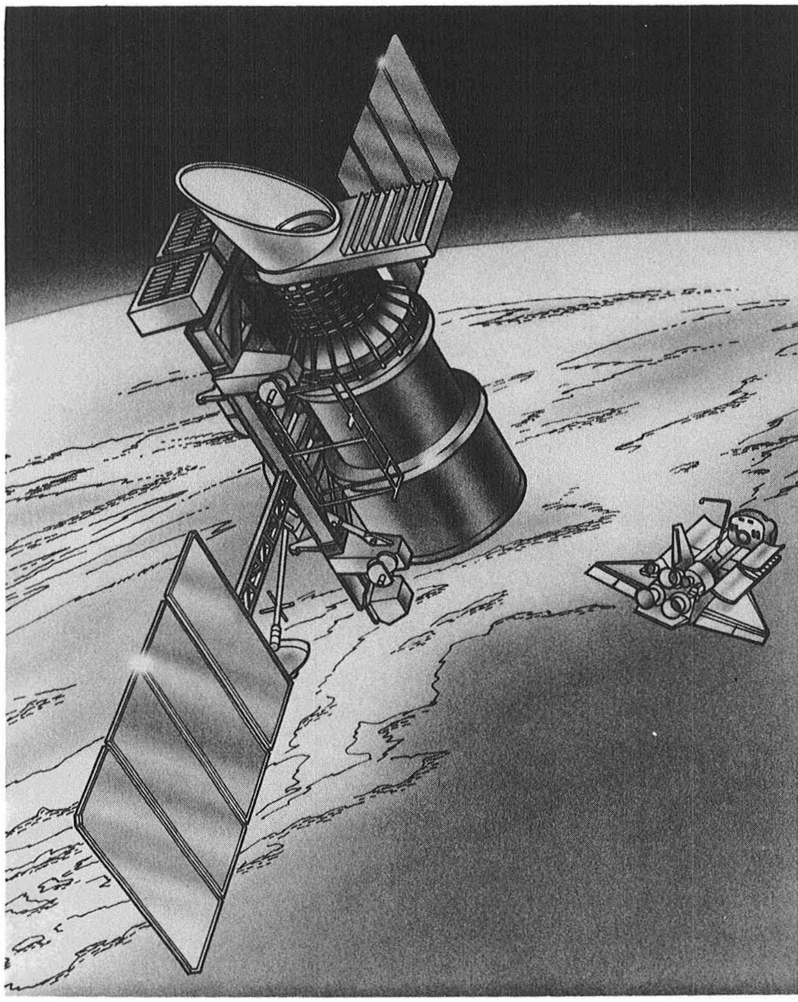
NASA TM-85931

NASA Technical Memorandum 85931

NASA-TM-85931 19840025294

NASA AMES SUMMER HIGH SCHOOL APPRENTICESHIP RESEARCH PROGRAM

JUNE 13 — AUGUST 19, 1983



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              DISPLAY 03/6/1
       84N33365*#   ISSUE 22   PAGE 3684   CATEGORY 99   RPT#: NASA-TM-85931
       A-9689 NAS 1.15:85931   84/08/00  141 PAGES   UNCLASSIFIED DOCUMENT
UTTL:  NASA Ames summary high school apprenticeship research program, 1983
       research papers   TLSP: Report, 13 Jun. - 19 Aug. 1983
AUTH:  A/POWELL, P.
CORP:  National Aeronautics and Space Administration. Ames Research Center,
       Moffett Field, Calif.    AVAIL.NTIS   SAP: HC A07/MF A01
MAJS:  /*EDUCATION/*FEMALES/*MINORITIES/*RESEARCH AND DEVELOPMENT/*SPACELAB/*
       STUDENTS
MINS:  / ASTRONOMY/ ASTROPHYSICS/ CHEMISORPTION/ HELICOPTERS/ MICROPROCESSORS/
       PROJECT SETI/ SPACE EXPLORATION/ WEIGHTLESSNESS
ABA:   Author
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NASA Technical Memorandum 85931

NASA Ames Summer High School Apprenticeship Research Program June 13 — August 19, 1983

STUDENT PAPERS

Coordinated by Patricia Powell, Ames Research Center. Moffett Field, California

NASA
National Aeronautics and
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N84-33365 #

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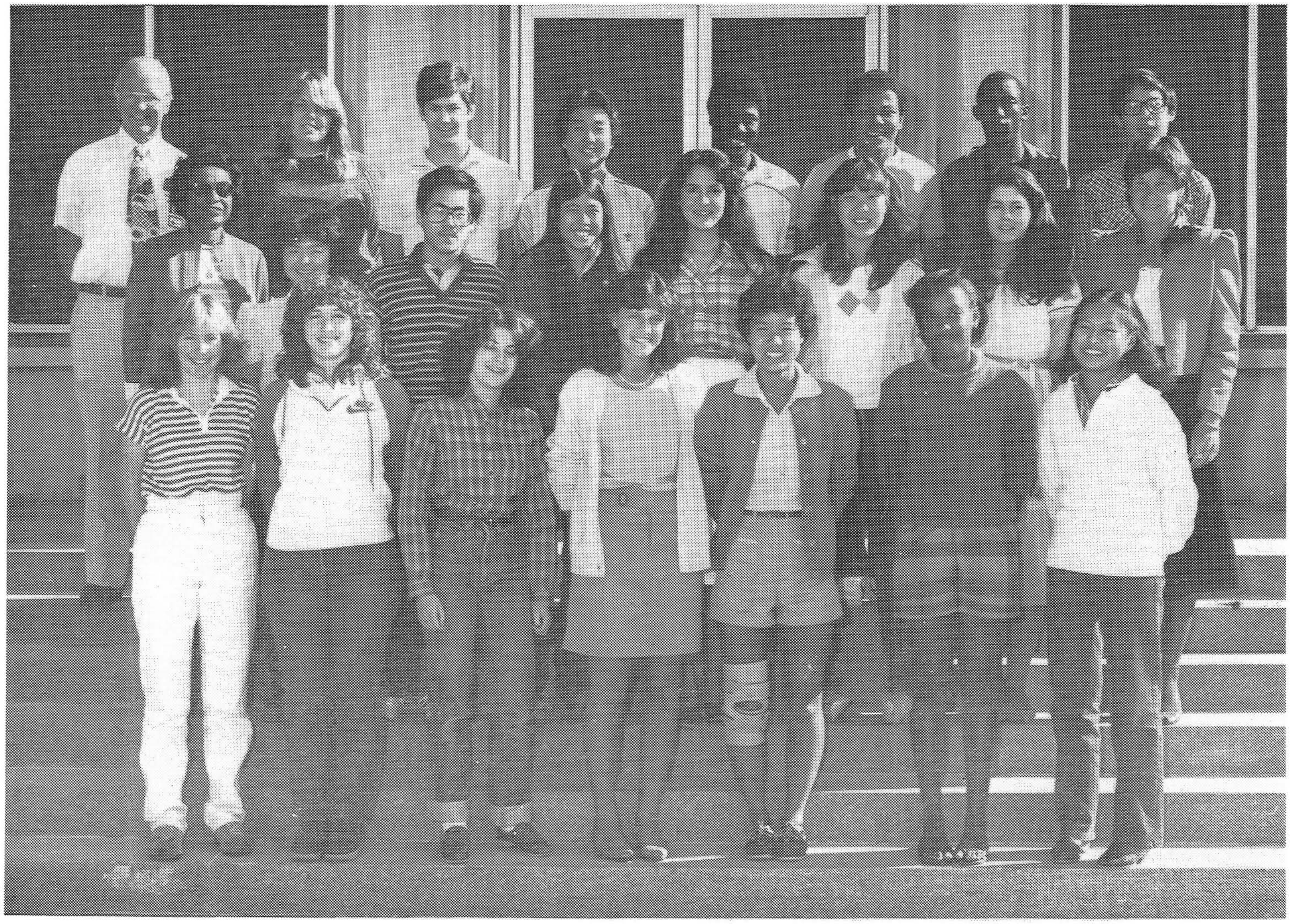

Pictured from left to right, front row: Carrie O'Donnell, Cara Meredith, Jill Berman, Stephanie Blank, Yvonne Yeh, Alice Criner, Jacqueline Chang; second row: Patricia Powell (SHARP Faculty Coordinator), Lai Chi Yip, Cedric Chin, Stacy Chin, Nicole deNecochea, Linda Rhough, Karen Gulick, Meredith Moore (Employee Development Specialist); third row: John Leveen (Chief, Training and Special Program Branch), Kathy Smith, Franklin Graham, Joel Lym, Johnny Davidson, Todd Barker, Kelvin Davis, Andrew Wang.

INTRODUCTION

Engineering enrollments are rising in universities; however, the graduate engineer shortage continues. Particularly, women and minorities will be underrepresented for years to come. As one means of solving this shortage, Federal agencies facing future scientific and technological challenges were asked to participate in the Summer High School Apprenticeship Research Program (SHARP). This program was created 4 years ago to provide an engineering experience for gifted female and minority high school students at an age when they could still make career and education decisions.

The SHARP Program is designed for high school juniors (women and minorities) who are U.S. citizens, are 16 years old, and who have unusually high promise in mathematics and science through outstanding academic performance in high school. Students who are accepted into this summer program will earn as they learn by working 8 hours a day in a 5-day work week. This work-study program features weekly field trips, lectures and written reports, and job experience related to the student's career interests.

The experience of SHARP '83 will be long remembered by the fortunate high school students who worked with the team of mentors from many different branches here at Ames Research Center. Some of the spirit of excitement and challenge of the students and the dedication of the scientist-mentors has been captured in this volume and in the following comments from some of the students.

"More important than increasing my gamut of knowledge, my experience has given a direction to my studies. I hope to work in college toward a bachelor's degree in electrical engineering; with this background I believe I will have many options open to me. On one hand, I can continue my education in graduate school and become an engineer. On the other hand, if I choose to pursue a career in a field such as medicine or business, my technical background will still be a valuable asset."

"I have gotten a look at how engineers work, and this experience has made me think about a career in engineering. This experience has enabled me to appreciate the application of computer technology to the development and achievements of our Information Age."

"An astrophysicist? . . . I had never considered such a career, but thanks to SHARP and my work experience, it is definitely a career interest."

"One of the many things that I have learned is how to write test procedures, and I have begun to realize how much other paperwork accompanies a test. I have come to realize that there is more to a job in this field than I had previously thought."

"SHARP is a valuable program. I was able to have my potential and capabilities recognized. It has enabled me to gain experience and knowledge I could not have acquired from books. It has given me the opportunity to speak with engineers and scientists and learn about their careers. The exposures to the working world of engineers, scientists, and technicians has encouraged me to pursue a career in the field of science. The SHARP program has helped me to plan a science and mathematics-based curriculum in college. This I feel is needed because of the importance of these disciplines in the complex world of today as well as tomorrow."

COVER PHOTO: Space Infrared Telescope Facility (SIRTF)

JOB DESCRIPTION

Todd Barker

The Research Support building is where I work. I am working with electrical engineers. Within the field of electrical engineering there are many aspects. I deal with System Controls and Design Engineering, which can be considered a major part of Electrical Engineering. My supervisor is Steve Lakowske.

Working for the government as a Civil Servant (Junior Engineer) has been very exciting. I am constantly learning new information. I do word processing on computers to organize data. Recently, I organized an electronics parts list for a 1987 Space Shuttle test. The experiment consists of a centrifuge which will spin frog eggs. Organizing information by using computers is a valuable part of my job. At present, I'm designing a microprocessor reset panel for the 1990 Advanced Flight Simulator System. The simulator creates a realistic flight environment for the pilots so that scientists and avionic specialists can judge their performance. I've learned that one must also organize new knowledge and creative ideas.

My knowledge about electronics will gradually expand. I'm learning about D.C. electronics; soon I'll attend soldering school. Becoming a NASA Certified Government Solderer will aid me now and in the future. I am also going to be building electronic kits, radios, digital clocks, and electronic meters. I can definitely say that there is much to be learned in electrical engineering.

MICROPROCESSORS: THE RESULT OF RESEARCH AND DEVELOPMENT

Todd Barker

Every day new high technology products are being produced or modified to meet the demands of our society. Technology can be described as the "state of the art" in a socioeconomic environment. It symbolizes the knowledge of a society which stems from various cultural objectives. Microprocessors are an application of technology. The designing and building of microprocessors require a long and intensive process called research and development.

Research and development (R&D) has stimulated large amounts of activity in industries. Some companies spend millions of dollars in the research and development area. The concept of R&D was initiated in the late 1960s by many companies, such as Datapoint, Intel Corporation, Texas Instruments, and Busicom (a Japanese firm). The companies set out to design and build custom circuits. These circuits, also known as integrated circuits, contain a certain number of gates. A gate is a device on a microprocessor where information can be entered and then processed. There are three types of integrated circuits: medium-scale integration (MSI), large-scale integration, and very large-scale integration. The MSI can hold from 100 to 1000 gates on a chip. The large-scale integration circuit holds 1000 to 10,000 gates. The very large-scale integration circuit contains more than 10,000 gates. The companies, some independently and others not, came out with programmable chips which contained electronic logic (fig. 1).

The logic of the original computers built in the 1950s was placed on vacuum tubes and circuit wires. The logic (or the way the computer thought, predicted, and responded) was the result of being built out of bi-stable logic devices. These devices are the building blocks of digital computers. The devices have two stable states, and the ability to switch, on command, from one stable state to another.

Technology, research, and development are all closely related. Technology is the application of scientific information. It represents the systematic utilization of knowledge. The first models of microprocessors were the MCS-4, 4004, and 8080. As years went by, the microprocessors were constantly being changed and modified to meet many different needs.

One of the most attractive features of the microprocessor is cost effectiveness (fig. 2). This is primarily a company's justification for using one. Five important changes came about because of the invention of the microprocessor.

1. A decrease in manufacturing and testing costs.

2. An increase in a company's share of market and product sales.

3. An increase in capabilities because of programmable control. Also an increase in attractive products bringing a higher price in the marketplace.

4. A decrease from 40% to 60% in design cost and development.

5. An increase in product confidence, thus reducing costly service and increasing customer warranties.

Research is an intensive and organized study directed toward extending scientific knowledge. There are two types of research: basic and applied. Basic is more practical because the purpose is to increase scientific knowledge. A person will aim more at a comprehensive understanding of the subject being studied. Applied research involves practical applications of findings, and a person will not obtain many new discoveries. Research was used to form the very vast and broad concept of microprocessors.

A microprocessor is a scaled integrated circuit fabricated by using metal oxide semiconductor (MOS) technology. The microprocessor has electronic logic, which is on microscopic circuits of tiny silicon pieces called chips. The chips are mounted on dual in-line packages (DIPS). The microprocessor contains the logic of a central processing unit (CPU) and other depository and conduit logic. A microprocessor solves problems through programming, rather than circuitry with an excess amount of wires, and it is the equivalent of 2000 transistors.

A microprocessor consists of three basic parts: semiconductor memory, interpreting section, and an output section. The semiconductor memory can be inside or outside the microprocessor chip. There are four types of memory: random access memory (RAM), read only memory (ROM), programmable read only memory (PROM), and erasable programmable read only memory (EPROM). The memory contains a set of instructions used to instruct the interpreting section of the system. The system will always follow the set of instructions. The interpreting section is a main part of the microprocessor, or the central processing unit. It performs a certain action based also on instructions (figs. 3 and 4). The output section performs an action, but in the form of digit outputs, i.e., binary digits.

Development is the application of basic research. It is a task which usually involves a product, and is part of a technological cycle. There are many applications of microprocessors in business and industry (fig. 5). They are appearing for communications systems, security purposes, switching and routing information to and from large data bases, police files, credit information, and inventory control systems.

The experience I have with microprocessors was developed while working on the Man-Vehicle Systems Research Facility (MVSRF). The purpose of the facility is to control and study aviation operations. The MVSRF uses many microprocessors to form a major computer system. I designed the microprocessor reset panel, or the hardware of a minor computer function. At the touch of a button, a person can reset a microprocessor to start different operations. Even though I did not actually design or build a microprocessor, I gained valuable knowledge of its importance in engineering.

A key factor in implementing designs with the microprocessor is the designer. A total system must be designed, rather than just parts of it. Instrumentation consisting of microprocessors is constantly being used by scientists and engineers. The process of R&D has helped build an important piece of high technology equipment. Microprocessors are definitely contributing to the creation of new knowledge for man.

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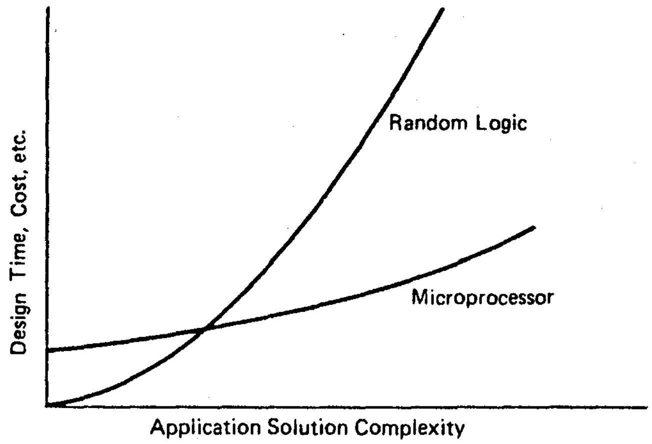

Figure 1.- Cost trends of random logic versus microprocessors.

	Without Microcomputer	*With Microcomputers*
Sales	100%	100%
Cost of Goods Sold	−55	−45
Gross Margin	45%	55%
Development		
Engineering	8%	6%
Documentation	1.5	1
Warranty	1.5	1
Marketing	20	20
G&A	3	3
Engineering and Marketing Costs	34%	31%
Before-Tax Profit	11%	24%

Figure 2.- Effect of microcomputers on total profits.

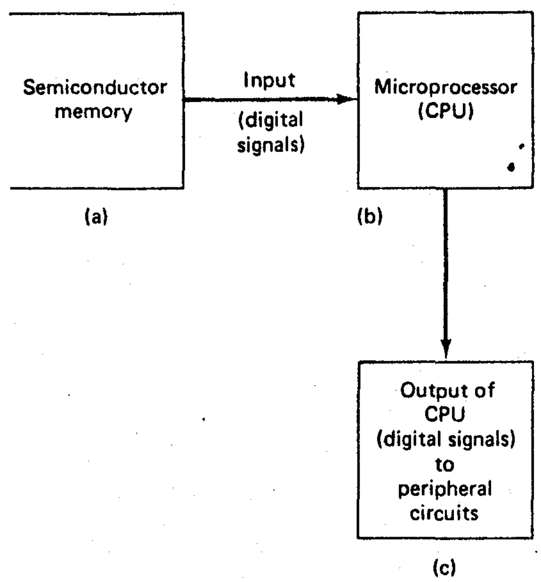

Figure 3.- Three basic parts of a microprocessor system. (a) Semiconductor memory (data input to be interpreted); (b) microprocessor (data interpretation section, or CPU); (c) output signals from the CPU after interpretation of data input.

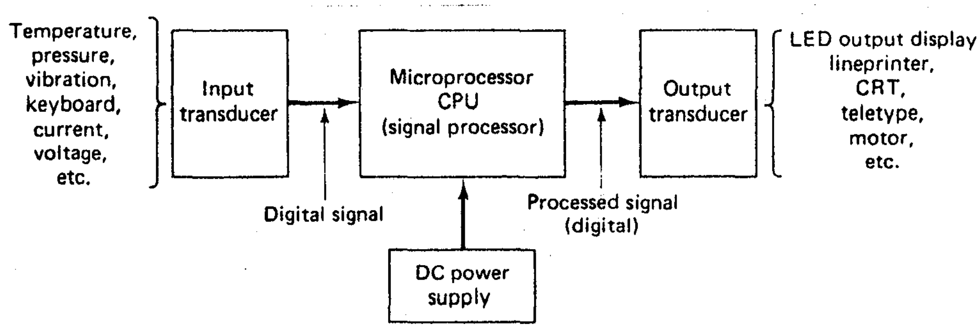

Figure 4.- Functional organization typical of most microprocessor systems.

	Conventional System	*Programmed Logic*
Product Definition		Simplified because of ease of incorporating features
System and Logic Design	Done with logic diagrams	Can be programmed with design aids (compilers, assemblers, editors)
Debug	Done with conventional lab instrumentation	Software and hardware aids reduce time
PC Card Layout		Fewer cards to lay out
Documentation		Less hardware to document
Cooling and Packaging		Reduced system size and power consumption eases job
Power Distribution		Less power to distribute
Engineering Changes	Done with yellow wire	Change program PROM

Figure 5.- The effects of a microcomputer on development time and cost.

JOB DESCRIPTION

Stephanie Jill Berman

I am working with the Space Sciences Division for a theoretical astrophysicist, Dr. Robert Rubin. The project I am involved with is aimed at improving the present model of an H II region. A model is a simplified schematic description; in other words, a set of generalizations that we hope accurately describes the processes taking place. An H II region is an area in space close to a young, hot star that has formed inside a cloud of gas and dust: a nebula. The gas close to the star, which is about 90% hydrogen, is heated by the star's radiation, and is ionized by the ultraviolet rays. The region of ionized hydrogen is called an H II region.

My specific work is charting the results of Dr. Rubin's latest calculations. These calculations indicate the extent to which other elements block the stars' radiation, since the presence of the other elements has an effect on the overall size of the region. My job has been to find the numbers that we need on the computer printouts, chart them, graph some of them, and enter them into a computer in final form for publication as a catalog in The Astrophysical Journal.

At the same time I am doing my own research to strengthen my knowledge of astronomy and astrophysics. The more I learn of the basics, the more I understand the front-line research taking place here.

DEVELOPMENT OF A MODEL FOR H II REGIONS

Stephanie Jill Berman

Nebulae have long been the most beautiful objects that can be seen through an astronomer's telescope. The most spectacular of these clouds of interstellar matter are the emission nebulae that glow red against the black background of space. These clouds are made up almost entirely of hydrogen, just as the entire universe is composed of 90% hydrogen (by number of particles), 9% helium, and 1% of all the other elements combined. An emission nebula that is excited by a young, hot star or a cluster of such stars is called an H II region. H II simply means "the second state" of hydrogen: H^+ — ionized hydrogen. H II regions are of great interest to astronomers because they are sites of active star formation, a process about which we still know relatively little. In addition, the newly discovered relationship between the abundances of the heavier elements and the distance of the H II region from the galactic center shows that the regions can provide information about galactic evolution (ref. 1). Of course, in research it is often impossible to predict what new discoveries might follow one's work.

Ever since Bengt Strömgren wrote his classic paper on interstellar hydrogen in 1939 (ref. 2), astrophysicists and astronomers have been trying to formulate an accurate picture of an H II region. Most H II regions are so far away from us, and some are so obscured by interstellar matter, that observing them in detail always has been difficult. In addition, many important features of H II regions only can be observed by using the tools of infrared and radio astronomy.

Strömgren and his colleagues in the late '30s discovered the first tangible facts about nebulae. For example, Strömgren's thesis was that H II regions consist of interstellar hydrogen (ref. 3). After the end of World War II, the scope of astronomical research expanded considerably. Our understanding of H II regions also has grown considerably, but it still is difficult to make generalizations about them. We do not understand fully what occurs inside such a region; we can guess at some things, such as the movement of gases, the gradual expansion or contraction of the region, or the clumping of the gases. To compound the problem, there may well be factors at work that we simply don't know about. In addition, there are certain properties of the regions that we cannot determine, such as the depth of a given region. Since we only can see a two-dimensional picture of the cloud, we can distinguish between areas of lower and higher luminosity. This tells us that there is more gas in the more luminous areas but does not tell us whether the cloud is more dense at this point or is thicker than its neighboring areas.

There are definite limits as to what present observations can tell us; therefore, at a given time various scientists take different approaches. They propose hypotheses, taking into account all the data they can. In this instance, theoretical astrophysicists are making models of a generalized H II region. They look at the effect of one condition upon another. For example, if one posits a sphere of gas (excited by only one star whose effective temperature is 40,000 K) and a cloud with a density of 10^5 particles/cm^3, what would be the other properties of the region? The theorists take as many of the known physical factors into account as they can before making their predictions. These complex numerical calculations take a very long time and require the most advanced mathframe computers. In fact, this kind of research could be done adequately only after the advent of the computer. Computers are absolutely vital because they allow more equations of greater complexity to be solved simultaneously. Each model depends upon various input parameters which describe the assumed properties of the region. The important study here is to see the effect on the predictions of the model of a change of one or more of its input parameters. It is these results that give a clearer picture of what must be happening in an H II region.

What we do know about H II regions is actually quite extensive. Some of the most basic facts about H II regions come from quantum mechanics and atomic physics. When a hot star forms inside a nebula, the area around the star becomes hot as well because of the star's radiating energy. Most of this electromagnetic radiation (radio waves, microwaves, infrared, and visible light) has too little energy to ionize hydrogen; however, the photons (quanta of light) of the shorter ultraviolet wavelengths do have enough energy to do this. These photons ionize the nebular hydrogen surrounding the star, each photon ionizing one atom of hydrogen into a free proton and an electron. Hydrogen is ionized when the photon transfers its energy to the atom and this excitation energy is sufficient to make the electron leave the atom. Sometimes, however, the amount of energy transferred to the atom is not enough to ionize it, but only enough to excite some intermediate quantum level. These excited atoms can then deexcite by the emission of visible, infrared, radio, or near ultraviolet photons. Some of the deexcitation photons are now able to escape from the nebula; this radiation is emitted with equal probability in all directions. When a large amount of dust is present, most of these photons that escape are in the infrared part of the spectrum; this is why nebulae of this type glow when observed with an infrared detector.

Within the nebula the star's ultraviolet radiation ionizes the hydrogen in a region around it which is roughly spherical. The boundary of this region is very sharp, with H^+ on one side of it and H^0 on the other. The ionization of the hydrogen is one of the most important kinds of events that takes place in an H II region, but there are many other kinds of events that occur as well. It must be remembered that H II regions are not static; internally, they are changing constantly. The hydrogen is not ionized just once, permanently, but is continually recombining and then ionizing again. At the same time, not all the photons that are absorbed by atoms have enough energy to ionize the atoms. Some only excite an atomic electron to a higher state, and then the electron might deexcite spontaneously, emitting a photon. The most common visible wavelength of the photons thus emitted corresponds to the shade of red that we see. The processes of excitation and deexcitation of electrons can occur in many different ways, and the photons which are emitted can be of many different energies. What determines the overall appearance of the region is the distribution of probabilities for each kind of event to occur. The more likely events dominate. Much of the quantum mechanics used here is the calculation of these probabilities; the equations that utilize these probabilities go into the computer program when a model is being made.

In order to have a computer calculate the values that go into a catalog with which one can compare the H II regions of different stars, a long computer program has to be written. The computational method chosen in this instance (ref. 4) begins with the loading of certain initial parameters into the computer. From these initial values, some of these quantities are computed for each of many small steps along the radius of the sphere, which is called the Strömgren radius. At each step, the computer prints out the opacity of the various elements, the number of photons remaining that can ionize hydrogen and helium and other pertinent information. At certain points the optical depth for a given element reaches unity, which means that the region becomes "thick" at this distance from the star. The points at which this occurs are tabulated for the catalog. When so many ionizing photons are absorbed so that not enough can get through to ionize more hydrogen, the H II region, and this part of the printout, ends abruptly. The computer then calculates the average gas temperature and the percentage of each element that is ionized. Finally, the cycle is repeated with slightly different input values.

The present model (ref. 5) improves upon previous models by calculating the effects of different amounts of heavier elements in the nebula upon the amount of hydrogen ionized and upon the dimensions of the H II region. Previously, the effect of the opacity of "metals" (meaning, to an astrophysicist, all elements heavier than helium) was considered negligible. From this new model, it can be seen that the abundance of certain "metals" with high photon-absorption probabilities (particularly oxygen) has an appreciable damping effect upon the penetration of the radiation from the star into the H II region. In any case, this model is more accurate than its predecessors because it takes this property of the metals into account.

The next step in the process of making a better model is to compare the theoretical results with the existing observations. However, this comparison is not simple. On the one hand, real H II regions may not have the particular specifications that have been assumed in the model. On the other hand, the data may have been tabulated according to different criteria. An example is a recent report of observations (ref. 6), in which the abundance of the various metals is tabulated as a function of the distance of the H II region from the galactic center. In addition, the velocity of the electrons in the region is studied. The comparison of the predictions of the present model with the existing data on the average velocity of electrons with the distance from the galactic center will be attempted over several months.

Future extensions of the present model of H II regions will take into account several additional factors. These include the movement of gases inside the nebula (their kinematic properties), the effects of the stellar wind, and the evolution of the region. Along with the evolution of the H II region, it may be necessary to consider as well the changes that will occur in it as the star itself ages. Such changes also have not been considered in previous models. Another future project is the calculation of the effect of nonuniform density of the gases, called the clumping factor. Some preliminary effort has been made to include this factor in the present model.

The process of making a new model for H II regions is a long one. First comes the study of what others in the past have accomplished. Next comes the decision of just what is needed in order to make a better model. The goal having been set, the problem arises of the best way to accomplish this objective. When the planning is done and the program written and run, the most difficult and important step begins: the analysis of the results. At this stage the scientist must use discretion to sort out the results in a meaningful way, to separate the more important information from the less important, and to communicate results and conclusions to others. The importance of each of these steps must not be underestimated, for the project cannot be completed without each one. But at this point the work is not yet finished. Now is the time to look critically at the new model and compare its predictions to the observations to date.

Astrophysicists already have plans for future models. Perhaps in a few years, they will be able to simulate the life span of an H II region. And perhaps, in the more distant future, they will be able to better understand these beautiful objects in the night sky.

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JOB DESCRIPTION

Stephanie Blank

When Spacelab 4 is launched in January 1986, I will know that flammable alcohol swabs ride on board. I will have helped train the four squirrel monkeys in the lab, and I might know the man being interviewed on my television set.

This summer I have a job others envy. I have been lucky enough to help plan and design the success of Spacelab Mission 4. I am working at NASA Ames Research Center on the Life Sciences Flight Experiments Program (LSFEP) under Henry Leon, the Experiment Manager for Spacelab 4's primate experiments. And I work as my boss does; I actually help manage the experiments.

Managing SL-4's primate experiments involves tasks as diverse as discussing the workings of mechanisms with engineers and training squirrel monkeys, as well as many duties in between. I have been primarily concerned with the experiment kits, packaged materials with which the experiments are performed. Organizing the kits includes every step, from choosing and ordering materials to figuring out storage configurations, to arrive at the most effective packaging arrangements at gravity.

When SL-4 goes into flight I will not only know that there are flammable alcohol swabs inside, but I will also know that there are 36, and they are all prepackaged from American Hospital Supply. I ordered them.

SQUIRREL MONKEYS: HOMEOSTATIS DURING SPACEFLIGHT

Stephanie Blank

Spacelab 4, the first dedicated Life Sciences Spacelab, will ride into space as part of the Space Shuttle Columbia. It will carry four squirrel monkeys away from the Earth's gravitational field to permit a study of the mechanisms responsible for fluid and electrolyte homeostasis that occurs during spaceflight. The specific focus of this study will be on identifying the links in the chain of bodily functions which cause the alterations of these functions in space. A squirrel monkey will be used for invasive physiological studies which cannot be conducted in man. Additional objectives include documenting in detail the "physiological adjustments occurring during the first few days of spaceflight,"[1] and examining the "diuretic and natriuretic renal response to weightlessness and the role of cardiovascular receptors, sympathetic nervous system efferent pathways, the renin-angiotensin system, and aldosterone to this response."[2] Also, comparing the squirrel monkeys' internal reactions to weightlessness to those of man will determine whether primates can substitute for man in future spaceflight studies.

In the research proposal submitted for his experiment, Dr. Martin C. Moore-Ede, the Principal Investigator for the SL-4 experiment "Fluid and Electrolyte Homeostasis During Spaceflight," wrote:

> To examine in detail the mechanisms which are responsible for regulating fluid and electrolyte homeostasis in space, an animal preparation is required which has a similar physiology to that of man. Not only must the mechanisms of fluid and electrolyte control be similar, but because circadian modulation plays a major role in man, the animal must have a circadian system which is comparable.
>
> Few laboratory animals meet this criteria. Most either have a poorly organized circadian system (e.g., dogs, cats), or are nocturnal animals (e.g., rodents). Primates, however, meet both requirements.[3]

Among monkey species, squirrel monkeys are small and therefore conservative of space and consumables. They are docile, easy to train, and hardy.[4] In addition, a squirrel monkey's cardiovascular parameters — blood pressure, heart rate, ECG — are similar to man's. Their hematology is almost identical. Their visuo-vestibular system replicates that of man. And "although not bipedal, they have a human-like musculo-skeletal system complete with large veins in the lower extremities in which blood pools, as it does in man."[5] The only nonhuman primates approved for spaceflight, squirrel monkeys have been used extensively in aeromedical research since their introduction to spaceflight in 1958.

Detailed studies of fluid and electrolyte balance have been published, but these rely primarily on experiments using weightlessness substitutes, such as bed rest and water immersion. A summary of these findings appears in figure 1.

There is considerable evidence to suggest that one of the primary events occurring during weightlessness is a shift of body fluids from the legs into the upper body. In man, this represents a movement of approximately 600 ml of blood from the lungs and abdomen to the chest and head, with the majority moving into the thorax. "This fluid shift (is) presumed to be due to the unopposed action of anti-gravity venous return mechanisms in the lower body which normally play a major role in counterbalancing the gravity-induced tendency to venous pooling in upright man."[6]

The increase in central blood volume that results from the fluid shift is interpreted by central vascular receptors as an increase in total blood volume. Over the first 48 hr of bed rest, in response to this apparent blood volume expansion, there is an increase in sodium and water excretion, leading to an approximate 20% decrease in plasma volume.

From the evidence of these studies it is hypothesized that the increase in central blood volume is sensed by receptors in the central vascular system. This means that "information appears to travel from central vascular receptors to hypothalamic and brainstem processing centers."[7]

The goal of the altered functions involves a decrease in antidiuretic hormone (ADH) secretion and a decrease in aldosterone production. These changes are postulated to induce a diuresis and a natriuresis, ultimately leading to a decrease in plasma volume.[8] The intermediate steps, however, are not well understood, although a reduction in sympathetic nervous tone and a consequent decrease in the activity in the sympathetic nervous system is one possible mechanism accounting for the decrease in aldosterone secretion.

Thus, it has been possible to develop ideas regarding fluid and electrolyte adjustments to zero gravity using weightlessness analogs. Later, the three Skylab missions confused scientists, as a consistent decrease in the plasma volume of astronauts was noted. Also, despite an increase in plasma aldosterone levels, there was a natriuresis. Finally, doubts were cast on the validity of data collected aboard Skylab, and ". . . findings from the Skylab missions by no means conclusively rule out the pre-Skylab hypotheses . . . (as) several major mission-determined events made it difficult to test the hypotheses."[9]

Accordingly, Dr. Moore-Ede predicted his squirrel monkeys' responses to weightlessness would duplicate those observed in pre-Skylab studies. Aboard SL-4, the primates' motor activity, feeding and drinking activity, arterial blood pressure, heart rate, central venous pressure, and ECG will be monitored and plasma, urine, and fecal samples will be taken. These measurements and samples will enable the study of the monkeys' homeostases which exist in the animals' plasma, urine, and cardiovascular system.

Blood plasma, the pale yellow liquid part of the blood in which the corpuscles are suspended, contains all the chemical constituents of whole blood except hemoglobin. Its electrolytes, fluids which conduct electricity by means of their ions, are of particular importance in the experiment.

To obtain the plasma, 1 ml of blood will be drawn from each squirrel monkey nine times during SL-4's 7-day voyage. Each blood sample will be centrifuged, separating red blood cells and plasma. The red blood cells will be mixed with saline and reinfused into the monkey. Plasma will be frozen and stored for analysis upon SL-4's return to Earth.

Urine will be collected in conical urine storage containers. As it is eliminated, the urine will flow through a rubber transfer tube to a carousel which holds nine containers and rotates every 4 hr. Once obtained, the samples are frozen for later biochemical analysis. However, due to oversubscribed freezer space on SL-4, an alternate way of storing urine at ambient temperature is under consideration.

Once SL-4 has landed, the analyses on plasma and urine will occur as follows:

Plasma	Urine
Plasma potassium	Urine potassium
Plasma sodium	Urine sodium
Plasma cortisol	Urine chloride
Plasma aldosterone	Urine calcium
Plasma renin activity	Urine phosphate
Plasma arg-vasopressin	Urine osmolarity
Plasma sample volume	Urine volume
	Urine aldosterone
	Urine cortisol
	Urine creatinine
	Urine arg-vasopressin (ADH)

Cardiovascular fluid shifts and deconditioning which occur in weightlessness constitute the greatest potential consequence to the health of astronauts, particularly upon return to Earth.[10] "The direct chronic measurement of systemic arterial and central venous pressures is the key first step to understanding the problem."[11]

These measurements together with blood pressure and heart rate will be continuously monitored using implanted arterial catheters which extend from the monkey to the outside of his section of the cage. At least 1 month before the experiment, by using a sterile operative procedure, the arterial catheters will be inserted in the internal iliac artery and will then lead out under the skin to the monkey's back. The catheters will be protected by placing the monkey in a light nylon mesh jacket which otherwise allows the animal freedom of movement. The catheters can be maintained in good condition for 6 months or more without difficulty. During the experiments they will be linked to extension tubing passing outside the isolation chamber to syringes containing saline solution powered by infusion pumps. For monitoring blood pressure, the arterial catheter will extend and connect outside the chamber to a pressure transducer and the output will be recorded on a recorder. An ECG tachograph will be used to determine heart rate from the arterial blood pressure recording, and this is similarly continuously recorded on the recorder.

Spacelab 4 will be launched in January of 1986 with Dr. Moore-Ede's experiment "Fluid and Electrolyte Homeostasis during Spaceflight" on board. The results of the experiment will provide insight into many health-related fields, from space sickness to food consumption. The data obtained during the experiment just might provide scientists with the information they need to make spaceflight a more comfortable, predictable experience that will one day be accessible to the common man.

FOOTNOTES

[1]Moore-Ede, Martin C.: Fluid and Electrolyte Homeostasis During Spaceflight: Elucidation of Mechanisms in a Primate. Research proposal, June 1, 1978, p. 2.

[2]Ibid., p. 2.

[3]Ibid., p. 11.

[4]Schatte, Christopher: Advantages of the Squirrel Monkey. Memo, July 13, 1983, p. 4.

[5]Ibid., p. 4.

[6]Moore-Ede, op. cit., p. 7.

[7]Ibid., p. 8.

[8]Ibid., p. 8.

[9]Ibid., p. 8.

[10]Schatte, op. cit., p. 5.

[11]Ibid., p. 2.

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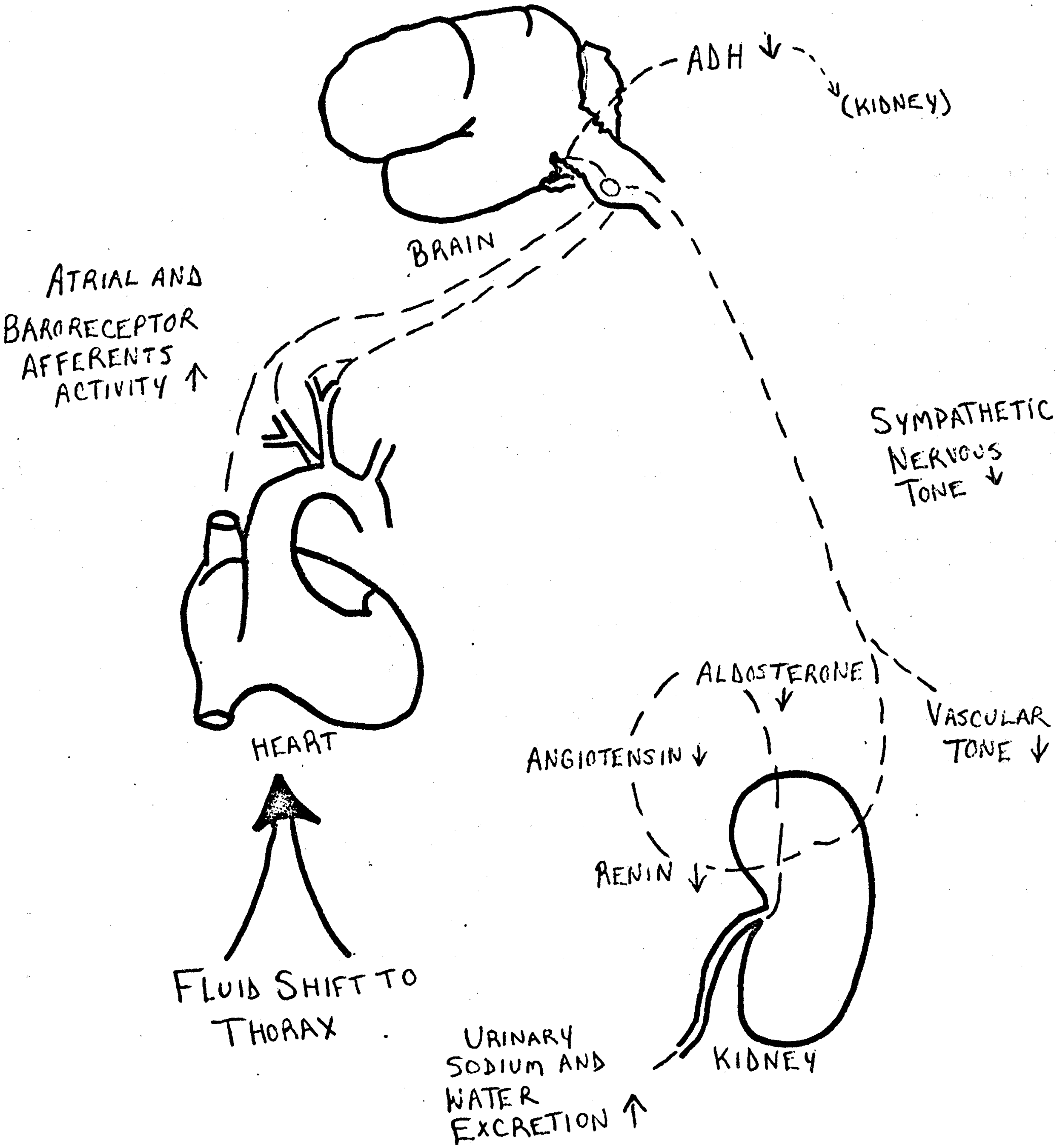

Figure 1.- Based on Dr. Moore-Ede drawing in June 1978 proposal.

JOB DESCRIPTION

Jacqueline Anne Chang

In 1979, NASA Ames, in conjunction with the Vestibular Research Facility Advisory Committee, established a facility at Moffett Field to study space sickness, a malady similar to motion sickness. For up to 5 days, space sickness can hinder an astronaut's ability to work efficiently in space. Its cause is unknown, but there are two distinct possibilities: a misfunction of the vestibular system in reaction to varying levels of subgravity, or a conflict between the sensory and the vestibular system.

In order to investigate both possibilities, the facility at NASA has been divided into the Variable Gravity Research Facility (VGRF) and the Vestibular Research Facility (VRF). In the VGRF, various specimens will be subjected solely to the motion of a centrifuge simulating gravity. However, in the VRF, extra equipment inside the centrifuge will subject the specimens to one or two additional angles of rotation in an attempt to create confusion between the sensory and vestibular system. NASA has contracted with Nelson and Johnson Engineering to build the equipment for these two projects. During my summer apprenticeship working with Nelson and Johnson, I have tested and built circuitry as well as carried out research for the upcoming experiment with a gerbil in a centrifuge.

In my work with circuitry, I have been mainly testing and building a "power-clock board," which distributes power to the centrifuge and the equipment inside it, and turns the chips of the other circuits on and off by periodic voltage changes. Before building the board, I tested a specific section responsible for the voltage changes. Then, after the engineer chose the preferred combination, I made the wire connections for the board by following a schematic diagram.

Besides working with the power-clock board, I tested an amplifier which will amplify bioelectrical impulses which are picked up by one of the following sensor systems: electrocardiogram (EKG), electroencephalogram, or microelectrodes placed at the vestibular nerve. I tested whether the part could amplify the signal to certain gains specified by the engineer.

My research for the centrifuge experiment focused on the electrocardiograph: the information content of the signal, the characteristics of a normal EKG, the different electrode systems practicable for research, and the requirements for accurate data. With this information, the engineers not only can learn the equipment requirements they must meet but also they can gain a better understanding of the medical aspects of the EKG.

From my summer experience with NASA I have gained insight and enthusiasm for engineering. In addition, I have the satisfaction of knowing that I have made a small contribution towards solving an important problem in spaceflight.

BIOMEDICAL INSTRUMENTATION: THE ELECTROCARDIOGRAPH AND ELECTROENCEPHALOGRAPH IN RESEARCH

Jacqueline Anne Chang

Since their development, the electrocardiograph and electroencephalograph have had influence far beyond clinical care and into bioresearch. Particularly in experiments with animals, because of their inability to communicate any changes in their general health, it is critical to use sensor systems monitoring basic body functions, in addition to those dealing more directly with the area under study. Since electrocardiography and electroencephalography have developed into an exacting science, these recorders have become the most commonly used supplementary systems in such experiments. Thus an understanding of the function and the signals of these recorders, as well as an awareness of the specifications necessary for accurate results are essential for a successful, thorough study.

The electrocardiograph, commonly known as the EKG or ECG, refers to the sensor system which monitors the electrical impulses stimulating the contraction of cardiac muscle. Since its development, the EKG has played a key role in the advancement of both clinical care and bioresearch. In clinical use, anomalies in the amplitude or the frequency of the electrocardiogram have helped physicians diagnose conditions such as arrhythmia (irregularity in the heartbeat) and myocardial damage (injury to the heart muscle). However, its application in most bioresearch is broader: determining the heart's reaction to various abnormal conditions.

Understanding the information content of the EKG signal primarily depends upon a fundamental understanding of bioelectrical impulses, called action potentials, in the heartbeat. The beginning of the heartbeat occurs when an action potential originating at a region of the heart known as the sinoatrial (SA) node propagates multidirectionally across the surface of the atria and causes it to contract. When the action potential reaches another region known as the atrioventricular (AV) node, it stimulates a second action potential, which travels through the walls of the ventricle and causes it to contract also. Because the body is a conductor, these electrical currents diffuse to the skin and are detected by the electrodes of the electrocardiograph. Thus in the EKG signal, as shown in figure 1, the principal parts (the P wave, the QRS complex, and the T wave) represent the activity of these potentials at the various stages of the heartbeat. The P wave represents the passage of the first potential from the SA node across the atria; the QRS complex marks the stimulation of the second potential at the AV node; and the T wave shows its dissipation. During the key part, the QRS complex of the normal EKG, the voltage level indicated by the peak-to-peak amplitude ranges from 0.001 to 2 mV.[1] The normal frequency of the wave ranges from 0.05 to 100 Hz.[2] Deviations from the normal voltage or frequency can suggest a change in the specimen's general health. For example, a decrease in either the amplitude or frequency of the wave is an indication of a weakening of the heart.

Because of the valuable information contained in the EKG reading, a user must try to reduce artifacts or spurious signals. First he must choose the type of metal for the electrode which will both minimize inaccuracy and meet his needs. The two metals commonly used for the electrode are silver and silver chloride. However, in most cases silver is used only for short experiments lasting 15 to 20 min because of its ionization with the chloride in the skin; this ionization creates an equilibrium in the "electrode-skin interface," a space between the electrode and the skin, which is easily disrupted by any ions in the vicinity. Because the EKG interprets any change in the equilibrium to be a bioelectrical impulse, this fragile equilibrium is too prone to producing artifacts. For this reason researchers using the electrodes for a long time prefer to use silver electrodes covered with a silver chloride coating, which controls the ion concentration in the interface.

In addition, a user must place the electrode in a configuration which will minimize the artifacts from action potentials controlling the contraction of other muscles; these potentials are a primary source of inaccuracy in experiments involving rigorous activity. Scientists have developed several electrode configurations to minimize this artifact. However, one of the most commonly used configurations is the extremely effective MX placement, developed by L. A. Geddes, in which one electrode is set on the manubrium and the other on the xiphoid process (fig. 2).[3]

Finally, the user must meet the specifications involving the amplifier which is responsible for increasing the voltage of the impulse so that it can be measured and observed on the oscilloscope. Because the amplifier can operate on only small amounts of current at a time, it must have a high "impedance" or resistance which will prevent overloading of the signal. In addition, because the voltage of the bioelectrical impulse is so small, the amplifier must be able to increase the signal up to a thousand times. These numerous specifications reveal the fragility of the EKG signal and the consequential difficulty of obtaining accurate results. However, a user must also keep in mind that an abnormal EKG because of real changes in the heart condition may change amplitude or frequency but will, for the most part, maintain the characteristic waveform.

Like the electrocardiograph, the electroencephalograph (abbreviated to EEG) records bioelectrical impulses. However, instead of measuring action potentials in the heart, it measures minute fluctuating potentials generated by nerve cells in the cortical regions of the brain. In most cases, approximately eight different pairs of test points are recorded simultaneously. Thus the EEG is a general indicator of brain activity in different areas of the cerebral cortex.

The EEG signal is much more complex than the EKG signal. Normal signals can range between 5 and 200 mV in people[4] and between 5 and 75 mV in animals.[5] Frequency can also vary between 1 and 50 Hz for people[6] and between 1 and 100 Hz in animals.[7] Yet unlike the electrocardiogram, there is no one normal waveform but rather four prominent waveforms. The alpha wave, most prominent in healthy adults, represents the brain in a relaxed, idling state. The voltage ranges from 10 to 100 μV and the frequency from 7.5 to 13 Hz.[8] The theta wave ranging from 50 to 200 μV in amplitude and from 3.5 to 7.5 Hz in frequency[9] is common only in infants; the presence of the theta wave in an adult can be an indication of brain damage. The beta wave, ranging from 10 to 50 μV and 13 to 30 Hz,[10] represents intense mental activity even possibly psychological stress. Lastly, the delta wave, a large, slow moving regular wave, represents the brain in its most relaxed state, such as sleep or under anaesthesia. The voltage ranges from 10 to 50 μV, and the frequency ranges from 0.2 to 3.5 Hz.[11] Each of these four waveforms is illustrated in figure 3.

Interpreting EEG signals is further complicated by the numerous biological and instrumental artifacts to which the EEG is prone. From the eye alone there are three different kinds of artifacts which commonly produce spurious signals: blinking, general eye movement, and lid flutter. In people and animals with large muscle mass the major source of artifact is action potentials controlling muscle contraction. Furthermore, sources such as respiration, ballistocardiographic motion, sweat, and heart activity add to the inaccuracy of the signal but to a lesser degree. Nonbiological artifacts are equally numerous. The most common source is a hum resulting from 60-cycle/sec ambient interference, especially if the contact between the electrode and skin is poor. An additional source is apparatus movement, either movement of the electrode on the head or movement of the head in respect to the electrode. The final major source of inaccuracy is the switch; turning the switch often results in the appearance of spikes on the EEG. Because of the immense variety of artifacts the recorder must be skeptical of all that is seen in the signal.

In order to minimize artifacts, a user must try to meet as many instrument specifications as possible. First, EEG recording should be carried out in a shielded room to minimize ambient light, sound, and vibration. Secondly, the amplifier should have a high impedance to prevent overloading. Third, the amplifier should be able to increase the signal as effectively as the electrocardiograph. And finally the amplifier must have a high common mode rejection ratio, 10,000 to 1;[12] thus it must be able to amplify bioelectrical impulses while reducing surrounding interference.

The last consideration which a user must observe is choosing an appropriate type of electrode. As in electrocardiography, silver/silver chloride electrodes are preferred because of their stability. In research, the most commonly used electrode is the silver/silver chloride pellet because of its small size and commercial availability. However, in clinical care the most common electrode is the pad electrode consisting of a pad of wool soaked in saline placed at the end of a silver rod. Regardless of what electrode system is used, the conventional configuration for both clinical care and bioresearch is the "10-20" system. The numbers 10 and 20 refer to the spacing of the electrodes in relation to the total circumference of the head from front to back.

Despite the innumerable complications and considerations involved with both electrocardiography and electroencephalography, each has proven to be extremely useful toward obtaining a general idea of a specimen's overall health. For this reason both the EKG and the EEG will be used in the upcoming gerbil experiment.

FOOTNOTES

[1]Considine, Douglas, ed.: Electrocardiograph. Van Nostrand's Scientific Encyclopedia, Fifth Edition, vol. I, p. 913.

[2]Ibid., p. 913.

[3]Geddes, L. A.; and Baker, L. E.: Principles of Applied Medical Instrumentation. John Wiley and Sons, New York, 1968, p. 221.

[4]Norton, Harry: Biomedical Sensors. Noyes Publications, Park Ridge, 1982, p. 92.

[5]Klemm, W. R.: Animal Electroencephalography. Academic Press, New York, 1969, p. 15.

[6]Norton, Harry, p. 92.

[7]Klemm, W. R., p. 15.

[8]Norton, Harry, p. 92.

[9]Ibid., p. 92.

[10]Ibid., p. 92.

[11]Ibid., p. 92.

[12]Ibid., p. 92.

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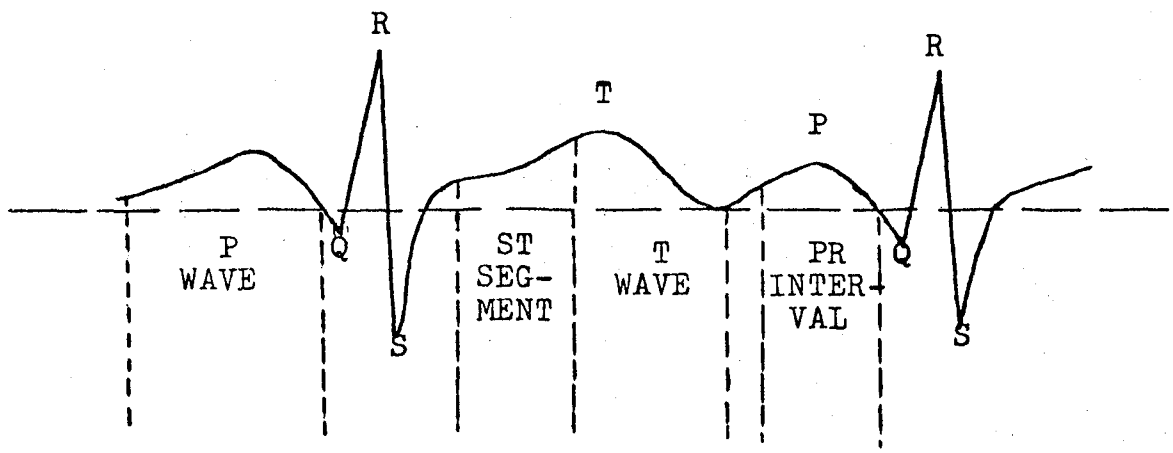

Figure 1.

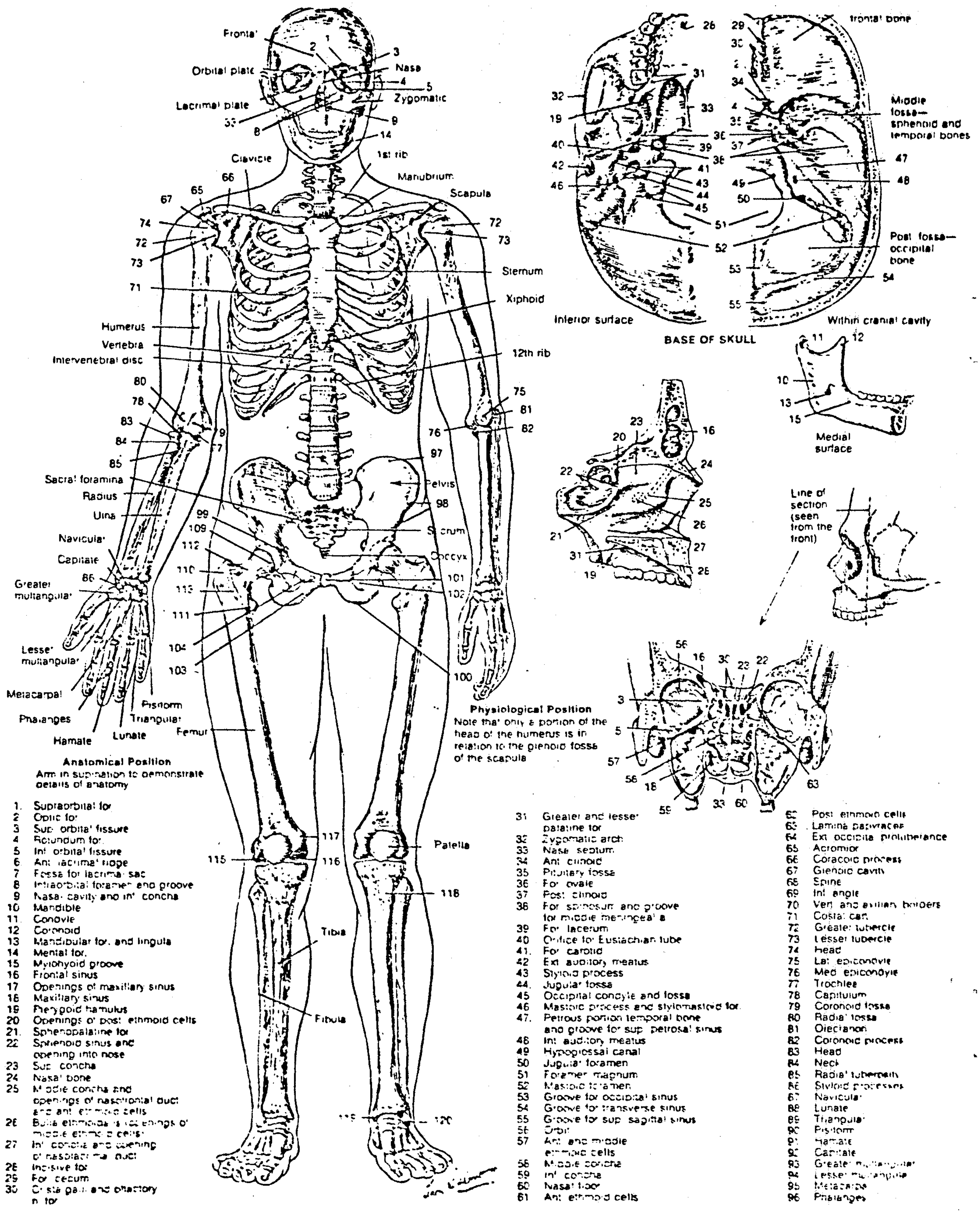
Frontal
Orbital plate
Lacrimal plate
Nasal
Zygomatic
Clavicle
1st rib
Manubrium
Scapula
Sternum
Xiphoid
Humerus
Vertebra
Intervertebral disc
12th rib
Sacral foramina
Radius
Ulna
Navicular
Capitate
Greater multangular
Lesser multangular
Metacarpal
Phalanges
Hamate
Lunate
Pisiform
Triangular
Pelvis
Sacrum
Coccyx
Femur
Patella
Tibia
Fibula
Anatomical Position
Arm in supination to demonstrate details of anatomy
Physiological Position
Note that only a portion of the head of the humerus is in relation to the glenoid fossa of the scapula
frontal bone
Middle fossa—sphenoid and temporal bones
Post fossa—occipital bone
Inferior surface
Within cranial cavity
BASE OF SKULL
Medial surface
Line of section (seen from the front)
1. Supraorbital for
2 Optic for
3 Sup orbital fissure
4 Rotundum for
5 Inf orbital fissure
6 Ant lacrimal ridge
7 Fossa for lacrimal sac
8 Infraorbital foramen and groove
9 Nasal cavity and inf concha
10 Mandible
11. Condyle
12 Coronoid
13 Mandibular for. and lingula
14 Mental for.
15 Mylohyoid groove
16 Frontal sinus
17 Openings of maxillary sinus
18 Maxillary sinus
19 Pterygoid hamulus
20 Openings of post ethmoid cells
21. Sphenopalatine for
22 Sphenoid sinus and opening into nose
23 Sup concha
24 Nasal bone
25 Middle concha and openings of nasofrontal duct and ant ethmoid cells
26 Bulla ethmoidalis (openings of middle ethmoid cells)
27 Inf concha and opening of nasolacrimal duct
28 Incisive for
29 For cecum
30 Crista galli and olfactory n for
31 Greater and lesser palatine for
32 Zygomatic arch
33 Nasal septum
34 Ant clinoid
35 Pituitary fossa
36 For ovale
37 Post clinoid
38 For spinosum and groove for middle meningeal a
39 For lacerum
40 Orifice for Eustachian tube
41. For carotid
42 Ext auditory meatus
43 Styloid process
44. Jugular fossa
45 Occipital condyle and fossa
46 Mastoid process and stylomastoid for.
47. Petrous portion temporal bone and groove for sup petrosal sinus
48 Int auditory meatus
49 Hypoglossal canal
50 Jugular foramen
51 Foramen magnum
52 Mastoid foramen
53 Groove for occipital sinus
54 Groove for transverse sinus
55 Groove for sup sagittal sinus
56 Orbit
57 Ant and middle ethmoid cells
58 Middle concha
59 Inf concha
60 Nasal floor
61 Ant ethmoid cells
62 Post ethmoid cells
63 Lamina papyracea
64 Ext occipital protuberance
65 Acromion
66 Coracoid process
67 Glenoid cavity
68 Spine
69 Inf angle
70 Vert and axillary borders
71 Costal cart
72 Greater tubercle
73 Lesser tubercle
74 Head
75 Lat epicondyle
76 Med epicondyle
77 Trochlea
78 Capitulum
79 Coronoid fossa
80 Radial fossa
81 Olecranon
82 Coronoid process
83 Head
84 Neck
85 Radial tuberosity
86 Styloid processes
87 Navicular
88 Lunate
89 Triangular
90 Pisiform
91 Hamate
92 Capitate
93 Greater multangular
94 Lesser multangular
95 Metacarpal
96 Phalanges

Figure 2.

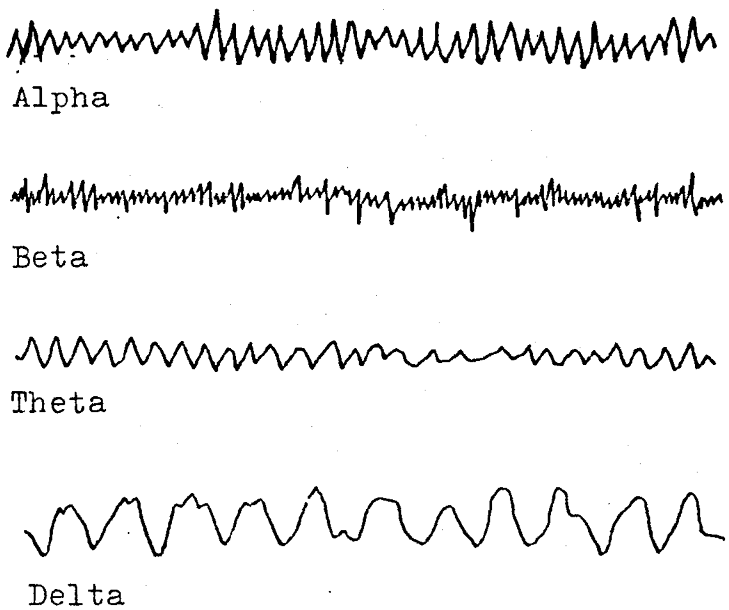

Figure 3.

JOB DESCRIPTION

Cedric Chin

In Extraterrestrial Research, I am creating a diagram of how to use a continuous culture device to study the photosynthetic assimilatory quotient of algae. To do this, I operate the CADFLO computer graphics program. Bob Wharton, my supervisor, was hired by NASA Ames through a fellowship (as were many of the people working with me in the computer room).

The continuous culture device is part of the Controlled Ecological Life Support System (CELSS) project. A CELSS will be used in outer space for a multiyear mission whose costs for food storage exceed those for a closed food system. An example of a closed system: CO_2 is taken in by plants, converted to O_2, and used by humans who in turn give off CO_2. Ideally, the CO_2 respired equals the CO_2 assimilated by plants (and likewise, for O_2). Because this is not so on Earth, the device tries to create this ideal situation by altering variables (nitrogen, temperature, and quantity of algae) which affect algae growth. The device seems complex (tubing carries different colorless gases in many directions) but actually, anyone will be able to use it with the help of a diagram which I am drawing by using CADFLO.

CADFLO is a computer graphics program adopted by Silvano Colombano from GREDIT, which plots straight lines, circles, and text on a Cartesian plane. CADFLO more easily copies a previous drawing onto a current drawing and it also prints out new drawings. CADFLO, however, is a new program and therefore has its share of "bugs," which will be corrected in future sessions.

Though I have experience with software use on terminals and home computers (I know BASIC, but this is fast becoming a dead language), this is the first time I have used a large business computer and a graphics program — a <u>new</u> graphics program whose user's guide is not even finished yet.

CELSS AND PCELSS: AN OVERVIEW, AND THEIR USE IN GAS RECYCLING

GREDIT AND CADFLO: A COMPARISON

Cedric Chin

AN OVERVIEW OF CELSS AND PCELSS

Because of the high storage costs in the manned multiyear missions of the future, recycling wastes and growing food biologically rather than chemically are being considered. The resulting programs are Controlled Ecological Life Support System (CELSS) and Partially Closed Ecological Life Support System (PCELSS).

Models are very valuable; try painting a still-life model without a bowl of fruit! Unfortunately, no models for a partially or totally closed system exist. On Earth, the closest thing to a PCELSS is a self-sufficient farm needing only the supplies which it cannot make (e.g., electricity and machinery). But it does not need to concern itself with the issue of asphyxiation. Earth is a perfect closed ecological life support system. Perfect, but far too unwieldy when exploring the final frontier.

And so, the CELSS researchers were left only with objectives. Objectives are not as useful as models, but objectives are at least better than nothing. The objectives of the CELSS research program in its formative stages are described thus: Since water and oxygen are such simple compounds (I have yet to see a cookbook about either of the two), much research about recycling them exists and therefore will be used by the CELSS research programs. Until now, little research has been done relative to recycling food — its chemical structure is extremely complex — so this is where the CELSS research program will start (but not with recycling nonbiological food, which may not be practical and economically feasible within the next generation). Biological food recyclers to be studied include algae, higher plants, bacteria, and animals. Note that the last two cannot use light directly as energy, which means that they possibly require an expensive and somewhat inconvenient intermediate step while algae and plants do not. Meat may be a rare thing in the great beyond.

Research into the nutritional aspects of food recycled products is needed. This does not merely mean finding out the percentage of the US RDA of how many nutrients a food product satisfies, but also methods of processing and preparation, psychological attitudes towards a food produced (algae flour creates green toast), and both short- and long-term responses to foods (especially nontraditional foods and foods whose composition, e.g., amount of fiber, fat, and protein, varies with growth).

Both food organisms and astronauts will create waste. Waste includes toxins of which some ". . . may elicit metabolic responses that can range from simple avoidance or attraction to the triggering of hormonal or other intrinsic control responses . . ." (ref. 1) (i.e., they may be beneficial if used correctly). Recycling waste through biological means is being studied because of ". . . energy costs, equipment weight and volume, and process material holdup volumes . . ." (ref. 1) associated with oxidation.

Inorganic materials require special attention; they ". . . are not easily transferred within a closed system because they exist in a liquid or solid state only.

The constraints on soluble minerals include the desirability of removing them from potable water, and maintaining their concentration in growth media at levels that are appropriate for the food organisms. Even gradual changes in the concentrations of these materials can have significant effects on the growth and metabolic characteristics of organisms . . ." (ref. 1). Though inorganic materials can be both removed from potable water and used for growing plants, inorganic materials are inconvenient to transport within a CELSS and are toxic in small doses.

Oxidation is the breaking down of complex compounds (typically wastes) into simpler ones. For example, in the San Jose sewage treatment plant, sewage in large vats is oxidized by the bacteria into less hazardous forms. CELSS uses another type of oxidation, heating and pressurizing wastes (complex forms of carbon, hydrogen, oxygen, nitrogen, and sulfur) with air (oxygen (O_2) and nitrogen (N_2)) to make simpler and usable compounds: carbon dioxide (CO_2), ammonia (NH_3), and water (H_2O).[1]

The C in CELSS stands for "Controlled."

> The primary functional components of the system will be food production; food processing; atmosphere composition; environmental parameter maintenance; volatile organic, particulate, and aerosol control (e.g., bacteria and viruses); organic waste processing; inorganic materials separation and concentration control; and organism growth medium maintenance and control. Each of these functions must be monitored in such a way that the state of the system as a whole is known. The activity of each function must be susceptible to control to allow the smooth cycling of materials and to permit intelligent use of energy and other resources. Finally, the system must be managed in such a way as to meet both anticipated and unanticipated demands on various parts of the system at a future time [ref. 1].

Note the last sentence; not only must everything work, but if something goes wrong the system must still work as a whole.

Attaining this objective, then, will be a long and difficult task. This is a pioneer project leading to new concepts which, several years ago, were not seriously spoken about. Science will be pushed to its utmost limits as Man tries to create a relatively or totally closed ecological life support system which, so far, only God has done when He made the planet Earth.

GAS RECYCLING IN RELATION TO CELSS AND PCELSS

Though gas recycling in a closed system has been well researched, typical previous experiments went like this: place mice and algae in an airtight container, keep them living, and observe. The result: large fluctuations in the atmospheric concentrations of oxygen and carbon dioxide (mostly too much carbon dioxide but sometimes too much oxygen). The reasons:

1. An imbalance between the rate of photosynthesis and respiration.

2. An imbalance between the assimilatory quotient (AQ) and the respiratory quotient (RQ).

3. The anaerobic and/or aerobic respiration by bacteria of fecal material.

4. A leakage in the closure of the system by (a) lack of balance between inputs (e.g., food) and removals (e.g., algal harvest) and (b) physical leaks in the apparatus.

5. The inability of endogenous (biological) mechanisms to create a successful closed environment.

6. The lack of exogenous human manipulation; i.e., changing the environment (e.g., temperature, light) to counteract the instability.

What does all this mean? The first two causes of these fluctuations are due to reality: respiration by heterotrophs (say, a lizard which produces 0.7 volume of carbon dioxide for every 1.0 volume of oxygen) is not equivalent to photosynthesis by autotrophs (say, a tomato plant which consumes 0.7 volume of carbon per 0.7 volume of oxygen). This causes a loss of 0.3 volume of oxygen. On Earth, this difference is made up by the oxygen stored in oceans and the atmosphere (buffers); in a space colony or a space station, this is not possible.

Photosynthetic and respiratory rates and AQ and RQ are similar. However, photosynthetic and respiratory rates deal with the amounts of carbon dioxide and oxygen per unit of time, but AQ and RQ concern (respectively) an autotroph's ratio of moles of carbon dioxide consumed:moles of oxygen produced, and a heterotroph's ratio of moles of carbon dioxide produced:moles of oxygen consumed. Since a change in the rate of oxygen supply causes a change in the rate of carbon dioxide supply (and thus the RQ and AQ remain constant while the rates of photosynthesis and respiration do not), AQ and RQ are used.

The next two causes for oxygen/carbon dioxide fluctuations exist because of human error. Because both bacteria and mice consume the oxygen raises the question of which animal consumed how much oxygen and produced how much carbon dioxide. An example of a balance between inputs and removals: a mouse is given only enough food to maintain its original size, and the algae is harvested from the system so that the amount of algae remains constant within the system. Therefore, throughout the experiment both organisms neither increase nor decrease their oxygen and carbon dioxide consumption and production. However, feed the mouse too much food and he will consume too much oxygen; the result is a large increase of carbon dioxide. Conversely, remove too little algae and more carbon dioxide will be converted to oxygen; the result is a large increase in oxygen. By a lack of balance between outputs and removals, two conflicting results occur. Balancing outputs and removals is not easy but it is required nonetheless. Allowing the apparatus to leak is almost unforgivable.

The last two causes of oxygen/carbon fluctuations are quite forgivable. We assume that the gas exchange between autotrophs and heterotrophs is equal because there hasn't been an oxygen or carbon dioxide shortage on our Earth for a few billion years. Therefore, we assume endogenous systems are possible. Exogenous control implies outside interference upon a closed system, in short, a contradiction in terms.

So, what we find is this: not very much information except that (a) gas exchange hinges upon the difference between AQ and RQ, (b) (from Russian studies) mathematical models based on research data can be useful, and (c) (also from Russian studies) physical removal was not the only management strategy (exogenous control) that existed.

On the whole, then, the goal is to take advantage of anything endogenous which will reduce the cost of exogenous control.

The hypothesis is to minimize ". . . the mismatch or its effects on the rates of respiration and photosynthesis and AQ and RQ . . . (by forms of) exogenous control overlaid on endogenous control . . ." (ref. 2).

The objectives are determining ". . . the photosynthetic rate and AQ of specific algal species and the rate of respiration of mice as a function of selected environmental parameters and operating regimes (i.e., a hypothetical environment in space) . . . the effect of atmospheric closure . . ." (ref. 2) on the system, a free-running closed system, and a controlled closed system.

To accomplish these objectives, research data will create mathematical models which will create experimental systems which will create research data which . . . and so forth and so on.

Three important system components are plants, mice, and a buffer. Algae used are the well-researched Chlorella pyrenoidosa, the temperature resistant Chlorella sorokiana, and the edible Spirulina maxima. Some research about higher plants exists and because of size and data, some small crop species (tomatoes, rice, lettuce, and soybeans) are likely candidates. The mouse (you always have to have a mouse) used will be a dwarf strain of the Swiss brown mouse. Buffers will be needed, say, to store carbon dioxide at night (plants respire and don't photosynthesize at night) and to reintroduce it to plants during the day.

The main control strategies involve lessening the difference between AQ and RQ. The ratio of carbohydrates to fats in the heterotroph's diet is proportional to RQ. Plant cells grown photosynthetically on nitrate have a lower AQ than those grown on ammonia or urea (nitrate, ammonia, and urea are all nitrogen sources). In plants, AQ is inversely proportional to temperature up to a certain point (which varies from plant to plant); after which AQ is then proportional to temperature (though AQ is never less than one). In addition to temperature, other exogenous human manipulation such as light concentration, carbon dioxide concentration, and activity levels of the animal will vary AQ and RQ. Buffers may help counteract short-term instabilities.

This proposal is but a start. Our final goal is to send humans up there, not mice. Only gas is recycled in this proposal, not nutrition. Though oxygen can also be regenerated from water and carbon dioxide from plant material and animal wastes, these possibilities are not considered — yet. In order to send manned multiyear missions into space, we must start somewhere. And this proposal is a start.

A COMPARISON BETWEEN CADFLO AND GREDIT

CADFLO originated from GREDIT. The reason GREDIT was made can be found in the GREDIT graphics program's OVERVIEW paragraph located on p. 12 of the utilities section of the TERAK/UCSD PASCAL VERSION II.0 SOFTWARE USER'S GUIDE:

> The 8510A system allows the direct viewing of a 320 by 240 dot graphics page. Graphics displays are usually created under the direct program control by direct storage and retrieval of the display memory contents. Under many circumstances, however, programming is not practical. These circumstances include cases where the image desired is

difficult to express in programming steps, where the overhead program in one-time-only code is intolerable, and where quick display results are required. For these cases, GREDIT is used to allow creation of a data file with a binary image of the display. Such files can then be used as background displays for other programs, or may be further modified by GREDIT or other programs, and may be printed into hard copy by GREDIT.

In plain English, this means that the TERAK computer allows the user to actually see the graphics which the user programs on a video screen whose area is 320 by 240 pixels (to be, yet again, explained later). Graphics displays are usually created by programming in some computer language, BASIC, PASCAL, etc. However, programming is often not practical, much less convenient. Examples: the programming language is not capable of doing what you want; numerous though repetitious drawings must each be drawn individually; and the picture cannot be seen until programming is completed. For these cases, GREDIT is used to allow creation of a file containing the drawing commands (not the actual drawing) in computer memory and a white and black display on the screen (binary images will be explained with pixels). Such files can then be used as background displays for other programs (e.g., the motionless Moon landscape in the Lunar Lander game). Or they may be further modified by GREDIT and other programs (thus changing the picture), and the picture may be printed on paper by GREDIT.

GREDIT may seem helpful but it wasn't. Something better was needed, but graphics programs cost from $5000 to $50,000, depending on such things from "bells and whistles" (frills) to compatible hardware required by the software program. And so came the impetus for a new but necessary graphics program: CADFLO (more later).

Pixels are those tiny dots of which newspaper pictures are made. By altering the color and closeness of the pixels, different shades of different colors can be made. On a black and white monitor or a printer, however, only two colors (and no shades of them) are made: black and white. The screen uses pixel graphics because electrons are shot from a place behind the screen so that particular areas (pixels) are lit up and others stay unlit. "Either a pixel is lit or not lit" means "either on or off" means "binary." On the screen is an image. And so the term, "binary image." Printers employ binary images by printing a black dot when the pixel is on. This is a disadvantage of GREDIT: no color.

The main problem with pixels is that they have area. An analogy: Let a pixel be represented by a square on a piece of graph paper. Draw a diagonal line by filling in squares. If the squares are small enough, say 1 mm × 1 mm, an acceptable diagonal line will be made. But if those squares were to be enlarged to 1 in. × 1 in. perhaps, the line will become longer but jagged.

To solve this, GREDIT merely does not allow expanded (or shrunken) pictures (still, this is not a good solution — see the GREDIT diagram). Naturally, since there's only a one-picture size, there's only one size of text. The size of the one-size picture is the size of the monitor screen; thus, what you see on the screen is what you get on the printer.

On the other hand, CADFLO uses pixels on the screen only to resemble the vectors which are stored in memory and are sent, say, to a plotter. The advantage of vectors can be found again, on graph paper: Select a point where two lines intersect. Select another point where two lines intersect. Draw a line from one place to another. This is a vector. Vectors are enlarged simply by increasing the distance between the ends of the vector and drawing a line again, from one place to another. The result is a perfectly straight enlarged line. To accompany different sized pictures, five different sized texts are featured. Though screens don't use vectors, each pixel is small enough to imitate vectors on the screen. Via vectors, CADFLO prints hard copies such as paper drawings, transparencies, and other images not found on screens. This is done by a plotter which uses vectors (not pixels) and colored lines (not found on nearly all printers) (solid color is made through a sister program, HIPTEK[1]).

Another problem with GREDIT is the erasing of curved lines, for example. Curved lines are parts of a circle and a circle is really a polygon with an infinite number of sides. Thus, each and every side of a curved line must be individually erased; a tedious task to say the least. An alternative is sweeping out a whole area at once. This method is only reasonably helpful, because it is like correcting a typing error with correction fluid applied with a paintbrush.

In CADFLO, each step which makes the picture is shown on the screen, one by one. To erase a step, press the "E" key; to keep it, press the space bar. When the erasure is made, or if all steps past a step are not needed, another key is pressed. Difficulties occur only when the user "overshoots" a line to be erased or if the picture is made of many, many steps.

Because both of GREDIT's erasing methods have their faults, a second screen has been added to the first (only one is seen on the monitor at a time). Thus, two copies of the same picture can be made, one to work on and another to act as a backup in case some horrid error ruins the first. In addition, one screen can be overlaid upon the other for more flexibility but not enough; GREDIT can't place one picture over particular areas of another.

CADFLO needs no alternative screen. Backups are made by simply duplicating a file. However, symbols cannot be drawn all at once; each vector must be drawn individually — no problem for short files, but a long wait for pictures with many vectors. The solution is to call a nonappending file a "foto." This actually creates two files, one for the screen and the other for the plotter. Fotos appear instantaneously on the screen in pixel form (pixel forms of vectors are made simply by turning on any pixels covered by vectors) and send a symbol to the plotter. At this writing, the foto-making procedure is in the process of removing the bugs.

CADFLO's capabilities are extended through another program and a graphics department machine, and by newer versions — facilities unavailable to GREDIT. HIPTEK takes CADFLO files and can add such things as Gothic fonts, solid color backgrounds, and thicker lines. DICOMED[2] takes HIPTEK files and makes high-resolution slides and instant photos from them (see photo). Version one of CADFLO was made over a year ago. Version two added the symbol. Version three (the version now in use) removed miscellaneous bugs and added an automatic debugger which shows what commands the computer is following while a file is being executed on the screen. Version four (now being debugged) will add the foto. Future versions will have such features as a pad which inputs directly to the computer any lines drawn upon it.

FOOTNOTES

[1]CADFLO and HIPTEK were made and are being improved by Silvano Colombano. As of this writing this is the only paper about CADFLO. The User's Guide should be out soon; Dr. Silvano Colombano's (the programmer of CADFLO) research paper will not be completed for some time.

[2]DICOMED is a machine in the NASA Ames graphics department.

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JOB DESCRIPTION

Stacy Chin

I work in the Life Science Flight Experiments Program, which was organized to accomplish three types of mission.

The first phase consists of developing ground-based facilities, management and operational procedures, data management systems, ground support equipment, flight support equipment, flight laboratory development requirements, and life science laboratory equipment.

While in the "Life" program, I have worked on projects to be used on Spacelabs 3 and 4. For the SL-3, I worked on crew training flowcharts. These flowcharts showed the steps for the crew to follow if something were to go wrong with one of the animals or the Research Animal Holding Facility (RAHF).

I am currently working on critical design review (CDR) schedules, and also I do some crew training schedules. I work on these schedules using the Apple computer and the Visischedule disk which does most of the work. Critical design reviews are for reviewing equipment and safety checks. I help to schedule these reviews so that the equipment can be ready for the launch dates.

SPACELAB-4: A BIOLOGICAL LABORATORY

Stacy Chin

The Space Shuttle is a work vehicle designed to accommodate a variety of payloads and users. The Shuttle contains a cargo bay for payloads. One of these payloads is the Spacelab. The Spacelab missions are a combined effort of NASA and 11 European nations which make up the European Space Agency.

With the development of the Space Shuttle and Spacelab, scientists can now do research that is not possible on Earth. Scientists can now examine many more aspects of life science. The Spacelab is capable of flying between 20 and 30 life science experiments on dedicated missions. A dedicated mission is one in which Space Shuttle/Spacelab facilities and equipment are designated to support one area of investigation. Dedicated life science missions will be staged at 2-yr intervals. Although Spacelabs 1, 2, and 3 will carry some life science experiments, Spacelab 4 will be the first dedicated to a life science mission.

With the Spacelab coming into existence, the science community has shown increased interest in the space program. In the LSFE program, NASA promoted participation by promoting what was called "Invitation to Participate in Planning the Nasa Life Science Program in Space." Thousands of responses came in to NASA. Twenty-five have tentatively been selected for the dedicated mission, SL-4.

The missions and equipment for the life science laboratory will be different on each mission, depending on the schedule of experiments. SL-3 will carry squirrel monkeys and rats. NASA will keep a close eye on the health of the animals, monitoring heartbeat, food consumption, and other bodily functions. With the help of these animals, scientists can hopefully research the causes and a cure for space sickness. The Spacelab is an important step in the direction of possible space settlements.

On Spacelab 4, NASA will realize its greatest ambition in the investigation of life in space. Because the SL-4 will be the first dedicated life-science mission, it means that the entire crew will be involved in life science experiments. The original launch date was November 1985; the launch is now scheduled for January 1986. The Shuttle will stay in space for 7 to 10 days. The crew will consist of six astronauts: the commander, the pilot, two mission scientists, and two payload specialists. The mission scientists and payload specialists are primarily concerned with gathering data while the commander and pilot will be concerned with flying the Orbiter.

Spacelab is a versatile modular facility installed in the Space Shuttle Orbiter and will be exposed to space when the Shuttle takes it into Earth orbit. It consists of an enclosed, pressurized laboratory containing utilities, computers, workbenches, and instrument racks for conducting experiments, as well as outside pallets (platforms) where such equipment as telescopes, antennas, and sensors are mounted for direct exposure to space. These units may be used in various combinations, returned to Earth, and reused on other flights.

For the first time, men and women who are not astronauts will have access to space. The Spacelab will be used primarily by both government scientists and by those in the private sector. Spacelab will have a shirtsleeve environment. This means the scientists can enjoy the comforts of an earthbound laboratory with a few exceptions. In space there is almost an unlimited amount of energy, but no raw materials. This is the exact opposite of the conditions on Earth. Space has low gravity, high vacuum, high-energy radiation, and large volumes of ionized gases that are difficult to obtain in earthbound laboratories. Other important research can be performed only in space, where certain conditions occur naturally. With the Spacelab, man will be able to view the Sun, planets, and stars more often than before. Scientists will get firsthand and clear views of the Earth.

The Spacelab offers scientists the opportunity to work on simultaneous experiments and investigations. This can save them money and time. After each mission, and with a few modifications, the Spacelab will be ready for reuse.

In January 1986, the Spacelab will be ready for the life science experiment. On the first three Spacelab missions, enough data should have been collected to make SL-4 trouble free. On SL-4 scientists can observe the effect of zero gravity on animals and humans. It may also provide some answers to the motion sickness and cardiovascular and metabolic changes which sometimes continue even after the flight. Experiments will also be done to help in the diagnosis and cures of diseases.

The SL-4 experiments have been designed in keeping with the theme of life. The experiments will study the effects of weightlessness on gravity-born life, through careful integrated measurements that span all the organ systems of the body. Interdependence within a living body is such that a change in any one organ system generally produces complex ripple effects on other organ systems. These ripple effects cascade through the body — making cause and effect relationships difficult to discern. The synergistic design of the Spacelab 4 experiments and their supporting hardware permits intersystem, time dependent, microgravity-induced changes to be studied as they occur and for as long as they exist.

The SL-4 mission will use six double and four single racks. The disciplines under investigation on SL-4 will be:

1. Cardiovascular/cardiopulmonary: The system responsible for the transportation of gases, fluids, and other vital materials throughout the body.

2. Vestibular: The system responsible for maintaining equilibrium and balance, and for locating position with respect to gravity.

3. Renal/endocrine: The system pertaining to the kidneys (renal) and the metabolic regulatory functions (endocrine).

4. Hematology: The study of the characteristics of blood and blood-forming tissue.

5. Immunology: The study of the structures and processes involved with the body's defense against diseases.

6. Muscle: The system involved with locomotion, movement, and support of the body in a gravity field.

7. Calcium metabolism/bone: The processes involved with the maintenance of the skeletal system.

8. Gravitational biology: The study of the evolution, development, and physiology of living organisms in a gravity field.

The major objectives of the Spacelab-4 investigations are to determine the events that lead to, and the immediate responses that follow, the redistribution of blood and other body fluids from the lower extremities to the upper body. Other objectives are: to discern the mechanisms by which the body accommodates this volume overload; to determine the relationship between the vestibular system and space motion sickness; to qualify the rat and the squirrel monkey as effective analogs to human responses to weightlessness; to evaluate ground-based simulations of weightlessness against in-flight data to determine their effectiveness as zero-gravity analogs; and to investigate the role that gravity plays in fundamental biological responses in primates, plants, and amphibians.

Animals, especially rodents and primates, have been used for biomedical research throughout the ages because they offer crucial aspects of experimentation that are not possible on human subjects. In the Spacelab-4 mission, the validity of these animals as analogs of human responses to weightlessness will be tested and then responses will be measured in experiments that parallel those of human investigations. Ground-based experimental methods on humans, including prolonged bed rest, head-down tilt bed rest, and immersion studies will use Spacelab-4 results to determine their validity as zero-gravity analogs.

JOB DESCRIPTION

Alice Criner

I work in the Physical Sciences at NASA Ames with my mentor Mickey Shanabarger, a physicist. He studies the dynamics of chemical reactions, and is mainly interested in the surface area of substances and the process by which gases adsorb and desorb onto surfaces. Dr. Shanabarger is conducting experiments with chemisorption. This is a process in which molecules of hydrogen, oxygen, and hydrogen sulfide gases (H_2, O_2, and H_2S) land on an iron surface, then split up into separate atoms. They then form a chemical bond with an iron atom and become O-Fe, H-Fe, or HS-Fe. This process causes the iron to turn brittle, and iron that is brittle is more likely to crack.

These studies are important because this embrittlement process may take place in structures like bridges, planes, or buildings. If this happens, the structure may collapse.

My job duties are to correlate data from the experiments. Some of the data have not yet been calculated, so it is my job to measure the data from the auger spectra (which looks somewhat like a seismograph measurement). I then normalize the data, making it possible to fit all the data on a piece of graph paper. Finally, I graph the data so that they can easily be compared.

Equations can describe the iron surface concentration change, but a computer is needed to quickly and correctly solve these equations. I am in the process of learning a new language, FORTRAN (a computer language). Then I can program specific equations into the computer and perhaps find a solution that correlates with the hydrogen, oxygen, and hydrogen sulfide experiments.

This step-by-step process sometimes is frustrating because my program has to be perfect or else the computer will not understand it. But there is a feeling of relief and satisfaction when my program finally runs perfectly.

My summer here at NASA Ames has been a great learning experience. I have discovered that scientific research is more than mixing chemicals. A lot of paperwork goes along with conducting experiments, yet this has not discouraged me from pursuing my career goals in the scientific field.

CHEMISORPTION OF HYDROGEN SULFIDE AND OXYGEN ON IRON SURFACES

Alice Criner

INTRODUCTION

An important part of any material is the surface area because any substance which penetrates that material has to enter through the surface. The process by which substances adhere to a surface is called chemisorption. If chemisorption takes place in iron (Fe) or other ferrous metals, it corrodes these metals and can cause them to become brittle. When a ferrous metal becomes brittle in a structure (like a building, bridge, or airplane), this may cause the structure to collapse. Impurities affect the rate by which substances chemisorb onto metals, and may be a factor contributing to the amount of structural damage caused by embrittlement.

Dr. Mickey Shanabarger of the University of California, Santa Barbara, has conducted experiments of oxygen (O_2) and hydrogen sulfide (H_2S) gases chemisorbing onto iron surfaces. In these experiments, oxygen was the impurity which was used to affect the rate of chemisorption of H_2S onto Fe.

The purposes of these experiments were to:

1. Discover how oxygen affects the saturation coverage of H_2S, and how O_2 modifies H_2S chemisorption kinetics.

2. Find out how the oxygen layer modifies the nature of the sulfur (S) bonding.

3. Discover if there is a specific order in which S and O layers bond to the iron surface.

CHEMISORPTION

Chemisorption is the process by which substances chemically bond to a surface.

Oxygen Chemisorption

It is believed that O_2 molecules land on the iron surface symmetrically between four iron atoms. The oxygen molecule splits into two oxygen atoms which bind to the surface to form new molecules (fig. 1).

Hydrogen Sulfide Chemisorption

Hydrogen sulfide (H_2S) chemisorbs to the iron surface by occupying every other available space between the iron atoms. Hydrogen and sulfur molecules split and become H and HS. They then bond chemically with the iron atoms (fig. 2).

$$H_2S \text{ (gas)} \rightleftarrows H_2S \text{ (precursor)} \rightleftarrows HS\text{-}Fe + H\text{-}Fe$$

EXPERIMENTAL PROCEDURES

These are the experimental procedures for H_2S on an iron surface, and for H_2S and O_2 on a surface on which there were two sets of films. One set was exposed to H_2S, the other to both H_2S and O_2.

H_2S/Fe, H_2S/O_2/Fe Experimental Procedure

1. Polycrystalline films were prepared by evaporation from high-purity iron wire onto glass substrates.

2. The iron films were observed by Auger electron spectroscopy (AES) to make certain the iron surfaces were clean.

3. The fresh iron film for the H_2S/O_2/Fe experiment was exposed to oxygen gas at a fixed pressure for a fixed amount of time.

4. The oxygen gas was pumped out.

5. The oxygen saturated iron film for the H_2S/O_2/Fe experiment and the clean iron film for the H_2S/Fe experiment were exposed to hydrogen sulfide gas (H_2S) at a fixed pressure for a fixed amount of time.

6. The H_2S gas was pumped out.

7. The iron surfaces were measured by the Auger spectra to measure how much sulfur was adsorbed onto the iron surfaces.

RESULTS

Auger Electron Spectroscopy Results for H_2S/Fe

The data taken from the Auger spectra show that the ratio of sulfur (S) to iron (Fe) is 1.48. This ratio is proportional to the amount of sulfur on the iron surface, and is calculated by dividing the length of the sulfur amplitude by the length of the iron amplitude (fig. 3).

Auger Electron Spectroscopy Results for H_2S/O_2/Fe

The data taken from the Auger spectra (AES) show that the surface concentration ratio of sulfur to iron for the oxygen-exposed iron is 3.2. This ratio is calculated by dividing the sulfur amplitude by the iron amplitude (fig. 4).

CONCLUSIONS

The data from the Auger spectra show that the amount of sulfur on the iron surface that was exposed to oxygen was greater (3.2) than the amount of sulfur on the iron surface which was not exposed to oxygen (1.48). This work demonstrates that:

1. The oxygen layer increases the amount of hydrogen sulfide on an iron surface.

2. The oxygen layer modifies the nature of the sulfur bonding (see figures for difference in sulfur Auger line shape).

3. The oxygen layer modifies the hydrogen sulfide adsorption kinetics (data not shown).

4. The sulfur layer always is on top of the oxygen layer (data not shown).

FURTHER STUDY

To understand the mechanism by which oxygen changes the hydrogen sulfide adsorption kinetics, equations describing the adsorption process were programmed. The equations describe how the sulfur surface concentration changes during hydrogen sulfide adsorption as a function of time. The calculated points are compared with the experiment after adjusting the adsorption parameters in the equations. If successful, the calculated curve will fit the curve from the actual experiment (fig. 5). The experiment curve shows that as the concentration of sulfur on the iron surface increases, the concentration of oxygen on the iron surface appears to decrease.

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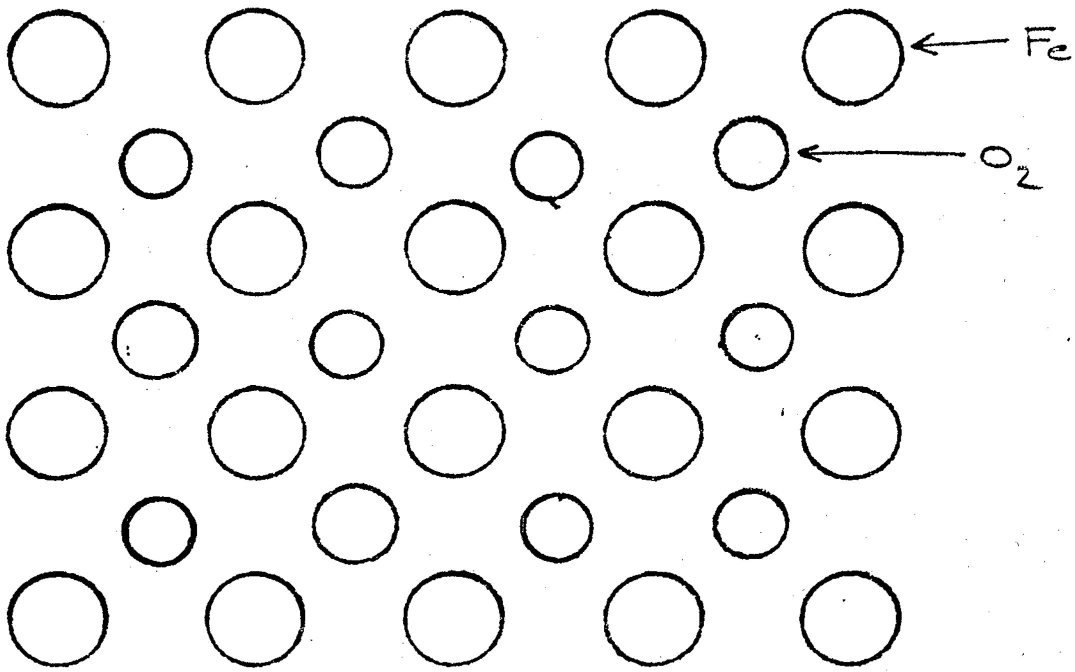
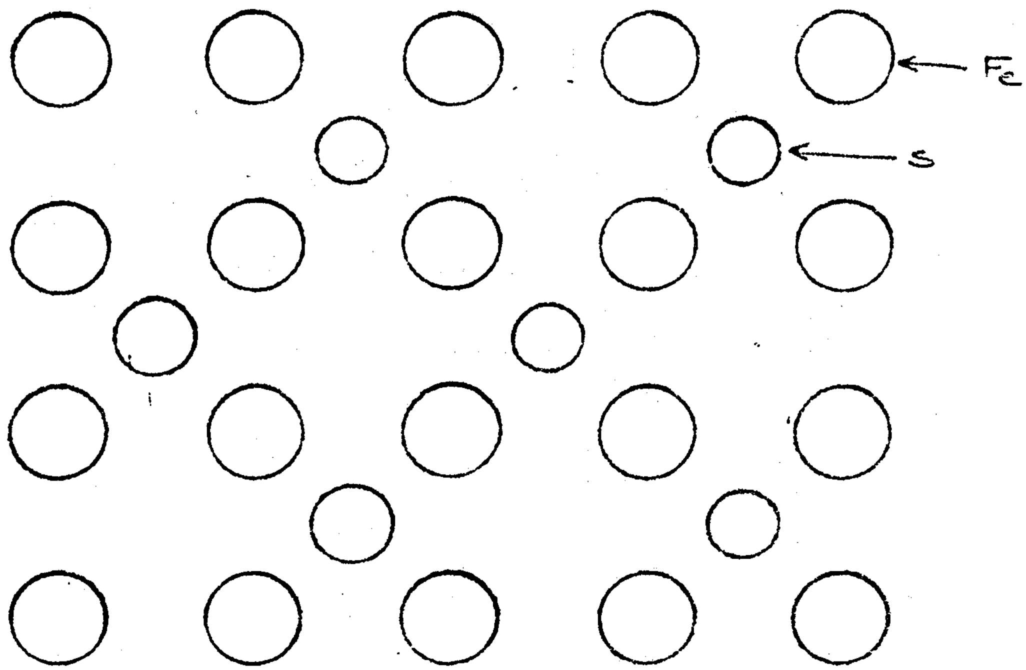


$$O_2\ (\text{gas}) \rightleftarrows O_2\ (\text{precursor}) \rightleftarrows 2(O - Fe)$$

Figure 1.- Oxygen structure on Fe(001) at saturation coverage.



FOR $Fe(001): (\Theta_S)_{SAT} = 1/2$

FOR POLY FILM ESTIMATE : $(\Theta_S)_{SAT} \approx 0.44 \Rightarrow \langle S/Fe \rangle \approx 3.33$ FOR $\Theta_S = 1$

Figure 2.- Sulfur structure on Fe(001) at saturation coverage.

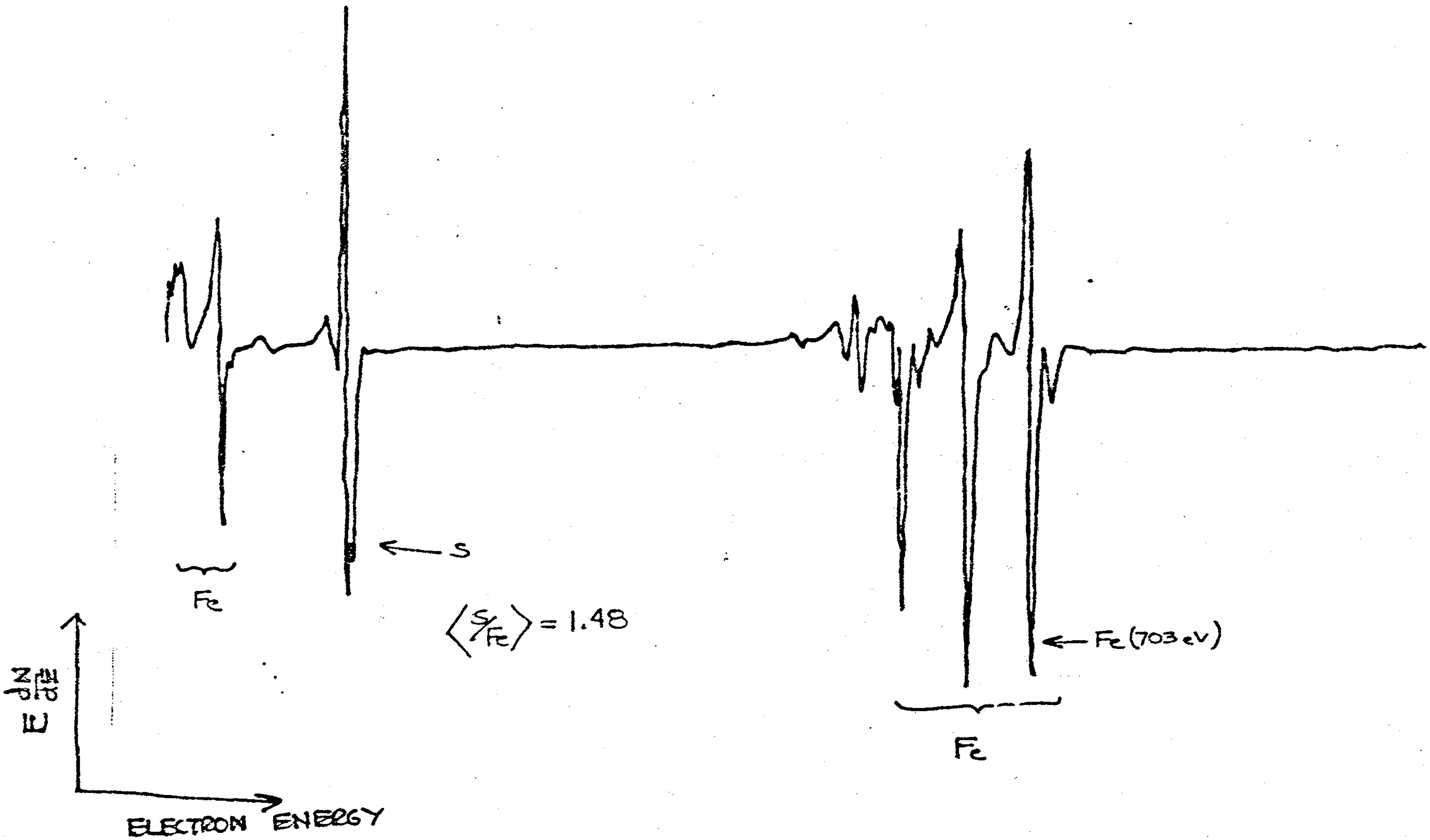
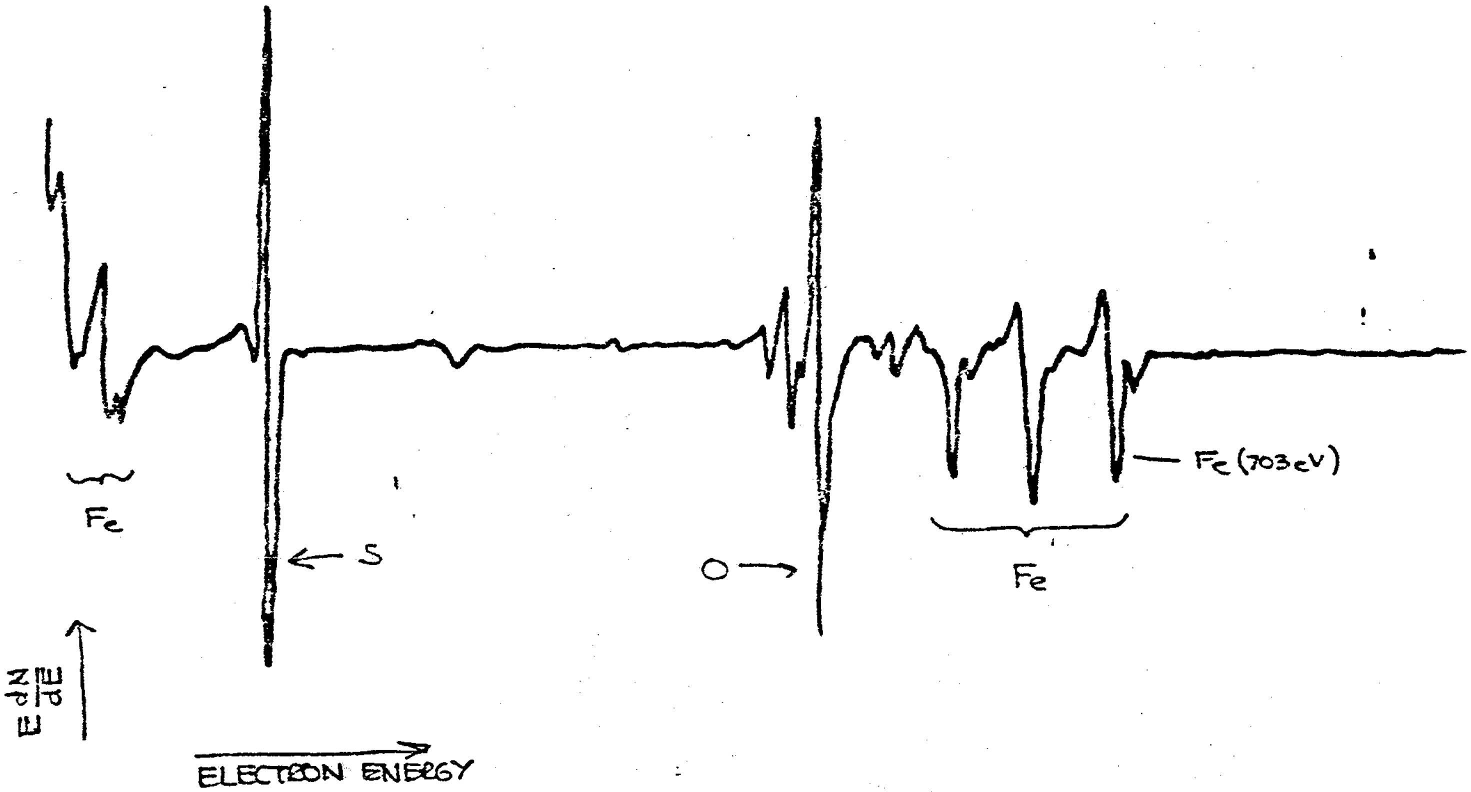


Figure 3.- AES spectrum for H_2S/Fe.



S/Fe ∝ AMOUNT OF S ON SURFACE $\langle S/Fe \rangle = 3.2$

O/Fe ∝ AMOUNT OF O ON SURFACE

Figure 4.- AES spectrum for $H_2S/O_2/Fe$.

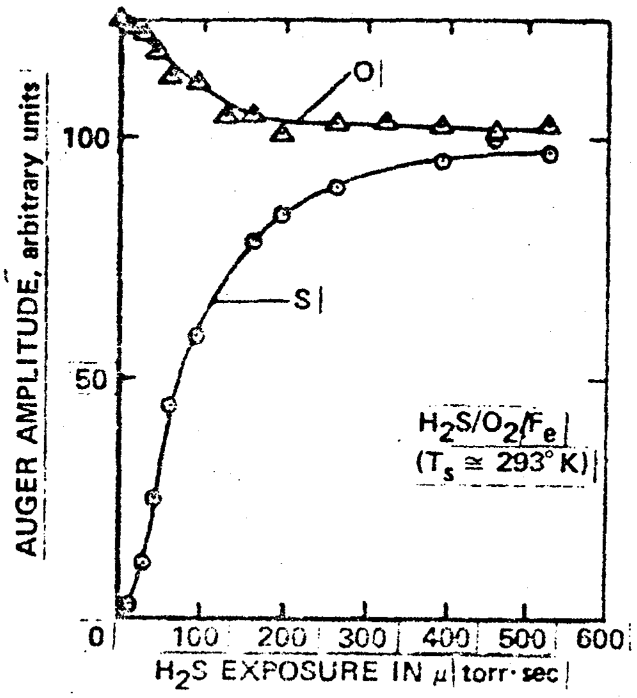


Figure 5.- Adsorption of H_2S on an oxygen overlayer adsorbed onto an Fe Film.

JOB DESCRIPTION

Johnny Davidson

I have been working with Robert Rubin in the Astrophysical Experiments Branch, on a catalog on properties of diffuse nebula, which is soon to be published. A nebula (a Latin word for mist) is a gas cloud which is made up of 90% hydrogen, 9% helium, and 1% every other element in the world.

Not a single diffuse nebula is close enough to the Sun to allow a direct determination of its distance; the nearest one is about 300,000 light years away. It is necessary, therefore, to use an indirect method to find the distance. The method we use is to estimate the true rate emission of one of the hydrogen lines from the nebula (from the gas, density, and temperature) and compare this with observed brightness. From the intrinsic and apparent brightness, the distance can be found. Once distance is known, other properties such as size and mass can easily be found.

I have been writing down numbers of brightness of diffuse nebula. Having finished writing down those numbers, I learned the FORTRAN computer language so that I could make a data table for these numbers. That data table then will have the computer print out the data in an organized form.

THE STUDY OF PLANETS AND NEBULAE

Johnny Davidson

In 1755 Immanuel Kant, a German philosopher, proposed a nebular theory for the origin of the solar system. Forty-one years later, Pierre Simon Laplace, a French astronomer, came up with the nebular hypothesis which endeavored to explain how the solar system was formed. He said, at certain times equatorial rings of gas and dust became detached from the central mass of the rotating gas. The rings cooled, and contracted to form the planets; the central mass of the gas became the Sun. This theory had many weak points, because Laplace did not have any proof that this happened. By the 1900s, Laplace's theory was discredited on the grounds that the Sun could not have rotated fast enough to throw off such rings.

The inner planets (Mercury, Venus, Earth, and Mars) are better known as the terrestrial planets. They are small, dense bodies like the Earth, with masses about equal to that of the Earth. The terrestrial planets are composed of heavy materials such as iron and rock. The surface of Mercury is heavily cratered and looks much like the surface of the Moon. Its interior is much like the Earth. These planets have low surface gravities and cannot retain lighter gases, such as hydrogen and helium. Because of their low surface gravities, Mercury has no observable atmosphere and Mars has a very thin atmosphere, with less than 1% of the density of Earth's atmosphere. Earth and Venus have atmospheres largely composed of such relatively heavy gases as nitrogen, oxygen, and carbon dioxide.

Except for Pluto, the outer planets (Jupiter, Saturn, Uranus, and Neptune) are large, massive bodies with small densities. The outer planets, on the other hand, have such high surface gravitational attraction that they can retain large quanities of hydrogen and helium. Some of them may not have clearly marked boundaries between their gaseous atmospheres and their surfaces; they might simply be composed of a slush of frozen gases that gets gradually thicker and denser with increasing depth.

The physics of the nebular and planetary studies are about the individual characteristics of nebulae and planets, as well as the origin and evolution of each. That is why forbidden lines play an important part in nebulae studies. Forbidden lines are a means of measuring the density and temperature of nebulae.

The rate at which a collision excites the various upper levels depends on the temperature, which can be determined by comparing the strengths of lines arising from different upper levels of the same atom. The derived values are 6000-9000 K for diffuse nebulae, and 7000-17,000 K for planetary nebulae. Similarly, for rather high density objects the densities can be found by comparing two forbidden lines that are collisionally deexcited at different rates. The strongest lines are singly ionized oxygen, at 3726 and 3729 Å, which are usually used for this purpose.

There are many different kinds of nebulae: diffuse, planetary, supernovae remnants, dark, and reflection. The diffuse, planetary, and supernovae remnant nebulae consist of material in which each atom has been ionized; that is, it had one or more electrons stripped from it. The other types of nebulae — dark and reflection — are composed of almost completely neutral or nonionized gases.

The H II region of a diffuse nebulae is where hydrogen emits and absorbs a set of spectral lines that fall across the visible spectrum in a distinctive pattern. These lines are called hydrogen lines. The strongest hydrogen line is the red line at 6563 Å, the second strongest is the blue line at 4861 Å, the third strongest is farther in the blue, and the other lines continue in this series, with the spacing between the lines getting smaller and smaller.

It is easy to visualize how the hydrogen spectrum is formed by using pictures that Niels Bohr, the Danish physicist, laid out in 1913. In the Bohr atom, electrons can have orbits of different sizes that correspond to different energy levels. Only certain orbits are allowable, which is the same as saying that the energy levels are quantized. This simple picture of the atom was superseded by the development of quantum mechanics, but the notion that the energy levels are quantized remains.

The H alpha, the red hydrogen line at 6563 Å, corresponds to a transition from energy level 3 to energy level 2; the H beta, the blue hydrogen line at 4861 Å, corresponds to a transition from energy level 4 to energy level 2. They are called the Balmer series, and are the hydrogen lines in the visible part of the H II region of the spectrum. The Lyman lines ending on ground level, $n = 1$, are stronger but are all at shorter wavelengths.

NASA Ames Research Center has two major projects dealing with the study of nebulae and planets. One is the Space Infrared Telescope Facility (SIRTF), a telescope that will go up on the Shuttle in 1991. It will give astrophysicists and astronomers a better resolution of lines and better indication of motion in the H II region of a spectrum. The diameter of the lens of the SIRTF telescope will be 0.85 m and it will be liquid-heated and liquid-cooled.

The large deployable reflector (LDR) is going to be even larger than the SIRTF telescope and it will go up on the Shuttle in the year 2000. This will help both astronomers and astrophysicists come up with a better idea of where the solar system formed and the part in forming the solar system that the nebulae played.

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JOB DESCRIPTION

Kelvin Davis

As an apprentice mechanical engineer at Ames Research Center, I have been exposed to the world of engineering. Engineering is exciting and challenging, and there is always something to learn. It also requires a lot of hard work as I discovered very quickly.

I worked under the direction of Dennis Matsuhiro, and Julie Lewis (with whom I worked more closely). My duties were to draft the plans for a physical support platform, which would be used to make secure a computer and instruments for the study of hydroxyl radicals. My platform, as well as the computer and instruments, will go aboard NASA's CV990 Airborne Laboratory.

My job requires many hours at a drafting board, using rulers, compasses, circle templates, triangles, and drafting pencils. Drafting can sometimes become hectic when assemblymen find errors in your drawings and you have to change them. Along with drafting, I was also responsible for making blueprints and overseeing construction of the platform.

HYDROXYL RESEARCH SUPPORTED BY THE CV-990 AIRCRAFT

Kelvin Davis

HISTORICAL BACKGROUND OF HYDROXYL RADICALS

As the 1980s and high technology are upon us, it has become increasingly more important for scientists to find faster and more efficient ways to conduct experiments and record data. In one instance, in the study of hydroxyl radicals, there have been numerous advances over the years.

Just 80 years ago H. J. H. Fenton reported (ref. 1) that ferrous ions strongly promote the oxidation of malic acid by hydrogen peroxide. Subsequent work has shown that the combination of H_2O_2 and a ferrous salt, "Fenton's Reagent," is an effective oxidant of a wide variety of organic substrates.

Forty years later, Haber and Weiss (ref. 2) proposed that the hydroxyl radical is the actual oxidant in such systems. In the 1940s Merz and Waters, in a series of important papers (ref. 3), showed how by using the Haber and Weiss scheme, product-reactant quantity relations could be employed to determine the relative susceptibilities of various substrates to hydroxyl radical attack and the fate of subsequent radical intermediates.

Therefore, hydroxyl radicals have been studied by means of more advanced techniques and equipment. As examples, their production by flow systems in the ESR cavity, a technique originated by Dixon and Norman (ref. 4), has been used to generate a variety of radicals and to study both their reactions and the details of their ESR spectra. Radiation chemists who combined pulse radiolysis and competition techniques have determined the absolute rates of hydroxyl radicals with several hundreds of substrates with varying degrees of precision.

In the late 1950s and 1960s, many scientists concerned themselves with alkoxy radical chemistry. In 1969 chemists decided to include the hydroxyl radical in their studies, but they took a long time getting back to Fenton's Reagent (which had received little attention in the meantime) and the product-reactant quantity analysis of Merz and Waters.

HYDROXYL RADICAL — CURRENT RESEARCH

Now, in the 1980s, Malcolm Campbell, a chemist at Washington State University, is continuing to research hydroxyl radicals using new techniques and advanced equipment. Campbell, along with engineers from Ames Research Center, is working on this project. The engineer is responsible for designing and drafting the plans for the support equipment, and he is in charge of correcting and checking stress analysis and equipment to be sure that it meets the specifications of the CV-990 Airborne Laboratory. Campbell is responsible for the computer equipment and hydroxyl collecting probe. The support equipment must be strong enough to withstand certain atmospheric pressures because it will be supporting a probe which sits outside the plane. The probe is designed so that wind will flow through it, and hydroxyl radicals would be caught and stored for later study. There will also be a computer which will be used to collect and store data for later reference.

THE CV-990 AIRCRAFT

It was in April 1965 when NASA first began operating the Convair 990 aircraft. This aircraft was designed for research activities in atmospheric and space sciences, applications technology, and aeronautics. The plane has been transformed into a flying laboratory and is based at Ames Research Center, Moffett Field, California. It may be used only by researchers whose proposals have been approved by NASA headquarters. Flights may be conducted out of Moffett Field or from remote bases worldwide.

The CV-990 is a four-engine jet transport aircraft with a range of 3000 n. mi., a ceiling of 41,000 ft, and an experiment payload of about 20,000 lb. Its regular flight time is 400 to 500 hr/yr. Special viewports, power systems, and instruments have been installed to support a wide range of research programs.

RESEARCH CONTRIBUTION BY KELVIN DAVIS

One would be inclined to think that a high school student could add little to the Fenton and Campbell study and its application on the CV-990 aircraft. I am proud to be able to say that I, Kelvin Davis, a 1983 SHARP student, have contributed to this research by drafting the plans for a support platform to go aboard the CV-990 Airborne Laboratory. The platform is designed to house a computer and support the hydroxyl radical probe, which sits outside the plane.

In addition to the drafted plans I have completed, I have also learned to operate a blueprint machine, drafting machine, and a transparency developer.

EXPERIENCE AT ARC

In my spare time, I saw what other engineers were doing. It was interesting to me to observe the engineers who used the Calma computer graphics system to do their drafting instead of having to draw by hand as I had to do. It takes longer to use the Calma because you have to plot your drawing, program the computer to make the drawing on the screen, and then have it printed on vellum paper, but the drawings are more accurate and they look better.

My summer here at Ames has given me some idea of what career I may pursue upon graduation from college. My research has narrowed my career choices to either mechanical or architectural engineering. Therefore, my college curriculum will more than likely be geared in the direction of mathematics and science.

Thanks, SHARP.

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JOB DESCRIPTION

Nicole deNecochea

Until this summer, I had never considered a career as an astrophysicist, but thanks to SHARP and my work experience with Dr. Edwin Erickson in the Astrophysical Experiments Branch of the Space Science Division, it is now a welcome career choice.

Dr. Erickson directs a project to develop an infrared camera to photograph astronomical objects in the infrared part of the light spectrum. My work involves designing and constructing the driver electronics for the CCD Driver box, one of the camera's three control boxes. Similar to electrical engineering, this work entails drawing the chassis, front panel, and circuit diagrams, as well as assembling the electronic parts. After a few lessons with an electronics technician, I began soldering the parts together, i.e., coaxial cable to connectors and resistors. It was exciting to see my efforts materialize!

I also assist Dr. Erickson in his laboratory, taking data to calibrate an infrared grating spectrometer used on the Kuiper Airborne Observatory (KAO), a C-141 jet used for airborne astronomical research.

Learning comprises a significant part of my job. My educational pursuits include attending weekly seminars and conferences on astrophysics; reading books and research papers about physics, infrared astronomy, and electronics; and a calculus class twice a week. Yet these are not the only modes of learning. Talking, listening, and working with NASA scientists is a great learning experience in itself.

ASTROPHYSICAL EXPERIMENTS

Nicole deNecochea

An important objective of Dr. Erickson's research group is the development of a 10 μm array camera to photograph astronomical objects in the infrared region of the light spectrum. The camera would use an infrared charge-coupled device, one of the first of its kind, providing infrared astronomers with valuable new data about infrared-emitting celestial objects.

Infrared astronomical objects are those sources radiating energy predominantly in the infrared wavelength region, i.e., between visible and microwave wavelengths.

Traditionally, astronomers have studied astronomical objects solely in the visible spectral region. Since many bodies emit less than 10%, and some less than 1%, of their energy in the visible, restricting observation to the visible impedes the study of much of the mass in our universe. In their quest for a solution to this problem, astrophysicists in the last two decades have focused much of their attention on the development of devices for astronomical observation in other parts of the spectrum, particularly in the infrared. Measuring devices sensitive in the infrared spectral region possess the potential to identify much of the "missing" mass in our universe, an outstanding problem in galactic and extragalactic astronomy (ref. 1). Such devices will also glean new information about previously identified bodies.

Although infrared radiation can be detected from the ground, observation from aircraft and spacecraft yields better results. Using the Lear jet, C-141 Kuiper Airborne Observatory jet, and NASA's Infrared Astronomical Satellite, astrophysicists can observe infrared sources at altitudes above interfering water vapor. Water vapor in Earth's atmosphere accounts for most of the absorption of infrared radiation from space, severely impeding the infrared astronomers' observations. Thus observations at high altitudes, where much of the radiation has yet to be absorbed, are highly desirable.

Although scientists intend to use the infrared array camera in ground-based research, still it will produce infrared photographic results superior to those of any other currently operating device in infrared astronomy. The camera will employ a charge-coupled device (a sensitive radiation detector with excellent quantum efficiency, dynamic range, color response, photometric accuracy, geometric range, and reduced noise level) (ref. 2). Attached to a large telescope at the Mauna Kea Observatory in Hawaii, the world's highest astronomical observatory at an elevation of 13,800 ft, the camera will observe brown dwarf stars, bipolar nebulae, planetary nebulae, and H II regions through a 10 μm "window" in the atmosphere.

As of now, little is known about the celestial bodies to be photographed by the 10 μm infrared array camera. Brown dwarfs, for example, are believed to exist, but are undetected. Astrophysicists predict that brown dwarfs are cool, low-mass objects in space, but no infrared device presently possesses the sensitivity to confirm their existence (ref. 3). Bipolar nebulae are quasi-rectangular clouds centered on a luminosity source, often thought to be a planetary nebula. Planetary nebulae are hot stars surrounded by immense "shells" of tenuous gas. H II regions, clouds of ionized hot stars, will also be studied. Scientists will acquire a great deal of new information about these celestial bodies which, in turn, will help them determine how stars evolve, and whether the universe may eventually collapse.

Figure 1 demonstrates how the 10 μm infrared array camera will operate. Developing the charge-coupled device (CCD) driver, one of the camera's three control units, comprises my contribution to the camera. I help design the chassis electric layout, procure the electronic devices, and assemble the CCD driver unit. I also assist Dr. Erickson, in his laboratory work that consists of taking data to calibrate an infrared grating spectrometer used on the C-141 Kuiper Airborne Observatory jet. My educational pursuits include attending weekly seminars and conferences on astrophysics; calculus class twice a week; reading books and research papers about physics, infrared astronomy, and electronics; and soldering instruction from an electronics technician.

SHARP gave me the invaluable opportunity to work and learn simultaneously. Dr. Erickson, his colleagues, and other NASA personnel devote much of their time every day to teaching me new things, ranging from the academic (astrophysics and computer science) to the mechanical (soldering). Besides appreciating the distinguished scientists I work with for their outstanding scientific achievements, I came to identify with them as personal and career role models. Thank you, NASA, for making me realize that I, too, can attain an exciting, rewarding career in science.

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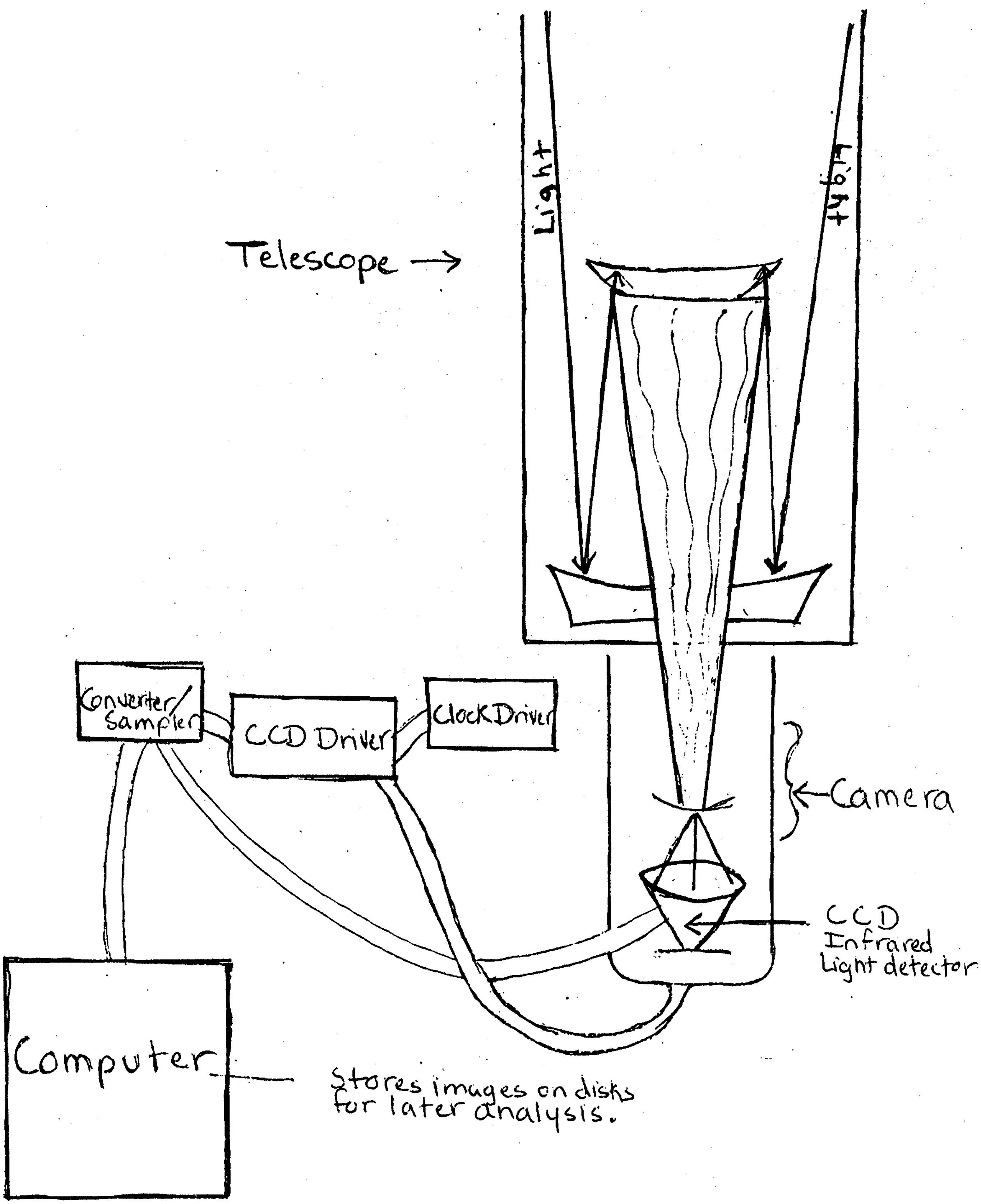

Figure 1.- Operation of the 10 μm infrared array camera.

JOB DESCRIPTION

Franklin Graham

Some astronomers here at NASA Ames Research Center are working on the proposed SIRTF project. SIRTF is the acronym for the Shuttle Infrared Telescope Facility. The facility will be placed aboard the Space Shuttle and flown into orbit, where it will perform the many tasks to which it has been assigned. Because the telescope will be free from the screening effects of the Earth's atmosphere and will be cryogenically cooled, it will be more sensitive and better able to see things in the infrared spectrum than any other telescope of its kind. The telescope will be pointed toward all kinds of stellar objects, including planets, quasars, and the distant galaxies; perhaps even discovering the manner in which they are formed.

One of the major components of the SIRTF is the Fine Guidance Sensor or FGS. As the name implies, it will guide the telescope and "keep it on track" of whatever stellar object it is investigating at the time. However, as with all proposed projects, there exists a question of whether it will be able to function as desired.

This is the question that I dealt with. When entering any new field, there is always a certain amount of disorientation which can be remedied by reading. Intensive reading on infrared astronomy is exactly what I did for 2 weeks.

Upon completion of my "cram course" I began writing my program in BASIC (Beginner's All-purpose Symbolic Instruction Code). The program is primarily a simulation. It uses Max Planck's Function on blackbody radiators to approximate the amount of energy emitted by stars. With these data, the program can determine the number of photons emitted, the colors and their relationships or color indexes, the number of photons lost to absorption by the telescope and FGS, and finally whether enough light has reached the FGS to keep it on track. Of course, the program prints out all this information in tables and on graphs. This program will be particularly useful, in that the transmission and sensitivity factors for different detectors can be inputted and the efficiency of one detector can be compared to that of another.

INFRARED ASTRONOMY

Franklin F. Graham

In man's quest for knowledge, he has often looked to the stars for answers. The study of the stars has undergone immense changes since its beginning as visual observations of the heavens. Indeed, astronomy has evolved into a multifaceted science; so diverse, in fact, that specialized scientists study just one of its aspects. Infrared astronomy is one of its major subsections. What is infrared astronomy, and how it is studied here at NASA Ames Research Center, will be the main concern of this paper.

Because astronomy is realistically the study of the light emitted by stellar objects, a good understanding of light and its properties is a basic requirement in this science. Perhaps, the greatest achievement in the investigation of light was the dividing of light into a spectrum, through the use of a prism, by Sir Isaac Newton in 1666. From this and later studies, it was generally deduced that light is a wave and its color is determined by its wavelength (fig. 1). The visible spectrum shows the constituent colors of "white light" arranged with blue and red lights having shorter and longer wavelengths, respectively. Expanding on Newton's work with prisms, Sir William Herschel in 1800 was investigating the effects of the constituent colors on temperature. He noted that as the light of the prism became more red, the temperature of his thermometer rose. One day he accidentally placed his thermometer below the red region of light and discovered an increase in temperature. He called this invisible light infrared light, meaning "below the red." Soon light was discovered beyond the blue region, until finally the visible spectrum was put into perspective with the entire electromagnetic spectrum (fig. 2).

One of the most important aspects of astronomy is observation. This is actually harder than it seems. Stellar infrared light is very difficult to observe accurately for two reasons: absorption and emission of light in the infrared wavelengths by all objects with a temperature above absolute zero (-273°C or 0 K). To an infrared astronomer this absorption and emission of infrared radiation is most disturbing in the Earth's atmosphere. The atoms and molecules, which compose the atmosphere, absorb most infrared radiation, thus virtually blinding the earthbound infrared astronomer to objects to be observed. To add to the dilemma, all atoms and molecules tend to remain in their lowest energy state. When an atom or molecule is excited to a higher energy state, it will reemit the same amount of energy to lower its energy level. Much of this reemittance is in the infrared wavelengths. In addition, when molecules and atoms collide as a result of molecular activity, the energy produced by such collisions is in the infrared wavelengths. Thus, also, the atmosphere adds a thick background of infrared radiation (fig. 3).

SIRTF PROPOSAL

The infrared astronomers at NASA are working on the Shuttle Infrared Telescope Facility, or as it is called, "SIRTF." As the name suggests, it will be carried by the Space Shuttle into orbit around the Earth. Because it is outside the Earth's atmosphere it will be free of the screening effects of absorption and emission, which have for so long plagued infrared astronomers. Although there is dust in the solar system and interstellar dust in space, which radiates at infrared wavelengths, the strength of the radiation is relatively low compared with that of the atmosphere.

Since all objects above absolute zero emit infrared radiation, there still remains the radiation of the telescope, itself; and this is, indeed, a problem, almost as severe as the Earth's atmosphere. To combat this, the optical system of the telescope will be cryogenically cooled with supercritical helium to a temperature of about 20 K, and the detectors and instruments will be cooled to less than 10 K (fig. 4).

One of the major components of the SIRTF is the fine guidance sensor, or FGS for short. It is situated at the end of the telescope, as in figure 4. The main purpose of the FGS, as the name implies, is to guide or keep the telescope "on track" on any object it is examining. This task is made especially difficult by the orbital movements of the Space Shuttle and the relatively faint magnitudes of the available stars. So before the facility can be sent up, it must be known whether the FGS will function as planned.

One of the ways to test the FGS without actually putting it into space is to use a "model" with varying parameters to see how it fares under different conditions. The model, in this case a computer program, allows the input of various criteria.

The program (Beginner's All-Purpose Symbolic Instruction Code), written in BASIC, is primarily a blackbody simulation. A blackbody is a theoretically perfect radiator of energy; and stars for the present purposes are "perfect" radiators of energy, as can be seen in figure 5.

The program uses Max Planck's Function, which basically gives the number of photons of a certain wavelength, passing a square centimeter area, every second (fig. 6).

Using Planck's Function, the program will integrate over a 0.4 to 1 μm wavelength span. It will also take into account the loss of light because of the absorption of the detector and telescope; and compute Ne, the rate at which electrons are produced in the FGS (fig. 7).

By checking the temperature of the blackbody, the program can classify the colors. For example, a very hot star will radiate most of its light in the blue region, whereas a cooler star will emit most of its light in the red end of the spectrum. Also, the color indexes can be found. These indexes show the ratios of blue light to visual light, or visual light to red light, or any other index desired. And, of course, all the information on the response of the FGS to stars of ranging brightness and color is printed out on graphs and tables.

The practical purposes of the program are comparative. Because the program allows input of various parameters, a person can input the characteristics of one detector and compare it with another's, allowing a quick and efficient way to find which detector affords the most sensitivity or whatever other feature is considered desirable. Although the program makes many assumptions and approximations, its main purpose is to see whether the FGS's sensitivity is, so to speak, "in the ballpark"; consequently, exact calculations are not imperative.

In summary, SIRTF is the most important project to date in infrared astronomy. Its unsurpassed sensitivity in space will afford the opportunity to explore the universe as it has never been done before. It can look into regions of dust, which were previously inaccessible in the visible spectrum, but which are translucent in the infrared. It can look at objects of the universe, such as planets, comets, and asteroids, which are too "cool" to emit their own visible light, but which radiate in the infrared. Or it can look at the distant galaxies, which are speeding away from us with such great velocity that their "red shifts" are actually in the infrared wavelengths. The infrared light from these objects would just be reaching us after a journey of 17 billion years, believed to be the age of the universe. Perhaps, SIRTF will discover the way in which the universe formed, and consequently how life began.

Upon hearing of the opportunity to work at NASA Ames Research Center, I was struck by the awesome reality that I might be able to work with the famous NASA scientists, who have for so long achieved wonders in the fields of science. I had the idea that NASA scientists were pinnacles of learning and understanding, in a realm inaccessible to just anyone. And, indeed, they are rather gifted and special; however, they are also just as human as the next person. It was this idea that brought home the fact that even I, given the proper schooling and experience, could achieve this noteworthy level of excellence.

Before I came to NASA Ames Research Center I was reasonably sure that I would enter a math, science related field of work; and as a result of my stay here this summer, I have confirmed my belief that these are my interests. I used a computer here at NASA; and consequently spent most of my time programming. This narrowed my career outlooks to a math, science, and computer related field. Although these new parameters still encompass a rather broad spectrum of occupations, they have given me a general indication of which schools and which careers I should look into. Basically, NASA has impacted my life in two ways: first, it has shown me that you can be and do whatever you wish, if you put forth the time and effort; and, secondly, it has confirmed my thoughts on which careers would be of interest to me. These are, in fact, two very important factors in the shaping of my life; and I am indebted and grateful to NASA.

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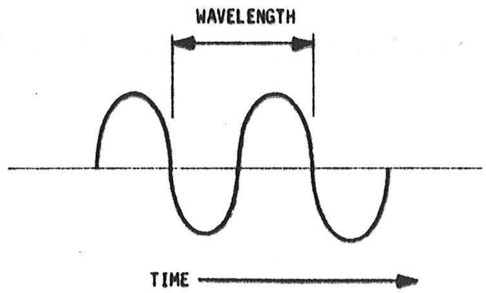

Figure 1.- Basic waveform.

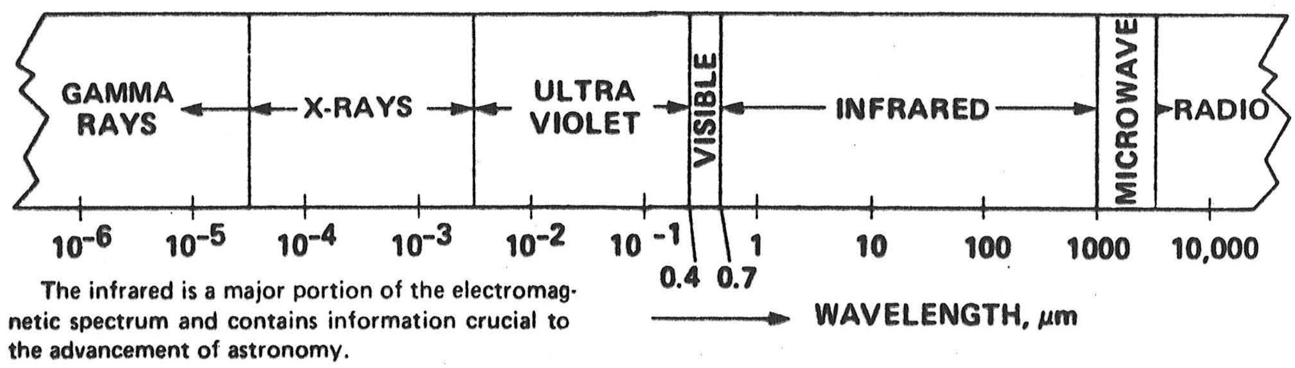

Figure 2.

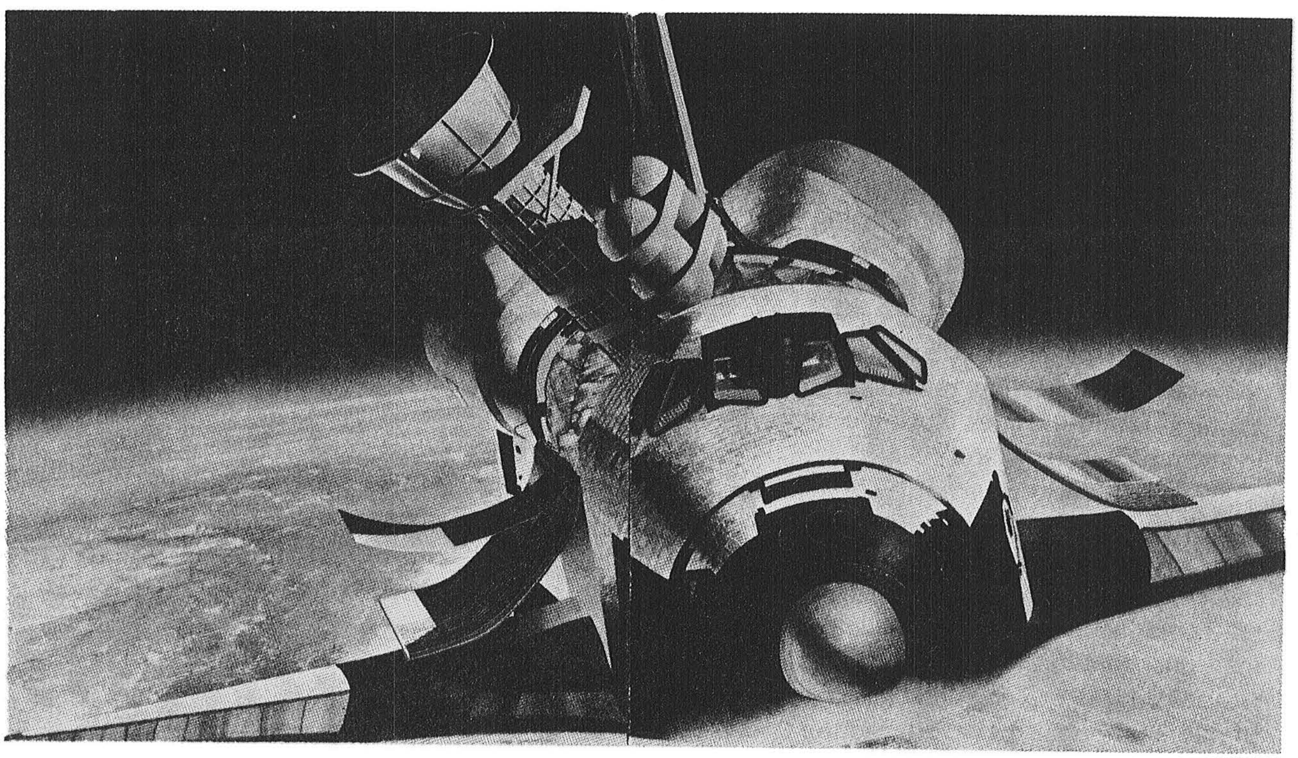

Figure 3.

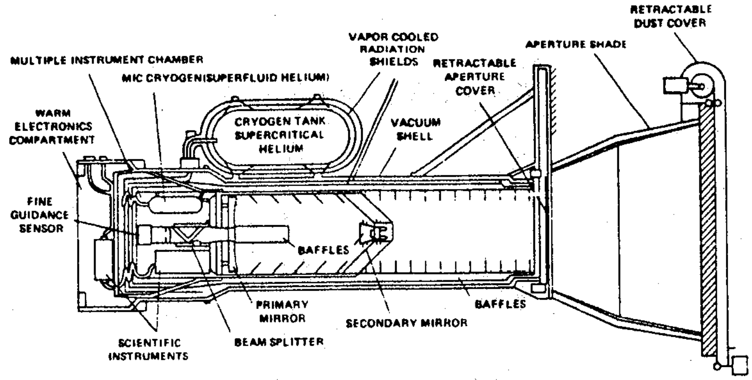

Figure 4.- SIRTF telescope concept. The primary mirror diameter is 90 cm. The overall length is 7.4 m.

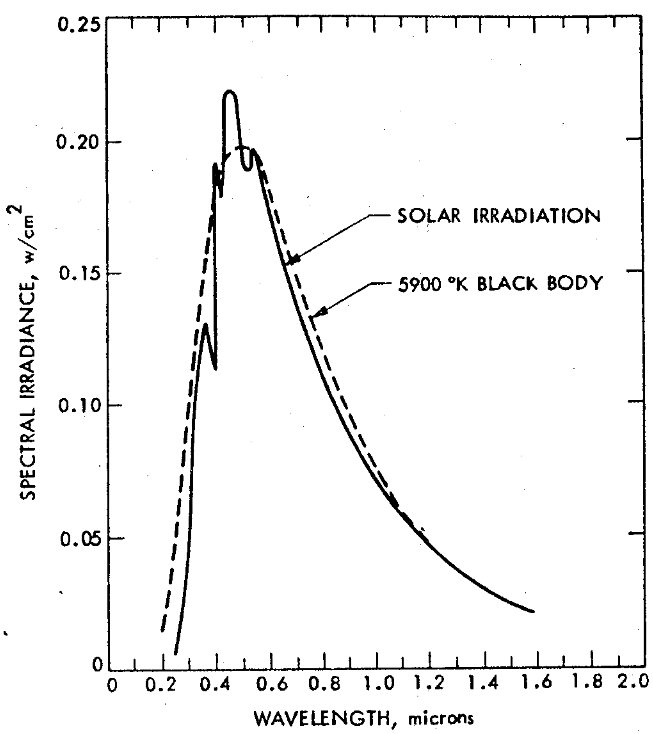

Figure 5.- Solar spectral irradiance at Earth, outside the atmosphere.

$$N_\lambda(T) = 2\pi c \lambda^{-4} (e^{hc/k\lambda T} - 1) \quad \text{photons/cm^2*sec}$$

where

π = Pi = 3.141592654

c = Speed of light = 2.997925E+10 cm/s

λ = Radiation wavelength in centimeters

h = Planck's constant = 6.626E-27 erg*s

k = Boltzmann's constant = 1.380E-16 erg/deg

T = Temperature of black-body in Kelvin

Figure 6.

$$N_* = \int_\lambda N_\lambda(T) \; QE(\lambda) \; A \; T(\lambda) \; d_\lambda$$

where

$N_\lambda(T)$ = Photon flux of star in photons/cm^2*sec

$QE(\lambda)$ = Detector spectral quantum efficiency function

A = Telescope light collection area = 5.6E+3 cm^2

$T(\lambda)$ = SIRTF Optical system spectral transmission function

Figure 7.

JOB DESCRIPTION

Karen Gulick

When I began to work in the Space Projects Facility at Ames, I knew that the summer would be both challenging and exciting. Dr. Roger Craig, the Pioneer Venus Science Chief, Data Processing Manager for Pioneer, and Aircraft Science Coordinator, has allowed me to become involved in virtually all of his projects. As an assistant to Dr. Craig in the setup of a program to coordinate the flight experiments aboard the U-2 and the ER-2, I have become familiar with word processors by using them to update files for experiments, research, contracts, U-2 flights, and special meetings. My work has also taken me from the U-2 office to the hangar, and even to the runway!

While Dr. Craig would like me to have a thorough understanding of his work, he believes that I should learn about all kinds of research and explore anything that is of special interest to me. Several mornings a week I have a calculus lesson with Dr. Craig, and he is always nearby to explain any new concept of the project.

Another aspect of my job involves computer programming. I began using FORTRAN immediately and, with the guidance of several coworkers, I wrote my first program within 2 or 3 days. Since then I have been learning more about computers by writing and running several programs on my own.

I am now beginning the programming of a scientific problem involving chemical thermodynamics. Early in the formation of the Earth, a primitive atmosphere was formed after gravitation became great enough to retain the gases that were being emitted by the molten lava near the surface. The program that I am writing will use a lava composition that will be determined by NASA scientists. When it is finished, the program will relate the chemical composition of gases above the magma (molten lava) stage as a function of temperature and pressure. This information will be used in a study of the formation of the Earth and its early environment.

PHENOMENA IN THE ATMOSPHERE

Karen Gulick

The atmosphere of the Earth may be thought of as an envelope which is composed of a mixture of gases and aerosols. The atmosphere is primarily composed of nitrogen (78%), oxygen (20%), and argon (0.9%) (ref. 1). Water vapor is also an important constituent because of its role in the absorption of infrared radiation emitted by the ground. Its concentration in the lower layers of the atmosphere varies between 40 and 40,000 ppm as a function of its supply by evaporation and its depletion by precipitation after conversion to the solid and liquid phases. Aerosols, which are solid and liquid particles in suspension, are deposited in the atmosphere as the result of natural events such as the eruptions of volcanoes, and human activities such as the combustion of fuel from jet or automobile engines.

The atmosphere was formed when gravity became great enough to retain the gases and aerosols being emitted by molten lava near the surface of the Earth. The atmosphere becomes less and less dense as the altitude increases. In fact, 90% of the atmosphere's mass is concentrated within the first 20 km from the surface of the Earth (ref. 2). This mass is responsible for the absorption of solar radiation.

The Sun radiates much light that is invisible to the human eye. This electromagnetic radiation may be thought of as a stream of particles called photons. Solar radiation may be placed in three divisions according to its wavelength and the altitude at which it is absorbed. Ultraviolet radiation of wavelengths less than 1000 Å is absorbed at and above altitudes of 100 km where its absorption results in the ejection of an electron from the absorbing molecule, leaving behind a positively charged ion. This process is called photoionization. Absorption of solar ultraviolet radiation of wavelengths between 2000 and 3000 Å occurs at altitudes near 30 km and leads to the disruption of the absorbing molecule. Finally, solar visible and infrared radiation of wavelengths greater than 3000 Å is absorbed at the surface of the Earth.

The absorption of radiation between 2000 and 3000 Å occurring near 30 km is a process called photodissociation. The molecules dissociated are ozone molecules (O_3). Ozone reaches a maximum concentration of only 8 to 15 ppm between altitudes of 20 to 30 km; however, it preserves life on Earth by absorbing radiation that would otherwise damage or destroy living cells (ref. 3). The concentration of ozone is controlled naturally by the rate at which it is produced from atomic and molecular oxygen (reaction 2) and the rate at which it is destroyed in reactions with sunlight (reaction 3), atomic oxygen (reaction 4), and nitric oxide (reaction 5).

Important Reactions in the Production and Destruction of Ozone

(1) $O_2 + \text{photon} \rightarrow O + O$

(2) $O + O_2 + M \rightarrow O_3 + M$ (three body reaction)

(3) $O_3 + \text{photon} \rightarrow O_2 + O$

(4) $O_3 + O \rightarrow 2\ O_2$

(5) $NO + O_3 \rightarrow NO_2 + O_2$

(6) $NO_2 + O \rightarrow NO + O_2$

One natural source of nitric oxide (NO) is nitrous oxide (N_2O), which rises from the Earth as a result of the actions of denitrifying bacteria on nitrates in oxygen-poor soil and water. As can be seen in reaction 5, nitric oxide destroys ozone in a direction reaction. The by-product of this reaction, NO_2, will then react with atomic oxygen to form nitric oxide and molecular oxygen (reaction 6). Therefore, within this circular pattern, each nitric oxide molecule introduced into the atmosphere may destroy thousands of ozone molecules before it drops out of the atmosphere in the form of nitric acid in raindrops (ref. 4).

On the graph of the characteristics of the Earth's atmosphere (fig. 2), wavelengths of solar radiation and their subsequent altitudes of absorption are noted. For each point of maximum absorption there is a corresponding peak in the temperature graph. This heat is the result of the energy absorbed by the particles. The atmosphere may now be divided into different "spheres" to be defined by variations in vertical temperature.

The troposphere extends from the surface of the Earth to altitudes of 10 km at the poles and 16 km at the tropics, and is considered to be the seat of all important weather phenomena. There are daily and seasonal variations in the height of the troposphere, as well as the aforementioned latitudinal variation. It is characterized by a general lapse rate (decrease in temperature with height) of $6.5°C/km^{-1}$, although greater lapse rates and shallow inversions (increases in temperature with height) do occur. A peak in temperature at the surface of the Earth is due to the absorption of solar visible and infrared wavelengths greater than 3000 Å. The tropopause is a boundary at the top of the troposphere which is the level above which the lapse rate becomes less than $2°C/km^{-1}$. The difference in the height of the troposphere at the tropics and the poles causes a break, or "tropopause gap," between 30° and 40° latitude where the tropical and polar tropopauses overlap in the region of the subtropical jet stream. Such a break also occurs near the polar jet stream.

The stratosphere reaches from the tropopause to about 50 km, and is characterized by constant or slightly increasing temperature with height. Its peak in temperature at 50 km is the result of the absorption of energy through photodissociation of ozone molecules. The mesosphere covers the area from the top of the stratosphere to about 80 km and is marked by a decrease in temperature with height. The thermosphere begins at 80 km and continues until the density diminishes and is equal to that of the interplanetary medium. An increase in temperature begins at 80 km and is a result of photoionization. Further discussions of the atmosphere will involve only the troposphere, the tropopause, and the stratosphere.

If a parcel of gas at the surface of the Earth is heated, it will expand and begin to rise. As it rises and the density of the air surrounding it decreases, it will continue to expand. Because expansion leads to cooling, the parcel of gas will experience a gradual reduction in temperature with height (ref. 5). Provided that the temperature of the air is the same as that which a parcel of air would assume if raised from the surface to the same height, the rate of decrease in temperature with height is called the adiabatic lapse rate (ref. 5). If the lapse rate in the atmosphere is higher than the adiabatic lapse rate, a parcel of gas displaced upward will not cool as quickly as the surrounding air and its buoyancy will make it rise still further. This is generally true in the troposphere; thus, it is said to be "unstable," or well mixed.

In the stratosphere, however, a parcel of gas displaced upward will find itself to be cooler than the surrounding air, and being more dense, it will fall back into its original position (ref. 6). The air in the stratosphere is said to be "stable" because its vertical temperature distribution discourages vertical motion. Gases and aerosols in the stratosphere generally spread out horizontally into "stratified" layers.

Substances introduced into the atmosphere may rise until they reach the tropopause and the stability of the stratosphere begins. The gas or aerosol may gather at the tropopause for 10 or 20 yr before penetrating into the stratosphere. Thus, it may be many years before a noxious substance, such as nitric oxide, will accumulate in the stratosphere and reach a peak in the destruction of ozone. If, however, nitric oxide were introduced directly into the stratosphere, it would be trapped in the stable area for a long time while it destroys ozone molecules (ref. 7).

During the past two decades much attention has been focused on the destruction of ozone. Just as a variation in the intensity of radiation from the Sun will alter the amount of ozone produced, so will a variation in the amount of nitric and nitrous oxides. Nitric oxide has been released directly into the stratosphere as an effluent of jet engines. This affects the natural balance of ozone production and destruction. Concern has also risen over the production of freons, which are principally used in air conditioners and aerosol spray cans. The photodissociation of freons in the stratosphere releases chlorine atoms which react similarly to nitric oxide in the destruction of ozone. Such interference in the natural balance of ozone which is caused by human activity is thought to alter the amount of solar ultraviolet radiation allowed to penetrate the atmosphere and subsequently influence changes in atmospheric circulation, weather, climate, agricultural yield, natural ecosystems, and the occurrence of skin cancer (ref. 8).

Much of the atmospheric research being conducted by NASA is an attempt to understand effects of the Earth's environment caused by emissions of gases and aerosols from natural and man-made sources. The manner in which substances are transported from the troposphere into the stratosphere affects the distribution of the aerosols and their subsequent effects on the ozone layer. Therefore, a comprehension of transport mechanisms is essential in studies of the atmosphere.

Scientists at NASA conduct theoretical, laboratory, and field investigations in their studies of the atmosphere. The U-2, ER-2, and CV-990 aircraft serve as platforms for experiments. The U-2 and ER-2 are able to cruise well into the stratosphere at heights of 70,000 ft; however, the experiments flown on board must be fully automated. The CV-990, which flies at altitudes of 35,000 to 40,000 ft, can accommodate instruments that must be personally operated by the experimenter.

Whenever possible, aircraft flights are coordinated with balloon and satellite data collections. Although balloons are used because of their access to high altitudes, restrictions on their use may be set by the weather, launch location, and operational costs.

Many experiments have been conducted to explore the vertical transport of gases and aerosols from the troposphere into the stratosphere. Two fairly recent experiment programs were based in Panama. The choice of this tropical location was based on a theory that the low water vapor content in the stratosphere must be the result of vertical mass transport occurring in the equatorial regions. The temperature of the atmosphere continues to fall at greater heights above the tropics, resulting in a lower tropopause temperature. Vertical transport of air at the tropical tropopause would allow for cooling of the air, ice crystal growth, and precipitation, which would leave the inflowing air with a low water vapor content correlating to that of the stratosphere.

Results of the 1977 Intertropical Convergence Zone Experiment in Panama added to the belief that although "some tropospheric air is mixed into the stratosphere by slow meridional circulations associated with the jet stream, the extreme dryness of the stratospheric air suggests that the primary transport of mass from the troposphere into the stratosphere takes place in the equatorial region" (ref. 9).

Suggestions from the 1977 Experiment that cumulonimbus clouds might play a role in the transport mechanism led to the 1980 Stratospheric-Tropospheric Exchange Experiment, which was also based in Panama. Models involving cumulonimbus clouds were tested. Cumulonimbus clouds are very dense clouds that are often responsible for the precipitation in heavy rain showers. The clouds develop a great vertical length, and when they reach high altitudes, up-currents will carry ice crystals that have been formed (as a result of the cool temperature) into the stratosphere. There, the stability will cause them to spread out in horizontal layers. Thus, an anvil-like top is formed (fig. 2).

A proposal has recently been made for a set of experiments to test two popular theories on vertical transport. One of these theories is rapid ascent by connective clouds whose turrets penetrate into the lower stratosphere. It is thought that active cumulonimbus clouds in the tropics would provide strong vertical motions which would allow trace constituents to enter the atmosphere while causing the condensation of water vapor.

The experiments would be conducted in the area of Micronesia from a base in Australia in early 1986. This region has been selected because it has the coldest upper tropospheric and lower stratospheric monthly mean temperatures. These cool temperatures could allow slow mean vertical transport to be the primary mechanism for the exchange between the troposphere and the stratosphere. This regional ascent model is the second theory to be tested.

Because human activities do influence the chemical composition of the atmosphere, it is important that we have a thorough understanding of the atmosphere. The studies of stratospheric-tropospheric exchange are important because of the role that the exchange plays in the distribution of gases and aerosols that affect the ozone layer. The result of NASA's research on the transport mechanisms will give mankind the knowledge that it needs to protect the ozone layer for the preservation of life on Earth.

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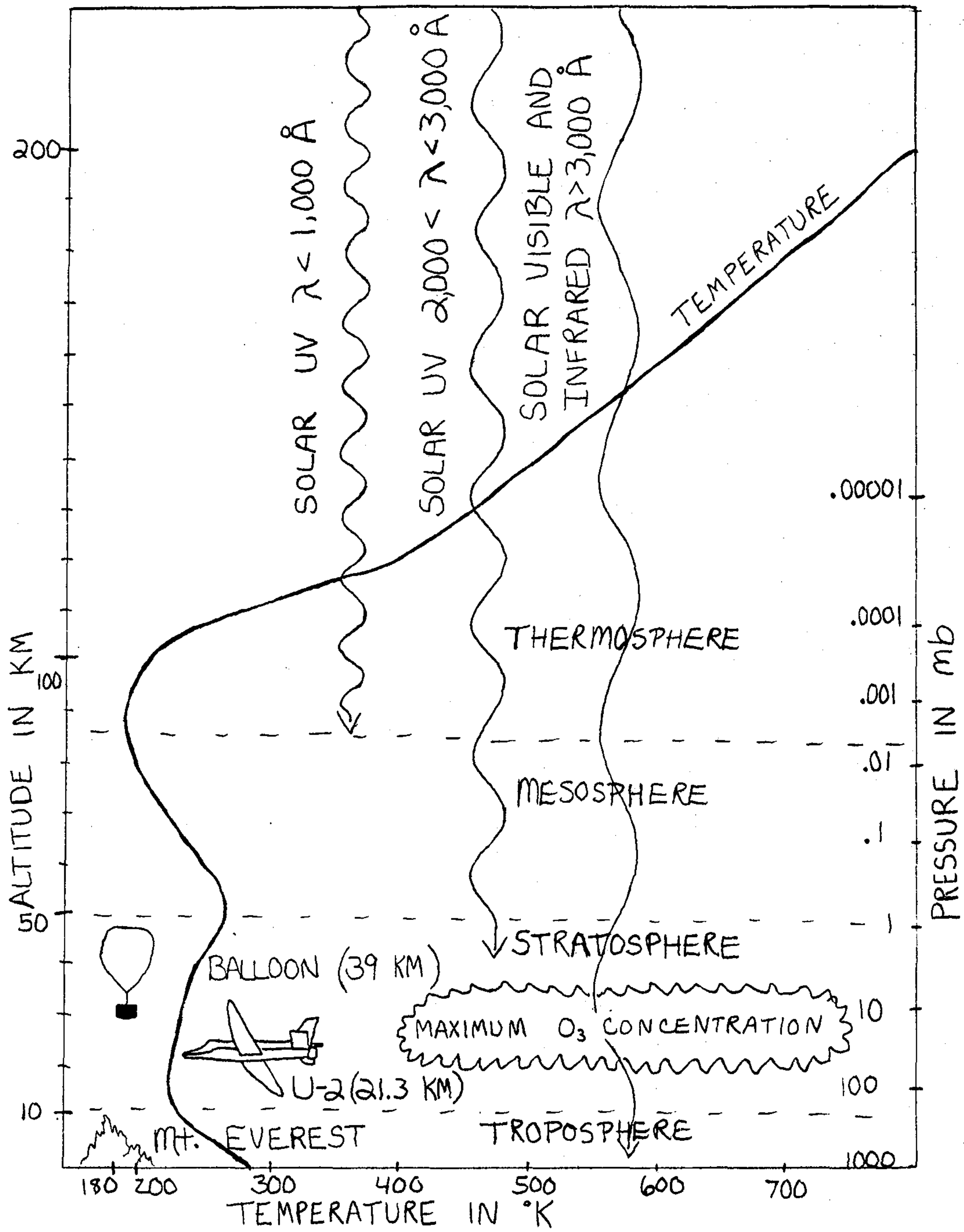

Figure 1.- Characteristics of the Earth's atmosphere.

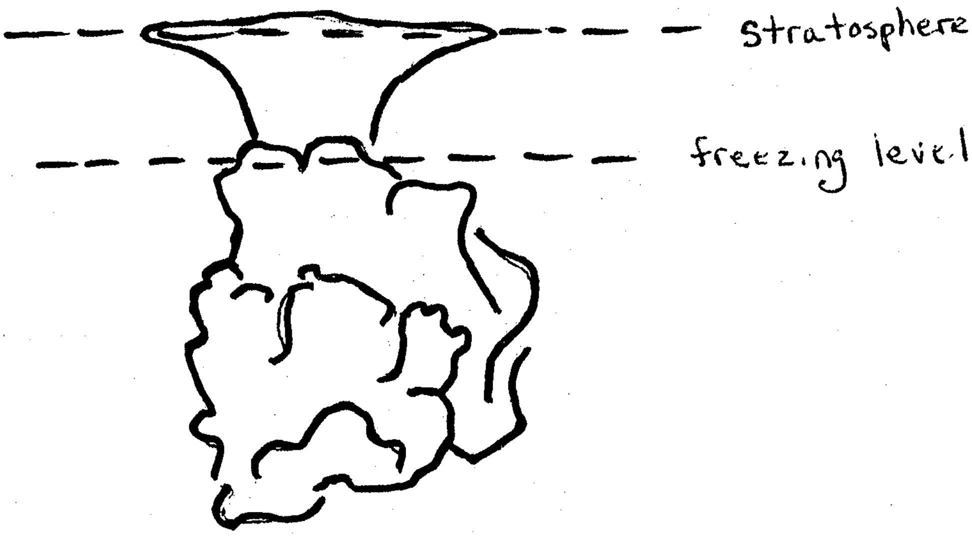

Figure 2.- Picture of cumulonimbus cloud (ref. 5).

JOB DESCRIPTION

Joel Lym

In February of 1979, the International Vestibular Meeting held in Washington, D.C., emphasized the need for animal research in the study of space motion sickness, and decided that an understanding of the vestibular system and its interaction with other sensory organs should be developed. As a result, NASA was recommended to originate a Vestibular Research Facility (VRF). Through the use of a centrifuge and a linear acceleration sled, the VRF was to provide many motion/visual environments for animals ranging from frogs to squirrel monkeys. In addition, the Variable Gravity Research Facility (VGRF) was developed to study the effects of the hypogravity of space upon living organisms, particularly to obtain an understanding of the mechanisms responsible for space motion sickness.

I have worked primarily on the VRF project, and have made contributions in many ways. I helped construct a clean lab, an ideally dust-free room, in building N-239A which will serve as the temporary construction area for the centifuge. It is desirable to have the room dust free in order to prevent particles from settling between moving parts of the centrifuge and wearing the metal.

I have studied the set of assembly plans for the building of the main drive of the centrifuge. As a result, I have learned to interpret certain terms and symbols often shown on engineering drawings.

I constructed approximately 80% of an S-100 circuitry "cage," which serves as an interface between the computer and the centrifuge. The several circuit boards on the S-100 cage collect centrifuge data, and monitor and regulate the centrifuge's movement.

I have drawn the final schematic diagram of the circuitry for the power and clock board. Not only does this board supply power to the centrifuge, but it also activates chips by periodically changing voltage.

One of my projects is concerned with thermoelectric modules which will be used to cool the specimen testing container (STC) and provide a moderate temperature for the animal under study. I have phoned several electronic corporations requesting specification sheets and pricing information on thermoelectric modules. In addition. I plan to write a research report on thermoelectric modules for the Vestibular Research Facility.

I appreciate all that I have experienced in SHARP, and I now realize how significant physics, computer science, math, and English are. With my supervisor's advice on college and careers, I can define my goals and career interests more precisely. Also, I am sure that I will apply the valuable skills and knowledge I have gained towards my education and future occupation.

THE VRF/VGRF SCIENTIFIC RESEARCH PROGRAM REPORT

Joel K. Lym

INTRODUCTION

In February of 1979, an International Vestibular Meeting held in Washington, D.C. recognized the need for research in the study of space motion sickness. The assembly concluded that a better understanding of the vestibular system and its interactions with other sensory and motor systems should be obtained. In response to this recommendation, NASA organized the Vestibular Research Facility (VRF). This Facility was designed to study the effects of various motion/visual environments on animals. In addition, the Variable Gravity Research Facility (VGRF) was conceived. As its name implies, the VGRF intends to study the responses of animals under various gravities.

I will first portray the vestibular system and describe space motion sickness — its symptoms and possible causes. Secondly, I will present descriptions of the Vestibular Research Facility and the Variable Gravity Research Facility. Included are their purposes, how each will increase the knowledge of the vestibular system and of space motion sickness, and brief accounts of the components the facilities will use. In addition, I have illustrated how the facilities will develop in stages towards the flight research program. Lastly, I will conclude with the contributions and benefits the two facilities offer to the field of vestibular research.

THE VESTIBULAR SYSTEM

Located in the inner ear, the vestibular system is essential to maintaining postural and oculomotor control and perception of motion and orientation. This system consists of the otolith organs (the utricle and saccule) and the semicircular canals.

The utricle and saccule contain macula, sensory organs responsible for the perception of linear movement. The macula are composed of hair cells and sustentacular cells embedded in a gelatinous layer containing otoliths, crystals of calcium carbonate (fig. 1). The function of the macula depends upon gravity. By gravity the otoliths are forced upon the hair cells of the macula. When the body accelerates or decelerates linearly, the displaced otoliths distort the hair cells and activate nerve fibers. Without gravity to maintain the otoliths upon the hair cells, the macula function abnormally.

The three semicircular canals of the inner ear are located at right angles to each other. Each ampulla, the dilated end of the canal, joins to the utricle (fig. 1). Found on each ampulla, receptor structures, the crista ampullara, consist of supporting cells and hair cells surmounted by a gelatinous substance. The semicircular canals help the brain sense angular body movement. Under rotational acceleration or deceleration, the fluid within the semicircular canals pushes on the crista stimulating the nerve fibers to send impulses to the brain. Unlike the otolith organs, the canals are not directly dependent upon gravity to function. However, recent evidence indicates that semicircular response may be affected by otolithic output. Thus, gravity may influence both the semicircular canals and otolith organs.

SPACE SICKNESS

Space motion sickness or "Space Adaptation Syndrome" is a discomforting feeling characterized by nausea, vomiting, disorientation, and malaise. About half the Space Shuttle crew are expected to feel some degree of space sickness during 50-70% of Space Shuttle flights.

Presently, there are several factors believed to contribute to space motion sickness. In spaceflight, it is possible that the brain does not adapt well to conflicting inputs relayed from the eye muscles and the vestibular system. Space sickness may also result from a change in the fluid environment of the vestibular system. This condition may be caused by a shift of fluids from the lower body regions to the upper body.

At this time, there exist no effective countermeasures to space sickness. Hopefully, the VRF/VGRF program will provide information leading to a solution to the space sickness malady.

THE VESTIBULAR RESEARCH FACILITY (VRF)

The VRF program intends to develop an understanding of the vestibular system, how our central nervous system handles sensory interactions and conflicts, and the way our body adapts to zero gravity. The information obtained may increase our knowledge of the vestibular system's relation to space motion sickness.

The VRF will develop and employ several innovative modules or "hardware." The centrifuge (fig. 2), a rotating module, will accommodate a number of VRF components: the three-axis gimbal arms, specimen testing container (fig. 3), and possibly a chair for experiments on humans. Other modules of the VRF program include a linear acceleration sled and the control electronics and data collectors.

The VRF experiments conducted by the modules will stimulate animals with motion/visual environments. The experimental animals proposed for study are the gerbil, pigeon, cat, and squirrel monkey. Each environment is called a mode, a defined set of motions and visual stimuli that the modules will perform (fig. 4).

THE VARIABLE GRAVITY RESEARCH FACILITY (VGRF)

The purposes of the VGRF are to study the function of the vestibular system and its relation to space motion sickness. The VGRF subjects animals to different levels of gravity. This facility will attempt to correlate the effects of hypergravity and hypogravity. By conducting experiments of hypergravity on Earth, scientists hope to extrapolate how animals and humans will respond to hypogravity. The information obtained will eventually be compared under actual conditions of hypogravity in space.

The VGRF will employ a centrifuge based on that of the VRF, and will mount specimen cages upon its axis.

FACILITY DEVELOPMENT

The VRF and VGRF programs develop in stages. Initially, prototype versions of the VRF and VGRF modules were constructed. These modules, and the experiments performed by them, provided early test results important to scientists and engineers and identified any deficiencies to be corrected in the design and construction of the next stage, the ground-based modules.

The ground-based hardware is a refined version of the prototype components. In the VRF program, the ground-based modules are currently being assembled. However, those of the VGRF are not yet constructed. A large part of the VRF prototype may be utilized in the VGRF program.

The ground-based hardware will contribute in several ways. In a long-range program, the facilities will enable scientists to conduct experiments and possibly refine them for spaceflight. The modules will permit baseline investigations that will serve as comparisons for similar experiments in the future. As the need arises from proposed investigations and test results, the VRF and VGRF will modify or increase the capabilities of the ground-based hardware.

The Flight Research Program, an integral part of the VRF/VGRF Research Project, will gradually evolve as it meets stringent Space Shuttle flight regulations (figs. 5-7). The flight modules, based on designs of the ground-based program, will perform experiments investigating the effects of zero gravity on vestibular function. Much information discovered in space will be compared with data obtained on Earth.

Once the flight program is under way, the ground-based facility will conduct post-flight studies on the readaptation of the vestibular system to "normal" gravity.

CONCLUSION

In conclusion, the VRF and VGRF will respond to the need for obtaining knowledge on the vestibular system and its relation to other motor and sensory systems. As a result, these facilities will develop a better understanding of space motion sickness. The VRF and VGRF will provide state-of-the-art components for scientists and engineers to utilize. With the capability to develop many types of experiments and a means to test flight hardware, the VRF/VGRF program will contribute significantly to the area of vestibular research. In addition, the VRF and VGRF will strengthen the relation with the scientific research community outside NASA.

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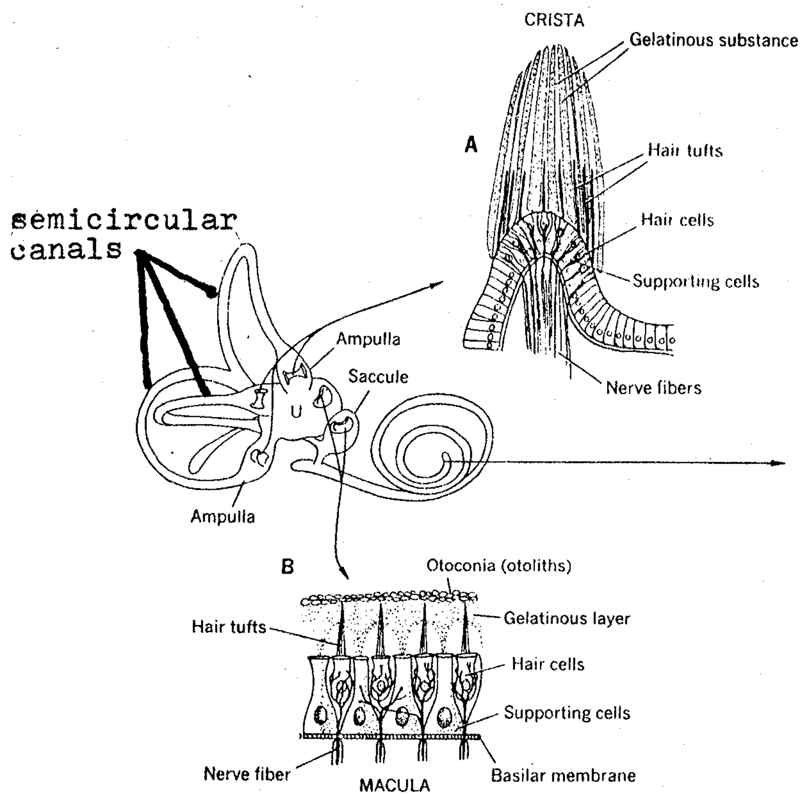


Figure 1.- Three components of the vestibular system: the semicircular canals, the crista, and the macula.

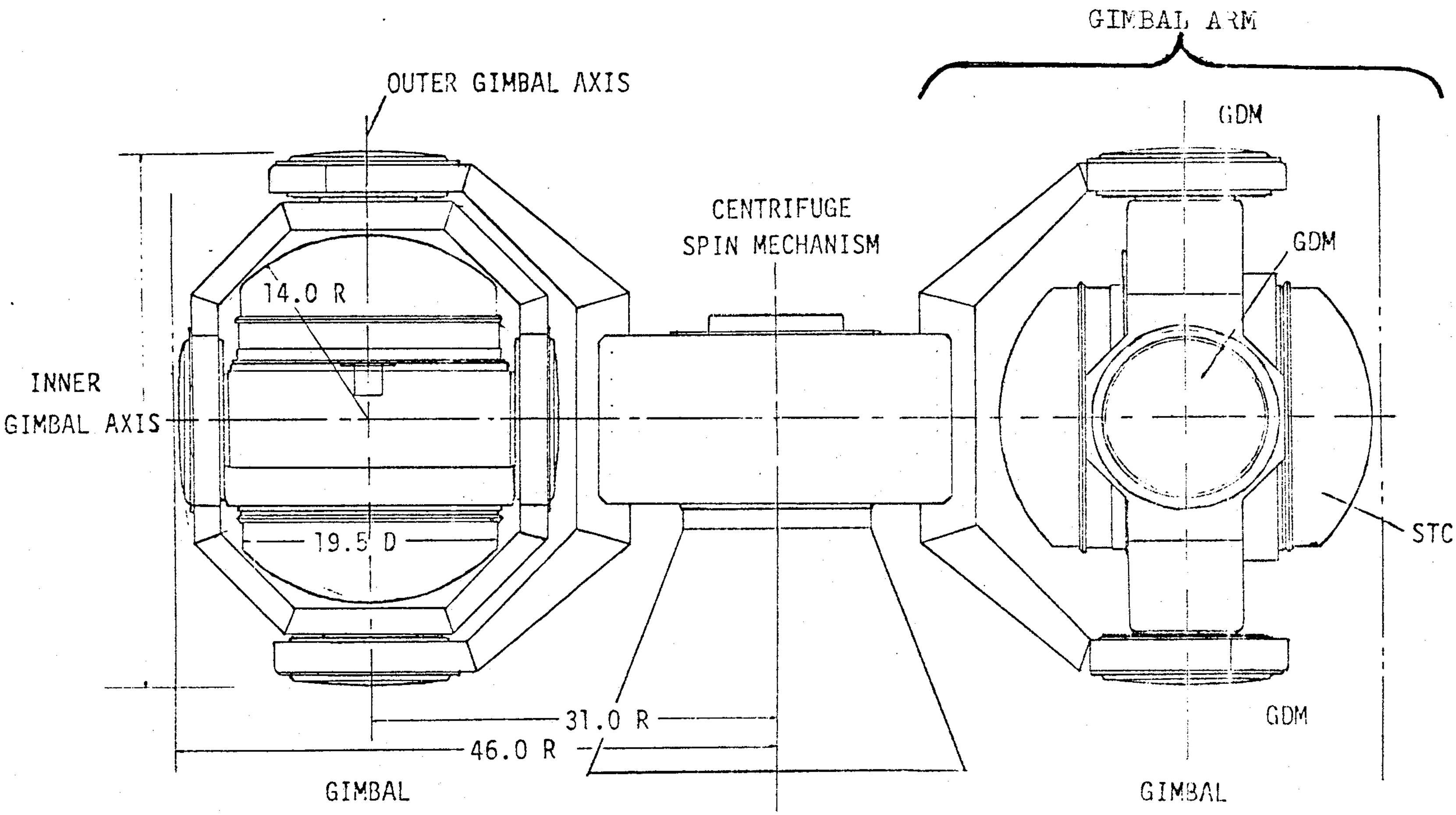


Figure 2.- Plan view of VRF ground centrifuge configuration.

VRF SPECIMEN TESTING CONTAINER

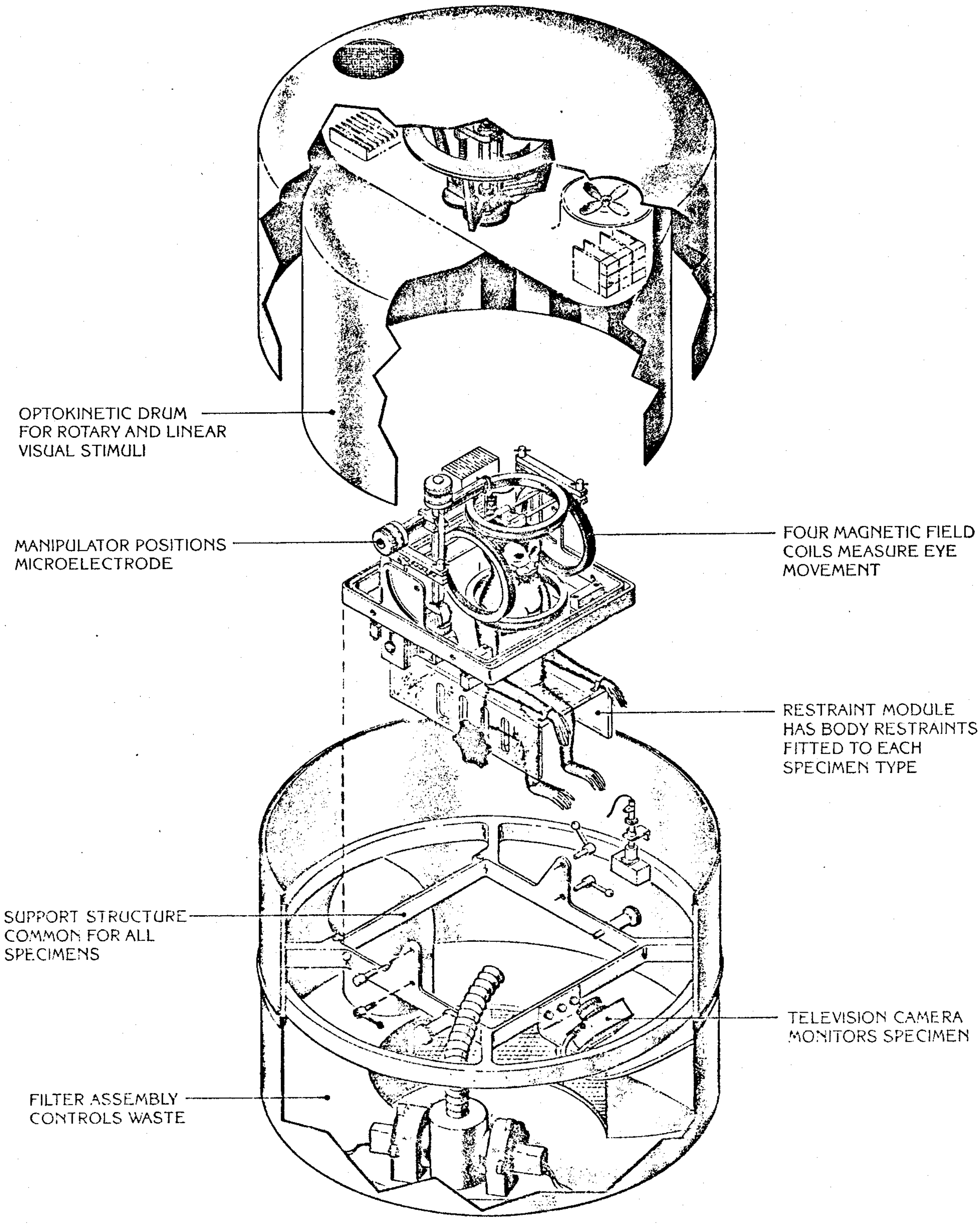


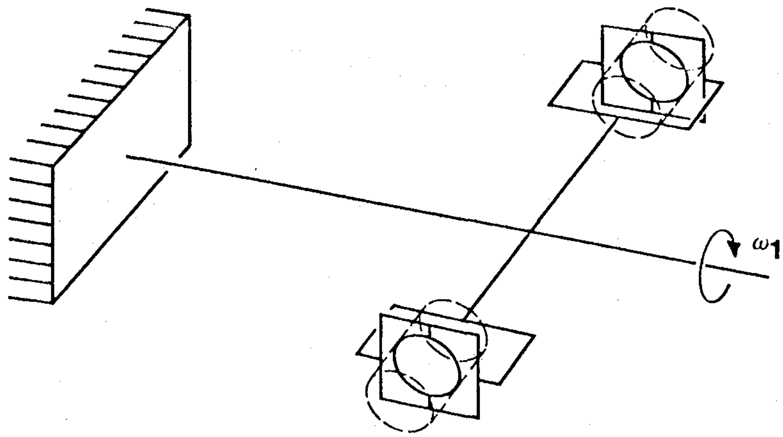
Figure 3.- Proposed arrangement of squirrel monkey subject and experiment hardware in STC.

Experimental Modes

Before, During, and After Periods of Weightlessness

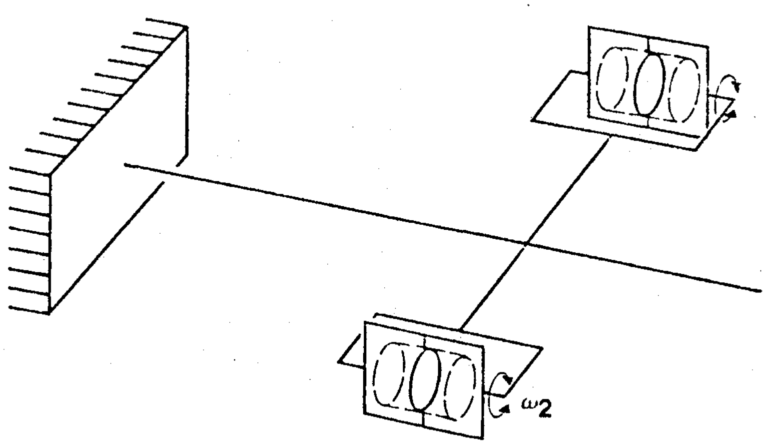
Controlled Acceleration Stimuli:

Mode 0 — Centrifuge Rotation Only
0A — Velocity Trapezoid
0B — Artificial Gravity



To investigate otolith responses to fractional accelerations up to 1.25g along any arbitrary anatomical axis.

Mode 1 — Gimbal Rotation(s) Only
1A — Velocity Trapezoid
1B — Sinusoidal Oscillation



To investigate semicircular canal responses to dynamic stimuli about any head axis. Dynamic stimuli include velocity trapezoids, sinusoidal oscillations up to 5 Hz, and wide band pseudo random oscillations.

Figure 4.- Experimental modes for VRF (two examples).

NASA Vestibular Research Facility

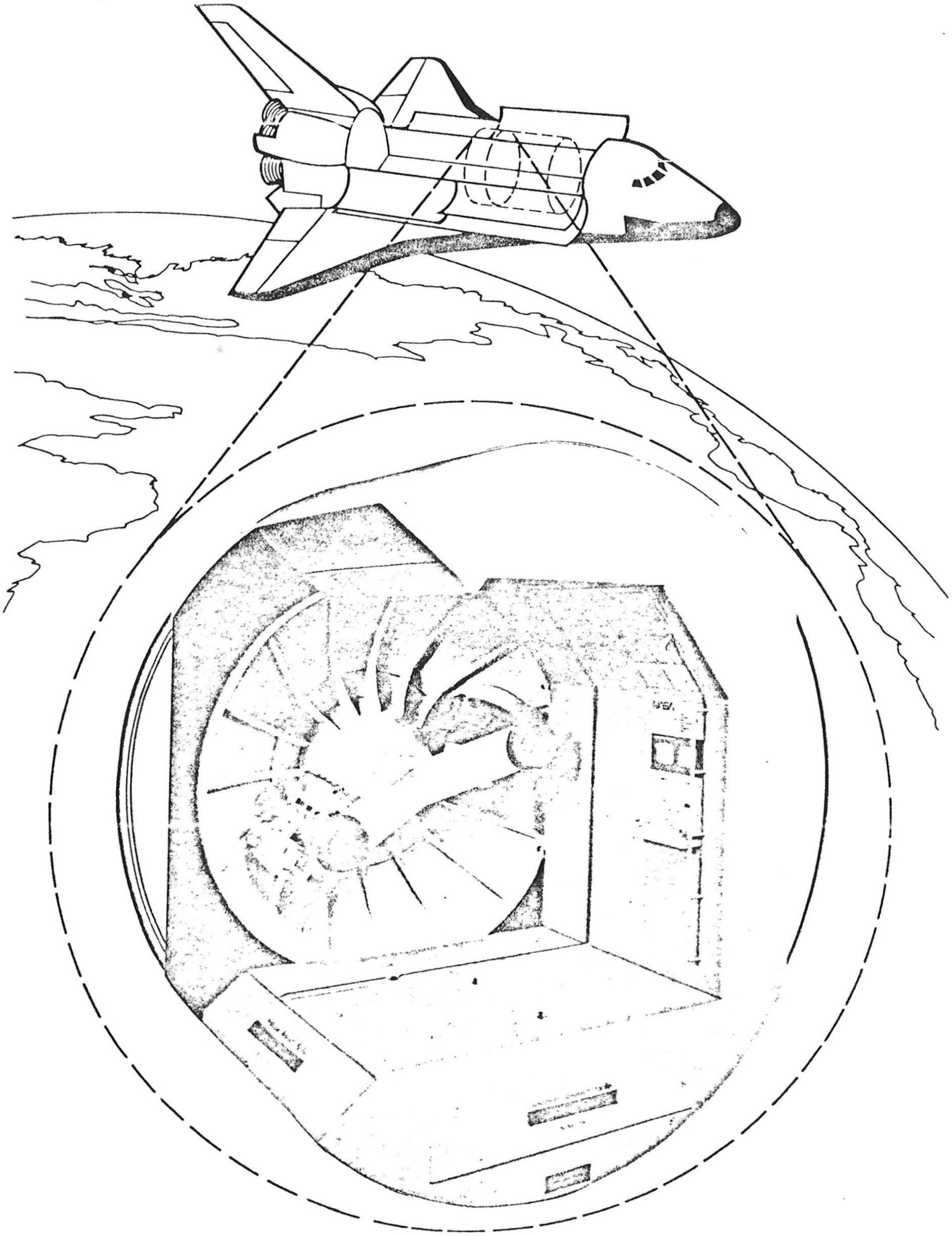
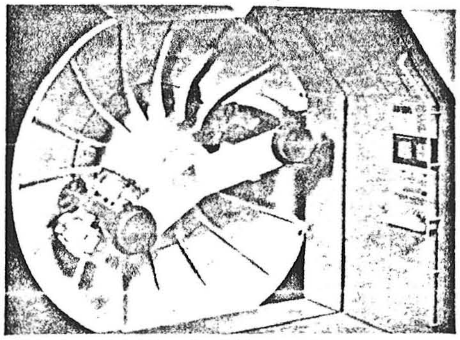


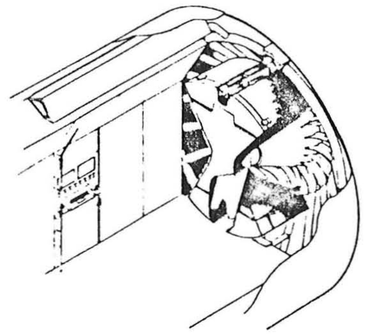
Figure 5.- The proposed flight VRF centrifuge for Spacelab.

Cost Effective VRF Modular Reconfigurations

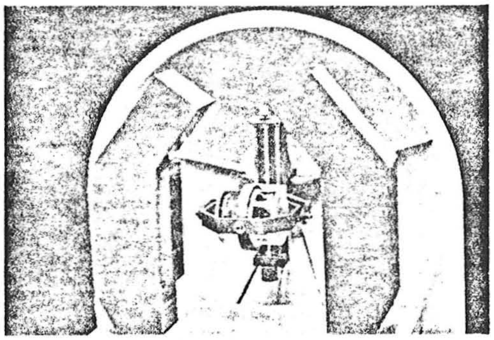
Core Modules



Basic Configuration

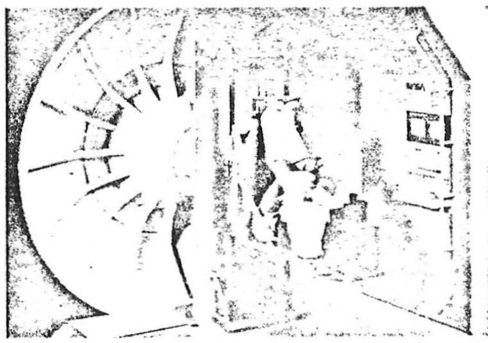


General Purpose Module mounted on Centrifuge provides "Variable Gravity Research Facility" capability

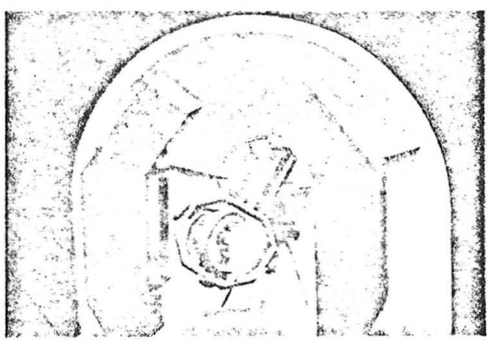


Specimen Testing Container mounted on "vertical" Linear Accelerator provides linear stimulation

Human Chair mounted on Centrifuge provides rotational stimulation



Human Chair mounted on "vertical" Linear Accelerator provides linear stimulation



Specimen Testing Container on Linear Accelerator mounted on Centrifuge provides combined linear and rotational stimulation

Human Chair mounted on "horizontal" Linear Accelerator provides linear stimulation

Figure 6.- Proposed VRF can be arranged in a variety of different configurations to meet specific payload experimental requirements.

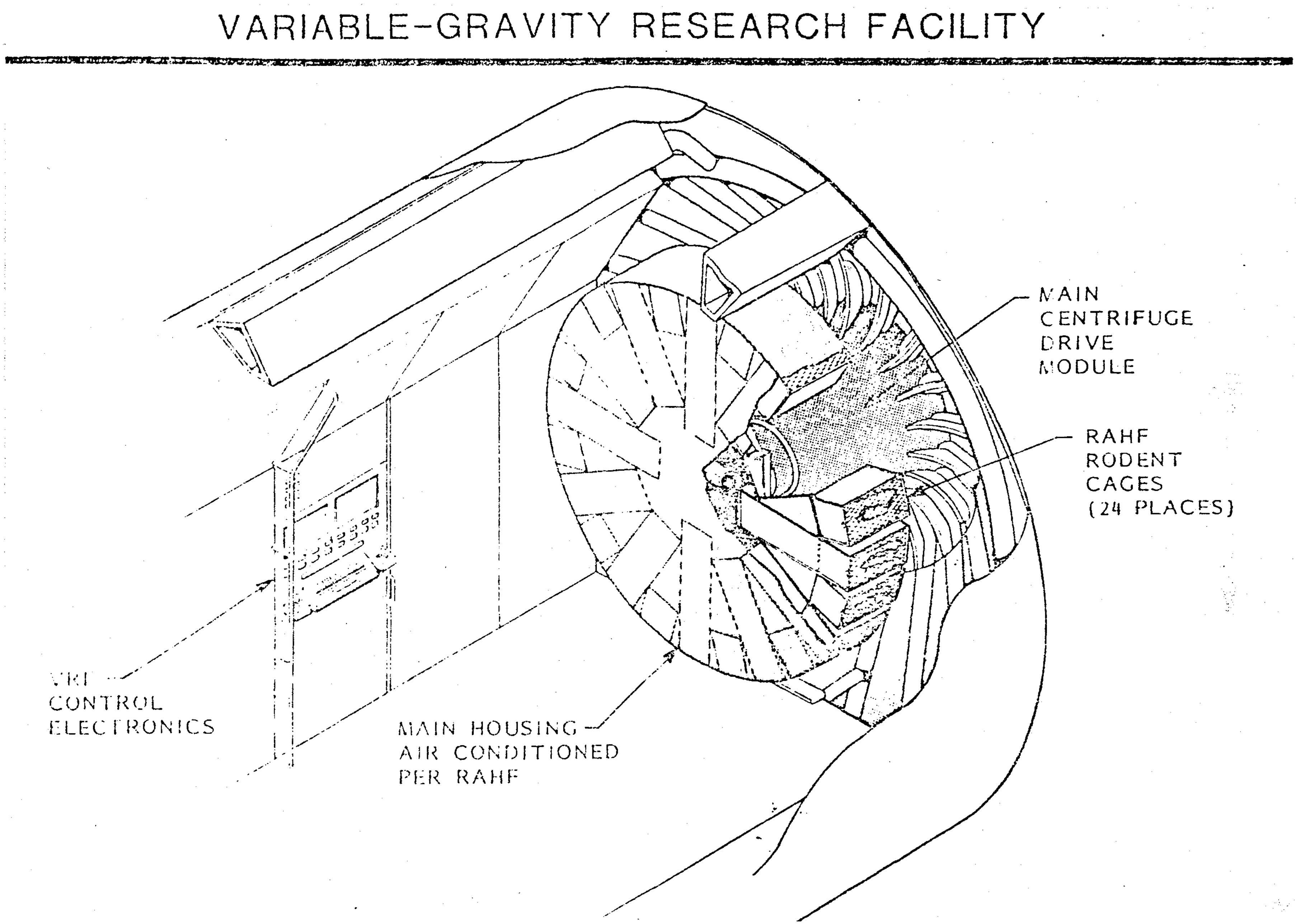


Figure 7.- Proposed location and configuration of single-platform VGRF in future Spacelab mission.

JOB DESCRIPTION

Cara Meredith

My work in the Cardiovascular Research Laboratory (CVRL) in building 236 is under the supervision of John Hines. I also work with Bruce Benjamin and Eileen Waterman.

Bruce Benjamin is conducting water immersion studies on rhesus monkeys for space science research. I assist in these studies by tranquilizing monkeys, helping in the preparation of the monkeys for the study, and recording data during the study. When studies are not taking place, I check the monkeys periodically to make sure they are in good health; I weigh them, change their jackets, and train them to sit in restraint chairs.

Eileen Waterman is in charge of the drug studies being done on dogs. Under her supervision, some of the duties I perform are weighing dogs, changing their bandages, and sling-training them in preparation for the studies. When blood samples are taken, I run them through the pH/blood gas analyzer and compare the results to accepted values of normal dogs. If the results are different from the normal values, we know that the dog could be ill and we investigate further in order to treat the dog appropriately.

The research and experimental nature of these studies make my tasks diverse and interesting, and I am truly grateful for this learning experience offered to me through the SHARP program.

SIMULATING THE EFFECTS OF ZERO GRAVITY THROUGH WATER IMMERSION

Cara Meredith

During space travel, astronauts experience weightlessness caused by a zero gravity environment. The physiological effects of zero gravity on the cardiovascular system during spaceflight are blood redistribution and a decrease in plasma volume. Upon reentry into the Earth's atmosphere, astronauts could lose some peripheral vision, and feel lightheaded and faint because of the cardiovascular changes that have occurred during their flight. Studies done on these astronauts after spaceflight have shown a decrease in their exercise capacity.

Further research established that while in space, astronauts undergo cardiovascular deconditioning. Cardiovascular deconditioning can be reversed in a short span of time, but experts think this cardiovascular deconditioning may affect the physical and mental performance of the astronauts especially during times of stress. These times of stress include extravehicular activity, reentry, and recovery on Earth. At the Cardiovascular Research Laboratory, experiments are conducted to find out what causes these physiological effects and what can be done to prevent them from happening.

On Earth, gravity makes the cardiovascular system work to circulate blood. Blood tends to pool in the legs, and the heart has to work against gravity to distribute blood throughout the body. In space, zero gravity presents no resistance to the cardiovascular system; therefore, blood circulates easily, and the heart does not have to work as hard to distribute the blood through the body. Instead of pooling in the legs, the blood redistributes and goes to the chest. Blood tends to go to the chest because of the subatmospheric pressure and the elasticity of the vessels there.

Hypothesized receptors around the heart detect the increase in central blood volume. These receptors then send messages to the brain indicating that the body's blood volume is too high. In actuality, the blood volume is the same. This is because the body is accustomed to most of the blood pooling in the legs, and not around the heart. The brain then sends messages to the kidneys telling them to eliminate the excess fluids. A diuresis is the excretion of excess body fluids through the urine. A natriuresis is the excretion of excess sodium through the urine. A diuresis and natriuresis take place as a result of the brain's message to the kidneys. The fluids and salts lost through diuresis and natriuresis may not be necessary in space, but they are essential to the body's functioning on Earth. When the spacecraft reenters the atmosphere, gravity pulls the blood back down into the legs, and suddenly the astronauts feel lightheaded and very thirsty.

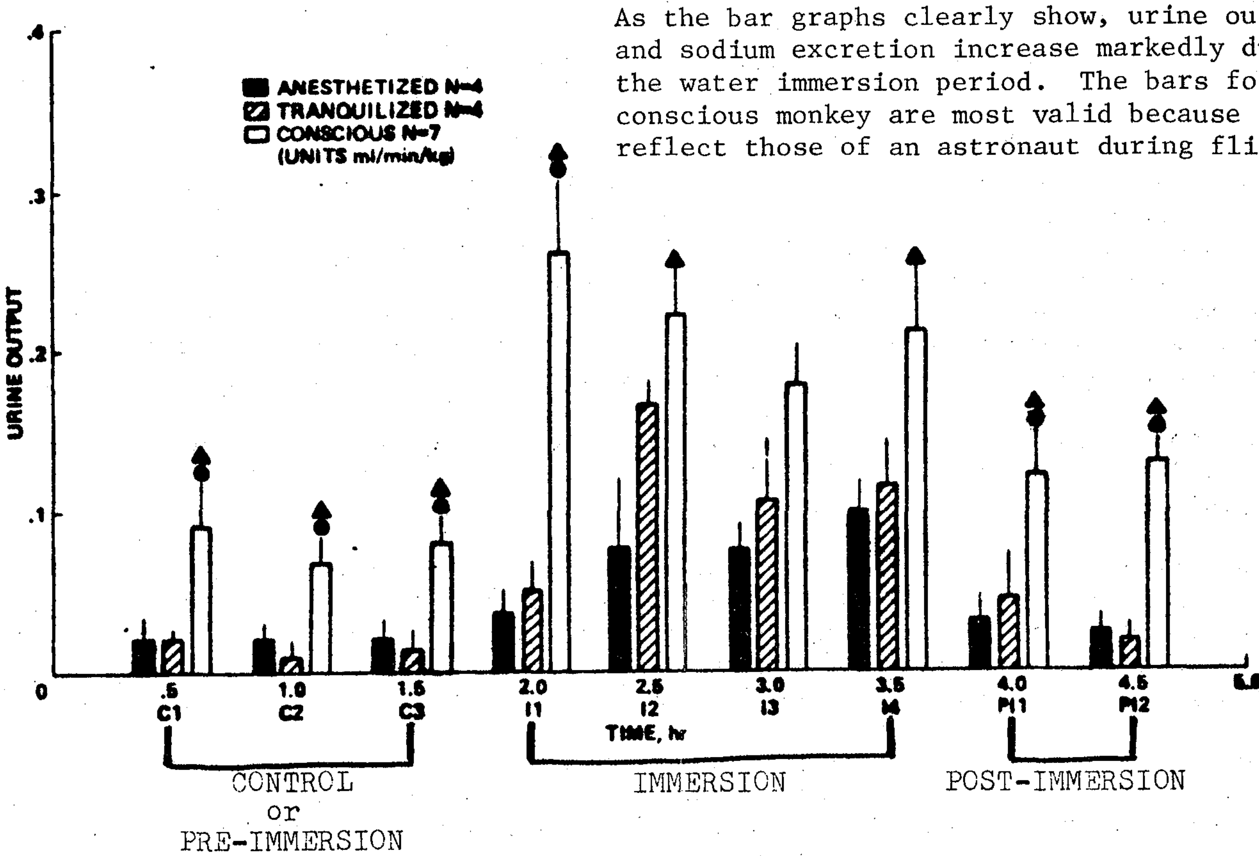
Since it is impractical and virtually impossible to duplicate zero gravity studies on Earth, water immersion serves as a good simulation in which to study weightlessness. Rhesus monkeys are conditioned to sit in specially designed, primate restraint chairs prior to a study. A chaired monkey is placed in a tank which is similar to a hot tub. The monkey usually stays in the tank for a period of 5 hr. The main sources of data collected during a study result from blood and urine analyses. A study consists of the following: a pre-immersion control period, an immersion period, and a post-immersion period. These three phases of a study relate to preflight, spaceflight, and reentry, respectively. The water immersion studies have been effective in that the rhesus monkeys experienced the same problems that the astronauts experienced in space (fig. 1).

Now that the investigators know the physiological effects of weightlessness, they are going to do research to determine exactly what causes the body to react the way it does. When that is learned, they will go on to try to find ways to prevent the negative effects of cardiovascular deconditioning.

ACKNOWLEDGMENTS

I would like to express my gratitude toward everyone in the CV Lab, especially Bruce Benjamin and Eileen Waterman, for their assistance and support during my summer here at NASA Ames Research Center. I would also like to thank Patricia Powell and the SHARP coordinators for all the time and energy they expended to make my summer an enjoyable and memorable learning experience.

As the bar graphs clearly show, urine output and sodium excretion increase markedly during the water immersion period. The bars for the conscious monkey are most valid because they reflect those of an astronaut during flight.



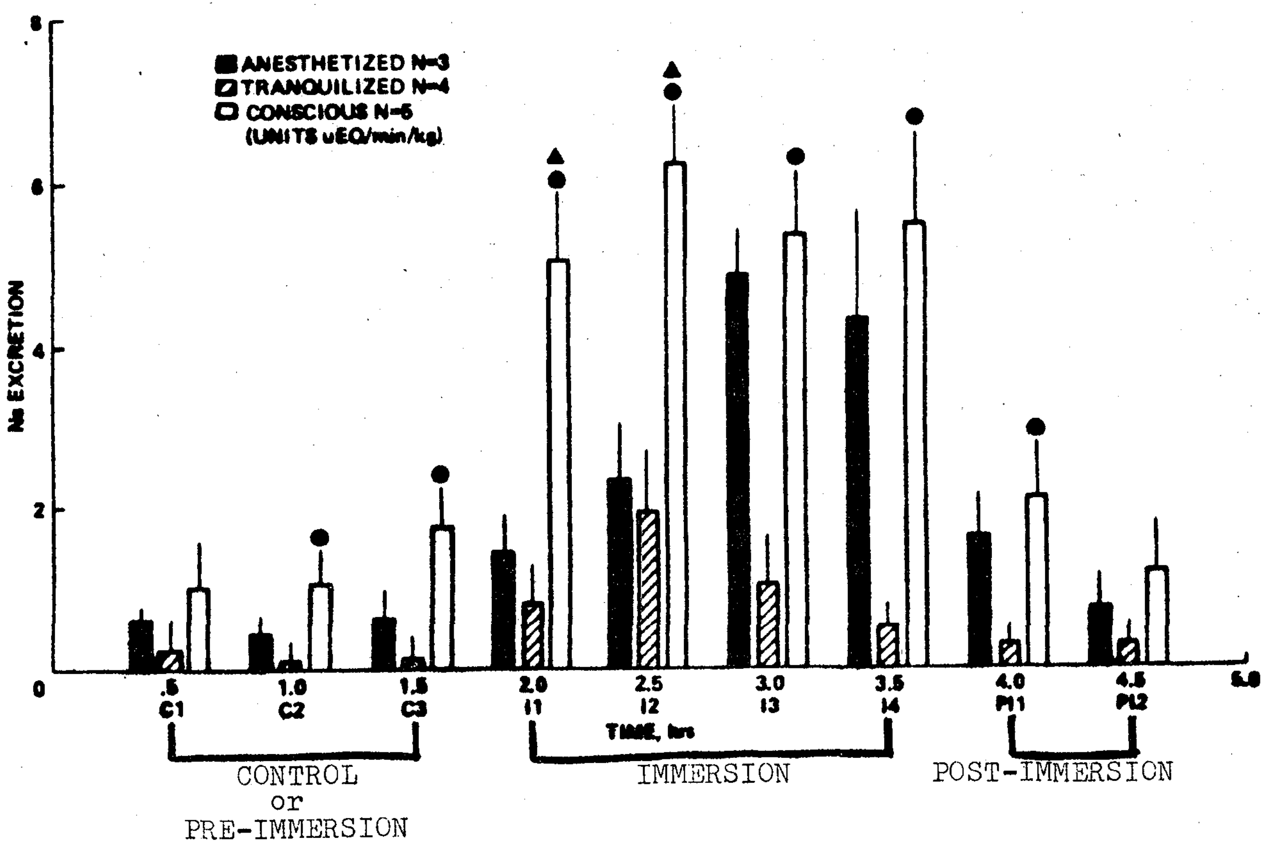


Figure 1.

JOB DESCRIPTION

Carrie O'Donnell

I work in the extraterrestrial division of the Life Sciences Building; specifically, the Closed Ecological Life Support System, or CELSS for short. The purpose of CELSS is to develop a self-sufficient, closed system that will operate as a space station. CELSS incorporates waste management, food production, human requirements, and systems management into one system for planetary lunar bases, long duration missions, and large space stations. The space station will maintain a balance between the gases in the air, and provide fresh food for the astronauts.

Our lab is running four experiments, all supervised by our principal investigator, Dr. Steve Schwartzkopf, who is working at ARC through the University of New Hampshire.

The entire laboratory is basically designed to support an aeroponic growth chamber. This chamber has highly accurate controls, allowing plants to be grown under specified conditions. Aeroponics is the method of growing plants by spraying the nutrient solution onto the roots. We have a lettuce plant in the chamber for preliminary studies because we have never grown a lettuce plant in the chamber before.

One major experiment is conducted in an environment room, using hydroponics to grow the plants. Hydroponics is the method of growing plants by submerging their roots in the nutrient solution. This particular experiment is testing the effect of killing the bacteria in the nutrient solution by use of ultraviolet light.

Another experiment, designed and conducted by Kevin Tavenner, an undergraduate at UC Berkeley, is for testing various bacteria-elimination processes. He has five methods: one solution is left stagnant, the second is the control, the third is treated with ultraviolet light, penicillin is added to the fourth solution, and ampicillin is added to the fifth.

I have worked on all of these experiments, but most of my time is spent working with Yvonne Yeh, a fellow SHARP student, on our experiment — carbon dioxide (CO_2) spiking. We are testing the effect of different concentrations of carbon dioxide on lettuce and tomato plants. We designed and built miniature greenhouses to hold the plants, and we have set up a system to analyze and inject the CO_2. The four different concentrations we are using are: 350, 2000, 4000, and 8000 ppm CO_2. We have done most of the work ourselves, with advice from Dr. Schwartzkopf.

THE EFFECT OF CARBON DIOXIDE ON LETTUCE SEEDLING GROWTH

Carrie O'Donnell

SUMMARY

Grand Rapids lettuce plants were grown at 350, 2000, 4000, and 8000 ppm CO_2. Four chambers were built to test the different concentrations. Plants grown in 2000 and 4000 ppm CO_2 grew the most, while those grown in the 350 and 8000 concentrations grew the least. Increased CO_2 concentration (more than the average in Earth's atmosphere) is beneficial to plants, but too little or too much CO_2 can inhibit plant growth.

INTRODUCTION

Closed Ecological Life Support Systems (CELSS) is a program of the Extraterrestrial Research Division at NASA Ames Research Center. Its purpose is to develop a self-sufficient, closed system that will operate in a space station — one that maintains a balance between atmospheric gases, and provides fresh food for the astronauts. To do this efficiently, many factors have to be considered and the best environment possible must be created. Many experiments have already been run to meet this goal, and this particular experiment is designed to find the best CO_2 concentration for growing plants, specifically, Grand Rapids lettuce seedlings. The Earth's atmosphere averages about 350 ppm CO_2. Many scientists have already found that plants grow better at higher concentrations of CO_2. The null hypothesis being tested is: Increasing the CO_2 concentration has no effect on the growth of lattuce plants, in relation to height, wet weight, and dry weight.

MATERIALS

1. Two crates (17 in. × 17 in.)
2. 1/8-in. wire
3. Plastic film wrap
4. Labeling tape
5. Duct tape
6. Fine wire
7. Plexiglas (8 pieces — four 1.5 in. × 13 in. and four 8 in. × 8 in.)
8. Tygon tubing
9. Grand Rapids lettuce seeds
10. Potting soil

11. Plant pots (36 for each type of plant) (two types were used in this experiment; this report focuses on the lettuce plants)

12. Water

13. CO_2 tank

14. Pump

15. Flow meter

16. CO_2 analyzer

17. 1/8-in. pipe

18. Eight size 3 rubber stoppers

19. Measuring devices for height and mass

20. Aluminum foil

21. Fluorescent lights

22. 50 cc hypodermic

23. 10 cc hypodermic

24. Swage locks

METHODS

To set up the experiment, first of all, small greenhouses were built by cutting the two crates in half and drilling two holes in the fronts of each of the halves. These holes were filled by size 3 rubber stoppers with size 1 holes bored in them. Next the long pieces of Plexiglas were fitted across the open sides of the crates and taped in place. The 1/8-in. wires were bent to fit diagonally across the crates. The back and sides of this structure were then covered with plastic film wrap. The two front vertical wires were covered with Tygon tubing. The Plexiglas doors were then placed across the fronts of the crates and taped and wired in place. A 1/8-in. pipe was put through each rubber stopper and a 6-in. piece of Tygon tubing was attached to the outer ends of the pipes and clamped off. A 12-in. piece of Tygon tubing was attached to one of the inner pipes in each chamber. Finally, the greenhouses were labeled for 350, 2000, 4000, and 8000 ppm CO_2 (fig. 1).

Next, the pots were sterilized in household bleach and filled three-quarters full with potting soil. Two seeds were placed in each pot, about 1/2-in. below the surface. The pots were then placed in a tub filled with 1-1/2 in. of water. The surface of the soil was watered, and nine plants were placed in each greenhouse. The fronts of the greenhouses were sealed and the seeds were allowed to germinate for several days.

The plants were grown under fluorescent lights and the chambers were surrounded by aluminum foil on four sides to increase the light intensity. Foil was also placed across the shelf that the plants rested on (fig. 2).

Then, the CO_2 analyzing system was set up by attaching Tygon tubing from the pump to the flow meter, and from the flow meter to the CO_2 analyzer. Long leads were also attached to the input on the pump and the output on the CO_2 analyzer. The 1/8-in. pipes and Swage locks were used for these fittings. The 1/8-in. pipes (1 1/2 in. long) were also attached to the leads. When the level needed to be checked, the leads were attached to the Tygon tubing on the greenhouses and the pump was turned on (fig. 3).

When this was all set up the greenhouses were opened, and the extra plants were removed from each pot by cutting the stem at the surface of the soil. Only one plant was left in each pot. The wet weight of the sacrificed plants was determined by weighing the plants individually, and the dry weight was obtained by counting the plants, drying them in an oven for 2 days (at 65°C), weighing the total, and dividing by the total number of plants. The height of the plants left in the pots was then determined, the plants were watered and placed back in the greenhouses, and the greenhouses were resealed.

The volume of the individual greenhouses was then determined (length by width by height) and the amount of CO_2 that should be added to each greenhouse was found. Next, two hypodermic needles were filed down. The greenhouses were then injected with the proper amount of CO_2 by filling the hypo from the CO_2 tank, removing the clamp on the tubing, and injecting the CO_2 into the tubing. The level of CO_2 was checked every day, and, if the level was too low, more CO_2 was added using the same method as before, but lesser amounts. If the level was too high, the air was pumped out until the level was correct. This was done by connecting the lead from the greenhouse to the pump only, and not the one from the analyzer to the greenhouse.

The plants were then left to grow without any further interference until it was time to harvest them; in this case, 3 weeks after planting. The plants were measured, and then cut at the base of the stem. The wet weight and dry weight were determined for each plant.

RESULTS AND DISCUSSION

The height of the plants was too inconsistent to be considered valid data, but the most important data, the biomasses, showed significant results. By comparing the average dry weight for each chamber, it was found that the plants grown in the 2000 and 4000 concentrations were heavier, while those in the 350 and 8000 concentrations weighed less (fig. 4). The wet weights, used mainly to show the general health of the plants, indicated that the plants in the 2000 concentration were the healthiest, the plants in the 4000 and 8000 concentrations were in the middle, and those in the 350 concentration lagged behind (fig. 5).

It was also noticed that the number of leaves was fairly constant throughout the four chambers, and the leaves were generally yellow to light green.

There were many problems with this experiment. First of all, the chambers leaked, so polyethylene bags were fitted over them. This made the greenhouses airtight, but, unfortunately, it cut down on the light intensity, too. Also, the temperature was too high. The average was about 86°F, while 75°F would have been more appropriate. Finally, the humidity level was too high (100%).

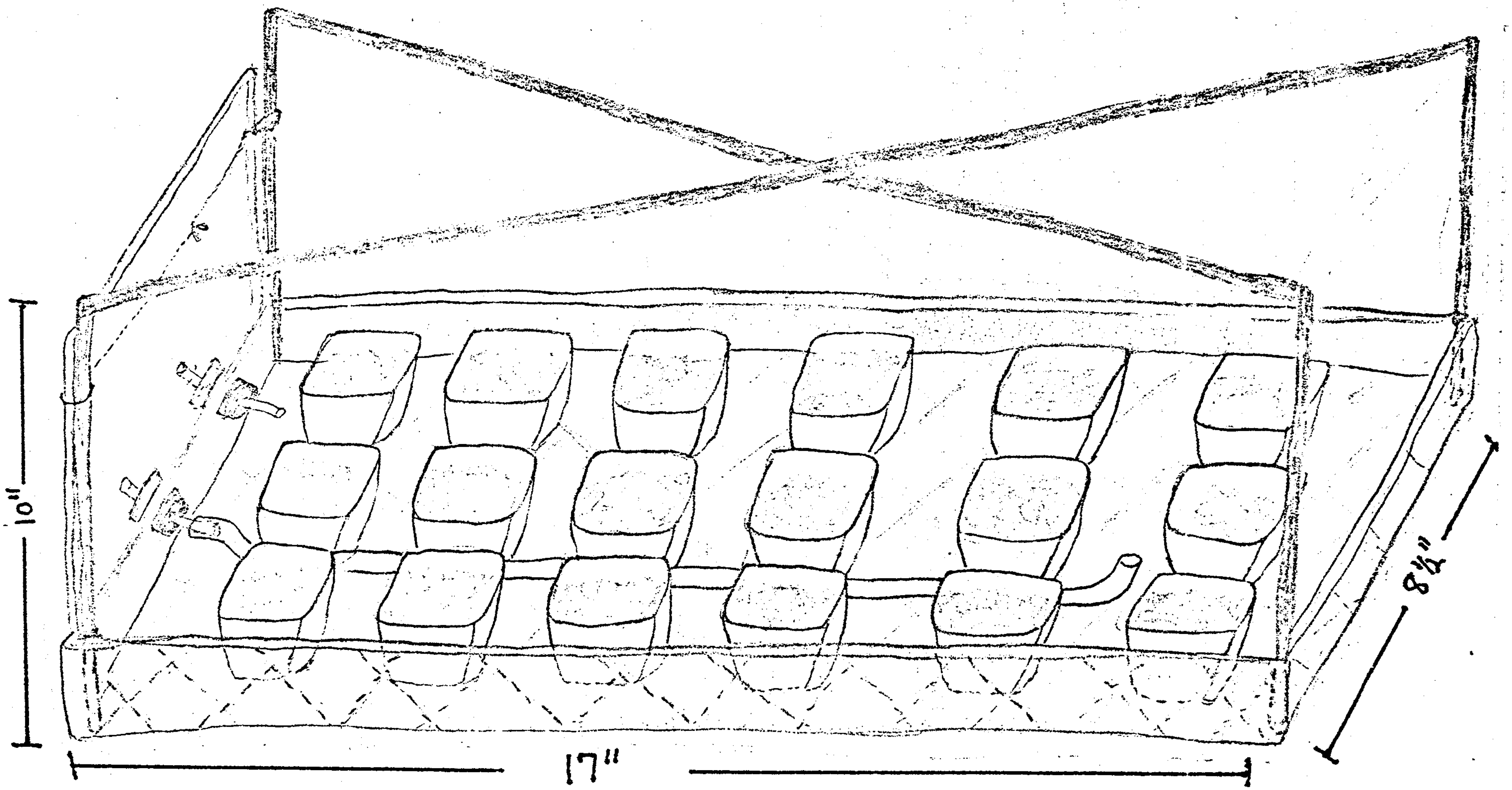
This experiment will be run again to clarify the results, but many changes will be made first. The new system will utilize hydroponics, a more efficient method of growing plants by submerging the roots in a nutrient solution. The chambers will be made of Plexiglas so as not to cut down on the light intensity. Finally, to help solve the problem of high temperature and humidity, a cooling coil will be run through the system.

CONCLUSION

Increasing the CO_2 concentration has a beneficial effect on the growth of lettuce plants, up to a certain point. The best level, as indicated by the results, is approximately 2000 ppm CO_2.

ACKNOWLEDGMENT

I would like to thank Dr. Steve Schwartzkopf for all the help and information he has given me on this experiment.



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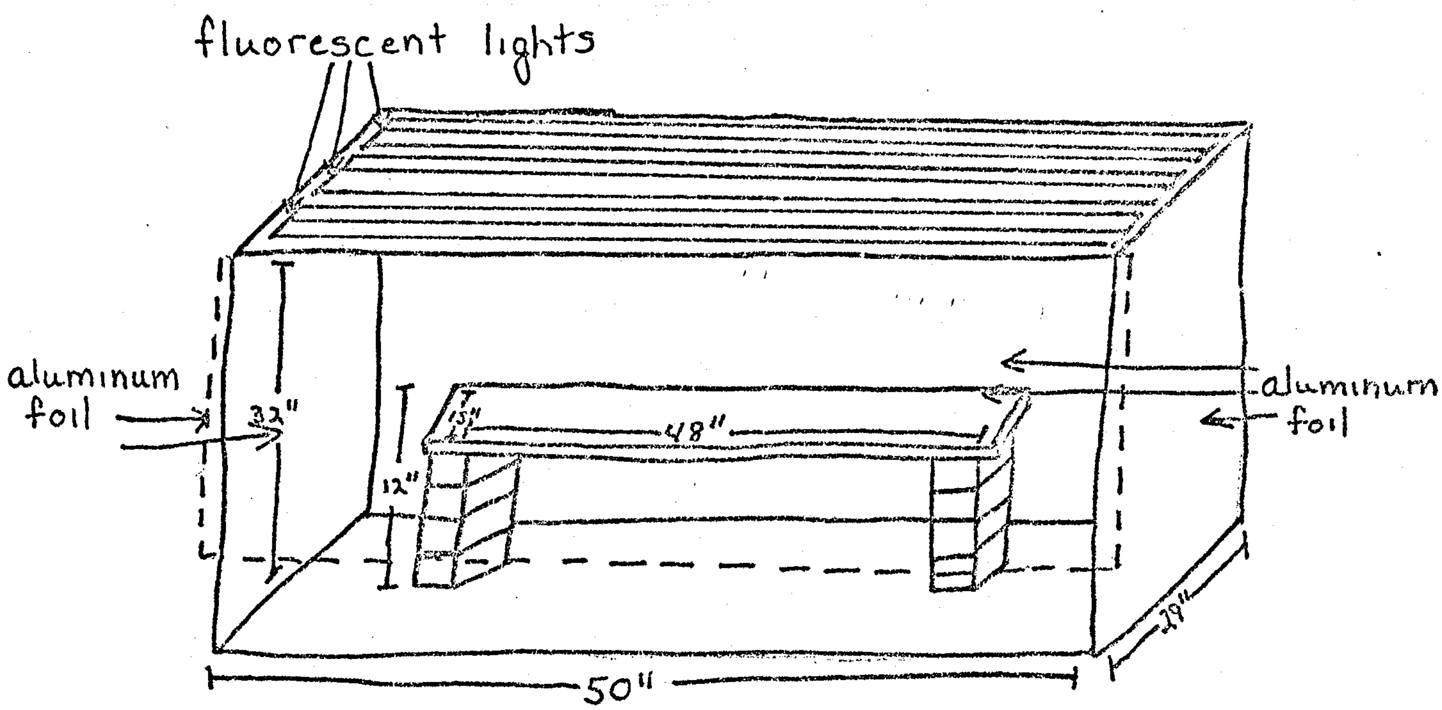

Figure 2.

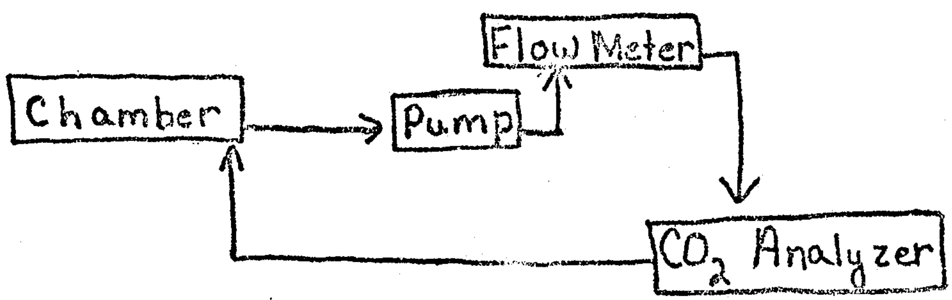

Figure 3.


Dry Weight
.009
.008
.007
.006
.005
.004
.003
.002
Grams
350
2000
4000
8000
ppm CO_2

Figure 4.

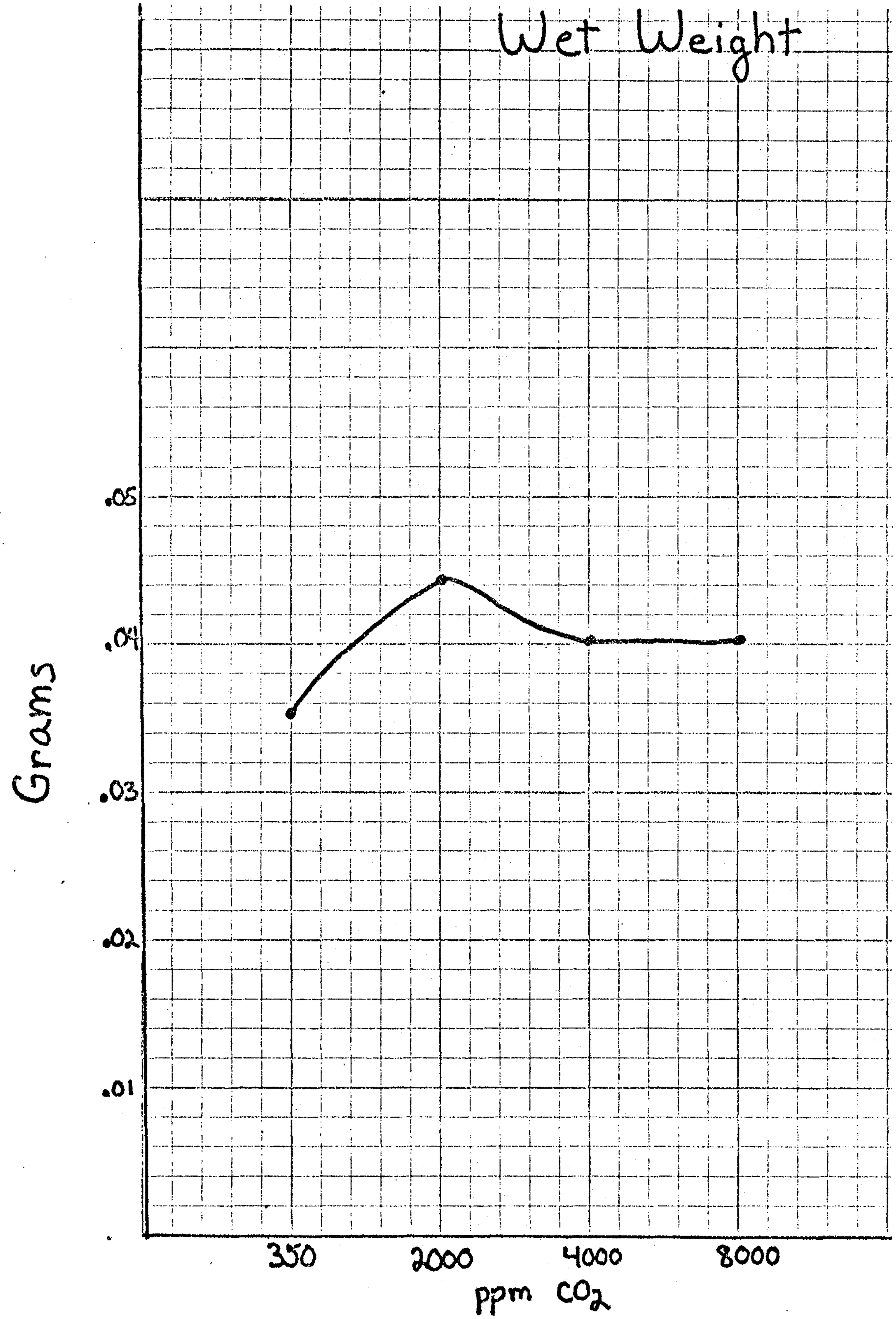

Figure 5.

JOB DESCRIPTION

Linda Rhough

Bonnie Dalton, the Test and Operations Manager, is my official supervisor, but I work mainly with a team of engineers employed by MATSCO, a company contracted by NASA Ames Research Center. The people in this building, the Life Sciences Flight Experiment Facility, work almost exclusively on the Life Sciences Payload Project that is to be included on Spacelab Mission 3.

My job here involves a variety of different skills. One of the most interesting things I do is to help the engineers test and integrate equipment belonging to the Life Sciences Payload. I get the opportunity to watch, learn, and actually take part in numerous testing operations. The computer science field has also been a part of my learning experience here. I learned how to use the VAX/VMS computer in its editing mode; now I input and edit files for my supervisor's future use. I have also been drawing several diagrams which schematically show test configurations in test procedures.

I feel that my job here at NASA has made me more aware of its working environment and of the responsibilities that accompany it. The skills and knowledge that I have acquired here will help me to choose the profession which I think I might best enjoy, and to function correctly in a working environment.

SPACELAB MISSION 3: RAHF, BTS, AND DEMS

Linda Rhough

Toward the end of 1984 the Shuttle Columbia will undergo another spaceflight called Spacelab Mission 3 (SL-3). The Shuttle will be the host of 11 experiments, three of which will be the responsibility of NASA Ames Research Center. These three experiments combined are known as the Ames Research Center Life Sciences Payload and are designed with the purpose of learning more about the effects of space on animals and about the performance of newly introduced data equipment. All three experiments, The Research Animal Holding Facility Verification Test (RAHF-VT), the Dynamic Environment Measurement System (DEMS), and the Biotelemetry System (BTS), will be located in the Spacelab module of the Shuttle where four other experiments will also be taking place (fig. 1). NASA Ames Research Center's contribution to the Life Sciences Payload will lie principally in setting up the equipment and making sure it operates correctly. Once simulation testing is completed, the flight equipment will be sent to Kennedy Space Center where it will be refitted for the Shuttle Spacelab itself.

The RAHF system, consisting of both a rodent RAHF and a squirrel monkey RAHF, is able to hold 24 rats and four squirrel monkeys. The two RAHFs are capable of monitoring the temperature, humidity, and environmental control system within each cage as well as each animal's activity rate, water intake, and food intake. Eight of the animals, four rats and four monkeys, will be monitored for their internal impulses and only four rats will be filmed on camera.

The activity rate is monitored by a sensor placed in the center of the cage. A laser beam from one side of the cage is projected to a receiver on the other side of the cage and each time the animal passes through the beam, his action is monitored and the count is advanced. The activity rate of the animals is monitored in order to measure the amount of stress that the animals undergo throughout all periods of the flight.

The drinking water intake of the animals is measured by the lixits contained within each cage. Each of the monkey cages and the top eight rat cages contain one lixit per animal. The bottom four rat cages, however, contain two lixits per rat. This is because the bottom rat cages were made to be able to accommodate mice also, which would occupy half the space it takes to accommodate rats. Each drink of water that is taken from the lixits is monitored by a counter.

The amount of food eaten by the animals is monitored in two different ways. The rat's food is in the form of a long, rectangular tube-like food bar. Because of this form, each bite that the rat eats cannot be counted. Instead, a string is attached to the length of the food bar and is pulled backwards as the food bar is eaten. Each time the rat eats 1/8 in. of the food bar, the counter is advanced. For squirrel monkeys, on the other hand, there is a more complicated system. The monkey food comes in the form of small pellets. Each time a pellet is taken, the counter advances one count. However, to obtain a pellet, the monkey must first tap a lever a certain number of times. The monkeys are trained beforehand to tap the lever, and the number of taps necessary to receive a pellet aboard the Spacelab Shuttle is the same number that is used in the monkeys' training. This method of obtaining food is a different method for measuring stress on the monkeys. A number of uneaten pellets lying on the floor indicates that a monkey is tapping the lever due to a nervous reaction and not due to hunger.

All four of the monkeys and four of the rats are implanted with transmitters to monitor their electrocardiograph (ECG) and deep body temperature (DBT). The four monitored rats are spread out into cages 2A, 3A, 6A, and 10A. The ECG and DBT readings enable scientists to monitor the general state of health of the animals. The ECG is a good indication of stress, and the body temperature is a good indication of health.

The movie camera is set up to film only the bottom four cages of the rats. The purpose of the camera is to enable scientists to see the rats' reactions during launch, flight, and reentry. The camera will take a series of photographs at periodic intervals from 7-1/2 min to 60 min. Some of the more important shots will be taken during the launch and reentry phases. Because the rats and monkeys are naturally nocturnal and because it is impossible to take pictures during the night, the more important shots will be taken toward the end of the day cycle.

The ECG and DBT readings are sent to the Biotelemetry System (BTS). Within the BTS, the animals' heartbeat count is calculated from the ECG. Then the ECG, the heartbeat count, and the DBT of the animals are sent to the Life Sciences Laboratory Equipment (LSLE) Microcomputer where the data are converted into digital signals. From the LSLE, the data are sent to the High Rate Multiplexer (HRM) which also contains the data from all the other experiments aboard the Shuttle. The HRM organizes all the different data into one datastream and then sends it to the ground via the Tracking and Data Relay Satellite System (TDRSS). On the ground, the data are sent to the High Rate Demultiplexer (HRDM), where the data are demultiplexed and converted by a computer to analog signals or other forms for analysis.

The activity rate, cage temperature, and food and drink count are monitored through the Command Data Management System (CDMS). The data first go to the Remote Acquisition Unit (RAU) which, acting somewhat like the LSLE Microcomputer, converts the analog signals to digital. Then the data are sent to the experiments computer on board the Shuttle and converted back into analog signals or into some other form. From there, the information is sent to the Data Display Unit (DDU) for the payload specialists to see, and also to the HRM for it to be sent to the ground.

The Dynamic Environment Measurement System (DEMS) monitors three different aspects of the environment that surrounds the animals. These three aspects are the acoustics, the vibration, and the acceleration of the Shuttle's cargo bay. The purpose of monitoring the environment is to enable scientists to take into account the conditions that the animals went through and, from that, to understand more fully the reasons for any reactions that took place.

The purpose of the RAHFs on SL-3 is to perform an engineering evaluation of the RAHF system and to provide a final biocompatibility assessment between selected animal specimens and the RAHF under space conditions. The other understood benefits of the mission, however, will be the abundance of new data and information that will be received. The information supplied by the internal transducers and by the measurements of the animals' drink and food intake will provide important new data for scientists to understand more about the effects of spaceflight on the human body. The rate of activity and the results from the movie camera will give scientists more insight into the effects of spaceflight in relation to human behavior.

From the information on SL-3, scientists can progress a little further into space experimentation to come to a more complete understanding of humans in space. SL-3 is just the beginning of a series of experiments to open our eyes to new areas of learning and knowledge. Hopefully, SL-3 will open new vistas for future experiments to follow and will enable SL-4 to be a complete success.

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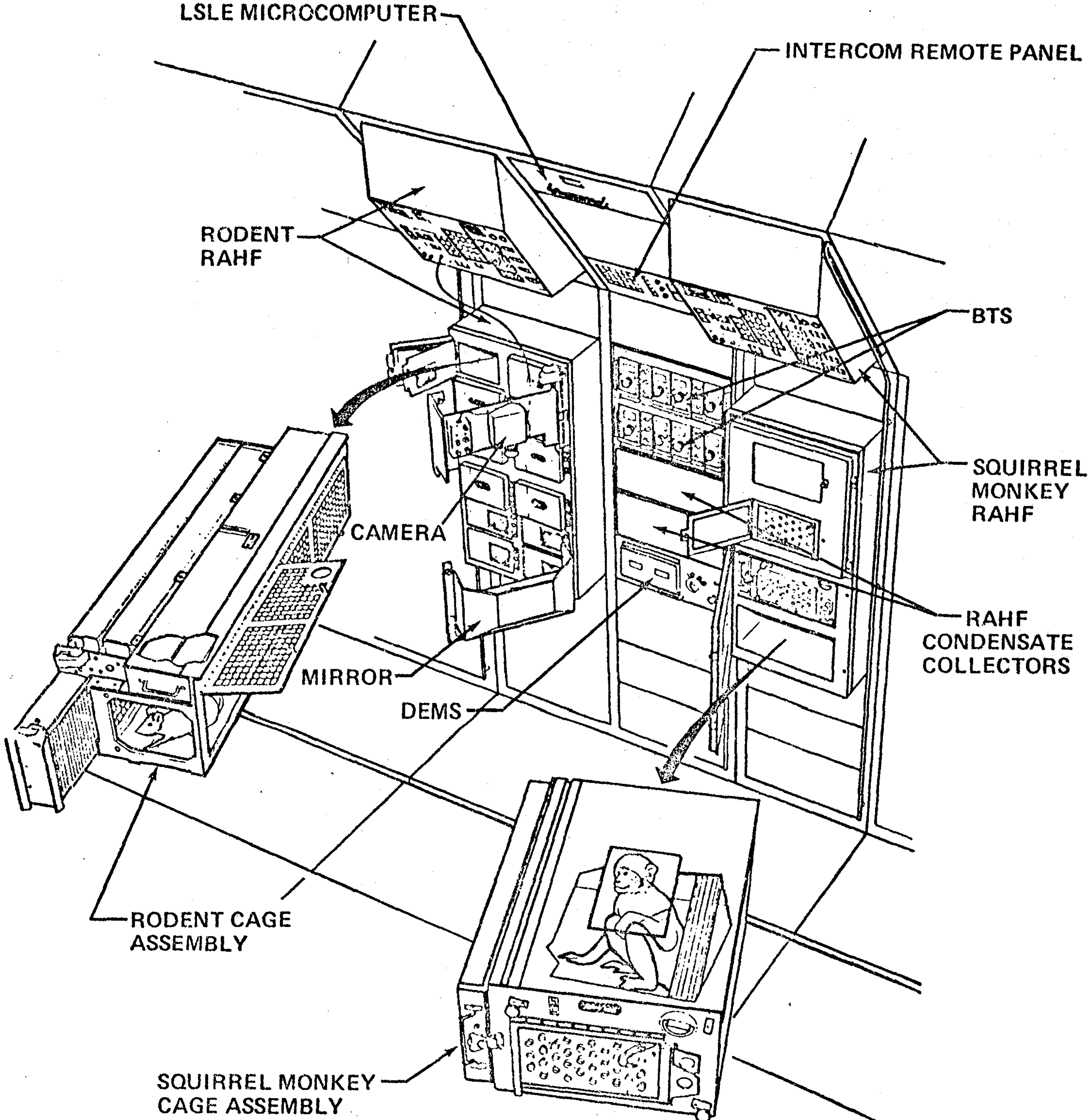

Figure 1.- Ames double rack (ADR) and Ames single rack (ASR); representation of RAHF-VT, DEMS, and BTS.

JOB DESCRIPTION

Kathy Smith

My supervisor, Major Charles Adam, needed several days to fully explain our project to me and my coworker, Lai Chi Yip. The blueprints for the CH-47 Chinook helicopter were in dire need of reorganization. Not only did they need to be put back in order and have duplicates removed, but they needed to be put on aperture cards (computer cards with a photographic negative on the right side) and have the appropriate information punched on each card. This was our long-term project for the summer.

What made our job different and definitely more challenging was that we worked on our own, without direct supervision most of the summer. Though many people could offer us help and advice, we were forced to make many decisions on our own.

Building 210, room 103, was our home for the first few days of the project while we worked and arranged blueprints into numerical order in piles by manufacturer. The remainder of our summer was spent in building 211, in a small storage room, room 252, affectionately referred to as the "broom closet." We were taught to use the 3M 2000 E processor and camera, and the IBM 029 card punch machine. After experimenting on our own and seeking the advice of more knowledgeable people, we learned to produce an aperture card that would make a good print, and a program card that would correctly set our tabs. We were in business.

Unfortunately, we encountered many obstacles along the road. Quickly we discovered that our original card punch machine was too old to be operative, but the keyboard of our new one froze and remains unfixed to this day. So most of the time we found ourselves in building 210, room 222, using the card punch machines up there. We had even less luck with the processor camera over the course of the summer. It was producing blank cards. The corners of the film were smudged. The cards wouldn't feed automatically and we ran out of chemicals; all in all, countless cards and many hours were wasted.

Despite some drawbacks, I've really enjoyed working here at NASA Ames. I've been given a chance to see what working in the "real world" is like, an opportunity many teenagers never get. I've been able to ask them questions about career choices: necessary education, salary, benefits, opportunities for advancement and travel. This is experience and knowledge that I couldn't have gotten from any textbook. Even though the work tends to be tedious, it's still a whole lot better than working just about anyplace else.

THE HISTORY OF THE CH-47 HELICOPTER

Kathy Smith

The importance of helicopters in aviation history is undeniable. Now, as in the past, helicopters are utilized around the world for varied military and commercial purposes. Although helicopters cannot fly as fast or as far as conventional airplanes, they have the unique ability to take off and land vertically, requiring very little space for the process, while airplanes require extensive open spaces for a runway. In addition, most helicopters are able to stabilize themselves for a period of time and carry heavy external sling loads, making them ideal for rescue missions. This paper will deal with the history of the Boeing Vertol CH-47 "Chinook."

Although the initial plans for the Vertol Model 114 tandem-rotor helicopter were begun in 1956 (ref. 1), it was selected in 1959 as the winner of a U.S. Army design competition for a "battlefield mobility" helicopter, with a design criterion of being capable of carrying a 2-ton load internally or 8 tons on an external sling. The design was based on an earlier model, the 107, but was considerably larger and with a number of new features (ref. 2). It was designated by the U.S. Army as the "CH-47 Chinook" (meaning the 47th design cargo helicopter). It is still today the Army's standard medium transport heliocopter. Although over the years many changes have been made and new models have been introduced (four to date: CH-47A, CH-47B, CH-47C, and CH-47D) the basic Chinook design remains the same.

The CH-47A was the initial production line version, a twin-turbine engine, tandem rotor helicopter powered by two 2200 shaft horsepower (shp) Lycoming T55-L-5 or 2650 shp T55-L-7 turboshaft engines (ref. 3) mounted on the aft fuselage. The engines simultaneously drove tandem, three-bladed, fully articulated, counterrotating rotors (ref. 4). Its first hovering flight was made on September 21, 1961 (ref. 5). It was mainly used for military exercises, service testing, and pilot training. A total of 354 of these aircraft were built for the U.S. Army (ref. 6).

Experience with this early version led to the development of the CH-47B, in the mid '60s. These new aircraft were a developed version of the CH-47A with 2850 shp T55-L-7C turboshaft engines, redesigned rotor blades with a cambered leading edge, a blunted rear rotor pylon, and strakes along the rear ramp and fuselage for improved flying abilities. Its first flight was in early October of 1966. A total of 108 were built for the U.S. Army (ref. 7).

A third model, the CH-47C, was given its first test flight on October 14, 1967. The improvements on this new model included two 3750 shp T55-L-11A engines, an increased integral fuel capacity, and strengthened transmissions. An Army contract of 1978 called for all U.S. Army CH-47As and CH-47Bs to be upgraded to this new standard (ref. 8).

More than 550 CH-47Cs saw action in the Vietnam war between 1968 and 1973. In addition to being used as a troop and supply carrier, the Chinook was used to rescue downed aircraft. More than 11,000 damaged fixed-wing aircraft and helicopters were airlifted for eventual repair or salvage (ref. 9). The Chinook was also used for evacuation of refugees. On one occasion, no fewer than 147 refugees and their possessions were airlifted on a single flight (ref. 10). Although Chinooks were rately used in combat, tests were being made in the late '60s of an armed and armored Chinook, equipped with a variety of weapons and more than 1 ton of armor plate (ref. 11).

The CH-47D is the most recent model of the CH-47. The Army has a 10-yr Chinook upgrade program that includes orders for 436 CH-47Ds to be upgraded from earlier A, B, and C models. Deliveries of this version are expected to run through 1991. The Army is also planning an additional purchase of 142 newly manufactured CH-47Ds, after the original fleet is upgraded, with deliveries that extend into mid 1995. This modernized fleet should satisfy the Army's requirements for a medium lift helicopter well through the year 2000 (ref. 12).

The CH-47D boasts of two Lycoming T55-L-712 turboshaft engines, with standard and emergency ratings of 3750 shp and 4500 shp, respectively. The rotor transmission rating is increased to 7500 shp, with integral lubrication and cooling. The new composite rotor blades are fitted. The flight deck is redesigned to reduce pilot workload. Other changes include improved electrical systems, modular hydraulic systems, an advanced flight control system, improved avionics, aircraft survivability equipment, and night vision goggle compatibility. A solar T62-T-2B auxiliary power unit runs the accessory gear drive, thereby operating all hydraulic and electrical systems. Also, a single-point pressure refueling system and triple cargo hooks have been installed. Only the basic airframe structure, the landing gear, and the seats have remained unmodified or unreplaced. Over 30 subcontractors to Boeing Vertol are working on this conversion program. This new D model offers a more than 100% increase in performance over the A model (ref. 13). A comparison of the characteristics of the four models is shown in table 1.

U.S.-built CH-47s not only have been used in the U.S. Army, but in the U.S. Army Reserve and in the U.S. National Guard as well. They are also in service in the armed forces of many other nations: Argentina, Australia, Canada, Italy, Iran, Korea, Libya, Morocco, Spain, Thailand, the United Kingdom, and West Germany (ref. 14).

Through extensive modernization programs such as the CH-47 has gone through, the Chinook fleet can always be kept up to date and the fleet life can be greatly extended as shown in figure 1. The Army has carefully calculated the time and money involved in these projects and has come out ahead of schedule and under cost (ref. 16). It becomes clear that the Army has plans to use Chinooks widely for quite some time. With good maintenance and perhaps future modernization, the Chinooks will always be ready, willing, and able!

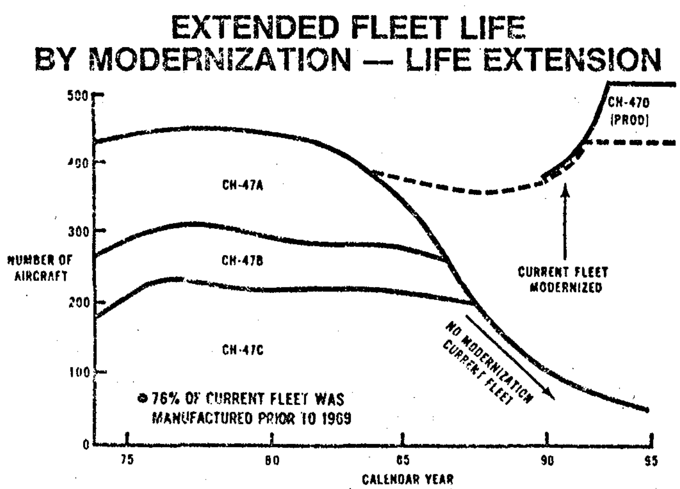

Figure 1.- Extended fleet life by modernization — life extension (ref. 15).

TABLE 1.- CH-47 CHARACTERISTICS COMPARED (ref. 17)

	CH-47A	CH-47B	CH-47C	CH-47D
Internal cabin dimensions				
Length, in.	366	366	366	366
Width, in.	90	90	90	90
Height, in.	78	78	78	78
Usable fuel capacity, gal	564	564	1,042	1,042
Transmission rating, shp	4,970	4,970	6,000	7,500
Avco Lycoming engines	T55-L-7C	T55-L-7C	T55-L-11	T55-L-712
Ratings (uninstalled, sea level), shp				
Maximum continuous	2,400	2,400	3,000	3,000
Intermediate (30 min)	2,650	2,650	3,400	3,400
Takeoff (10 min)	2,850	2,850	3,750	3,750
Emergency	--	--	--	4,500
External cargo load capacity, lb				
Forward	--	--	--	17,000
Aft	--	--	--	17,000
Center	16,000	20,000	20,000	26,000
Forward, aft dual point load	--	--	--	25,000
Capacity				
Empty weight, lb	18,288	19,676	21,586	23,093
Fixed useful load, lb	1,382	1,382	1,400	1,403
Design gross weight, lb	28,550	33,000	33,000	33,000
Maximum gross weight, lb	33,000	40,000	46,000	50,000
Rotor speed, rpm	230	225/230	235/245	225
Usable fuel capacity, lb	3,666	3,666	6,773	6,695
Performance (33,000 lb/std atmos)				
Maximum cruise speed at sea level, knots	110	155	161	158
Maximum rate of climb at sea level in 30 min, ft/min	2,040	2,080	2,590	3,100
Hover out of ground effect ceiling in 10 min, ft	8,800	10,100	13,600	17,200
Service ceiling (30 min rating) with one engine inoperative, ft	2,000	--	8,500	12,800
Mission capability				
External payload mission (sea level/59°F)				
Takeoff gross weight, lb	33,000	39,450	44,400	50,000
Total mission fuel, lb	2,267	2,545	2,848	2,818
Outbound cruise speed, knots	100	100	100	126
Inbound cruise speed, knots	130	132	137	135
Payload, lb	11,063	15,847	18,566	22,686
External payload mission (2000 ft/70°F)				
Takeoff gross weight, lb	33,000	38,200	42,950	50,000
Total mission fuel, lb	2,108	2,464	2,698	2,738
Outbound cruise speed, knots	100	100	100	112
Inbound cruise speed, knots	120	140	140	137
Payload, lb	11,222	14,698	17,266	22,766
External payload mission (4000 ft/95°F)				
Takeoff gross weight, lb	31,100	32,500	40,700	42,900
Total mission fuel, lb	1,988	2,222	2,542	2,548
Outbound cruise speed, knots	92	100	100	101
Inbound cruise speed, knots	103	144	146	140
Payload, lb	9,442	9,220	15,172	15,856

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JOB DESCRIPTION

Andrew Wang

During my summer stay at NASA Ames Research Center as a participant in the SHARP program, I became involved in the Search for Extraterrestrial Intelligence (SETI) project. Most of the scientists with whom I worked were either astronomers (radio astronomers in particular) or astrophysicists. Their work could be summarized as mainly the collection of large amounts of radio astronomical data from radio telescopes, and analysis of those data for radio signals that might possibly have been originated by an extraterrestrial intelligent specie.

I discovered that an extremely large proportion of the research is connected in some way with the use of the computer. Fortunately, I have had some experience in school with computers and thus was able to learn the predominant FORTRAN programming language in a relatively short period.

During the first few weeks, my work consisted primarily of writing self-contained computer programs, which modeled the response of the lower food chain, to a global blackout of the Sun. The biologist for whom I did this work was studying the evolution of complex life on Earth to better understand the prospects for life elsewhere in the universe. In the following weeks, I became somewhat more acquainted with the local computers on which I worked and learned how to interact with connected devices such as the magnetic tape drive. My work then consisted of sorting, arranging, and manipulating astronomical data read from magnetic tapes. Thus, my summer experience at Ames has given me a chance to increase my knowledge of computers and has allowed me the opportunity to work with top scientists in an exciting and interesting field of study.

SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI)

Andrew Wang

The stars have, since early history, held for man a special attraction as he looked to the sky in awe and wonder at mysteries beyond his comprehension. Ancient man saw the acts of the gods in the quirks of the heavens, and while modern astronomy has given us a better understanding of the universe, much is still to be learned. What is definite is that, in comparison to the infinite vastness and immensity of the universe, of time and space, man is very small, and thus the age-old question remains: What is man's role in the cosmos? Such a question may be for the philosophers, but after taking into account the innate curiosity of man about his surroundings and his desire to know, the question becomes a scientific one of whether or not we are alone in the universe. Does intelligent life exist elsewhere in the universe? This question has in recent years become the focus of serious scientific research, and this paper attempts to present briefly some of the ideas currently being discussed by those involved in the field.

Most scientists only a few decades ago would probably have scoffed at the notion of extraterrestrial intelligent beings, just as many people even today find the idea somewhat farfetched and akin to science fiction. But the search for extraterrestrial intelligence, although still controversial and much debated, is today legitimate science, and many scientists believe strongly that the great question "Is there life out there?" will be answered with a definite "yes." One reason for this change in opinion lies in the different view scientists now have of how the universe evolved, the current view being that the development of life and intelligence is just the final step in the evolutionary process of the universe as a whole. This single process (called cosmic evolution) began with the birth of the universe in "the Big Bang" and the formation of the stars and galaxies, and eventually resulted in the rise of life. In the large picture, Earth does not appear to possess any special attributes giving it an advantage in the evolutionary process; thus it should be only one of many life sites in the universe.

The Big Bang theory describes the origin of the universe as a tremendous explosion of matter approximately 15 billion years ago. The expansion of the universe today, as the galaxies continue flying away from each other, is evidence that such an event did indeed occur. As the hot gases of the initial explosion cooled, they condensed and formed stars composed of hydrogen and helium, the only elements then existing. Many of these early stars were short-lived and quickly died in supernova explosions, thus enriching the surrounding area with heavier elements created during the fusion process which had been providing the star with energy. Each succeeding generation of stars has an increased likelihood of having rocky planets orbiting about it as more heavy elements are added to the interstellar medium by dying stars completing their life cycle. Since organic chemistry is prevalent throughout the universe, on these planets the evolutionary process might bring forth life just as it did on Earth.

Life, however, may be delicate, and the processes and conditions which lead to life are not very well understood. Stars that are too massive have short life spans and thus cannot provide a stable environment long enough for life to evolve, and stars that are too small are unlikely to have planets which can support life. Only those stars similar to our Sun will possibly have the proper conditions for the evolution of life. Even around these stars, only on a few planets (if any exist at all) will the conditions for life be met. Once the conditions are fulfilled, does life necessarily have to arise? Further, once life arises, must it evolve to intelligence? The factors involved in the determination of whether extraterrestrial intelligent life exists are summarized in the Drake Equation (named after the American astronomer who developed it) which states:

$$N = R_* f_p n_p f_\ell f_i f_c L$$

where

N the number of technological civilizations existing

R_* the average rate (in stars per year) of star formation

f_p the fraction of stars having planets

n_p the number of suitable planets per planetary system

f_ℓ the fraction of planets on which life starts

f_i the fraction of life that evolves to intelligence

f_c the fraction of intelligent species which communicate

L the longevity in years of the technological civilization

Because of inadequate knowledge as to the values of the factors in the Drake Equation, N cannot be determined to any accuracy. Some say billions while others say none except for ourselves. Even so, the Drake Equation is useful in that it gives a concise statement of all the deciding factors which define the search for extraterrestrial intelligence.

If intelligent life does in fact exist elsewhere, how do we go about looking for it? Sending space probes to other stars is not technologically possible at the present time and may never be. The accepted method of search, perhaps the only feasible method, has been the analysis of the radio wavelengths from other stars for signals that might be of intelligent origin. (Such signals might be similar to ones the Earth generates as a result of radio and TV transmission.) The search has been narrowed to a range of wavelengths in the microwave region of the electromagnetic spectrum where the background noise from natural sources of radiation is at a minimum.

NASA, in its Ames/JPL Search for Extraterrestrial Intelligence (SETI) program, is currently approaching the problem from two directions. One, there will be a targeted high-sensitivity search aimed at known solar-type stars within 80 light-years of the Earth; and two, there will be an all sky survey of lesser sensitivity receiving signals from all directions of the sky. This program will begin with prototype equipment which has the ability to simultaneously monitor tens of thousands of frequencies and then immediately process the gathered data for signals which might be of interest. Eventually, machines capable of handling millions of frequencies at the same time will be developed. Looking farther into the future, in the 21st century, SETI enthusiasts can dream of putting huge radio telescopes into space and thus eliminate all the radio interference hindering observations here on Earth. But by then, perhaps we will have a partial answer to the great question — just perhaps.

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JOB DESCRIPTION

Yvonne Yeh

I work in the Life Science Building under the supervision of Dr. Steve Schwartzkopf, an ecologist specializing in plants.

When I first came to NASA, all I expected to do was observe and wash the equipment. Well, I was wrong . . . From the first day on, I've been doing more than just observing and washing. I've been involved in setting up equipment, doing experiments, doing electrical work, and designing my own experiment. Besides that, I've been doing filing, copying, washing, cleaning, and, of course, writing the research paper.

The first couple of weeks were really hectic because Steve was trying to set up an environment room to test a kind of hydroponics system with (or using) lettuce plants. The environment room involves a hydroponic technique, which just means that plants will be grown by suspending the roots through a circulating nutrient solution. In this experiment, we are trying to find how an ultraviolet treated nutrient solution affects lettuce plants.

I was able to help in setting up the environment room; specifically, the plumbing and drainage system. I also did electrical work such as making power cords, assembling float controls, and putting together thermostats.

Another project with which I am involved is the growth chamber unit designed by my supervisor. This chamber holds only one plant at a time, unlike the environment room which holds approximately 250 plants. In this experiment, the plant roots are constantly being run through aeroponics, which means the plants are being sprayed with nutrient solution. We are trying to discover under what conditions plants grow the best.

The experiment that takes up most of my time is a carbon dioxide spiking experiment that Carrie O'Donnell, another SHARP student, and I designed and built for our research paper. We built four minigreenhouses, placing in each nine tomato and nine lettuce plants. We made the greenhouses airtight by sealing them with plastic wrap. We had to determine the volume of each greenhouse so that we would know how much carbon dioxide to inject. Since the carbon dioxide would not be injected constantly, we had to build a system to control, inject, and analyze the gas.

We are trying to find the best carbon dioxide concentration for tomato and lettuce plant production. The experiment will run for 3 weeks.

Our lab is involved in the CELSS program. CELSS stands for Closed Ecological Life Support Systems. It is a system that incorporates waste management, food production, human requirements, and system management for use on planetary lunar bases, on long duration missions, and in large space stations. This type of system will be self-sufficient and recyclable.

THE EFFECT OF CARBON DIOXIDE ON TOMATO SEEDLING GROWTH

Yvonne Yeh

SUMMARY

Tomato plants (Beefsteak Tomato) were grown at 350, 2000, 4000, and 8000 ppm CO_2 concentrations. Four chambers were set up to test each treatment. The growth rate was greatest at 2000 ppm CO_2, and was less at 4000 ppm CO_2. Minimal growth was seen in the 350 and 8000 ppm CO_2 treatments. Wet and dry weights showed that 4000 and 2000 ppm CO_2 were better levels for the tomato plants to grow in than the 350 and 8000 ppm CO_2. The results suggest that too little CO_2 (350 ppm) is not optimal for plant growth and that very high CO_2 levels (8000 ppm) are inhibitory to plant growth.

INTRODUCTION

In the future, people will be setting up colonies in outer space. For this to happen, scientists will have to develop ways for people, animals, and plants to live and to grow in closed environments. So far, only a few researchers have experimented with plants in growth chambers which are completely sealed off from the outside environment. Later on, scientists will use humans in the growth chambers to find out whether they can really survive in outer space.

At Ames Research Center, studies have been done under the Closed Ecological Life Support Systems (CELSS) program. This type of system incorporates waste management, food production, human requirements, and systems management. Waste management processes human and plant waste so that the organisms can reuse the wastes later on. The plants produce food and oxygen. Human requirements involve certain substances needed for human survival — such as food, oxygen, and minerals. Systems management balances out these three components and makes sure that all of them are doing the right job; it makes sure that the carbon dioxide released by the humans will be used up by the plants; it makes sure that the oxygen released by the plants will be used by the humans. All of these factors are recyclable and self-sufficient. These are the main reasons CELSS will be used in long duration missions, on large space stations, and on planetary or lunar bases.

My experiment is part of the CELSS program. In order to make the program work, scientists have to deal with the first factor of CELSS: waste management. The carbon dioxide level in the air that we breathe is approximately 340 to 350 ppm. In space, people and plants will be enclosed in space stations. There will be less space for everyone and everything to live in. The plants will have to produce more oxygen for the people to breathe, and the plants will have to produce food by using the carbon dioxide gas emitted by the humans. The plants will be grown at the most efficient level of carbon dioxide so that they will produce the maximum amount of food possible.

The experiment that I'm conducting involves testing the growth rates of tomato seedlings which have been exposed to different concentrations of carbon dioxide. The experiment is set up so that the plants are being grown in a limited area, inside closed chambers. The null hypothesis is that changing the carbon dioxide concentration in closed, controlled chambers doesn't affect the growth of the tomato seedlings which are growing inside the chambers. The purpose of the experiment is to disprove the hypothesis; thereby, we would prove that carbon dioxide does affect the growth rates of tomato seedlings and discover at which level of the gas the plants grow best. Data will be taken on plant height, plant weight (wet and dry), leaf area, leaf color, and leaf number.

In the future, similar experiments will be run on many types of plants. These results will help scientists determine at which level of carbon dioxide plants will produce the most food most efficiently, using limited space.

MATERIALS AND METHODS

The first step in conducting an experiment is designing and constructing a workable experiment. Below are the various steps that were done in order to get the study started.

Conditions during Plant Growth

Two tomato seeds were planted in each of the 36 pots that were used in the experiment. The plants were grown in Clorox-sterilized pots which contained a soil-perlite mixture. Nine pots were placed in each chamber.

Two plastic trays (17 in. × 17 in.) were cut in half to make four separate bases for the chamber (17 in. × 8-1/2 in.). Size 3 rubber stoppers were put into the front (8-1/2 in.) side of the tray. Metal wire was bent and crisscrossed across the trays to make a frame for the plastic film wrap covering to fit against (fig. 1). The new chamber's measurements were 17 in. × 8-1/2 in. × 10 in.

Three sheets of plastic film wrap were duct-taped together and fitted over each of the chambers to form an airtight, leakproof covering.

An 8-1/2 in. × 8 in. piece of clear Plexiglas was used as a fold-down door on the front side of the tray. Wire hooks held the door in place. The door was used when the plants had to be taken out for data readings (fig. 1). The four chambers which were constructed were labeled 350 (B), 2000 (A), 4000 (C), and 8000 (D). They were placed on top of a shelf (4 ft × 13 in.) which was supported by concrete blocks (fig. 2).

Each chamber was provided with an inlet and outlet pipe for gas injection and gas analysis. Pipes 3-1/2 in. long × 1/8 in. wide were inserted through the size 3 rubber stoppers. A piece of Tygon tubing 14-1/2 in. long was connected to one of the pipes on the inside of the chamber. On the outside, both pipes were connected to pieces of Tygon tubing 6 in. long. Clamps were put on the Tygon tubing pieces so that no leakage could occur. A plastic bag was fitted over the completed chamber and the two Tygon pieces hung out the front end.

The chambers were illuminated 24 hr/day by three sets of fluorescent lights which were set on top of a metal frame. The light intensity was measured in terms of 1 sec/100X/quantum. The aluminum foil which covered the shelf and the four sides of the experiment area served as a light reflector (fig. 2).

Watering was done before any treatment was started and at the time of the data readings. In between those periods, the atmospheric humidity within the chambers was 100%; therefore, no watering was necessary in between data readings. Chamber temperatures were approximately 31°C.

Gas Injection Procedures

The volume of each chamber was required in order to inject the right amount of CO_2 into the correct chamber. The amount of gas to be injected was found by using the ratio of the proper CO_2 ppm over a million to X over the volume. The proper amount of gas was pulled into a 50 ml hypodermic needle and injected into the corresponding chamber through one unclamped tubing piece.

Gas Analyzing System

A CO_2 analyzer was used to check the levels of CO_2 in each of the chambers. A 0 ppm CO_2 was pumped directly into the analyzer to set the zero point on the meter; 10,000 ppm CO_2 was pumped in to set the span.

A pump pumped air into a piece of Tygon tubing that was hooked to the chamber while a flow meter regulated the flow rate of the pump. After the air inside the chamber circulated, the 14-1/2 in. long piece of tubing pulled out a sample and sent it back through the pump to the CO_2 analyzer (fig. 3). The CO_2 concentration was analyzed and the reading appeared on a meter. If the level was below the expected level, more gas was injected. If the gas level was too high, the Tygon tubing was left open until the correct level was reached.

Analyzing the Sacrificed Plants

Two tomato plants were planted in each of the pots so that at least one of the seeds would sprout. When the majority of the seeds sprouted, one out of each pot was taken out and analyzed. The sprout was cut at the base of the stem near the top of the soil. The sprout from each chamber was put in a water-filled beaker and wet weight readings were recorded. The wet weights of each set of sprouts were averaged out. The sprouts were then dried in a drying oven (65°C) for 2 days and the weights were recorded.

Terminating the Experiment

The CO_2 spiking experiment was run for approximately 3 weeks. At the end of that period, the plants' heights, leaf colors, and number of leaves were recorded. Wet and dry weights were also taken.

RESULTS

Plants grown in 2000 and 4000 ppm CO_2 were bigger than the plants grown in the 350 and 8000 ppm CO_2 concentrations. Both wet and dry weights showed differences in growth between the four treatments (tables 1 and 2).

Since wet weight includes the water in the plant leaves, dry weight calculations show the more critical differences in weight. Chamber A, with an average dry weight of 0.006154 g had the most plant mass as compared to chamber B (0.004942 g), chamber C (0.005878 g), and chamber D (0.004872) (table 1).

The dry-wet weight ratio shows a 10% difference in weight from the 2000 ppm CO_2 level to the other three levels (table 3).

Leaf color was uniform when comparing the four different sets of tomato plants. Leaf color was generally yellow to light green. Another observation about the leaves was that the leaves were limp and shriveled.

There were no significant differences in the plant heights or the leaf areas in the comparison of the four different CO_2 enrichment levels.

DISCUSSION

As the results show, the tomato plants grown in the 2000 ppm chamber had the best growth rate. When looking at the wet weights of the sacrificed plants before and after the experiment, there are indications that point out that the plants were heaviest in the 4000 ppm chamber (table 4). Usually, wet weights are used to see the general health of the plants.

In normal plant growth, the leaves absorb certain substances and release other substances through their stomates (pores in the leaves). In the case of the 4000 ppm CO_2 chamber plants, the wet weight shows that water was kept in the stomates. The 2000 ppm CO_2 chamber plants took in more carbon than water, while the 4000 ppm CO_2-exposed plants took in more water than carbon, which accommodates for the wet weight difference between the 2000 and 4000 ppm CO_2-treated plants. The carbon weight was seen after the plants had been dried in the drying oven. Dry weight generally is more accurate than wet weight; therefore, the actual biomass results were taken from the dry weight readings.

At 8000 ppm, the wet and dry weights showed that too much carbon dioxide can inhibit the growth of tomato plants. Toxic levels of the gas are harmful to plant growth and plant food production.

At 350 ppm, gas levels were too low. In this experiment, the 350 ppm chamber was used as a control.

New Design of Experiment

The carbon dioxide spiking experiment will be run again using a hydroponics system instead of using soil, and lettuce plants will be grown in place of tomato plants. The chambers will be redesigned to be made from Plexiglas. The benefits of Plexiglas are that it can be fitted to be airtight and it won't block out light. Other additions include a cooling coil which will be inserted into the chambers to keep temperatures at a constant level.

CONCLUSION

The tomato plants which were grown in the 2000 ppm chamber had the best growth rate. This level was found to be the most beneficial to the plants' growth.

ACKNOWLEDGMENT

I would like to extend my gratitude to Dr. Steven Schwartzkopf for his guidance and patience.

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TABLE 1.- DRY WEIGHT OF TOMATO PLANTS

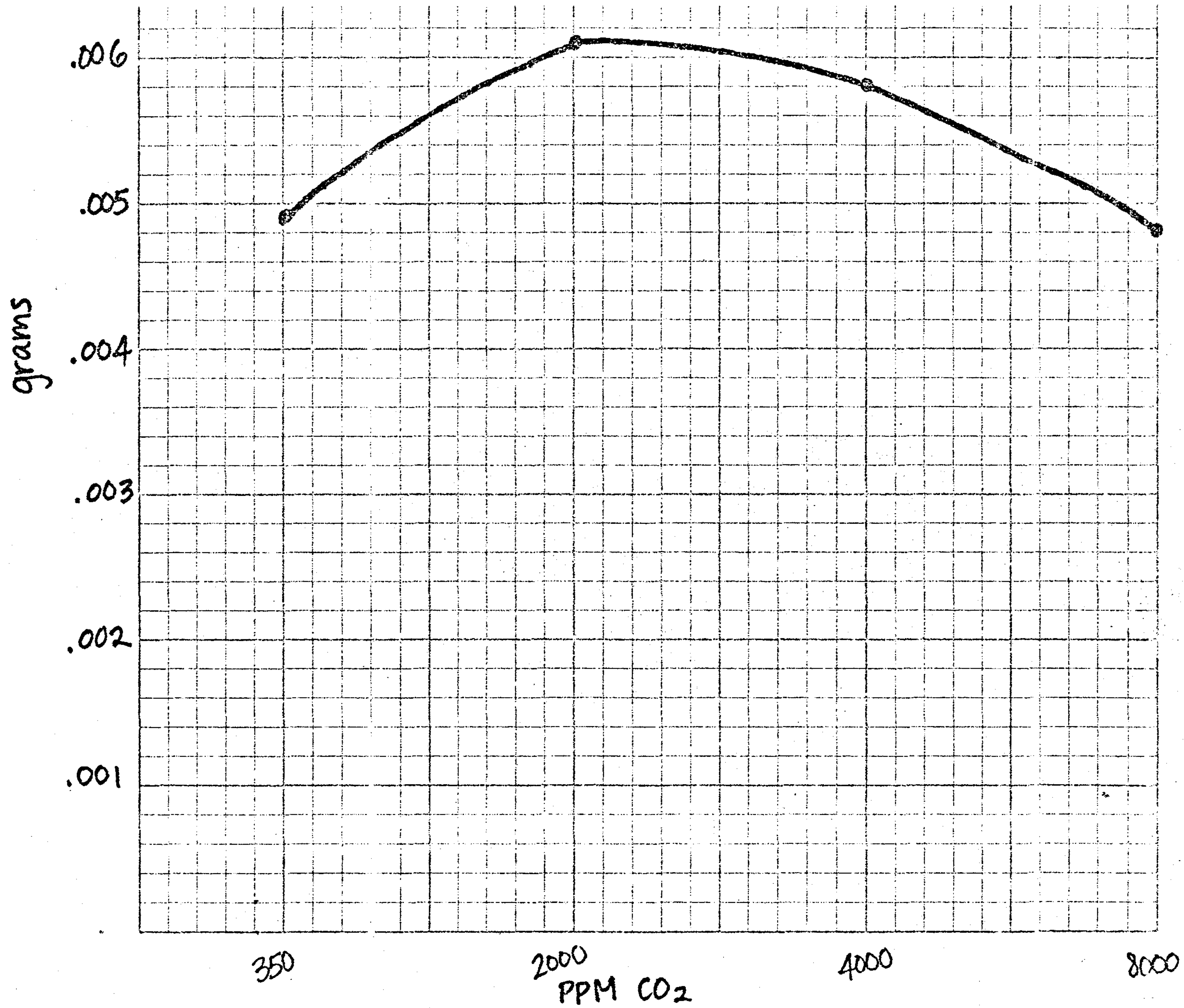

TABLE 2.- WET WEIGHT OF TOMATO PLANTS

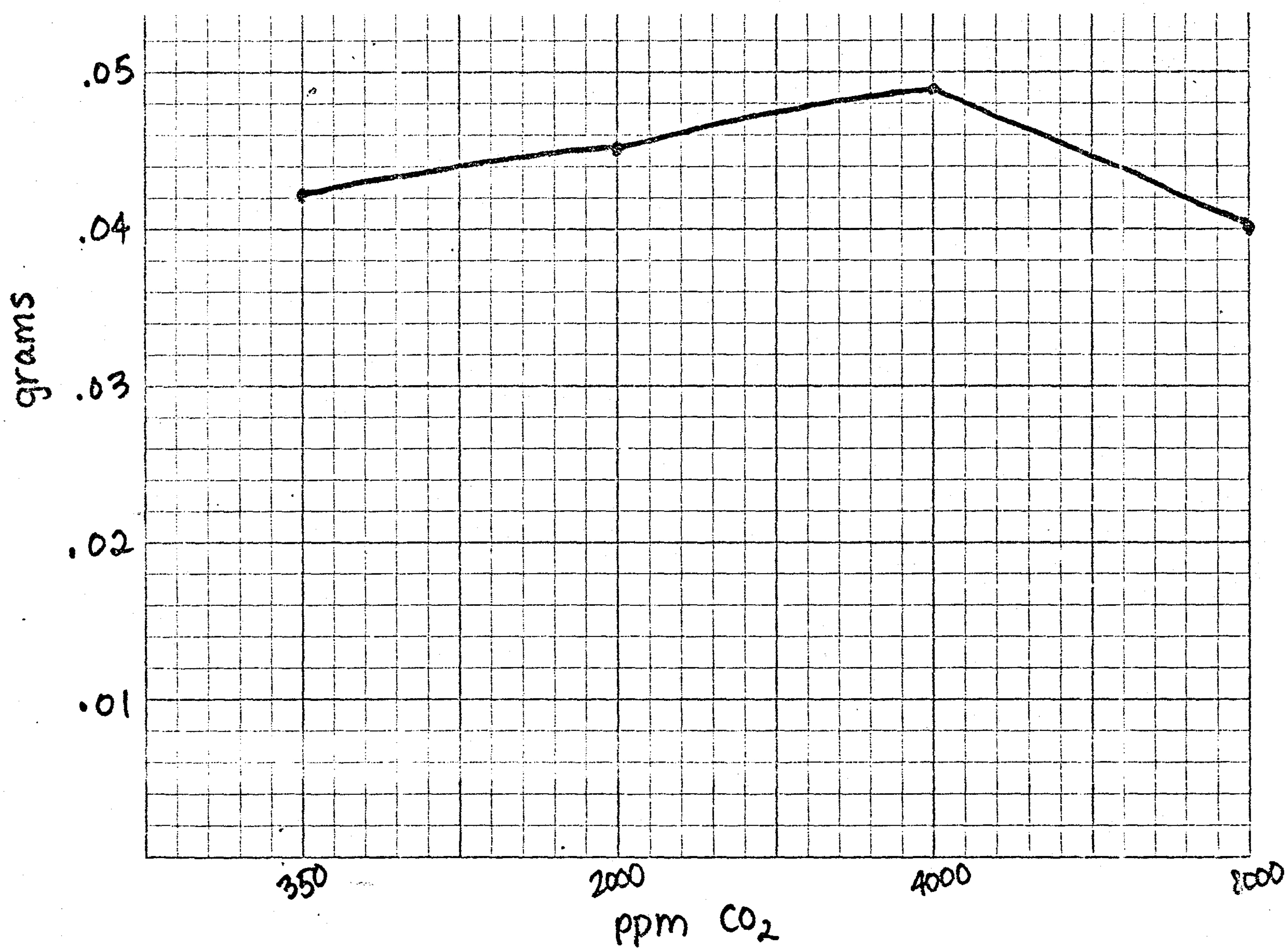

TABLE 3.- DRY WEIGHT-WET WEIGHT RATIO

Chamber	Dry/wet ratio
B (350 ppm)	0.118 g
A (2000 ppm)	.135 g
C (4000 ppm)	.120 g
D (8000 ppm)	.119 g

TABLE 4.- AVERAGE WET WEIGHTS OF SACRIFICED TOMATO PLANTS BEFORE AND AFTER EXPERIMENT

Chamber	Wet weight before treatment (g)	Wet weight after treatment (g)
B (350 ppm)	0.03142	0.042014
A (2000 ppm)	.02909	.045752
C (4000 ppm)	.02844	.049038
D (8000 ppm)	.02754	.040882

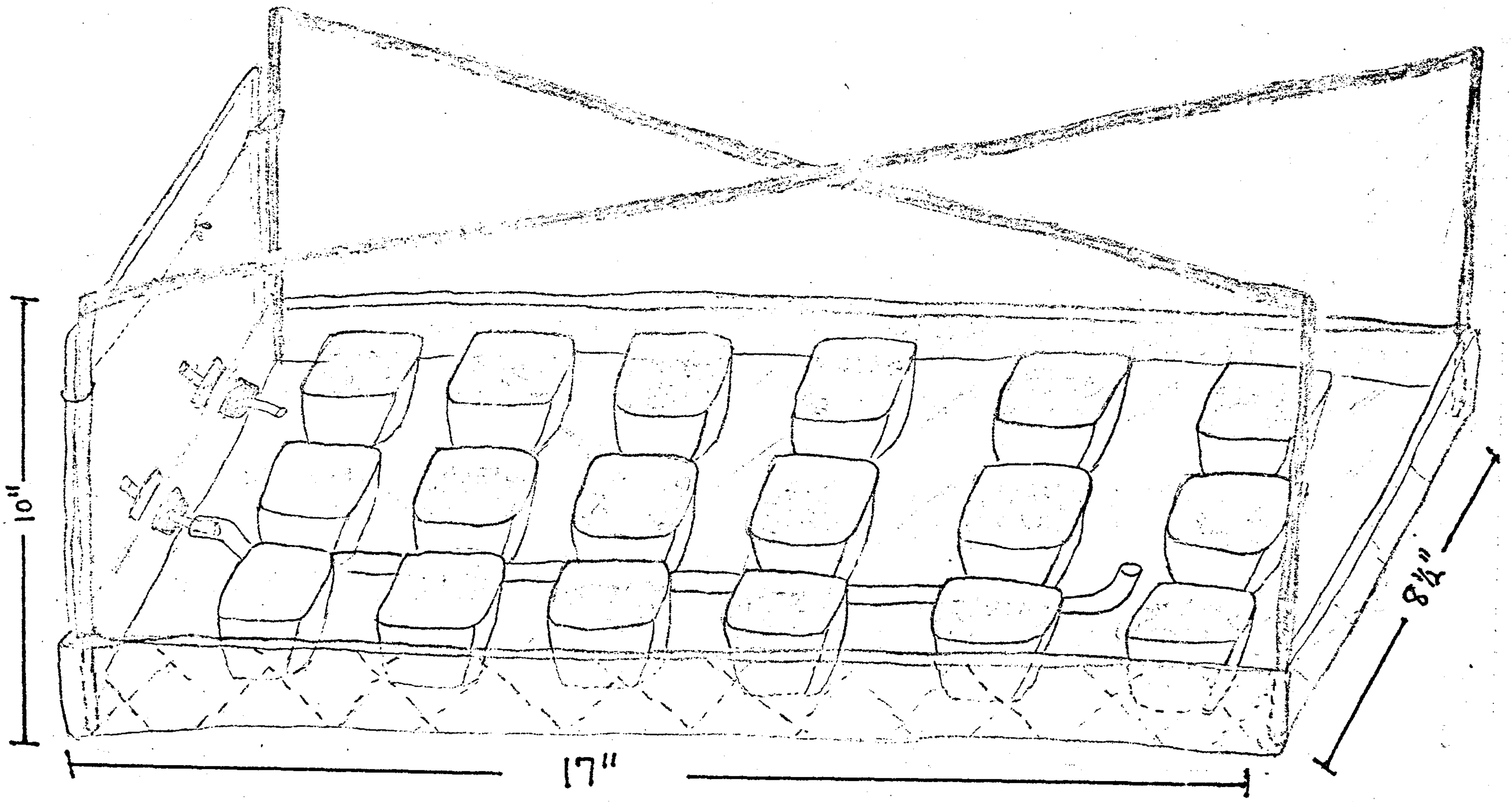

Figure 1.

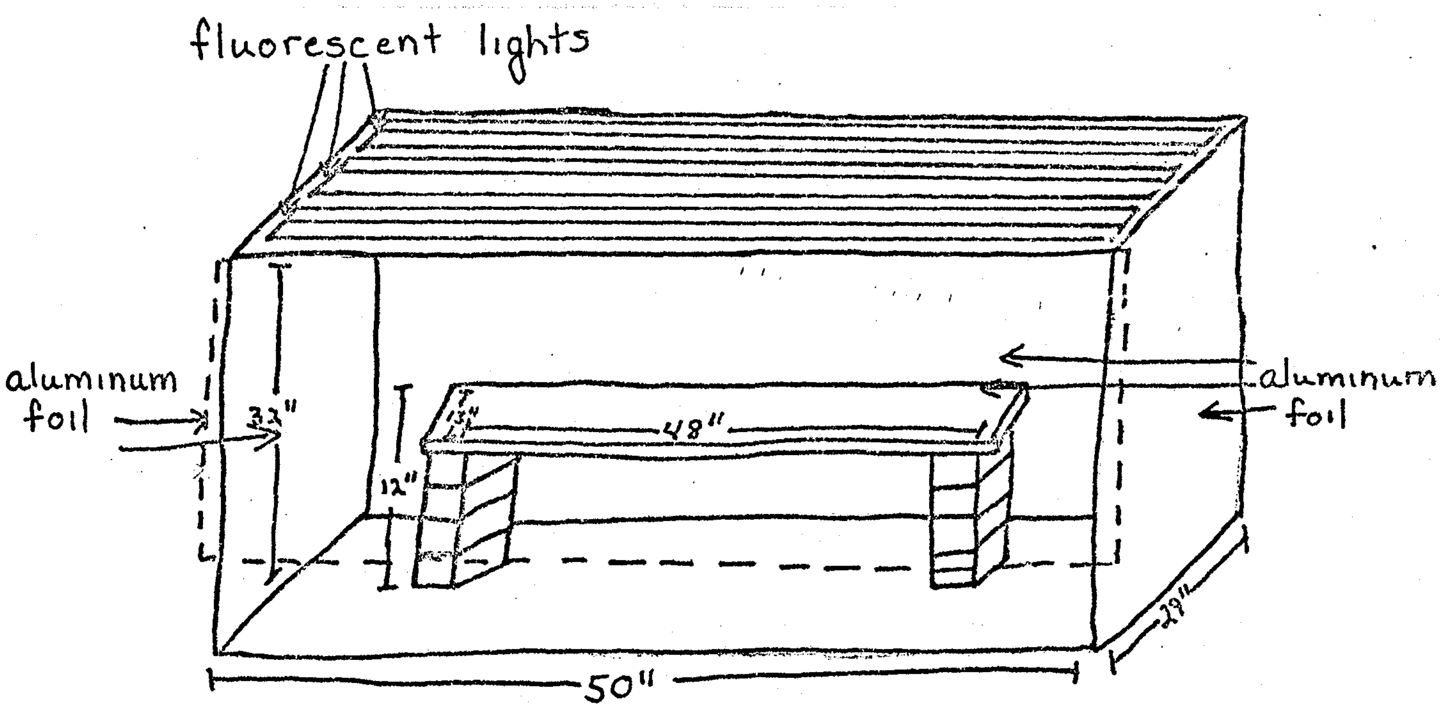

Figure 2.

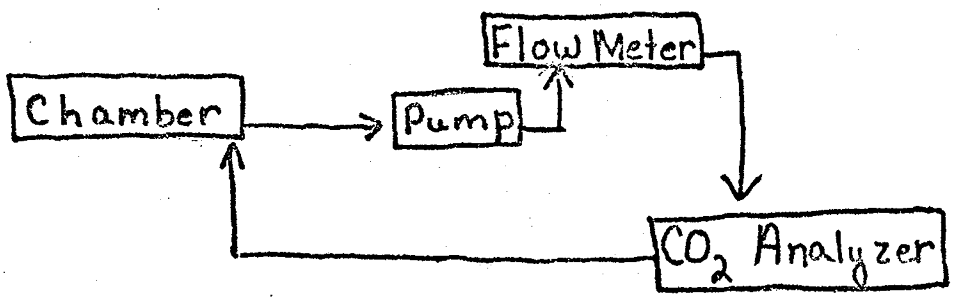

Figure 3.

JOB DESCRIPTION

Lai Chi Yip

Ames Research Center sponsors various programs to give students opportunities to gain experience, knowledge, and insights into the working world of engineers and scientists. One of these programs is the Summer High School Apprenticeship Research Program (SHARP).

As a participant in SHARP, I was assigned to work with Mr. Robert Reutter in building 210; I also assist Major Charles F. Adam, the aircraft manager of the CH-47B "Chinook" helicopter in the Aircraft Systems Branch of the Flight Systems and Simulation Research Division. This branch is responsible for aircraft research, flight simulation, and development and installation of interface systems. Major Adam manages the flying operations and maintenance of the CH-47B helicopter. My SHARP coworker, Kathy Smith, and I are involved with a reorganization project for the drawings of the CH-47B. We also have a direct role in accomplishing the installation of research equipment for the aircraft which will be used for research into various techniques of piloting heavy lift helicopters.

The drawings that we are organizing will be used and modified to aid in the rebuilding of the aircraft. During the first 2 weeks of our project, we filed each of the manufacturers' drawings in numerical order and removed the duplicates. We made a master list of all the drawings including the following items: drawing number, sheet number, complete title, type of drawing, revision letter, month/year, and assembly. Then we learned how to operate the 3M 2000E processor camera and the IBM 029 printing card punch. After mastering the techniques used to produce a clear aperture card with a correctly typed title, we were ready to continue our project.

Each day we spent our time in building 211 where we operated the processor camera to produce aperture cards. The process was fairly simple. We laid the drawing on the camera table, adjusted the lighting, density, and voltage to the proper settings, then pressed the "expose" button to take a picture. We waited 45 sec for the card to go through the cycle and drop down the card chute. We took three pictures of each drawing panel. The cards were then taken to the printing and punch machine with which we typed the drawing number, sheet number, revision letter, abbreviated title, and the month/year. We repeat this process about 400 times each day. The work tends to be tedious, but it is a necessary part in the life of an engineer.

SHARP is a valuable program. I was able to have my potential and capabilities recognized. It has enabled me to gain experience and knowledge I could not have acquired from books. It has given me the opportunity to speak with engineers and scientists and learn about their careers. The exposures to the working world of engineers, scientists, and technicians has encouraged me to pursue a career in the field of science. The SHARP program has helped me to plan a science and mathematics-based curriculum in college. This I feel is needed because of the importance of these disciplines in the complex world of today as well as tomorrow.

VSTAR CH-47B: A VARIABLE-STABILITY RESEARCH HELICOPTER

Lai Chi Yip

Since helicopters can do many jobs more efficiently than can cars, ships, or airplanes, they play an important role in civilian and military life. Helicopters can perform a variety of jobs, such as fighting fires, reporting traffic conditions, rescuing people, and spraying crops. In the military, some helicopters transport troops, cargo, and weapons. Because of the numerous uses and more complicated missions of the helicopter, research on variable stability to improve aircraft performance and reduce pilot workload is a much needed effort.

There are variable-stability research helicopters which have made major contributions to the formulation of aircraft handling qualities. These aircraft were used also to demonstrate aircraft control characteristics and to train pilots prior to flying a new aircraft. In the early days, variable-stability helicopters were used extensively as airborne simulation facilities because ground-based simulation capabilities were extremely limited. Although ground-based simulators have advanced in their capabilities, variable-stability research helicopters have continued to be used throughout this period (ref. 1).

NASA Ames presently is assigned a CH-47B variable-stability helicopter, designated NASA 737, V-STAR. In 1973, this CH-47B was modified for the Tactical Aircraft Guidance System (TAGS) program which was aimed at developing and demonstrating an advanced flight-control concept using computers. In order to support continuing flight research, the CH-47B had been modified extensively from the TAGS program to a general purpose variable-stability research helicopter (ref. 2). Now a NASA 737 is being researched under the aegis of the V-STAR program at Ames Research Center at Moffett Field.

The purpose of this paper is to discuss the applications and capabilities of variable-stability research helicopters with emphasis on the V-STAR CH-47B program.

For more than 25 years, variable-stability research helicopters were used to investigate a wide variety of problems associated with navigation, guidance, and control (ref. 1). The original requirement for the variable-stability helicopter in the past had been to investigate systems for aircraft instruments in flight conditions.[1] The aircraft were used for airborne simulation which is virtually the same as ground-based simulation, except that moving aircraft can follow motion commands without restriction.[2] Airborne simulation can provide a realistic environment and accurately reproduce aircraft dynamics (ref. 3). In response to all-weather capability, the variable-stability helicopters can be utilized for flight systems research involving advanced navigation equipment and programmable television displays (ref. 1). For critical situations, such as low visibility or unfavorable weather conditions, the reduced workload and the improved performance of the aircraft will help the pilot tremendously. More demanding missions increase the need for improving aircraft efficiency, and reducing pilot workload.

The Boeing-Vertol CH-47B "Chinook" helicopter is an all-metal, twin-turbine-engine, tandem rotor aircraft designed for the transportation of cargo, troops, and weapons. The CH-47B has a speed range up to 160 knots and a payload of approximately 9000 lb. The aircraft is equipped with electrohydraulic actuators that drive the control system (ref. 4). During variable-stability operations, the evaluation pilot operates the V-STAR CH-47B controls by sending inputs through both the analog and the digital computers and the clutching system.

The aircraft commander, who also serves as the safety pilot, takes control of the aircraft through the primary flight control system if the clutch fails to disengage (ref. 1). To enhance safety, hardover monitoring equipment (HOME) monitors the fly-by-wire actuators and automatically disengages the system if a failure should occur.

NASA 737 was originally modified by the Army for the Tactical Aircraft Guidance System in the early seventies. In the TAGS program, the CH-47B control system was modified to incorporate a full-authority, four-axis, fly-by-wire, variable-stability system (ref. 4). The triplex, full-authority, paralleled electrohydraulic actuators were added. These actuators were connected to the mechanical control system of the aircraft. The mechanical linkages between the pilot's controls and the stick-boost actuators were also reworked to reduce friction (ref. 2).

When the Army completed its program, NASA 737 was loaned to NASA's Langley Research Center to be used in the VTOL Approach and Landing Technology (VALT) program. The VALT program retained many of the modifications done by TAGS. At Langley, the IBM computer was removed and the Sperry 1819A computer was installed. Also, the triplex actuator system was modified by reducing by two the actuator channels for each axis. The result is a single actuator-clutch mechanism for each of the four control axes.[3] Langley used the CH-47B as its third generation variable stability aircraft (ref. 1) until 1979 when NASA went through a reorganization.

Ames Research Center was named to be in charge of all the helicopter research for NASA. The CH-47B was transferred to Ames on August 22, 1979. This aircraft is currently operating at Ames under the aegis of the VTOL Systems Technology Applications Rotorcrafts (V-STAR) program. The V-STAR program will continue the work done under the VALT program.[2]

The V-STAR CH-47B is used as an airborne simulator at Ames. The cockpit will be modified with an artificial feel-and-trim system on the right side of the cockpit. This will require the removal of the existing controls and the installation of a new servo-feedback system that will operate the computer directly. The computer in turn will feed back the feel of the aircraft to the pilot through this control system. The cockpit will be modified further with a head-up display system that will enable researchers to investigate the pilot-in-the-loop qualities.[4]

Both NASA Ames Research Center and Stanford University, through the Joint Institute of Aeronautics and Acoustics, will use NASA 737 to conduct research experiments. In the near future, the first two sets of planned projects are the Hovering Flying Qualities and the Instrument Approach Flying Qualities.[5]

Variable-stability helicopters, such as the V-STAR CH-47B, are useful tools in the development of better flying qualities. The capabilities of airborne simulation are less restricted than ground-based simulation. Because of the increasing role of helicopters in doing a variety of new tasks and more demanding missions, variable-stability helicopters will continue to have a useful role in handling quality development and aeronautical research.

FOOTNOTES

[1]Adam, Charles F., Major in U.S. Army, interviewed by Lai Chi Yip, Ames Research Center, Moffett Field, Calif., 3:00 p.m., July 26, 1983.

[2]Labacqz, J. Victor, interviewed by Lai Chi Yip, Ames Research Center, Moffett Field, Calif., 8:00 a.m., July 21, 1983.

[3]Ross, Victor, interviewed by Lai Chi Yip, Ames Research Center, Moffett Field, Calif., 10:30 a.m., Aug. 16, 1983.

[4]Robinson, Gilbert G., interviewed by Lai Chi Yip, Ames Research Center, Moffett Field, Calif., 10:00 a.m., July 19, 1983.

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3. Garren, John F., Jr.; and Kelly, James R.: Description of an Analog Computer Approach to V/STOL Simulation Employing a Variable-Stability Helicopter. NASA TN D-1970, Langley Research Center, Hampton, Va., 1964, p. 1.

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5. Labacqz, J. Victor: Memorandum for the Record: CH-47 Flight Research Experiments. Ames Research Center, Moffett Field, Calif., Dec. 1982, pp. 1-2.

1. Report No. NASA TM-85931	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle NASA AMES SUMMER HIGH SCHOOL APPRENTICESHIP RESEARCH PROGRAM, 1983 RESEARCH PAPERS		5. Report Date
		6. Performing Organization Code August 1984
7. Author(s) Patricia Powell, Coordinator		8. Performing Organization Report No. A-9689
9. Performing Organization Name and Address NASA Ames Research Center Moffett Field, CA 94035		10. Work Unit No. G-3265
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		13. Type of Report and Period Covered Technical Memorandum
		14. Sponsoring Agency Code 010-01-03

15. Supplementary Notes

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16. Abstract

Engineering enrollments are rising in universities; however, the graduate engineer shortage continues. Particularly, women and minorities will be underrepresented for years to come. As one means of solving this shortage, Federal agencies facing future scientific and technological challenges were asked to participate in the Summer High School Apprenticeship Research Program (SHARP). This program was created 4 years ago to provide an engineering experience for gifted female and minority high school students at an age when they could still make career and education decisions.

The SHARP Program is designed for high school juniors (women and minorities) who are U.S. citizens, are 16 years old, and who have unusually high promise in mathematics and science through outstanding academic performance in high school. Students who are accepted into this summer program will earn as they learn by working 8 hours a day in a 5-day work week. This work-study program features weekly field trips, lectures and written reports, and job experience related to the student's career interests.

17. Key Words (Suggested by Author(s)) Student research projects High school apprenticeship program		18. Distribution Statement Unlimited Subject Category - 99	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 141	22. Price* A07

*For sale by the National Technical Information Service, Springfield, Virginia 22161