrument detonation tube for acceleration measurements.
8. Develop dual spark light sources for shock tube Schlieren photography.
9. Develop small solid falling sphere experiment for use aboard Nike-Cajun rockets.
10. Launch 5 experiments from shipboard on cruise to Greenland (Oct-Nov. 1956)
11. Instrument Grenade experiment for Nike-Cajun
12. Direct development of firing circuitry for Strongarm rocket.
13. Direct project for composition measurements of upper atmosphere.

1957, Jan-Aug. 1958, Member Technical Staff, Ramo-Wooldridge Corp., (Later, Space Technology Labs.), Technical direction of Atlas flight test program. Determined detailed test objectives, evaluated results.

Professional and Honorary Societies:

Institute of Radio Engineers
Sigma Xi

Publications:

"Upper-Atmosphere Structure Measurements", University of Michigan Research Institute Report #2841-1-F, December 1959.

"Upper-Atmosphere Structure Measurements", University of Michigan Research Institute Report #3598-1-P, April 1960.

"Upper-Air Density and Temperature: Some Variations and an Abrupt Warming in the Mesosphere" (with co-authors), J. Geophys. Res., Vol. 64, No. 12, December 1959.

"A Mass Spectrometer for Upper-Air Measurements" (with M. H. Nichols) Presented at Nat'l IAS-ARS Joint Meeting, June 13-16, 1961. ARS Jour., Vol. 31, No. 12, December 1961.

"Neutral Composition Obtained from a Rocket-Borne Mass Spectrometer," (with Myron H. Nichols), COSPAR Paper for Fourth International Space Science Symposium, Warsaw, Poland, June 3-11, 1963.

"The Dissociation of Oxygen Measured by a Rocket-Borne Mass Spectrometer," Published in Journal of Geophysical Research, Feb. 15, 1963.

NAME: Hal F. Schulte, Jr.

TITLE: Associate Research Engineer

DATE OF BIRTH: July 23, 1923

PRESENT RESPONSIBILITIES:

UM/RAO rocket-borne galactic background temperature measurement program.

EDUCATION:

B.S.E.(E.E.), University of Michigan, 1949
M.S.E.(E.E.), University of Michigan, 1955

EXPERIENCE:

Academic:

Lecturer, Electrical Engineering, University of Michigan, 1956-present

Non-Academic:

Associate Research Engineer, University of Michigan, 1949-present

SUMMARY OF TECHNICAL EXPERIENCE:

Measurement of upper atmosphere temperature, pressure and density by pressure gages and falling-sphere via rockets, 10 years.
Supervisor, Electronic Instrumentation Laboratory, 3 years.
Radio Astronomy, 1 year.

SOCIETIES, ETC.:

Eta Kappa Nu
Member, Institute of Radio Engineers

PUBLICATIONS:

"Rocket Instrumentation for Reliable Upper-Atmosphere Temperature Determination," with H. S. Sicinski and N. W. Spencer, Proc. IRE, 42, No. 7, July 1954.

"Upper Air Density and Temperature: Some Variations and an Abrupt Warming in the Mesosphere," with L. M. Jones, et al., J. Geophys. Res., 64, No. 12, December 1959.

"Upper Air Densities and Temperatures from Eight IGY Rocket Flights by the Falling Sphere Method," with L. M. Jones, et al., Nat. Acad. Sci., IGY Rocket Report Series No. 5, December 1959.

"Characteristics of the McKibben Artificial Muscle," in "The Application of External Power in Prosthetics and Orthotics," Nat. Acad. Sci., Nat. Res. Council, Publ. No. 874, January 1961.

"The Effect of Artificial Unipolar Air Ionization on Hypersensitivity Phenomena," with R. C. Field, et al., The University of Michigan Medical Bulletin, 27, No. 5, September-October 1961.

"A Research Instrument for the Study of Raindrop-Size Spectra," with A. N. Dingle, J. of Appl. Meterology, 1, No. 1, March 1962.

Classified Title, with J. Nemrich, EDG Tech. Rept. 10, March 1953.

"Modification of Air Force Type J-8 Attitude Horizon Indicator for Aerobee Rocket Instrumentation," ERI Rept. 2096-12-T, December 1955.

"A Simplified Falling Sphere Method for Upper-Air Density. Part II, Density and Temperature Results from Eight Flights," with J. W. Peterson and E. J. Schaefer, UMRI Rept. 2215-19-F, May 1959.

"Formation of a Radio Frequency Plasma at an Antenna during Falling Sphere Measurements," with G. A. Burns, et al., Rand Corporation Rept. R339, June 1959.

"Falling-Sphere Instrumentation Development," with J. W. Peterson and D. A. Robinson, UMRI Rept. 2649-9-F, February 1960.

"Characteristics of the Braided Fluid Actuator," ORA Rept. 04468-5-T, November 1961.

"Falling-Sphere Experiment for Upper-Air Density: Instrumentation Developments," ORA Rept. 03558-6-F, April 1962.

"Rocket-Borne Alphatron Atmospheric Pressure Measurement System," with N. W. Spencer, IRE Conference on Airborne Electronics, Dayton, Ohio, 1951.

"Mach Number and Yaw Angle Determination for Conical Flow Regimes Using Two Surface-Flow Angle Indicators," with H. S. Sicinski, American Physical Society Meeting of the Division of Fluid Dynamics, Langley Field, Virginia, November 1954.

"Formation of a Radio Frequency Plasma (At Antenna) During Falling Sphere Measurements," with G. A. Burns, et al., Rand Corporation Conference on Aerodynamics of the Upper Atmosphere, Santa Monica, California, June 1959.

"Physical Characteristics of the McKibben Artificial Muscle," National Academy of Sciences, Meeting of the Committee on Prosthetics Research and Development, at Northwestern University, Chicago, Illinois, December 1959.

"A Research Instrument for the Study of Raindrop-Size Spectra," with A. N. Dingle, Instrument Society of America Conference, San Francisco, California, May 1960. Preprint No. 7-SF60.

"The Artificial Muscle," National Research Council Conference on Application of External Power in Prosthetics and Orthotics, Lake Arrowhead, California, September 1960.

PATENTS:

None

SIMMONS, FREDERICK S. RESEARCH ENGINEER

EDUCATION

BME	Mechanical Engineering	New York University, 1948
MS	Mechanical Engineering	Case Institute of Technology, 1951

EMPLOYMENT

Aeronautical Research Scientist, U.S. National Advisory Committee for Aeronautics, Lewis Flight Propulsion Laboratory, 1948-55
Principal Scientist, Rocketdyne, Division of North American Aviation, Inc., 1955-62
Research Engineer, The University of Michigan, IST, 1962-

EXPERIENCE

At the Lewis Flight Propulsion Laboratory, Mr. Simmons conducted experimental and analytical studies on measurement problems in the research testing of turbojet, ramjet, and rocket engines. He worked on the design and testing of new and improved instruments for pressure, temperature, and fluid-flow measurements, as well as fundamental studies in the meaning and measurement of temperature in flames and high-velocity gases.

At Rocketdyne, Mr. Simmons did experimental and analytical studies on measurement problems in the research testing of small liquid-propellant rocket engines and developmental testing of large liquid-propellant rocket engines; photometric studies of rocket exhaust jets to determine exhaust gas temperatures and spatial distributions of spectral radiance; and theoretical and experimental studies of the thermodynamic and aerodynamic processes in rocket nozzles and exhaust jets. During his employment here, his research involved the use of quantitative emission spectroscopy in the visible and infrared for determination of the spectral emissivity of exhaust products. He was also responsible for government supported programs of research on the optical and electromagnetic characteristics of rocket exahust plumes.

At the Institute, Mr. Simmons has performed research primarily in the areas of launch phase theory and analysis. He has supervised the efforts of several scientists to compare the results of theory with laboratory and field experiments.

PROFESSIONAL AND HONORARY SOCIETIES

American Rocket Society
Optical Society of America
The Combustion Institute

PUBLICATIONS

"Recovery Corrections for Butt-Welded Straight Wire Thermocouples in High Velocity High Temperature Gas Streams," NACA RME54 G22A, 1954
"Analytic Determination of the Discharge Coefficient of Flow Nozzles," NACA TN 3447, 1955
"Radiation and Recovery Corrections and Time Constants of Several Chromel-Alunel Thermocouple Probes in High-Temperature," NACA TN 3766 (1956, co-author
"Theory and Design of a Pneumatic Temperature Probe and Experimental Results Obtained in a High Temperature Gas Stream," NACA TN 3893 1957, co-author
"Photographic Technique for Measuring Temperatures in Luminous Rocket Exhaust Flames," Journal Optical Society of America, 48, 717, 1958
"Photographing Pyrometry of Rocket Exhaust Jets," Aircraft Engineering, 31, 144, 1959, co-author
"Photographic Pyrometry with a Color Separation Camera," Journal Optical Society of America, 49, 735, 1959, co-author
"Expansion of Liquid-Oxygen of RP-1 Combustion Products in a Rocket Nozzle," ARS Journal, 30, 193, 1960
"Spectral Emissivity of Dispersed Carbon in Rocket Exhaust Gases," Proc. IRIS, 5, 47, 1960
"Spectral Radiometry and Two-Path Pyrometry of Rocket Exhaust Flames," Temperature, Its Measurement and Control in Science and Industry, Vol. III, Reinhold Publishing Corp., 1962 co-author
"A 2000° Slit-Aperture Blackbody Source," Rev. Sci. Instr., 32, 1265, 1961 co-author
"Experimental and Theoretical Determinations of the Spectral Emissivities of Hydrogen Fluoride in Rocket Exhaust Gases," Proc. AMRAC VI, 865, 1962, co-author
"Infrared Spectral Emissivities of Rocket Exhaust Products for Various Propellant Combinations," Proc. IRIS, Vol. 7, No. 2. Aug. 1962

LISTED IN

American Men of Science

NAME: Newbern Smith

TITLE: Professor of Electrical Engineering

EDUCATION:

B.S.(E.E.), University of Pennsylvania, 1930
M.S.(E.E.), University of Pennsylvania, 1931
Ph.D. (Physics), University of Pennsylvania, 1935

EXPERIENCE:

Academic:

Professor, Electrical Engineering, University of Michigan, 1959-present
Lecturer, George Washington University, 1942-48
Teaching and Research, University of Pennsylvania, 1931-35

Non-Academic:

Head, Radar Laboratory, Willow Run Laboratories, University of Michigan, 1957-59
Supervisor, Project Michigan, Willow Run Laboratories, 1954-57
Head Radar Group, Willow Run Laboratories, 1954
Chief, Central Radio Propagation Laboratories, National Bureau of Standards, 1948-54
Assistant Chief, Central Radio Propagation Laboratories, 1946-48
Head, Interservice Radio Propagation Laboratory, National Bureau of Standards, 1942-46
Physicist, (Radio) National Bureau of Standards, 1935-42

SUMMARY OF TECHNICAL EXPERIENCE:

Reserach on ionosphere and application of radio-wave propagation to radio-communication problems; upper atmosphere; field station operations; frequency utilization; tropospheric propagation; radio standards and measurements. Teaching of physics (graduate and undergraduate), high frequency theory, communication engineering, radio wave propagation, and electrical engineering.

SOCIETIES, ETC.:

American Geophysical Union
American Association for the Advancement of Science
Institute of Radio Engineers
Optical Society of America
Philosophical Society of Washington
Washington (D.C.) Academy of Sciences
Eta Kappa Nu
Sigma Tau
Tau Beta Pi

PUBLICATIONS:

"The Ionosphere, Sunspots and Magnetic Storms," with S. S. Kirby, et al., Phys. Rev., 48, 849 (1935).

"The Ionosphere, Solar Eclipses and Magnetic Storms," with S. S. Kirby, et al., Phys. Rev., 50, 258-259 (1936).

"Ionosphere and Magnetic Storms," with S. S. Kirby, et al., Phys. Rev., 51, 992-993 (1937).

"The Nature of the Ionosphere Storm," with S. S. Kirby and T. R. Gilliland, Phys. Rev., 54, 234 (1938).

"Predictions of Normal Radio Critical Frequencies Related to Solar Eclipses in 1940," J. Research NBS, 24, 225-228 (1940).

"Characteristics of the Ionosphere and their Application to Radio Transmission," with T. R. Gilliland, et al., J. Research NBS, 20, 627-639 (1938), also published in Proc. IRE, 26, 1347-1350 (1938).

"Application of Vertical-Incidence Ionosphere Measurements to Oblique-Incidence Radio Transmissions," J. Research NBS, 20, 683-705 (1938).

"Trends of Characteristics of the Ionosphere for Half a Sunspot Cycle," with T. R. Gilliland and S. S. Kirby, J. Research NBS, 21, 835-845 (1938).

"Oblique-Incidence Radio Transmission and the Lorentz Polarization Term," J. Research NBS, 26, 105-116 (1941).

"Averages of Critical Frequencies and Virtual Heights of the Ionosphere Observed by the National Bureau of Standards, Washington, D. C., 1934-1936," with T. R. Gilliland, et al., Terr. Mag and Atmos. Elec., 41, 379-388 (1936).

"Critical Frequencies of Low Ionosphere Layers," with S. S. Kirby, Phys. Rev., 51, 890-891 (1937).

"Characteristics of the Ionosphere at Washington, D. C., January to May 1937," with T. R. Gilliland, et al., Proc. IRE, 25, 1174-1184 (1937).

"Extension of Normal-Incidence Ionosphere Measurements to Oblique-Incidence Radio Transmission," J. Research NBS, 19, 89-94 (1937).

"The Relation of Radio Sky-Wave Transmission to Ionosphere Measurements," Proc. IRE, 27, 332-347 (1939).

"The Variability of Sky-Wave Field Intensities at Medium and High Frequencies," with M. B. Harrington, CCIR Tech. Paper, Stockholm (1948).

"The Developments in Radio Sky-Wave Propagation Research and Applications during the War," with J. H. Dellinger, Proc. IRE, 36, No. 2, February 1948.

"Influence of the Sun upon the Ionosphere," Proc. American Academy of Arts and Sciences, 79, No. 4, 254-265.

"IRPL Radio Propagation Handbook," 1943.

IRPL and CRPL reports on ionosphere propagation 1942-1951; and technical working papers for and at international conferences.

A number of classified reports on Radar, Communications, Geophysics and Battlefield Surveillance by Technological Sensory Devices.

Editor and contributor, NBS Circular 462 "Ionospheric Radio Propagation."

STROKE, GEORGE W. PROFESSOR

EDUCATION

(Graduated)	Ecole Violet, Paris, France, 1941
B.Sc.	Collège de Perpignan, P.O. France, 1942
Bacc. ès Sc.	University of Montpellier, France
London Matr.	University of London (Extension Exam.), 1944
Ing. Dipl. ESO	Ecole Superieure d'Optique, Paris, France, 1949
Dr. ès Sc. (summa cum laude)	Sorbonne (University of Paris), Paris, 1960

EMPLOYMENT

War-time defense research (British Army), Goldberg Instruments, Tel Aviv, Israel, 1943-47
Consultant, Som Berthiot Optical Company, Paris, France, 1948-50
Chief Engineer, Boyer Optical Company, Paris, France, 1950-51
Research Associate, Spectroscopy Laboratory, Massachusetts Institute of Technology, Cambridge, Mass., 1952-56
Graduate Fellow (Sperry Gyroscope, 1954; AC Spark Plug, 1955), Massachusetts Institute of Technology, 1954-55
Consultant, Jarrell-Ash Company, Newtonville, Mass., 1954-59
Assistant Research Professor of Physics, Boston University, Boston, Massachusetts, 1956-57
Defense Research Staff, Instrumentation Laboratory, Massachusetts Institute of Technology, 1957-58
Research Staff, Massachusetts Institute of Technology, 1956-58
Research Fellow (NATO), University of Paris (Sorbonne) and Institut d'Optique Theorique et Appliquee, Paris, France, 1959-60
Consultant, Jobin et Yvon Company, Arcueil, S. et O. France, 1959-60
Research Staff and Lecturer, Massachusetts Institute of Technology, 1960-63
Consultant, Jarrell-Ash Company, Newtonville, Mass., 1960-63
Consultant, Lincoln Laboratory, Massachusetts Institute of Technology, 1961-63
Consultant, Perkin-Elmer Corporation, Norwalk, Conn., 1961-63
Professor, The University of Michigan, Electrical Engineering Department and The Institute of Science and Technology, 1963

PROFESSIONAL AND HONORARY SOCIETIES (continued)

Graduate Fellow, Mass. Institute of Technology, 1954, 1955
Advanced Research Fellow (NATO), North Atlantic Treaty Organization, 1959-60

PUBLICATIONS

Scientific Publications:

"A Direct Evaluation of Nonperiodic Variations in Diffraction Gratings by a Phase Contrast Method," J. Opt. Soc. Am., 42, 879, 1952, A
"Electronic Location of Interference Fringes," with J. Peters, J. Opt. Soc. Am. 45, 30, 1955
"Interferometric Control of Grating Ruling with Continuous Carriage Advance," with G. R. Harrison, J. Opt. Soc. Am., 45, 112, 1955
"Interferometric Measurement of Wave-Front Aberrations in Gratings and Echelles," J. Opt. Soc. Am. 45, 30, 1955
"A Proposed Method of Measurement of the Velocity of Light in Terms of Two Primary Standards Cs133 and Hg 198," with G. R. Harrison, J. R. Zacharias, S.J. Mason, and C.L. Searle, Quart. Report., Research Lab., Electronics, Mass. Institute of Technology, January 15, 1956
"Measuring the Velocity of Light," Quart. Report., Research Lab Electronics, Mass. Institute of Technology, October 15, 1956
"Ruling of Large Diffraction Gratings with Interferometric Control," with G. R. Harrison, N. Sturgis, and S. C. Baker, J. Opt. Soc. Am., 47, 15, 1957
"Photoelectric Measurement of Interference Fringe Visibility and Effective Length Corrections for Precise Length Measurements in Interferometers with Continuously Moving Mirrors," Bull. Research Council Israel, 5C, 339, 1957, (By Invitation)
"Photoelectric Fringe Signal Information and Range in Interferometer with Moving Mirrors," J. Opt. Soc. Am. 47, 1097, 1957
"Systemes Interferentiels a Miroirs en Mouvement Continu et Detectio Photoelectrique," J. Physique Radium, 19, 415, 1958 (By Invitation)
"Tracage de Grands Reseaux de Diffraction a l'Aide D'Un Chariot Mobile Asservi Par Interferometrie Photoelectrique," Optics in Metrology, (Colloquium of the International Commission for Optics, Pergamon Press Ltd. London, 1959, p. 98-118) [By Invitation]

"Measurement of the Velocity of Light," with J. R. Zacharias, Quart. Report. Research Lab. Electronics, Mass Inst of Technology, January 15, 1958, and October 15, 1958

"A High Resolution Dispersion and Intensity Spectrograph," with H. H. Stroke, Quart. Report., Research Lab. Electronics, Mass. Institute of Technology, October 15, 1958

"Mesures Interferometriques et Transformations de Fourier Electroniques dans L'Evaluation des Images de Diffraction Formees Par Des Reseaux Optiques," J. Physique Radium 21, 57S, 1960

"Interferometry with Electronic Aids," Interferometry, (Symposium No. 11 London: Her Majesty's Stationery Office, 1960, p. 223-224) (By Invitation)

"Electronic Fourier Computing and Interferometry in Diffraction Grating Image Evaluation," (Preprint), Paper no. 5, Fifth Congress of the International Commission for Optics (on "Modern Systems for the Detection and Evaluation of Optical Radiation), Stockholm, Aug. 24-30, 1959 (By Invitation)

"Sur L'Origine des Effets de Polarisation et de Diffraction dans les Research Optiques," with A. Marechal, C.r.Ac.Sc.t. 249, 2042-2044, 1959

"Etude Theorique et Experimentale de Deux Aspects de la Diffraction de la Lumiere par les Reseaux Optiques: L'evolution des defauts dans les figures de diffraction et l'origine electromagnetique de la repartition entre les ordres," Revue d'Optique, 39, 291-398, 1960; These, The Sorbonne (Paris), 1960 (these presentee a la Faculte des Sciences de l'Universite de Paris, 17 juin 1960, pour obtenir le grade de Docteur es Sciences Physiques)

"Attainment of High Resolution with Diffraction Gratings and Echelles," with G. R. Harrison, J. Opt. Soc. Am. 50, 1153, 1960

"Measurement of the Velocity of Light," Quart. Report No. 63, Research Lab. of Electronics, Mass. Inst. Technology, Oct. 15, 1961, p. 105-112

"Attainment of High-Resolution Gratings by Ruling Under Interferometric Control," J. Opt. Soc. Am. 51, 1321, 1961 (By Invitation)

"Alingment Interferometer for Precision Straightness Measurement and Control even of Rapidly Moving Carriages," J. Opt. Soc. Am. 51, 1340, 1961

Invited Communications:

Spectroscopy Symposium, Argonne National Laboratory, University of Chicago, Feb. 15-17, 1956: "Theoretical and Experimental Criteria for the Measurement of Diffraction Grating Performance

Colloque International du C. N. R. S. (Centre National de la Recherche Scientifique) sur 'Les Progres Recents en Spectroscopie Interferentielle', Bellevue, S. et O., France, Sept. 9-13, 1957: "Systemes Interferentiels a Miroirs en Mouvement Continu et Detection Photoelectirque."

Colloquium of the International Commission for 'Optics in Metrology', Brussels, Belgium, May 6-9, 1958: "New Methods of Length Measurements"

Interferometry Symposium, National Physical Laboratory, Teddington, Middlesex, Great Britain, June 9-11, 1959: "Interferometry with Electronic Aids

Fifth Conference of the International Commission for Optics on 'Modern Systems for Detecting and Evaluating Optical Radiation,' Stockholm, Sweden, August 24-30, 1959: "Electronic Fourier Computing and Interferometry in Diffraction Grating Image Evaluation,"

Societe Francaise de Physique; Annual Meeting, Marseille, France, May 7-10, 1959 "Un Nouveau Spectrographe Compact a Tres Haute Resolution, Luminosite et Dispersion Utilisant Duex Reseaux-Echelles en Serie Croeses avec un Reseau Concave"

Duetsche Gesellschaft Fur Angewandte Optik, Annual Meeting, Karlsruhe, West Germany, June 7-9, 1960; "Sur L'Origine des Effets de Polarisation et de Diffraction dans les Reseaux Optiques," with A. Marechal

Optical Society of America, Annual Meeting, Boston, Mass.,Oct. 12-15, 1960: "The Two Aspects of the Diffraction of Light by Diffraction Gratings"

Books and Articles:

"Optique Cinematographique, Prise de Vues, Projection, Enregistrement du Son," La Technique Cingematographique, Editor, Paris, 1954 (By Invitation) (Book)

Articles by Invitation:

"Les Problemes Optiques de la Cinematographie des Maquettes," La Tech. Cin. 78, 387, 1948

"Formation et Vision des Images Optiques," La Tech Cin 93, 263, 1949

"Objectifs Photographiques Modernes," Atomes, 47, 45, 1950

"La Cinema en Relief, Son Etat Actual, Ses Possibilities Futures," La Tech. Cin. 95, 47, 1950; ibid. 96, 69, 1950

"Les Ecrans Cinematographiques (Characteristiques Photometriques des Ecrans Translucides et Reflechissants," La Tech. Cin. 109, 99, 1951

"Systemes Optiques Propres a la Prise de Vues et a la Projection Cinematographiques," La Tech. Cin. 112, 199, 1951

"Optique Francaise," La. Tech. Cin. 112, 209, 1951

"Light", McGraw-Hill Encyclopedia of Science and Technology, p. 499-507, 1960

"Doppler Effect," McGraw-Hill Encyclopedia of Science and Technology, p. 264-265, 1960

"Light," Technical Report No. 348, Research Laboratory of Electronics, Mass. Institute of Technology, Jan. 9, 1959

"Michelson-Morley Experiment," Encyclopaedic Dictionary of Physics, Pergamon Press, London, 1962

"Velocity of Light," American Institute of Physics Handbook, 1961

"New Departures in the Ruling, Testing and Use of Optical Gratings for High-Resolution Spectroscopy," Progress in Optics, (Editor: E. Wolf), Volume II, 1962

"Diffraction Gratings," Handbuch der Physik, (Editor: S. Flugge), Volume on "Optical Instruments," 1962

EXPERIENCE

Dr. Stroke has an outstanding and unique combination of experimental and theoretical competence in physical and geometric optics, and expertness in quantum electronics. His varied experience includes instruction and research in fast-opening fields of optical processing of control system, research and communication-system data. His work has involved the exploitation of the new "laser" instrumentation technique, using quantum electronic principles for generating in the visible spectrum radiation having the signal coherence of radio and radar waves.

Dr. Stroke was employed by the Massachusetts Institute of Technology from 1952 to 1963, with two interruptions--one for an appointment at Boston University, and one at the Sorbonne. His work at MIT specifically included:

1. research on the interferometric control of the MIT grating ruling engine, grating-image evaluation, interferometry.
2. advanced studies in mathematics, electronics, servo-control instrumentation
3. design and building of an apparatus for a new measurement of the velocity of light in terms of primary constants
4. doctoral thesis research on the effects of grating-errors on spectroscopic image-formation. (Additional doctoral thesis research on the two aspects of the diffraction of light by diffraction gratings was done while Dr. Stroke was at the Sorbonne.
5. research on extending interferometric control to the ruling of 18-inch gratings, improvements of 10-inch ruling-engine

At Boston University, Dr. Stroke was involved in teaching courses in general physics.

PROFESSIONAL AND HONORARY SOCIETIES

Membre titulaire, Societe Francaise de Physique
Fellow, Optical Society of America

TESKE, RICHARD GLENN Instructor

Education: Bowling Green State Univ. (Ohio): B.S., 1952. Ohio State Univ.: M.S., 1956. Harvard Univ.: Ph.D., 1962.

Positions Held: Academic
Harvard Univ.: Teaching Assistant, 1956-58; Univ. of Mich.: Instructor, 1960-.

Publications: Articles--8 (5 with coauthors) on cepheid variability and stellar spectra.

Professional and Honorary Societies: American Astronomical Society, Astronomical Society of the Pacific, Sigma Xi, Sigma Pi Sigma.

Mental Health Research Institute

LEONARD MERRICK UHR — RESEARCH PSYCHOLOGIST

EDUCATION:

1944-1949	Princeton University: majored in Psychology, B.A. with High Honors, Feb. 1949, Phi Beta Kappa
1949-1950	University of Brussels: Fulbright Scholar, in Philosophy and French Literature
1950-1951	Johns Hopkins University: M.A. in Writing, 1951
1951-1957	University of Michigan: Department of Psychology Major areas: Personality and Clinical Psychology Minor areas: Social Psychology and Industrial Psychology Doctoral dissertation: Personality Changes During Marriage M.A., 1953 Ph.D., June 1957

POSITIONS:

1945-1946	U.S. Army, Private. Radar and radio repairman
1951-1952	Assistant Psychometrician, University of Michigan Elementary School
1952-1953	Veterans Administration trainee in Clinical Psychology, Dearborn, Michigan
1953-1954	Teaching Fellow, Department of Psychology, The University of Michigan
1954-1955	Year off to write (novel, short stories)
1955-1956	Research Assistant, Willow Run Research Center, Ypsilanti, Michigan
1956-1957	Research Assistant, The University of Michigan Medical School
1956-1957	Teaching Fellow, Department of Psychology, The University of Michigan
1957-1959	Research Associate, Mental Health Research Institute, The University of Michigan

1959-1960	Associate Research Psychologist, Mental Health Research Institute, The University of Michigan
1960-	Research Psychologist, Mental Health Research Institute, The University of Michigan. Dynamic modelling of perceptual and symbolic processes via computer simulations. Research on perception and language learning, behavioral effects of drugs, and sensory control.
1960-	Consultant, System Development Corporation, Santa Monica, Calif.
1962-	Lecturer, Department of Psychology, The University of Michigan
1963-	Consultant, RAND Corporation, Santa Monica, Calif.

MEMBERSHIP AND ACTIVITIES:

American Psychological Association
Association for Computing Machinery
Book Review Editor, Behavioral Science
Reviewer, Computing Reviews
Psychologist on N.S.F. Advisory Panel on University Computer Facilities

RESEARCH INTERESTS:

My chief research interest is in the building (via computer simulations) and testing of complex models of cognitive processes.

TECHNICAL SKILLS:

Design of experiments
Programming of electronic computers

TEACHING INTERESTS:

Simulation of Complex Models of Psychological Processes

PUBLICATIONS:

1. The Michigan project on the prediction of professional competence in medicine. J. Med. Educ., 1957, 32, No. 10, Part 2, 187-195. (With E. L. Kelly and W. Whitaker)

2. An anxiety scale for the Strong vocational interest inventory: development, cross-validation and subsequent test of validity. J. Applied Psychol., 1958, 42, 241-46. (With G. Garman)

3. An exploratory study of the behavioral effects of Suavitil (benactyzine hydrochloride). Univ. of Mich. Med. Bull., 1958, 24, 402-27. (With Smith, Pollard and Miller)

4. Continued meprobamate and prochlorperazine administration and behavior. A.M.A. Arch. Neurol. and Psychiat., 1958, 80, 247-52. (With Kelly, Miller, Marquis and Gerard)

5. Hamlet's "coold" mother. Notes and Queries, 1958, New series, 5, 189-190.

6. Learning under hypnosis: What do we know? What should we know? J. Clin. Exper. Hypnosis, 1958, 6, 121-35.

7. Objectively measured effects of the new psychoactive drugs. MHRI Preprint 17.

8. Personality changes during marriage. Diss. Abstracts, 1958, 18, 2204.

9. Personality differences and continued meprobamate and prochlorperazine administration. AMA Arch. Neurol. and Psychiat., 1958, 80, 241-46. (With E. L. Kelly, J. G. Miller, D. Marquis, R. W. Gerard)

10. Planning for beauty: Could the psychologist help? J. Amer. Inst. of Planners, 1958, 24, 18-21.

11. An experimental study of the behavioral effects of carbethoxysyringoyl methylreserpate (Singoserp). Toxicology & Applied Pharmacology, 1959, 1, 534-544. (With J. G. Miller)

12. Behavioral effects of chronic administration of psychoactive drugs to anxious patients. Psychopharmacologia, 1959, 1, 150-168. (With Miller and Pollard)

13. Drug effects on positive conditioning in human subjects. (With J. G. Miller, A. Platz, M. Clay and E. L. Kelly)

14. Effects of meprobamate on attention under experimentally aroused stress. MHRI Preprint 47. (With A. Platz, J. Miller and S. Fox)

15. Latest methods for the conception and education of intelligent machines. Behav. Science, 1959, 4, 248-251.

16. A general purpose intercorrelation program. Univ. of Mich., 1957, Abstracted in: Behav. Science, 1959, 4, 255.

17. Machine perception of printed and handwritten forms by means of procedures for assessing and recognizing Gestalts. In: Preprints of 14th Assoc. for Computing Machines Meeting, Boston, Sept. 1959. MHRI Preprint 34.

18. Sex as a determinant of driving skills. J. Applied Psychol., 1959, 43, 35.

19. Some further effects of response context on trait inferences. J. Psychol., 1959, 48, 79-85.

20. Time and dosage effects of meprobamate on visual detection. MHRI Preprint 61. (With A. Platz, M. Clay, J. G. Miller, and A. Kristofferson)

21. A computer model for pattern perception and language translation. Multilith paper.

22. A pilot experiment on the effects of meprobamate and prochlorperazine on tests of cognition and perception. Perceptual and Motor Skills, 1960, 11, 90. (With J. G. Miller) MHRI Preprint 41.

23. A pilot experiment on the effects of meprobamate on stereoscopic retinal rivalry of complementary colors. Perceptual and Motor Skills, 1960, 10, 230. (With Miller) MHRI Preprint 41.

24. Behavioral toxicity of emylcamate (Striatran). Am. J. Med. Sciences, 1960, 240, 197-203. (With J. G. Miller) MHRI Preprint 42.

25. Behavioral toxicity as measured by tests of complex simulated driving and vision. In: L. Uhr and J. G. Miller (Eds.), Drugs and Behavior. New York: Wiley, 1960. (With J. G. Miller)

26. Brain models that discover, gather, organize, and use patterned information. APA Paper. (With C. Vossler)

27. Computers, ditto paper.

28. Controlled sensory input: a note on the technic of drug evaluation with a preliminary report on a comparative study of sernyl, psilocybin, and LSD 25, Comprehensive Psychiat., 1960, 1, 377-380. (With Pollard, Bakker, & Feuerfile)

29. Drugs and Behavior. New York: John Wiley and Sons, 1960, Editor (With J. G. Miller)

30. Experimentally determined effects of emylcamate (striatran) on performance, autonomic response, and subjective reactions under stress. Amer. J. of the Medical Sciences, 1960, 240, 110/204. (With J. G. Miller)

31. Intelligence in computers: the psychology of perception in people and in machines. Behav. Science, 1960, 5, 177-182.

32. Objectively measured behavioral effects of psychoactive drugs. In: L. Uhr and J. G. Miller (Eds.), Drugs and Behavior. New York: John Wiley & Sons, 1960.

33. Prologue. In: L. Uhr and J. G. Miller (Eds.), Drugs and Behavior, New York: John Wiley & Sons, 1960. (With J. G. Miller)

34. A computer simulation of pattern perception and concept formation. Proceedings of the 1961 Bionics Symposium. (C. Vossler and L. Uhr)

35. A pattern recognition program that generates, evaluates, and adjusts its own operators. Proc. of the Western Joint Computer Conference, May 1961. (With C. Vossler)

36. An experimental study of the behavioral effects of isothipendyl hydrochloride (Theruhistin). Acta Allergologica, 1961, 16, 141-150. MHRI Preprint 19. (With J. G. Miller)

37. A possibly misleading conclusion as to the inferiority of one method for pattern recognition to a second method to which it is guaranteed to be superior. IRE Trans. Electronic Computers, 1961, EC-10, 96-97.

38. Computer simulations of a model for form perception. SP-472, System Development Corp., 15, 1961. (With C. Vossler)

39. Effects of meprobamate and of prochlorperazine on positive and negative conditioning. J. Abnorm. Soc. Psychol., 1961, 63, 546-551. MHRI Preprint 50. (With M. Clay, A. Platz, J. G. Miller, and E. L. Kelly)

40. Recognition of speech by a computer program that was written to simulate a model for human visual pattern recognition. J. acoustical soc. of Amer., 1961, 33, 1426. (With C. Vossler)

41. Replication Report: Three pattern recognition experiments with a computer simulation of a model for form perception as subject. MHRI Preprint 64. (With C. Vossler)

42. Suggestions for a general purpose adaptive computer model of brain functions. Behav. Science, 1961, 5, 91-97. (With C. Vossler)

43. Suggestions for self-adapting computer models of brain functions. Behav. Science, 1961, 6, 91-97.

44. A computer simulation of pattern perception and concept formation. In: E. E. Bernard & M. R. Kare (Eds.), Biological Prototypes and Synthetic Systems. New York: Plenum, 1962, 233-243. (C. Vossler and L. Uhr)

45. Effects of psychotomimetic drugs on subjects in a controlled sensory environment. Proc. of the First International Pharmacological Meeting. August 1961, New York: Pergamon, 1962. (With J. C. Pollard)

46. Hamlet's Gertrude: The Show of "seeme." The Shakespeare Quarterly.

47. Pattern recognition over distortions by human subjects and by a computer simulation of a model for human form perception. J. of Exp. Psychol., 1962, 63, 227-234. MHRI Preprint 64. (With C. Vossler and J. Uleman)

48. Time and dosage effects of meprobamate on simple behavioral tasks. J. Gen. Psychol., 1963, 68, 317-323. (With A. Platz and J. G. Miller)

49. A pattern recognition program that generates, evaluates, and adjusts its own operators. In: E. Feigenbaum and J. Feldman (Eds.), Computers and Thought. New York: McGraw-Hill, 1963, 251-268. (With C. Vossler)

50. Pattern recognition computers as models for form perception. Psychol. Bull., 1963, 60, 40-73. MHRI Preprint 60.

51. The development of perception and language. In: S. Tomkins and S. Messick (Eds.), Simulation of Personality Processes. New York: Wiley, 1963, 231-266.

52. The search to recognize. In: George L. Fischer, Jr. et al (Eds.), Optical Character Recognition. Washington, D. C.: Spartan Books, 1962, 319-329. ONR-NBS Symposium on Character Recognition. (With C. Vossler)

53. Studies in sensory deprivation. Arch. Gen. Psychiat., May 1963, 8, 435-454. (J. C. Pollard, L. Uhr, and C. W. Jackson, Jr.)

54. A "fact organizer" for pattern recognition and language manipulation. MHRI Preprint 114, 1963. Paper read at ACM Conference, Denver, 1963. (J. P. Benkard and L. Uhr)

55. Computer simulations of a perceptual learning model for sensory pattern recognition, concept formation, and symbol transformation. Proceedings of the IFIP Congress, 62. Amsterdam: North Holland Publishing Co., 1963, 413-418. Congress held in Munich, August 1962. Preprint 82. (C. Vossler and L. Uhr)

WILLIAM R. UTTAL

EDUCATION:

1951 B.S. University of Cincinnati: Major in Physics

1957 PhD The Ohio State University: Experimental Psychology and Biophysics

EXPERIENCE:

1. United States Air Force - January 1951 to October 1953

a. Following completion of basic training subsequent to enlistment, W.R.U. was assigned to the electrical engineering department of the USAF Institute of Technology at Wright-Patterson AFB, Ohio. His assignment was to set up an analog computational facility. During the next fifteen months the laboratory was expanded from the original model computer to include a Reeves REAC and a Philbrick System. W.R.U.'s responsibilities included the maintenance, use and instruction in the use of the systems as well as teaching electronics and calculus. In June of 1952 he was directly commissioned as a 2nd Lt. and following a short officer's training school assigned to the Air Force electronics school at Keesler AFB, Miss. for Radar systems training.

b. Upon completion of the Radar training he was assigned as chief of the Radar section of an early warning site in Japan. In addition to this technical responsibility he also served as executive officer and finally acting site commander before being returned to the United States for discharge.

2. North American Aviation - October 1953 to January 1954

Before returning to graduate school W.R.U. had the opportunity to learn programming for one of the early IBM 701 digital computer installations.

3. The Ohio State University - January 1954 to April 1957

W.R.U. resumed his formal education initially in the physics department of the O.S.U. but shortly transferred to the psychology department to more directly pursue his interests in the behavioral and physiological sciences. While in the physics department he held a teaching assistantship in the electricity and magnetism laboratory and later in the psychology department held various teaching and research assistantships and fellowships. During this period he carried out a research program which was to be submitted as his doctoral dissertation and which was entitled: Cutaneous Sensitivity to Electrical Pulse Stimuli.

4. IBM Research Center - April 1957 to June 1963

Upon graduation from O.S.U., W.R.U. joined the newly formed IBM Research Center and pursued a program of research applying computers to basic scientific problems in the behavioral and biological sciences. The attached bibliography details the specific results of this research which included problems selected from the following fields:

a. The neural coding of subjective sensory magnitudes in the human somesthetic system.
b. Spatial interaction in somesthetic stimulation.
c. Relationships between psychophysical measures and the human evoked brain potential.
d. Sensory communication and coding in the caudal photoreceptor of the crayfish.
e. The use of computers as automated teaching devices.
f. Digital computer simulation of the Limulus eye.

Each of these studies involved considerable use of automated data processing equipment and W.R.U. had the opportunity to add to his experience with the engineering techniques necessary for the development of input-output devices to be connected to digital computers. In 1962 he received a patent award for five filed dockets, three of which were systems involving man-machine interaction through special terminal equipment directly connected a digital computer.

At IBM W.R.U. was manager of the Behavioral Sciences group and supervised the activities of an interdisciplinary operation including 18 psychologists, biologists, computer programmers and engineering personnel. A 1410 computer system, under his supervision, was multiprogrammed to operate a multiplexed group of special terminal equipment for various psychological and physiological experiments. W.R.U. designed a fully buffered multiplexer to allow the system to be used for many simultaneous experiments.

5. The University of Michigan, Mental Health Research Institute - July 1963 to

In July of 1963, W.R.U. joined the faculty of The University of Michigan where he holds a joint appointment as Associate Professor of Psychology and Research Psychologist. During the coming years he will be teaching Sensory Psychology and Computer Applications in the Behavioral Sciences.

BIBLIOGRAPHY:

1. Uttal, W. R., Dickinson, C. A., Hom, C., Bernard, F. H., Selfridge, L. P., Cook, L., and Phillips, M. L., "A Modular, Fully Buffered Multiplever System for Real Time Man-Machine Applications," IBM Research Report RC-885, December 1962.

2. Uttal, W. R., "My Teacher Has Three Arms," IBM Research Report, RC-788.

3. Uttal, W. R., Charap, Marilyn, and Maher, Anna, "The Computer Tutoring of Stenotype: A Preliminary Report," IBM Research Report RC-663, April 1962.

4. Uttal, W. R., and Kasprzak, Hedwig, "The Caudal Photoreceptor of the Crayfish: A Quantitative Study of Responser to Intensity, Temporal and Wavelength Variables," IBM Research Report RC-620, published in the American Federation of Information Processing Societies Proceedings 1962.

5. Uttal, W. R., "On Conversational Interactions," IBM Research Report, RC-532. Also in Programmed Learning and Computer Based Instruction, J. Coulson, Ed.

6. Uttal, W. R., and Cook, L., "Systematics of the Evoked Somatosensory Cortical Potential," IBM Journal of Research and Development, April 1962. (Also to be published in Proceedings of New York Academy of Sciences.)

7. Uttal, W. R., and Roland, P. A., "A Terminal Device for Entry of Neuroelectric Data into an Electronic Data Processing Machine," EEG & Clin. Neurophysiol., 13, 11. 637-640, 1961.

8. Uttal, W. R., "Computer Studies of Neurophysiological Phenomena in Man and Clayfish," Proceedings of the 2nd Annual IBM Medical Symposium, Endicott, New York, September 26-30, 1960.

9. Uttal, W. R., "Neural Responses to Long Duration Electrical Pulse Stimuli in the Somesthetic System of Man," IBM Information Research Report IR-00195, October 25, 1958.

10. Uttal, W. R., "Use of Summary Card Punch as Simultaneous Stimulus Generator and Data Collector," Amer. J. Psychol., 75, March 1962.

11. Uttal, W. R., "Computers and Sensory Neurophysiology," Proceedings of the National Aeronautics Electronics Conference, NAECON, 39 No. Torrence St., Dayton, Ohio, May 1960, pp. 221-226.

12. Uttal, W. R., and Cook, L., "On the Absence of Contralateral Inhibitory Interaction to Electrical Stimuli in the Fingers," IBM Research Report RC-243, April 20, 1960.

13. Uttal, W. R., "The Three Stimulus Problem: A Further Comparison of Neural and Psychophysical Responses in the Somesthetic System," J. Comp. and Physiol. Psychol., 53, February 1960, pp. 42-46.

14. Uttal, W. R., "Inhibitory Interaction of Responses to Electrical Stimuli in the Fingers," J. Comp. and Physiol. Psychol., 53, February 1960, pp. 47-51.

15. Uttal, W. R., "The IBM Biophysical Research System," IBM Research Report RC-195, February 9, 1960.

16. Uttal, W. R., "The Neural Coding of Somesthetic Sensation: A Psychophysical Neurophysiological Comparison," IBM Research Report, RC-203, January 5, 1960, and U.S.A.M.R.L. Symposium on Cutaneous Sensitivity, February 11-13, 1960, Glen R. Hawkes, Ed.

17. Uttal, W. R., "A Comparison of Neural and Psychophysical Responses in the Somesthetic System," J. Comp. and Physiol. Psychol. 52, No. 4, August, 1959, pp. 485-490.

18. Uttal, W. R., "Cutaneous Sensitivity to Electrical Pulse Stimuli," J. Comp. and Physiol. Psychol. 51, No. 5, October 1, 1958, pp. 549-554.

NAME: Dennis Walsh

TITLE: Associate Research Physicist

DATE OF BIRTH: June 12, 1933

PRESENT RESPONSIBILITIES:

Full time research on UM/RAO space radio astronomy program. Primarily concerned with theoretical and scientific aspects of cosmic noise measurement program.

EDUCATION:

B.Sc. (1st class honors in physics), University of Manchester, 1953
Ph.D. (Radio Astronomy), University of Manchester, 1958

EXPERIENCE:

Academic:

Associate Research Physicist, Radio Astronomy, University of Michigan, 1960 to present
Research Associate, Radio Astronomy, University of Michigan, 1959-1960
Research Student, Jodrell Bank, Manchester, England, 1953-1957

Non-Academic:

Development Engineer, Ferranti, Ltd., Manchester, England, 1957-1959

SUMMARY OF TECHNICAL EXPERIENCE:

As research student at Jodrell Bank, built and operated sensitive, highly stable radio astronomy receiver for 92 Mc/s survey, employing Ryle and Vonberg switching pricipal; also designed, built and operated a phase-switched interferometer at this frequency. Assisted in system design of UM/RAO receivers for space cosmic noise measurements. Programmed and operated large analog computer in guided weapon program.

SOCIETIES, ETC.:

International Astronomical Union (member, Commission 40
Sigma Xi

PUBLICATIONS:

"A Radio Survey of The Great Loop in Cygnus," with R. Hanbury Brown, Nature, 175, 808, 1955.

"A Comparison of an Interferometer and Total-Power Survey of Discrete Sources of Radio-Frequency Radiation," with C. Hazard, Paris Symposium on Radio Astronomy, ed. Bracewell, 477, 1959.

"An Experimental Investigation of the Effects of Confusion in a Survey of Localized Radio Sources," with C. Hazard, M. N. R. A. S., 119, 648, 1959.

"A Survey of the Localized Radio Sources at a Frequency of 92 Mc/s," with C. Hazard, Jodrell Bank Annals, 1 (6), 338, 1960.

PATENTS:

None

NAME: Herschel Weil

TITLE: Associate Professor

DATE OF BIRTH: July 26, 1921

PRESENT RESPONSIBILITIES:

Theoretical work in radio-frequency radiation, generation, propagation and reception in plasmas with radio-astronomical applications. Teaching Electrical Engineering courses.

EDUCATION:

B.S. (Optics), University of Rochester, 1943
Sc.M. (Applied Math.), Brown University 1945
Ph.D. (Applied Math.), Brown University, 1948
Graduate work in Physics, Rensselaer Polytech. Inst. 1945-46

EXPERIENCE:

Academic:

Associate Professor, Electrical Enginnering, University of Michigan, February 1960-present
Lecturer, Electrical Engineering, University of Michigan, 1958-60
Lecturer, Mathematics, University of Michigan, 1956-58
Teaching Assistant, Mathematics, Rensselaer Polytechnic Institute, part-time, 1945-46

Non-Academic:

Research Engineer, University of Michigan, 1955-60
Associate Research Engineer, University of Michigan, 1953-55
Research Associate, University of Michigan, 1952-53
Engineer (Mathematical Consultant and Project Director), General Electric Company, Schenectady, New York, 1948-52
Research Associate, Brown University, Providence, Rhode Island, 1947-48
Research Assistant, Brown University, 1946-47
Laboratory Assistant, General Electric Company, summer 1945
Optical Engineer, Bausch and Lomb Optical Company, Rochester, New York, 1943-44

SOCIETIES, ETC.:

Sigma Xi
American Mathematical Society
Society of Industrial and Applied Mathematics
Senior Member, Institute of Radio Engineers

SUMMARY OF TECHNICAL EXPERIENCE:

Theoretical treatments of problems in: optical design, fluid mechanics, gas dynamics, mechanical vibrations and stress, electromagnetic theory, radar and computer design, radar countermeasures and plasma physics.

PUBLICATIONS:

PAPERS:

"Effects of Pressure Gradient on Stability and Skin Friction in Laminar Boundary Layers in Compressible Fluids," J. Aero Sci., 18, 311-18, May 1951.

"Conduction of Current in a Metallic Pipe Filled with a Conducting Liquid," with H. Poritsky, J. Appl. Phys., 22, 1002-1005, August 1951.

"On the Extrusion of a Very Viscous Liquid," J. Appl. Mech., 18, 267-272, September 1951.

"The Distribution of Radial Error," Ann. Math. Statistics, 25, 168-170, March 1954.

"Reduction of Runs in Multifactor Computations," J. Assoc. Computing Machinery, 2, 99-110, April 1955.

"The Influence of Radar Reflection Characteristics of the Moon on Specifications for Earth-Moon-Earth Communication Systems," with T. B. A. Senior and K. M. Siegel, 1958 IRE Wescon Convention Record, Pt. I, 197-201, August 1956.

"Forward Scattering by Coated Objects Illuminated by Short Wavelength Radar," with R. E. Hiatt and K. M. Siegel, Proceedings of the IRE, 48, 9, 1630-1635, September 1960.

"The Ineffectiveness of Absorbing Coatings on Conducting Objects Illuminated by Long Wavelength Radar," with R. E. Hiatt and K. M. Siegel, Proceedings of the IRE, 48, 1636-1642, September 1960.

"Scattering by a Spherical Satellite," with E. M. Kennaugh and S. P. Morgan, Proceedings of the IRE, 48, 1781, October 1960.

"On the Change in Radar Cross-Section of a Spherical Satellite Caused by a Plasma Sheath," with C. L. Dolph, Electromagnetic Effects of Re-Entry, Pergamon Press, 1961. This book consists of selected papers presented to the Plasma Sheath Symposium, AFCRC, Boston, Massachusetts, December 1959. Also, J. Planetary and Space Sci., June 1961.

"A Theoretical Lunar Ionosphere," with Murray L. Barasch, Icarus 1, 346-356, January 1963.

"Flow Field in Hypersonic Re-Entry," AIAA Journal, 1, April 1963.

"Radiation Resistance of an Electric Dipole in a Magneto-Ionic Medium," with Dennis Walsh, Proc. of 1963 PTGAP International Symposium on Antennas and Propagation, July 1963. (An expanded version of this material under the same title is expected to appear in the IEEE Transactions on Antennas and Propagation.)

ABSTRACTS:

"Electromagnetic Measurements of Fluid Flow in Pipes of Elliptical Cross Section," with M. Poritsky, Proc. 1950 International Congress of Mathematicians.

"On Non-Linear Combinations of Random Variables," Bull. Am. Math. Soc., March 1952.

"On the Convergence of the Mie Series for Scattering by Spheres," Bull. Am. Math. Soc., March 1957.

"Model of the Lunar Ionsophere," with Murray L. Barasch, Astronomical Journal 67, 1962.

UNCLASSIFIED REPORTS:

"Aerodynamics of the Oscillating Airfoil in Compressible Flow," F-TR-1167-ND and F-TR-1195-ND, Hq., AMC, WPAFB (Pt. I with S. N. Karp, S. S. Shu, 1947; Pt. II with S. N. Karp, 1948).

"Studies in Radar Cross Sections X-Scattering of Electromagnetic Waves by Spheres," Rept. 2255-20-T, Willow Run Research Center, University of Michigan, with M. L. Barasch and T. A. Kaplan, 104 pp., July 1956.

"Studies in Radar Cross Sections XXVIII-The Physics of Radio Communication via the Moon," with M. L. Barasch, et al., Rept. 2673-1-F Radiation Lab, University of Michigan, 86 pp., March 1958.

"Enhancement of Radar Cross Sections of Warheads and Satellites by the Plasma Sheath," with C. L. Dolph, Rept. 2778-2-F, Radiation Lab, University of Michigan December 1959.

"Transverse Whistler Propagation," with C. O. Hines and W. C. Hoffman, Rept. 2894-1-F, Radiation Lab, University of Michigan, June 1959.

"Radar Echo from Re-Entry Vehicles," RM-3251-PR The RAND Corp., May 1963. (A condensed version of this report is expected to appear in the AIAA Journal under the title "Radar Echoes from Ionized Wakes Behind Blunt Bodies.")

WILSON, DEAN H. RESEARCH ENGINEER, & HEAD, INDUSTRIAL SYSTEMS RESEARCH LAB.

EDUCATION

BS	Physics	The University of Michigan, 1948

EMPLOYMENT

Student Assistant, The University of Michigan, 1947
Technician, The University of Michigan, IST, 1947-48
Research Associate, The University of Michigan, IST, 1948-51
Lecturer for Industrial Engineering Department, The University of Michigan, 1956-
Lecturer, International Cooperation Administration, Waseda University, Tokyo, summer 1957
Research Engineer, The University of Michigan, 1951-

EXPERIENCE

Design of guided missile control systems. Design of high-speed electronic digital information processing systems. System evaluation, test and design of experiments for large scale man-machine information processing systems.

PROFESSIONAL AND HONORARY SOCIETIES

Member, Industrial Mathematics Society
Member, Institute of Management Sciences
Member, Operations Research Society of America
Member, Alpha Pi Mu
Member, Industrial Engineering Honarary Society

PUBLICATIONS

"Inventory Control - a Hypothetical Case," Introduction to Management Sciences, pp. 205-210, The University of Michigan Conference, 1956
"Interceptor Ground Control System," A Study of Air Armament Systems, pp. 7-12, H.C. Carver, Ed., The University of Michigan (Secret)
"First Interim Report on GSG-2-AAA - Comparison Test Evaluations," 2359-1-F, 31 October 1955 (Secret)