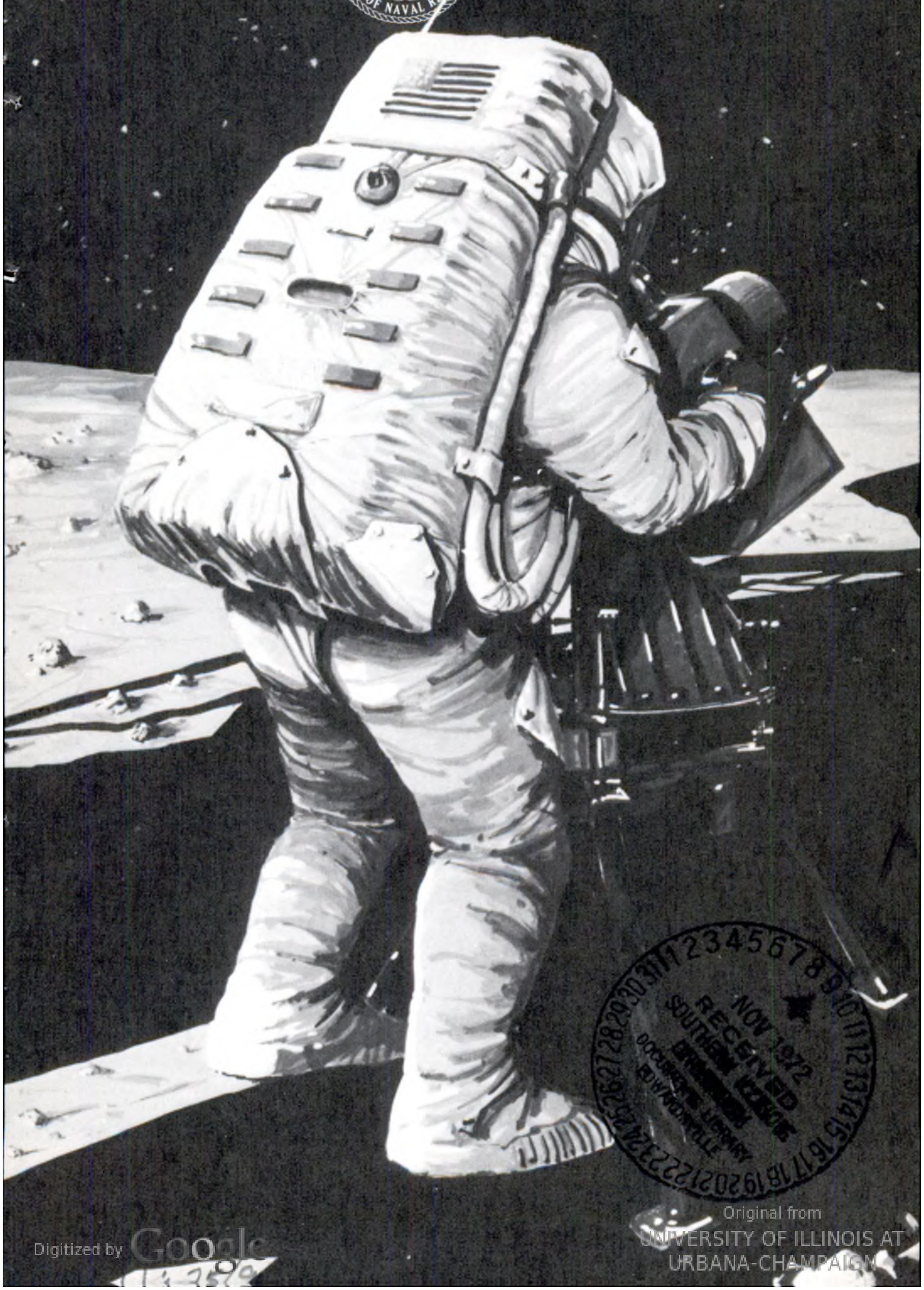
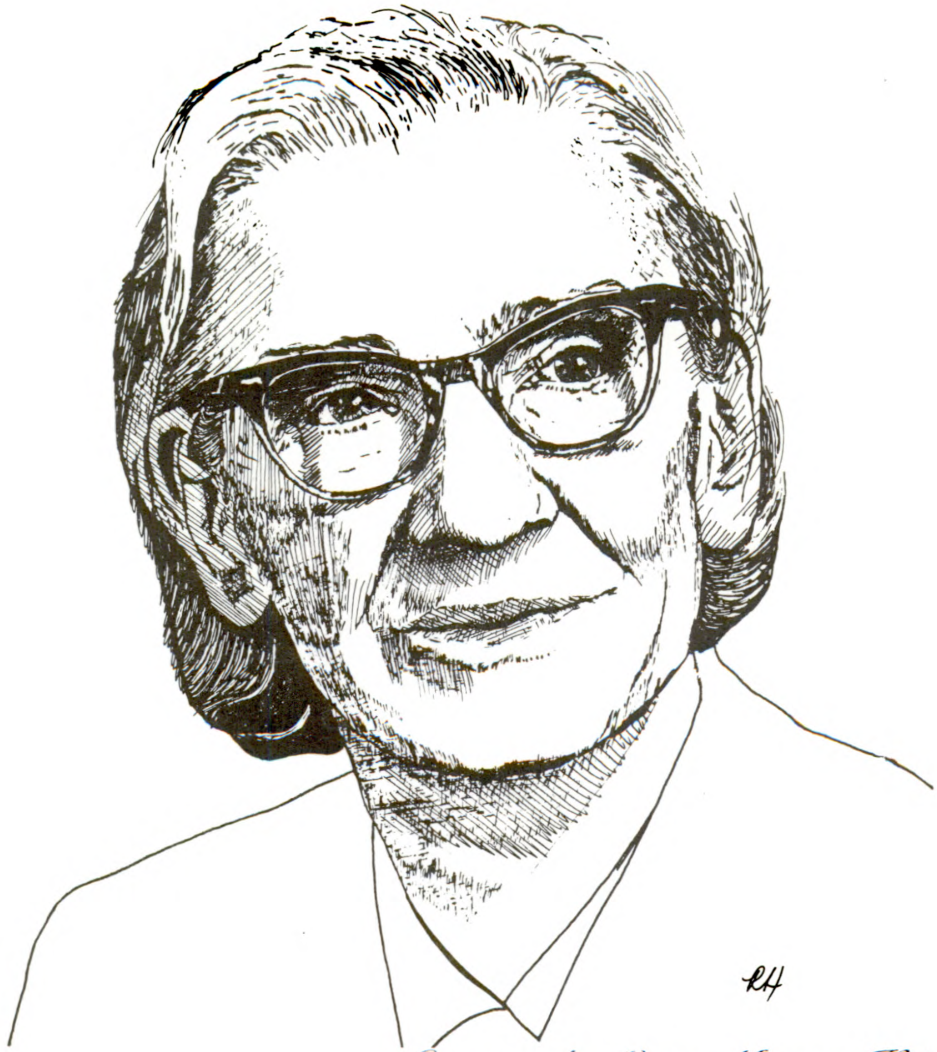
NAVAL RESEARCH REVIEWS

SEPTEMBER 1972



PROFILES IN SCIENCE



Commander Grace Murray Hopper

Commander Grace Murray Hopper, USNR, a pioneer in the field of computers, entered the U. S. Naval Reserve in 1943. She was assigned to the Bureau of Ordnance Computation Project at Harvard where she programmed the first large scale computer, Mark I. She then joined the Harvard Faculty and worked at the Computation Laboratory on the Navy's Mark II and Mark III computers. From 1949-1971 Commander Hopper was with Sperry Rand Corporation as Staff Scientist, Systems Programming where she published the first major paper on compilers.

Since 1959 she has been on the faculty of the Moore School of Electrical Engineering of the University of Pennsylvania as Visiting Associate Professor of Engineering and since 1971 as Professorial Lecturer at the George Washington University. She has published over 50 papers on computer programming. Her interest in computer programming led to standardizing computer languages. While at Sperry Rand Commander Hopper directed the project to standardize the many data processing languages than used by the Navy. COBOL, the present U. S. Government standard data processing language, was the result of this work.

She maintained her close connection with the Naval Reserve, and in 1966 retired with the rank of Commander. She was recalled to active duty in 1967. Commander Hopper is presently serving in the Information Systems Division of the Office of the Chief of Naval Operations.

Apollo 16 Ultraviolet Astronomy Observations

George R. Carruthers*
Naval Research Laboratory

The Naval Research Laboratory Far-Ultraviolet Camera/Spectrograph was successfully operated on the lunar surface during the Apollo 16 mission April 21-23, 1972, by Astronaut John Young. Nearly 190 frames of film were exposed during the mission, and were returned to Earth for processing at the NASA Manned Spacecraft Center.

The semiautomatic combination camera and spectrograph incorporates an electron intensifier. A Schmidt optical system focuses an image on a potassium bromide cathode, which emits electrons in proportion to the number of ultraviolet photons striking it. A 25,000-volt potential accelerates the electrons toward a special photographic film. The focusing magnet surrounding the camera ensures that the electron image is a faithful reproduction of the ultraviolet image. The electronic intensifier permits a 10- to 20-fold reduction in exposure time. (Figure 1).

One of the primary objectives of the experiment was to obtain imagery and spectrographic data on the Earth's upper atmosphere, and the outermost extension of it which consists mostly of atomic hydrogen and is known as the geocorona. The hydrogen geocorona had been shown by previous space probes and high-orbiting satellites to extend out to a distance of 10 Earth radii (about 40,000 miles) from the Earth.

The Earth photographs taken with this camera during the Apollo 16 mission have provided a much higher resolution picture of the geocorona than has been inferred from previous measurements. They will hence allow a detailed determination of the distribution, temperature, and velocity of hydrogen near the Earth. These studies are of practical importance to us on Earth, because the geocoronal hydrogen is believed to be the result of the dissociation of water vapor (into hydrogen and oxygen) in the upper atmosphere by solar ultraviolet radiation. Since the hydrogen is very light, it reaches high altitudes in the geocorona and eventually escapes the Earth's gravity altogether. The oxygen formed, however, is much heavier and remains in the atmosphere. Many scientists believe that this process, rather than photosynthesis by green plants, is the basis of the present oxygen content of our atmosphere. (Figure 2).

*Dr. George Carruthers is Research Physicist for the Naval Research Laboratory, specializing in astro-physics. He developed the electronic graphic camera which took the pictures described in this article.

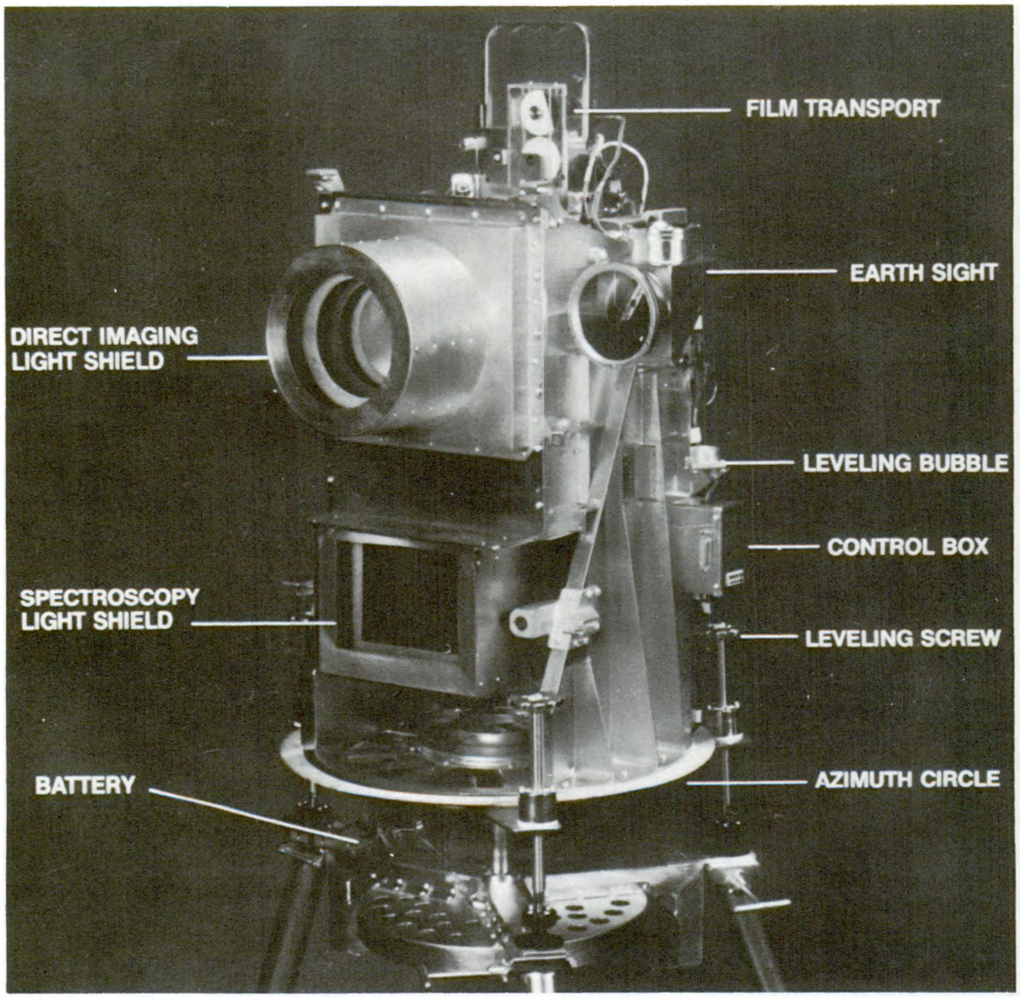


Figure 1 – The semiautomatic combination camera and spectrograph.

The ultraviolet Earth photographs have also provided, for the first time, a comprehensive picture of the polar auroras and various airglow phenomena. Observations of these phenomena from the ground, and from low Earth orbit, suffer, one might say, from an inability "to see the forest for the trees." Looking back at the Earth from a great distance allows simultaneous observations of the aurora at both the north and south magnetic poles, and yields as well an overall picture of the structure of the individual auroral zones. Also, it allows simultaneous observations of day and night airglow, and their distributions over a full hemisphere at one time. For example, the Apollo 16 photographs revealed a curious pattern of ultraviolet night airglow. This consists of two bands which start out at the sunset terminator on opposite sides of the magnetic equator. (These had been previously observed from Earth-orbiting satellites.) Then, however, the bands approach each other and cross near the midnight meridian, a phenomenon which had not been seen before. These pictures also revealed a very faint, general

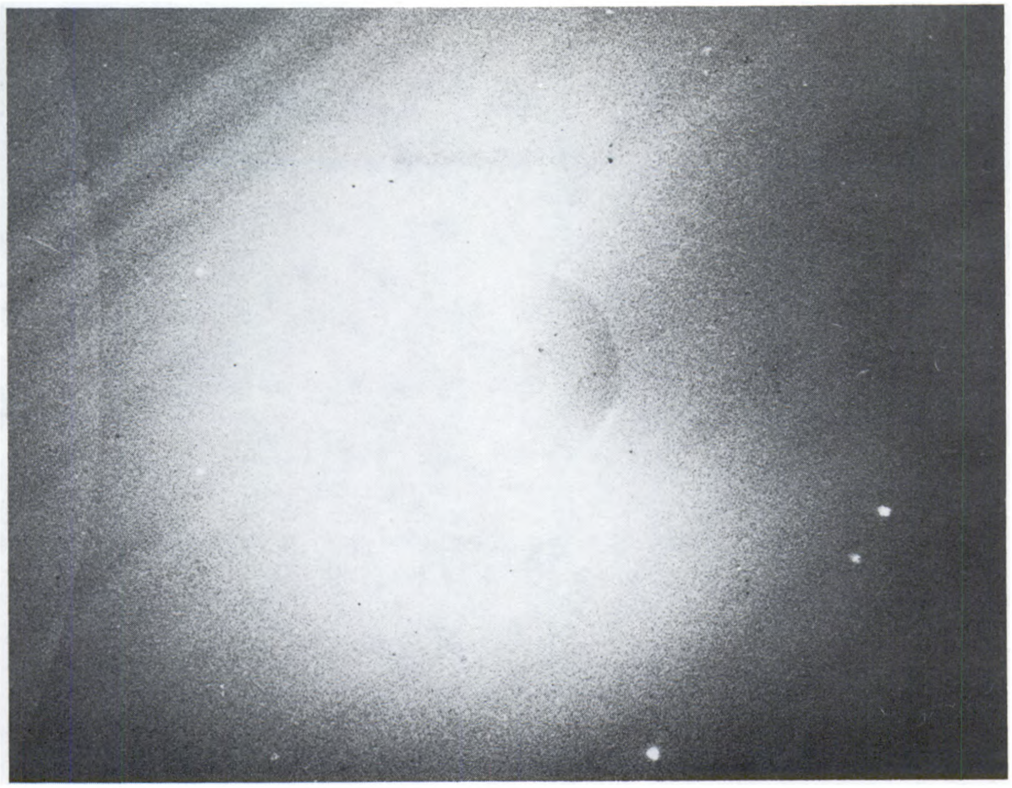


Figure 2 — A 60-second far-ultraviolet photograph of the Earth, showing the great extent of the hydrogen geocorona, which extends out to a distance of nearly 50,000 miles from the Earth. The diagonal streaks are instrumental.

night-side ultraviolet airglow which had been below the sensitivity limits of previous measurements. It is expected that these observations will contribute to our understanding of the Earth's upper atmosphere, which will have practical benefits in such fields as communication, and in understanding the possible long-term consequences of air pollution. (Figure 3)

The Apollo 16 experiment, operated as a spectrograph, extended measurements to much shorter wavelengths in the ultraviolet than had been reached by previous experiments. This enabled, for the first time, observations of helium, ionized oxygen, and ionized nitrogen in the upper atmosphere. These spectra provide information on the quantity and distribution of these constituents in the upper atmosphere.

In addition to the Earth observations, objectives of this experiment were to observe celestial objects, particularly diffuse nebulae, galaxies and clusters of galaxies, and also the solar wind and its interaction with the interstellar gas. The reason for doing these observations from the Moon, instead of from Earth orbit (as in the Orbiting Astronomical Observatory), is that observations of diffuse sources of far ultraviolet are greatly hindered by the much more intense glow of the Earth's hydrogen geocorona, which extends to at least 40,000 miles altitude.

Figure 3 — A ten-minute far-ultraviolet exposure of the Earth, taken with a filter which blocks the glow due to atomic hydrogen but transmitting that due to atomic oxygen and molecular nitrogen. Note that airglow emission bands are visible on the night side of the Earth, one roughly centered between the two polar auroral zones and one at an angle to this extending northward toward the sunlit side of the Earth.

The Apollo 16 observations not directed at the Earth showed that a diffuse ultraviolet glow due to atomic hydrogen is seen in all directions from the lunar surface. This glow is about one-fifth the minimum intensity seen from low Earth orbit (and about a fiftieth of the maximum), and is believed to be due to the interaction of the solar wind with the interstellar gas (which is mostly atomic hydrogen). This glow had been observed on previous space missions, but observations reported here should provide additional information on the intensity distribution over the sky and reveal any fine details in the glow, as might be due to discrete clouds in the solar wind. Also, an observation of the sunward boundary of the Earth's geocorona was made, which should provide information on the interaction of the solar wind with the near-Earth environment. The experiment also identified for the first time the diffuse glow from atomic helium in interplanetary space.

Among the objects photographed for the first time in the far ultraviolet by this experiment, were the North America Nebula and Loop Nebula, in the constellation Cygnus (The Swan). The North America

Nebula is a cloud of gas which glows as a result of excitation by the far-ultraviolet radiation of nearby very hot stars. The Cygnus Loop is the remnant of a supernova (exploding star) which is believed to have exploded some 50,000 years ago. Comparison of ultraviolet and visible brightnesses of these objects will contribute to our understanding of the two different types of emission nubulae. (Figure 4)

Figure 4 – A far-ultraviolet photograph of the Milky Way in Cygnus. The North America Nebula is faintly visible in the upper right hand part of the picture, and a portion of the Cygnus Loop Nebula is seen in the lower right.

Detailed observations of the nearest external galaxy, the Large Magellanic Cloud, in the far ultraviolet also were made for the first time. Comparison of ultraviolet with ground-based visible-light photographs will allow determination of the distribution of very hot stars, (which emit most of their radiation in the far ultraviolet) relative to the much more numerous cooler stars, which are brightest in the visible and infrared.

Also, comparison of ultraviolet and visible observations for the star fields observed in our own galaxy will permit better determinations of the distribution of hot relative-to-cool stars, and the ultraviolet observations permit better determinations of the temperatures and other properties of stars already known to be hot from ground-based

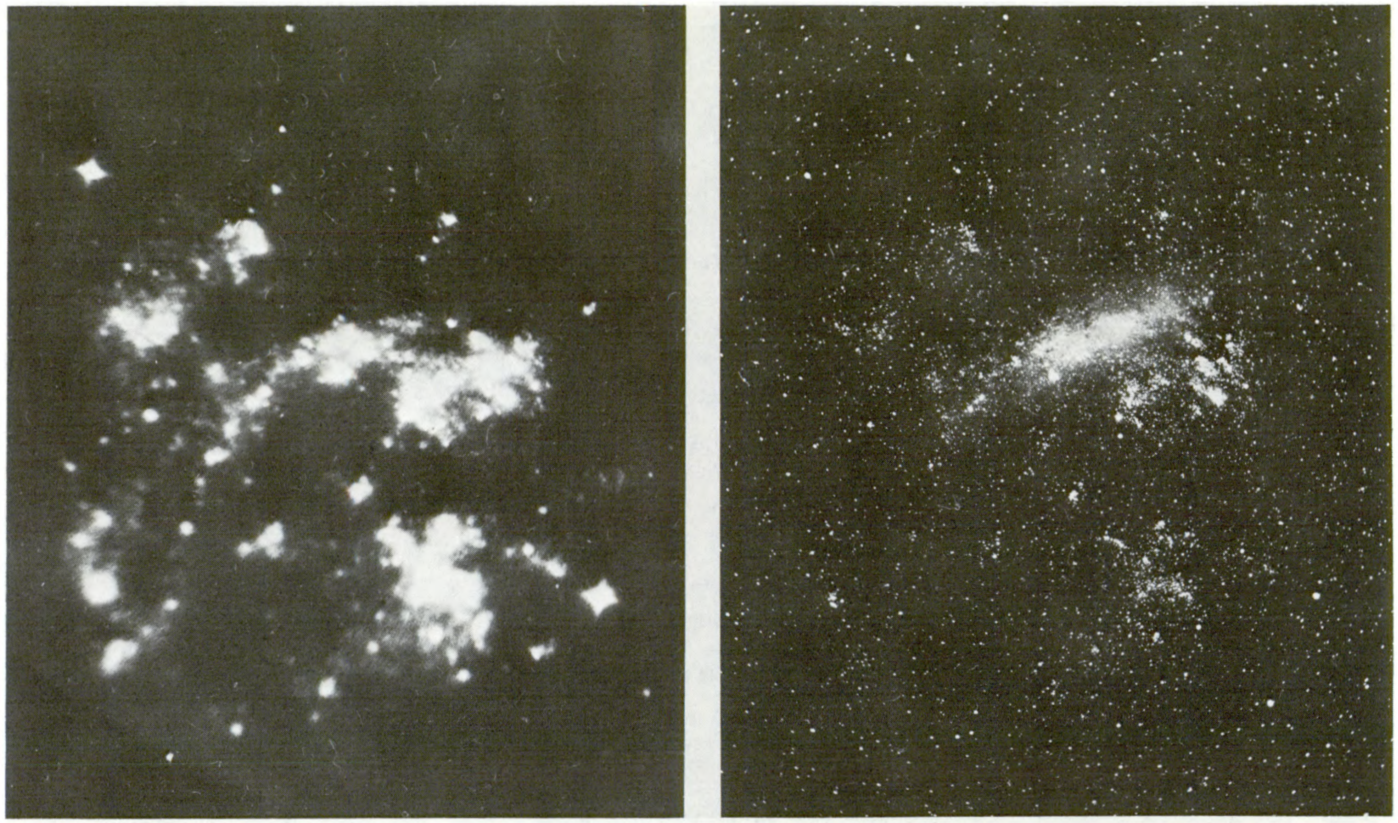


Figure 5 — A comparison of the Large Magellanic Cloud as photographed in the wavelength range 1250-1600 A by the Apollo 16 Far-Ultraviolet Camera/Spectrograph (left), and in visible light with a ground-based astronomical camera (right). Note that the central "bar" of the LMC, which consists of relatively cool stars (about the temperature of the Sun, or less) provides most of the visible light, but is not evident in the far ultraviolet. The hot, blue stars in the outer regions of the LMC are relatively inconspicuous in visible light but are much brighter in the far ultraviolet. (Visible light photo courtesy of Lick Observatory.)

observations. The far-ultraviolet observations also reveal new information on the properties and distribution of dust and gas in interstellar space from the manner in which they absorb ultraviolet star light. These studies will contribute to understanding star formation and provide useful information on how the earth and our solar system were formed.

An example of the power of ultraviolet observations to discriminate between hot and cool stars is given by the fact that first-magnitude stars (the brightest class of stars as seen from the Earth in visible light) of the temperature of the Sun, or less, are totally invisible to the ultraviolet camera, whereas very hot stars as faint as thirteenth magnitude (100,000 times fainter in visible light) were detectable in the far ultraviolet. (Figure 5)

Final objectives of the S-201 experiment were to study any lunar atmosphere, and to determine the suitability of the lunar surface as a site for future astronomical observatories. In pointings close to the lunar horizon, it was found that the sky glow was more intense than in other regions of the sky, and increased toward the horizon. This would be expected in the presence of a tenuous lunar atmosphere; however, we cannot as yet be certain that this effect was not produced by stray ultraviolet sunlight scattered into the camera by the lunar landscape. We can, however, say unequivocally that the lunar surface is a nearly ideal place for astronomical observations. The sky background radiation, except for that due to atomic hydrogen, is extremely low even in broad daylight, and relatively simple modifications to the instrument would allow much fainter objects to be studied. However, because the present lunar landing program ends with Apollo 17, and because the NRL camera/spectrograph experiment is not scheduled for this mission, it will be several years before any follow-up observations can be made.

NRL Acquires New Aircraft

The Naval Research Laboratory has recently acquired a Lockeed P-3A Orion patrol aircraft, which has been modified to serve as an oceanographic research platform for NRL's Ocean Sciences Division, as well as a general test bed for other NRL users.

The Ocean Sciences Division will equip the four-engine plane with research instrumentation to be operated by NRL scientists in an oceanographic study program at sea, sponsored by the Naval Air Systems Command. The aircraft will carry upward and downward-looking radiometric sensors to monitor the energy transfer between the sea and sky and its effect on the air-sea interface.

Also on board are temperature, pressure and humidity sensors; multi-directional cameras; an instrument for measuring radiation from the atmosphere

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Computer-Assisted Instruction

Marshall J. Farr*
Office of Naval Research

Computer-Assisted Instruction (CAI) refers to the use of the computer for instruction, *i.e.*, as a means of presenting material to, and interacting with, a student. Navy activity in this domain is directed toward utilization of the computer to provide adaptive, individualized instruction of the highest quality. Because computer technology and its programming arts are already so advanced, and are continuing to progress so rapidly, on-line interactive, man-computer communication need not be stilted and impersonal.

Research in CAI indicates that some students relate better to an interactive computer than to a human instructor. And, of course, a computer is not subject to human frailties. Modern time-sharing computers are highly reliable, work overtime without complaint, and never go on strike. Moreover, the computer is infinitely patient, and its programs can represent the teaching approaches and knowledge of the best minds in pedagogy as well as in diverse subject areas.

Despite the many advantages of CAI it should be recognized that the computer's tutorial effectiveness is limited by what we still do not know about basic learning processes, about why we learn, how we learn, how we remember, and how we integrate bits of knowledge into a coherent whole. These kinds of questions have been the subjects of investigations sponsored by the Office of Naval Research and directed toward the advancement of CAI technology. These studies shed light on such aspects as individual differences in learning and means for identifying and taking advantage of an individual's unique aptitudes and abilities, while maintaining his desire to learn. In other words, CAI research is as much concerned with exploring the learning process as with controlling it.

Under ONR sponsorship, Dr. Jaime Carbonell of Bolt, Beranek and Newman is pursuing research with a system called "SCHOLAR," which is characterized by a mixed-initiative dialogue between learner and computer. The term mixed-initiative indicates a man-computer relationship in which either party can take the initiative, *i.e.*, ask and answer questions and engage in discussion. The Bolt, Beranek and Newman approach with SCHOLAR generates the computer dialogue out of a data

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* Dr. Farr is Director of the Personnel and Training Research Program in the Psychological Sciences Division of ONR. He has also served as Assistant Director of ONR's Engineering Psychology Program. From 1960-1964, he was a Research Psychologist at the U.S. Naval Training Device Center, then located at Port Washington, New York. Dr. Farr has taught in the Psychology Departments of Fairleigh Dickinson University and the New School for Social Research in New York City.

base that is a complex but well-defined structure in the form of a semantic network of facts, concepts and procedures. A semantic information structure or network is an organization of units of information in terms of their meaning and mutual relationships. In contrast, when a network is based on how words are organized sequentially or grammatically within a sentence, it is serving as a *syntactic* structure.

SCHOLAR is different from the traditional approach to CAI, which may be considered to be *frame-oriented*. In such a system, a frame (each single display presented to the trainee) is constructed out of specific pieces of text, specific questions with their predicted answers, errors and anticipated branching. All frames in this kind of system are entered in advance by the teacher or programmer. In such a system, the student is capable of little or no initiative, and must communicate with the computer in a relatively restricted form of language. And the teacher has the burden of preparing questions, answers, and branching strategies. Here, the system controls the student; but it is incapable of real initiative or decision power of its own.

In contrast to a frame-oriented system, SCHOLAR's semantic network system represents what Carbonell calls an Information-Structure-Oriented (ISO) approach. The network allows SCHOLAR to generate the material to be presented to the student in reasonably natural conversational English. In its present implementation, the experimental program, which uses South American geography as its subject, is aimed at reviewing the student's knowledge in this field. But it is being designed with a good degree of modularity in both program and data base, in order to assure ready generalization to many other examples and fields of application. A good description, with illustrations of the way SCHOLAR works, is contained in Carbonell's article in the October 1971 issue of *Naval Research Reviews*. Carbonell will shortly begin to evaluate the instructional merit of the full mixed-initiative capability as compared to a reduced, less interactive, version of SCHOLAR. Both versions will operate on the data base.

Dr. Joseph Rigney, who directs the Behavioral Technology Laboratories at the University of Southern California, has been working on a method for computer-assisted performance training, using a computer time-sharing system to help trainees to learn serial tasks, from operating equipment to electronic troubleshooting.

TASKTEACH is the generic name of two large computer programs for this tutorial system. TASKTEACH provides the student with variable amounts of learning support, as he requests it, to help him organize the material and the processes which lead to mastery. During each learning session, TASKTEACH continuously updates the history of the student's progress and the state of the equipment or task structure that it is simulating. Thus it can generate responses to the student from this updated information. TASKTEACH logic is made specific to a particular equipment or task structure by relatively short lists which describe elements and relationships among them in sufficient detail for the simulation. These lists replace the conventional, frame-by-frame description of the typical CAI instructional sequence. (Figure 1).

To use TASKTEACH to learn to troubleshoot electronic devices from front-panel controls and indicators, the student selects a course, *e.g.*, on the AN/SPA-66 radar repeater, and enters a problem number. This directs the program to simulate a failure in a particular circuit of the equipment. The computer then describes to the student, during its interaction with him, those front-panel indicator symptoms that the malfunction would produce. The student proceeds to collect symptoms from

Figure 1 – Student station for TASKTEACH. Student interacts with a TASKTEACH program via keyboard-display terminal at lower left. Apparatus at right is AN/URC-32, on which student is learning to troubleshoot. List on upper left is for student's constant reference.

indicators by manipulating the front-panel controls in patterns that will (1) make particular kinds of information visible on each indicator when the equipment is functioning normally, and (2) uncover all possible symptoms of abnormal functioning. The student can do this symptom-collecting in any order he chooses. He is not constrained to a fixed procedural sequence. Furthermore, he can either ask for only one type of information at a time, or he can make a whole series of front-panel tests by entering a list of indicators and control settings in one input message. By using some of the commands in TASKTEACH that give him detailed knowledge of results, and that allow him to "look ahead" and test hypotheses about the malfunction, the student can learn about the effectiveness of each test he makes, and can increase his knowledge of possible causes of symptoms. In this way, he can learn to improve his troubleshooting strategy.

The student can also ask the program to "insert" a known malfunction in the equipment. He can then test his knowledge of the symptoms it would produce by attempting to predict the indicators and the types of information displayed by each, as they would be affected by this known malfunction. The program will, in this "backwards troubleshooting" mode, evaluate the student's predictions and correct those that are wrong.

Since equipment like the AN/SPA-66 radar repeater and the AN/URC-32 radio transceiver have from 20 to 40 front panel controls that have to be set in the right patterns before symptom information is visible on an indicator, the student must, of course, learn these patterns. The troubleshooting section of TASKTEACH not only corrects the student's incorrect patterns, but also includes a provision for drill in making these settings. The student can select the particular information he wants made known by some indicator. He then instructs the computer to set the controls in the correct pattern, and is given error-correcting knowledge of results by the program. The student can run through a series of these drills any time he chooses, in conjunction with a troubleshooting session.

In addition to the troubleshooting program, TASKTEACH includes a program to help students learn other types of task structures. Radio operators, for example, could learn how to tune the transmitter in the AN/URC-32, or how to set it up in a particular one-of-five "receive modes." Similarly, a mechanic could learn how to disassemble, repair, and reassemble a mechanical device such as a carburetor. As indicated earlier, this program is made specific to a particular task by list-structures which describe goals, subgoals, actions, and constraints that specify the ways these elements are organized sequentially. Since almost all human work can be described in terms of goal-action hierarchies, this part of TASKTEACH is potentially widely applicable.

The TASKTEACH programs were designed to be used with a variety of terminals, including on-line front-panel simulators analogous to those currently being used by IBM for their in-house computer maintenance training. However, these programs currently are used with teletypes or alphanumeric CRTs and random-access slide projectors under program control. The projectors are used to display color photographs of controls and indicators on the particular equipment that is the subject of the training.

In summary of TASKTEACH, it represents a capability which provides a number of learner options, and which can be used in a number of different ways or modes. The student need not have control over the learning-support functions. They can be made automatic, left to the instructor to control, or, with a little additional programming, they can be made part of an adaptive scheme. In a similar way different kinds of troubleshooting strategies could be included as models for the student to learn.

Processor Richard Atkinston, Chairman of the Psychology Department at Stanford University, has been in charge of administering a CAI course in computer programming at Di Anza College (a junior college near Stanford) and at UCLA. Students receive college credit for this course, which was originally developed with support from NASA Ames. For this ONR contract, Atkinson and his staff have been designing data-collection routines to measure student performance at frequent intervals during the course. In addition, the program has been constructed so as to analyze a student-written program to see if it will run on the computer. If not, the instructional program assists the student in debugging his own material.

The computer program for this course allows the *learner* to control what material is displayed to him, as well as his rate of learning. As the student goes through the course, his response history is recorded automatically in terms of how frequently he requests reviews, how long he devotes to various items and modules, how rapidly he responds, and so on. The Stanford group will analyze the dominant patterns of learner behavior, and correlate *each* individual's response-history with his course achievement. The findings will be examined to determine such things as the best time to branch, to repeat material, and to provide feedback to the student.

In the next phase of this research, two additional CAI modes will be tried. Their structure will be based on the recommendations for optimal patterns of presentation, review, feedback, *etc*., toward which the research on the ongoing learner-controlled CAI will lead.

Why is the mode of learner-controlled instruction a model from which optimal instructional strategies can be derived? When the student performs at his own rate, he is not constrained by a program. In a sense, he automatically selects what is most motivating to him, what he feels he *needs* and *wants* to learn. Learning might really turn out to be fun.

Good students can tackle complex problems and can concentrate on conceptual rather than computational matters. But most of all, who knows better than the pupil himself *what* he is *ready* to learn next, and *when* he is ready? After all, learning takes place, in the final analysis, between the ears.

Now, returning to Atkinson's work: The first additional mode, a *response-insensitive* one, will be a straight-line, completely canned course. This means that what is presented to the learner will be inflexible, and completely independent of his responses.

The second additional mode involves a *response-sensitive* program, which contains the necessary logic to branch (*e.g.*, for enrichment or remedial purposes) based on the student's ongoing course achievement and his pre-course knowledge base. Here, although the computer program tailor-makes the instruction provided to each student, based on continually-updated course-achievement information, the learner has no option to tell the program how *he* would like it to interact with him, or what *he* would like it to offer.

After these three different modes of CAI have been implemented, they will be compared with each other in terms of learning speed and quality. Each student's performance will also be examined in relation to certain personality characteristics: for example, to see whether certain types of individuals habitually do better in a highly structured, non-permissive learning environment.

A Florida State University (FSU) investigation in CAI was established as part of the THEMIS program. Because of this heritage, it deals with a broad range of research efforts, Hedl, in his doctoral research under the contract, has demonstrated the feasibility and validity of an interactive approach to the individualized assessment of intelligence. Test items from the Slosson Intelligence Test, developed in 1963, were individually presented on a CRT. Students typed in their answers for immediate computer evaluation. The answer-analysis algorithm was based upon a key word/phrase dictionary for each item, which was developed from previous test-item protocols. The computer in this case, for the first time, was used for automatically *administering* an intelligence test, and for real-time response-evaluation. If a student's answer was either correct or incorrect, the program moved to the next item. If the answer was interpreted as partially correct, the computer instructed the student to explain more fully his response. If time limits for a given item were exceeded, the computer asked the learner to "please answer the question or type pass," and then gave him another chance at the question. If time ran out again, the item was scored as wrong, and the program went on to the next item. The computer-based version of the Slosson Intelligence Test was experimentally compared with the oral administration of the traditional Slosson Test, as well as with the Wechsler Adult Intelligence Scale (WAIS). The computer-based Slosson

Intelligence Test correlated .75 with its traditional version. Equivalent concurrent validity relationships with the WAIS, for a college population were: a .54 correlation between the WAIS and CB-SIT; and a .52 correlation between the WAIS and the traditional SIT.

In other studies under this FSU contract, measures of both "trait anxiety" and "state anxiety" were taken of students engaged in learning mathematical material in a CAI mode. According to Dr. Charles Spielberger of FSU, who first conceptually differentiated these two anxiety conditions, "trait" anxiety represents the anxiety potential or proneness of an individual, or in other words, how likely he is to develop anxiety in situations commonly thought to provoke it. On the other hand, "state" anxiety is a temporary, transitory condition of actual apprehension and heightened autonomic nervous system activity. The common psychological test for measuring anxiety, the Taylor Manifest Anxiety Scale, seems to measure *trait* anxiety, even though Taylor, its author, propounded a theory based on state anxiety. Taylor never conceptualized two different dimensions of anxiety.

The CAI math learning investigations showed that high state-anxiety students make more errors on the difficult learning material than do low state-anxiety learners. On the *easier* material, both state-anxiety levels did equally well. The *trait*-anxiety level was not found to be related to performance.

Further FSU work on the effects of trait and state anxiety on CAI performance is more complicated, combining the types of anxiety with types of material (non-technical *vs.* technical) and various types of responses the subjects are called upon to make. Results here have been difficult to interpret because of interaction effects. More research is planned in this area.

The FSU researchers conceptualized curiosity as also being either trait curiosity or state curiosity. A "State Curiosity Scale" (SCS) was developed to measure this type. Since curiosity is a motivational construct, it can aid in stimulating the acquisition of knowledge or skills (which is, after all, the aim of all training). The particular type of curiosity studied by FSU, that most relevant to the learning process, was given the fancy name of epistemic curiosity, which merely referred to *knowledge-seeking* curiosity behavior. Research by FSU indicated that, when levels of curiosity are high, levels of anxiety are low. Given the debilitating effect of high-anxiety on performance and mental functioning, it can readily be seen that maximizing curiosity to minimize anxiety has definite implications for an optimal learning environment.

Project ENRICH, another major FSU research director, refers to a CAI/*CMI* effort undertaken by the Naval Reserve Training Facility (NRTF) in Tallahassee with the very close support of the FSU CAI Center. What is C*M*I? It stands for Computer-*Managed* Instruction, and, in contrast to CAI, refers to the *off-line* use of the digital computer to collect and analyze data about a student's cumulative performance and session-to-session learning progress, and then to diagnose his learning problems and make individualized decisions with regard to the optimum next learning step for the trainee. In CMI, then, the computer is not in the loop with the learner; rather, it serves as a record keeper, test scorer, decision-maker, and selector of appropriate remedial material.

Although CMI can play a valuable role in the instructional domain, the technology behind using a computer mainly to store information and process data is not really central to instructional-psychology or the tutorial side of education. The FSU research involved both CAI and CMI, in that it focused on using the computer to *manage* the training of, and do some *instruction* for, Seaman Recruit Reserves in the subject of Basic Military Requirements (BMR). The material programmed on the computer by the NRTF was taken from the Test Manual of the BMR Correspondence Cource for advancement to pay grade E-2. Part of the material was taught on a CRT display under computer control. Part was monitored self study, assigned by the computer, and part was homework to read selected BMR chapters or to complete Correspondence Course assignments. The effectiveness of the program was determined by comparing the performance of the Seaman Recruits trained with CMI procedures to that of recruits of comparable ability who were conventionally trained at NRTF, Tallahassee during previous years. The main measure of performance achieved was the Standard Navy Advancement Examination for Seaman Apprentice. Unfortunately, although 30 Seaman Recruits were requested, only six were made available. Although their average score on the final exam was no better that the average of the Seaman Recruits in the comparison group, they reached this level of achievement in about 33% *less* time.

Project ENRICH has demonstrated the potential value of computer-aided instruction and management in training Naval Reserve personnel. The results suggest that it would be worthwhile to carry out more definitive studies to determine the range of useful appliction of computer-assisted procedures in various types of Navy training programs.

There are several directions in CAI that could usefully be emphasized in the future. To permit optimum utilization of the computer for instruction (rather than merely use it as an automated textbook), it is desirable to develop improved methods for assessing learning progress and adjusting the pace of the computer teaching process accordingly. Learner control of the tutorial process would take into account the fact that the student himself may very well know better than anyone else when he is prepared to tackle the next task. Research is also required to show what types of information and skills can best be taught by computer, and to determine to what extent the costs involved can be amortized through many additional uses of the computer both ashore and onboard ship.

Examples as record keeping, job aids, instant technical manual update, and the like. The possibility of using satellites for remote-source instructional input to the computer on a ship should also be investigated.

Another effort which could be pursued with advantage would explore the use of the visual-display capabilities of computers in CAI. Computer graphics might allow evaluation of the extent to which "one picture is worth a thousand words" in a particular pedagogical process. The computer can, among other things, show three-dimensional representations, move complex figures through space, and depict the flow of electricity in electronic circuits.

Finally, there is need to evaluate the instructional effectiveness of CAI relative to conventional approaches. CAI, used in its most flexible way—interactively, with learner control—calls for a continual restructuring of content to adapt in real time to a students' needs and abilities. In comparisons of this approach to older methods, new kinds of base-line criteria may be required. Obviously, cost, although not an instructional criterion, will ultimately be an significant consideration.

Navy Study Points Way to Manipulating Body Temperature Up or Down

A Navy study has pointed the way to the possibility of manipulating body temperature up or down. Recent experiments have shown that the normal temperature of animals can be shifted as much as ten degrees (F) higher or lower than the usual norm.

The work is underway at Purdue University under the direction of Dr. Robert D. Myers under an Office of Naval Research contract, with additional funds provided by the National Science Foundation. Dr. Myers has been engaged in long-term research on the hypothalamus, a structure at the base of the brain containing the thermostat that regulates body temperature.

The Navy's objective is to develop means of protecting its personnel from exposure to prolonged severe heat or cold. In addition, lowering the temperature would reduce the risk in surgery while raising it would help in fighting certain infections.

Dr. Myers has discovered that temperature in sub-human primates (and presumably man) is set at what is called normal by a balance of calcium and sodium ions in the hypothalamus. Although the balance is occasionally upset by infection or exposure to cold or other causes, the set point never changes. The body continuously tries to return the temperature to the set point through various mechanisms, such as shivering and sweating.

(Continued on Page 26).

Ice Stalactites and the Desalination of Sea Ice

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Department of Oceanography
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Recent observations by scuba divers in both the Arctic and Antarctic Oceans show the presence of large (0.5-6.0 m in length) ice stalactites growing beneath the pack ice. The following article discusses these observations, compares them with some laboratory experiments, and describes both the ways in which stalactites form and grow, and their relation to the desalination of sea ice. This work was sponsored by the Office of Naval Research.

Field Observations

Ice stalactites consist of tapered cylinders of ice, ranging in length from 0.25-6.0 m, and in diameter from 1-20 cm, which grow under the pack ice of the polar oceans. The stalactites freeze around very cold, dense streamers of brine which flow out of the pack ice. The largest observed stalactites grow in the sheltered waters of McMurdo Sound, Antarctica (1,2). Here, Dayton (1) observed a number of stalactites (Figures 1 and 2), one (not shown) reaching a length of 6 m. The stalactites occur fairly infrequently, Paige (2) observed 3 or 4 stalactites for approximately every 25 m^2 of under-ice area.

In the Arctic, divers have observed similar stalactites at several stations, although because the motion of the pack ice relative to the ocean periodically breaks off the stalactites, none have been reported with lengths greater than 0.5-1.0 m. During the winter of 1970-71, divers working for the Navy reported stalactites from the following locations: in November of 1970, Point Barrow, Alaska, and the ice island T-3, which was located at approximately 85°N, 98°W; in April of 1971, the joint Canadian-American Camp, Cape 200, which was located roughly 300 miles north of the MacKenzie River delta. Stalactites then, occur over large areas of the Arctic Ocean.

From all field observations, the stalactites are extremely fragile. Attempts by divers to break off a stalactite and bring it to the surface, for example, have always concluded with the stalactite disintegrating in the diver's hands. The stalactites which we grow in the laboratory

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are equally fragile, although by using great care, we have been able to recover one or two of them. There is no danger, then, of divers or under-ice vehicles being damaged by either running into or being impaled on the stalactites. The stalactites, however, may serve as acoustic scatters or attenuators and very likely play a role in the desalination of sea ice.

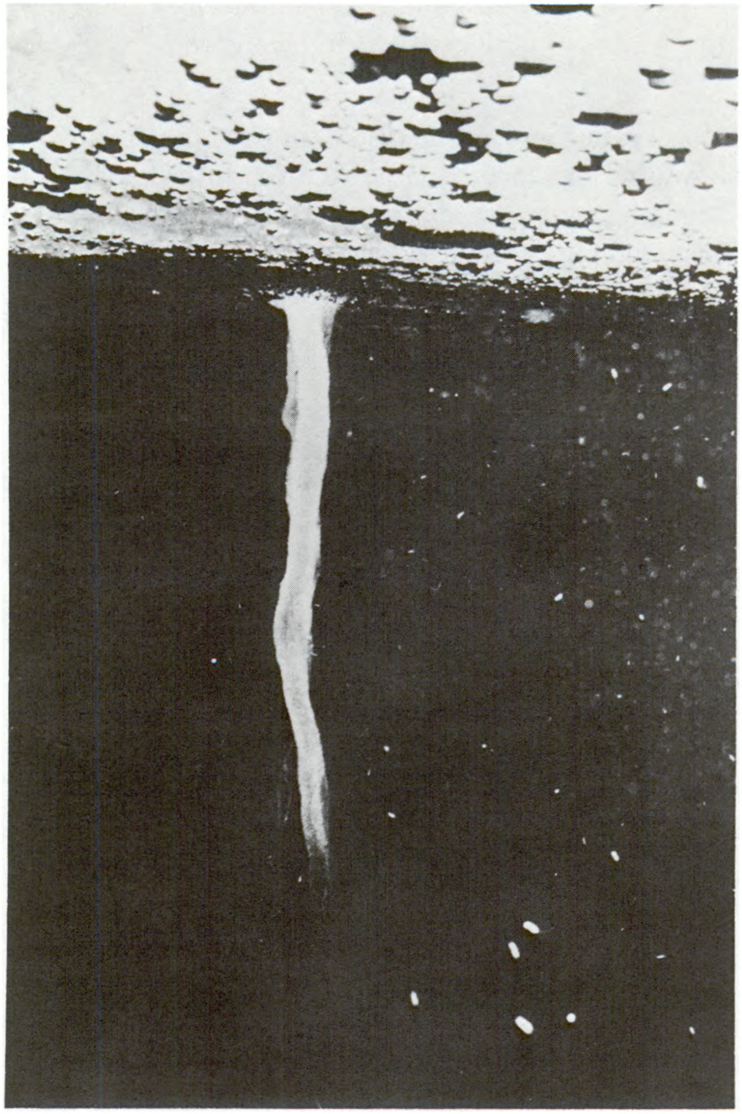

Figure 1 – An ice stalactite measuring 1.5 m in length and 10 cm in diameter. Dayton (1) took the photograph during November of 1968 off Cape Bird in McMurdo Sound. The bubbles on the lower surface of the ice come from the scuba apparatus.

Causes of the Stalactites

When sea ice forms, some salt water is trapped within the growing ice. The salt, however, is not uniformly incorporated within the ice; instead, sea ice contains small brine pockets, of order 1 mm in diameter, which are scattered throughout a matrix of fresh ice crystals (3). To understand how the brine in the brine pockets escapes from the ice to form stalactites and how the stalactites grow, let us briefly discuss the response to changes in temperature and salinity of a mixture of ice and a solution of the major constituent of sea water, sodium chloride.

The temperature at which a brine solution and fresh ice exist in equilibrium varies from 0°C for ice and fresh water, to −21°C for ice and a saturated salt solution (Figure 3). At temperatures below −21°C, the brine solidifies. Therefore, if we slowly lower the temperature of a mixture of ice and brine of the salinity of sea water (33°/∘∘), then ice freezes from the brine so that the salinity of the brine remains on the equilibrium curve. The effect of cooling, then, is to concentrate the brine.

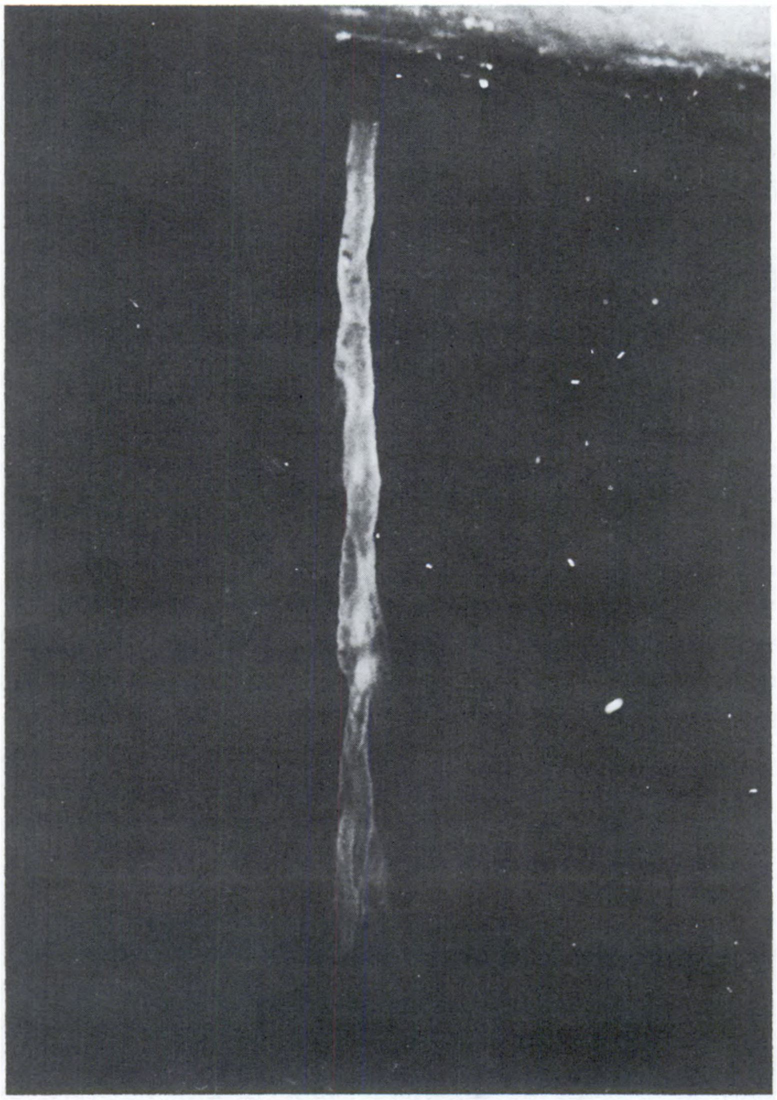

Figure 2 — Another McMurdo stalactite measuring 2.5 m in length and photographed at approximately the same time and location as Figure 1.

For sea ice during winter, the temperature at the upper surface generally falls in the range $-20°$ to $-50°C$, while the temperature at the lower surface is very nearly constant at $-1.8°C$, so that the environment imposes a large temperature gradient across the ice, and the salinity of the brine contained in the brine pockets of the sea ice increases upwards. Through some mechanisms which are only qualitatively understood, the dense, cold brine in the upper part of the sea ice drains into the underlying sea water through vertical tubes called brine channels. Lake and Lewis (4) in a field experiment which involved removing from pack ice a block of sea ice $2.2 \times 1.8 \times 1.8$ m thick, cutting this block into vertical and horizontal sections, and photographing each section, document in detail these brine channels. Since the sea water under growing sea ice is at its freezing point, when the brine exits from the brine channel into quiescent sea water, the dense cold brine can only be warmed by a tube of ice freezing from the surrounding sea water around the descending brine streamer.

To understand what subsequently happens, we consider the following experiment: Suppose we place a mixture of fresh ice and saturated salt water solution in an insulated box at an initial temperature 0°C. Since the equilibrium temperature for this mixture is $-21°C$, the ice melts to dilute the brine, and in melting absorbs heat, so that the temperature of both the ice and the brine drops. The temperature of the mixture will continue to drop until the temperature is low enough and the brine is dilute enough that the mixture reaches equilibrium.

Under the sea ice, the tube of ice which forms around the brine streamer permits the horizontal transfer of heat, but not salt. Therefore, immediately after formation of the tube, the fresh ice of the stalactite contains warm, dense brine. As shown from the experiment in the insulated box, ice and warm brine are not in equilibrium; to regain equilibrium, the inside of the ice tube melts to both cool and dilute the brine. The melting requires heat, which is provided by the latent heat released from the growth of more ice on the outer wall of the tube. As long as brine flows through the tube, the stalactite accretes on the outside and ablates on the inside, as well as constantly gaining ice from the cold brine flow.

Laboratory experiments confirm these ideas. Figure 4 shows a schematic view of our apparatus, in which cold, dense brine is pumped into an insulated container filled with salt water solution with an equivalent salinity to sea water, hereafter called "sea water," held at its freezing point. At the bottom of the tank, a recirculation system constantly injects sea water and removes the dense brine, which sinks through a diffuser to the bottom of the tank. Plexiglas viewports in the box allow us to both see and photograph the growth of the stalactite.

Figure 5 shows a sequence of 6 photographs taken by Donald Immerwahr, at 4-minute intervals of a growing stalactite. The brine is dyed a

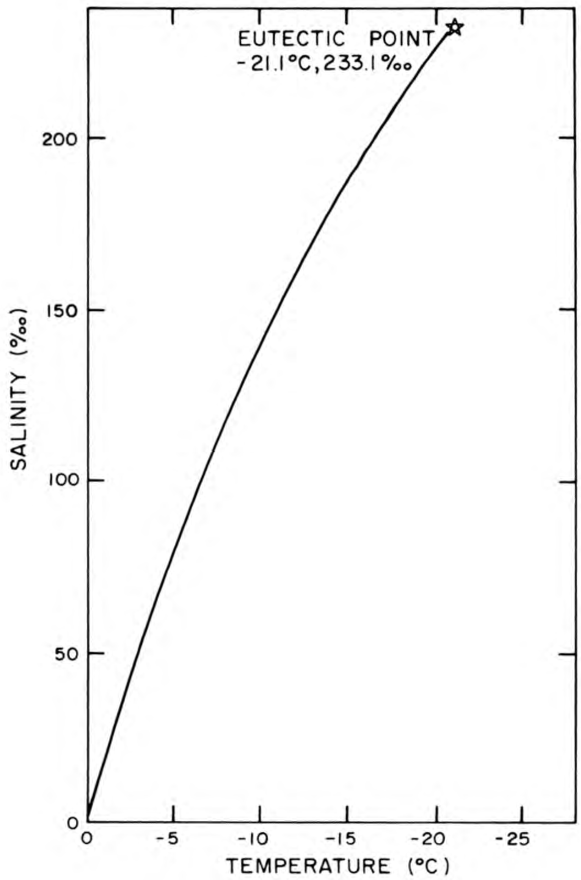

Figure 3 — Plot of the temperature at which fresh water ice and a solution of sodium chloride exist in equilibrium. (From the Brine Tables of the Morton Salt Company).

dark blue, and the stalactite is sidelighted to make visible both its inner and outer walls. Because the individual ice crystals which make up the stalactite are thin needle-like crystals oriented radially, light passes through the stalactite on any diameter. Thus, if we light the stalactite at right angles to the direction in which we photograph it, the stalactite wall facing the camera becomes nearly invisible, so that we can see the change with time of both the inner and outer walls of the stalactite. The series of photographs shown in Figure 5 illustrate the dramatic growth in both length and diameter of the stalactite.

Growth of the Brine Channels

The stalactite experiment suggests that a similar enlargement of the brine channel takes place inside the ice. Consider the flow of cold, dense brine through an initially small diameter brine channel from the cold, upper part of the ice to the warm lower part. To warm the cold brine, the surrounding ice conducts heat to the brine channel. Just as in the

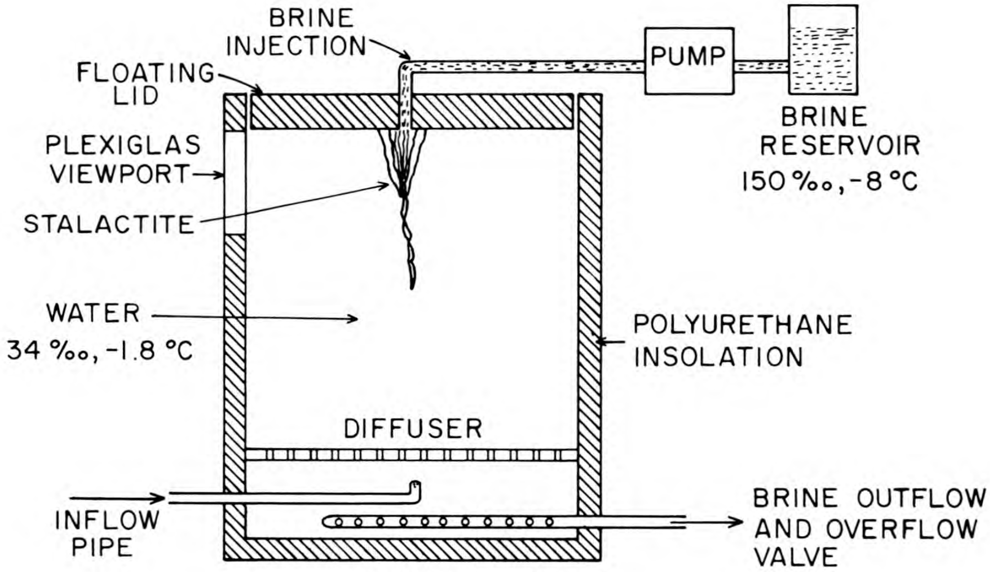

Figure 4 — A schematic, unscaled view of the freezing tank.

stalactite case, the brine temperature rises above equilibrium, so that to cool and dilute the brine, the channel wall melts. This melting requires an additional heat flow from the interior of the ice. The effect of pumping brine down through the ice is both to increase the diameter of the brine channel and to cool intensely the adjacent ice.

To investigate this process, we floated a block of transparent bubble-free fresh water ice with a thickness of 28 cm in a sea water solution in our tank. The temperature varied nearly linearly from −1.8°C at the bottom of the block to −11°C at the top. Into the block, we drilled a vertical hole with a diameter of 0.3 cm, through which we injected brine. Figure 6 shows two photographs of the brine tube and its stalactite. The first picture is taken 1 minute after the start of the pump; the second, 25 minutes later. During this interval, the tube diameter increased from 0.3 to 1.5 cm and the accompanying stalactite grew to a length of about 20 cm. In sea ice, the increase in diameter of the brine channel would both entrain brine pockets and reduce the viscous drag on the downward flowing brine.

The arrows on the photographs illustrate the effect of the stalactite on the brine channel. The upper arrows show the height of the sea water in which the block floats, and the lower arrows show the height of the brine in the first photograph. The growth of the stalactite causes an approximately 3 cm drop in the brine level. In the first photograph, a balance between the pressure caused by the weight of the brine in the tube and the hydrostatic pressure of the sea water at the bottom of the ice determines the brine level. As the stalactite grows, the length of the tube filled with brine increases, so that to maintain the hydrostatic

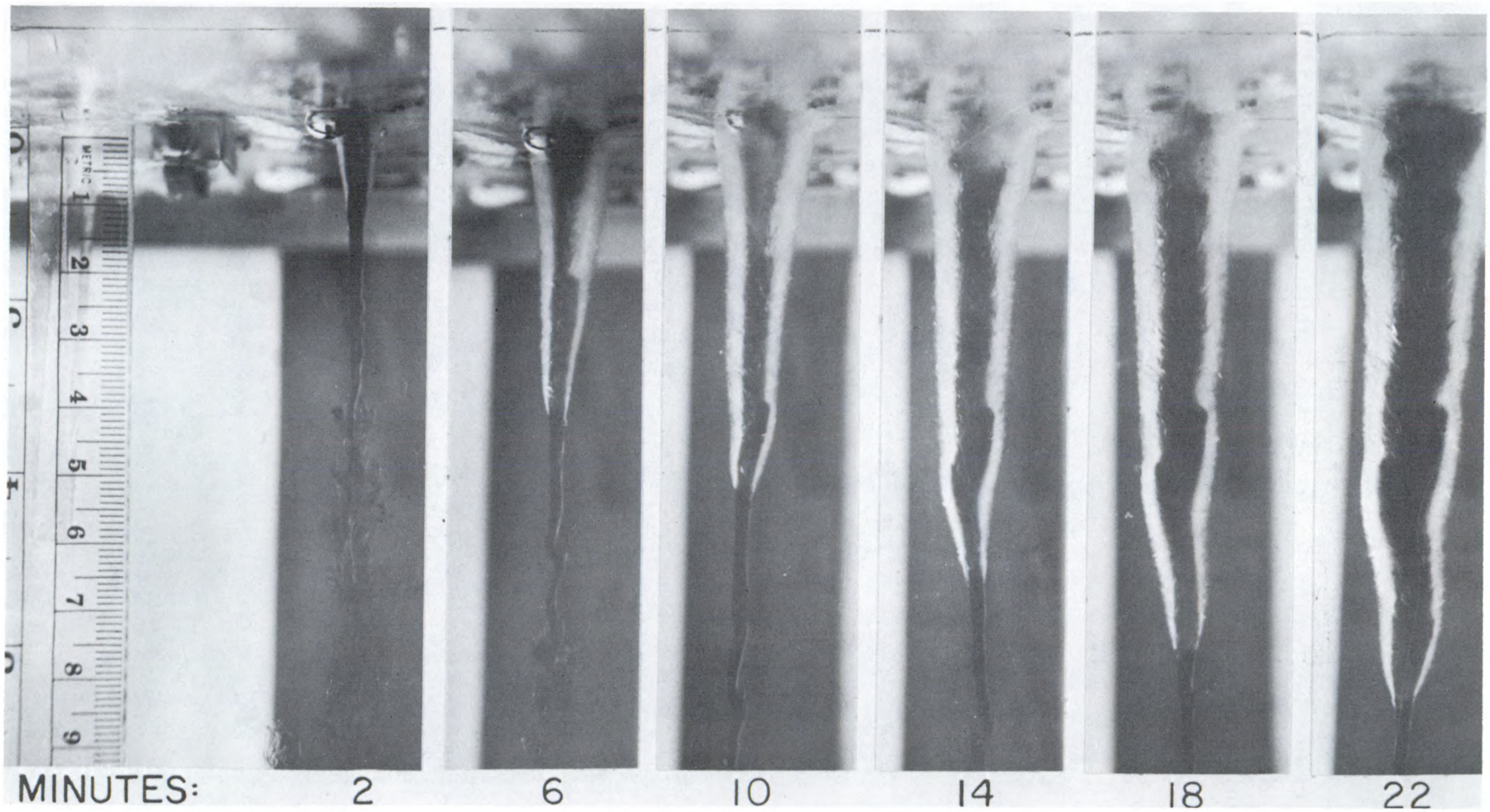

Figure 5 – Successive photographs of a stalactite formed by injecting brine at −8°C and 15°/₀₀ at a flow rate of 16 cm^3 min^{-1} into the freezing tank.

balance, the brine level in the channel drops. Figure 7 is a sketch of the hydrostatic pressure distribution caused by both the sea water outside and the brine inside the tube. From the figure it is seen that the pressure in the tube is less than that of sea water, so that in the ice surrounding the channel, the pressure gradient is toward the channel. In sea ice, this pressure force provides for gravity drainage of brine from the surrounding ice into the drainage channel.

Finally, both the cold injected brine and the melting of the channel wall cause a strong flux of heat to the brine channel. Repeat of the above experiment using a block of fresh ice with thermocouples embedded in the ice near the channel showed that adjacent to the channel

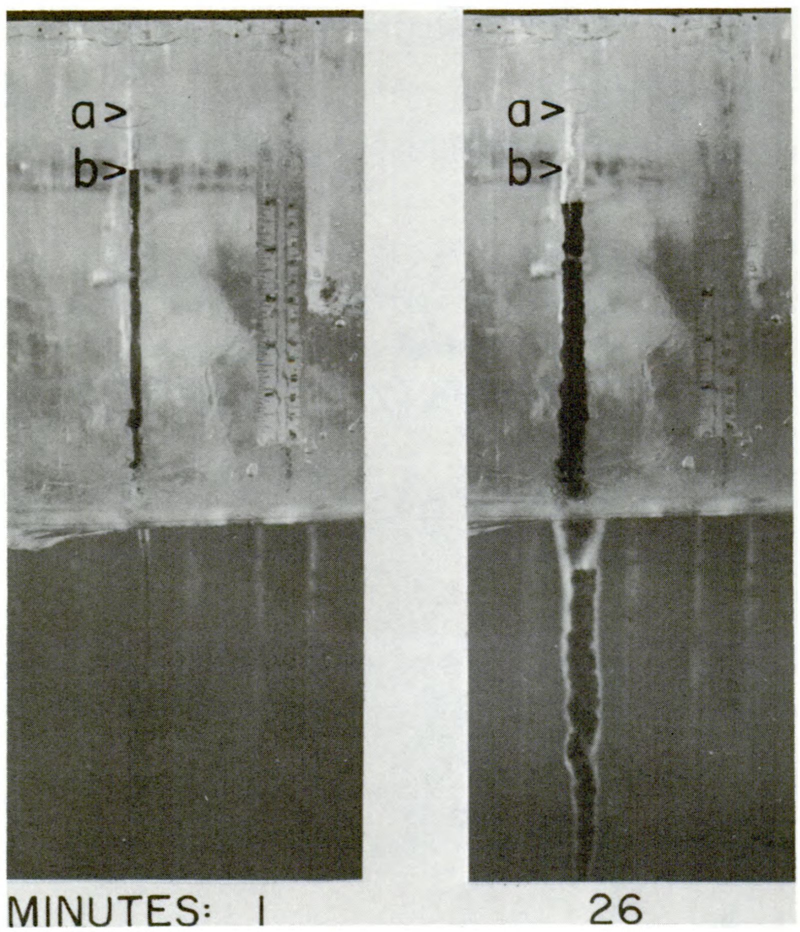

Figure 6 — Two successive photographs of the growth of a brine channel and its accompanying stalactite. Brine at −20°C and 225°/₀₀ is injected into the block at a flow rate of 16 cm³ min⁻¹. Because this flow rate is only 1 or 2 drops per second, the brine entering the ice is not visible. The faint vertical lines in the background below the ice are heating wires on the side of the tank. The arrows marked "a" show the level of the sea water in which the block floats; "b" shows the brine level in the first photograph.

wall, the temperature dropped by as much as 5°C, and the horizontal temperature gradients were of order 1°C cm^{-1}. If we replaced the fresh ice with salt ice, this drop in temperature would cool the surrounding brine pockets, and freeze some of the brine. The pressure build-up in the brine pockets caused by the expansion of water upon freezing could be relieved by the expulsion of the brine to the nearby drainage channel.

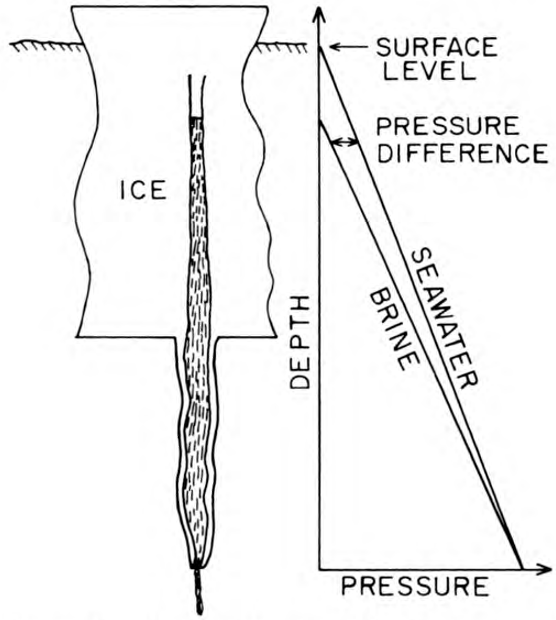

Figure 7 — A schematic view of the brine channel and its accompanying stalactite and a plot of the pressure distribution caused by both the brine and the sea water.

Summary

The brine channel-stalactite combination provides three possible ways of natural desalination:

(1) The growth in the diameter of the brine channel both entrains brine pockets and reduces the viscous drag of the outward flowing brine,
(2) the pressure drop caused by the stalactite generates gravity drainage to the brine channel,
(3) the cooling of the ice surrounding the brine channel leads to brine expulsion to the drainage channel.

Further investigation should show whether these processes initiated by the flow of brine in actual sea ice will be sufficient to sustain both the flow of brine and the subsequent growth of stalactites observed in the polar oceans.

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(Continued from Page 16 – Navy Study Points Way to Manipulating Body Temperature).

Dr. Myers has found that if excess calcium ions are allowed to enter the hypothalamus, temperature is reduced and stabilizes at a lower point. An increase in temperature happens with sodium ions. Tiny specific areas of the hypothalamus were perfused with solutions of the calcium or sodium ions to achieve the alteration in temperature. A reduction of ten degrees was achieved, for example, by three perfusions over a five-hour period.

Generally animals were kept at the new high or low temperatures for about 12 hours. Repeated perfusions kept one animal at low temperature for three days. The highest temperature reached was 109 degrees, and the lowest was 87.8 degrees.

As a test to see whether the new set point would hold, animals with low temperature settings were given a dose of water equal to two cups of hot coffee. Although their temperature rose one degree, their heat-dissipating mechanism went into action, and their temperature dropped to the previous level. Animals with high temperatures were dosed with ice water, and the temperature after a brief drop returned to the new high set point.

With present techniques, the chemical solutions must be piped directly to the brain since that is the only way known to bypass the blood-brain barrier, which is the brain's natural defense against foreign substances. It is anticipated, however, that this barrier will eventually be bridged by certain substances, which might permit a physician to control a patient's temperature by pills or injections. Further experimentation with animals will continue.

Atmospheric Sound Ray Tracing Technique

Scientists at the Naval Research Laboratory have developed a computerized program to predict acoustical ray paths in the atmosphere which could provide a criterion for selecting appropriate airport locations with minimal noise annoyance.

Until now, and ever since the introduction of commercial jet aircraft more than a decade ago, there has been no standard method of pre-determing desirable locations for airports to minimize undersirable noise effects on nearby residents.

The new NRL technique not only predicts acoustical ray paths in the atmosphere, but can determine the transmission loss in air as well. By observing the locations where the sound rays strike the surrounding terrain and the resultant transmission losses, a suitable air terminal site could be selected which would produce the least sound pollution.

The program, which was written for the CDC-3800 computer, accepts data in the form of temperature or sound speed *versus* height profile. A wind velocity profile also may be entered, and a printplot produced of the ray trajectories and transmission loss.

On the Naval Research Reserve

The Research Reserve program is composed of 66 companies throughout the United States. The Naval Reserve Officers are qualified in the conduct and/or administration of scientific research, or in patent, trade mark, and copyright matters. These officers are available in the event of national emergency to meet the needs of the Office of Naval Research and the Naval Establishment. Through the year the companies report on their activities and training programs.

Meeting Highlights of NRRC 6-17

The members of NRRC 6-17 are fortunate to be able to call upon outstanding speakers and guest lectures from Redstone Arsenal, the home of both the U.S. Army Missile Command and Marshall Space Flight Center (MSFC) of the National Aeronautics and Space Administration. Many members of NRRC 6-17 are employed at Redstone Arsenal.

A member and "plankowner" of the unit is LCDR Roland F. Griner, who is Project Officer for the Saturn S-IVB Stage in MSFC's Astronautics Laboratory, and is now helping direct the development of the Skylab Orbiting Workshop. He has arranged several talks at unit meetings on Skylab technology including experiments and an inspection of the Skylab simulator. Skylab will be placed in earth orbit in 1973, where it will remain active for eight months carrying over 50 experiments designed to test the effects of long duration space flights on men and systems.

At another meeting Eugene Cowart of Boeing Company talked on the Lunar Roving Vehicle which has extended the range that the Astronauts can explore the surface of the moon. Other subjects discussed included the development of MSFC's High Energy Astronomical Observatory, Laser Gyros, Earth Resources, problems connected with the docking of large space vehicles, and the Army's Safeguard Program.

Cardiopulmonary Resuscitation Course

Members of NRRC 6-18 Nashville, Tennessee recently attended a course on cardiopulmonary resuscitation at Nashville's Cardiovascular Education Center. The course featured an introductory talk by a physician, a movie that showed the theoretical background for cardiopulmonary resuscitation, and a demonstration of how it's done. A nurse demonstrated on dummies which were instrumented to indicate whether the proper effort was being applied. Then the members tried their new skills of mouth-to-mouth resuscitation and external heart massage on the dummies.

Meritorious Civilian Service Award for Member of Naval Reserve Research Company 6-8

LCDR Albert H. Marshall, USNR, a member of Naval Reserve Research Company 6-8, Orlando, Florida, was awarded the Meritorious Civilian Service Award by CAPT Frank H. Featherston, USN, Commanding Officer, Naval Training Equipment Center, Orlando, Florida. LCDR Marshall serves as a Research Physicist at the Center.

The award stated in part, "You are awarded the Meritorious Civilian Service Award for outstanding insight in exploring and applying semiconductor laser technology to a number of successful training device oriented programs. In particular, you are commended for your dedicated efforts in the development of the feasibility model which was demonstrated successfully to General William C. Westmoreland, Chief of Staff, U.S. Army, by General O. Talbot, Commanding Officer of Fort Benning. You followed up this effort by developing a prototype which was evaluated by the Infantry Board with tests conducted at Fort Jackson. The results of these tests revealed that the M-16 laser rifle system is useful for training. In addition, you have recently successfully developed for Brigadier General Paul F. Gorman, Assistant Commandant of Fort Benning, a feasibility model of a laser rifle/projection system for which you have been commended."

Reserve Unit Benefits from University Affiliation

A university is an advantageous site for a Naval Reserve Research Company; NRRC 6-6, Chapel Hill, North Carolina benefits from the University of North Carolina. The members of the unit can keep abreast of a variety of research projects by inviting research investigators from the campus to make presentations at unit meetings. Sometimes the Navy background of the members can help them with their university projects. Such was the case of LT Lee W. Hauser, a new member of the unit and a graduate student in the Department of Radio, Motion Pictures, and TV. His thesis topic was *A History of the American Forces Vietnam Network, 1962-1972*.

Research Notes

Symposium on Chemistry of Upper Atmospheres

A Summer Advanced Study Institute on the Physics and Chemistry of Upper Atmospheres was held 31 July-11 August 1972 at the University of Orleans, France. The sponsors of the Institute were Defense Advanced Research Projects Agency, Army Research Office, Defense Nuclear Agency and Office of Naval Research. The meeting was operated by the Lockheed Missiles and Space Company, Palo Alto Research Laboratory. Some 150 scientists (West Europe, USA) attended and heard lectures by 35 researchers who discussed the current state of and future trends in ionospheric work. The research output in England, West Germany, France, Belgium and Scandinavia is of very high quality. The main emphasis was an attempt to evaluate the physical processes in terms of input energy, chemistry, and dynamics to account for experimental measurements of electron and ion temperatures, species concentrations, winds, electric fields obtained with radio and optical techniques and to unify experimental results due to rockets and satellites.

An adequate model of the ionosphere is needed. Such a model could help answer the pertinent questions summarized by a National Academy of Sciences Report on the Physics of the Earth in Space 1969 which still hold. These are: Is there evidence that any unrecognized photochemical processes are important in determining the electron and ion density distribution in the upper ionosphere under unusual solar-geophysical conditions? What is the relative importance of photochemistry and dynamics in explaining the anomalies and irregularities of the ionosphere? What is the origin of the electric fields that drive the electron drifts, particularly the mild variations that are observed and that cannot be accounted for by dynamo theory? Have all the important sources of electron heating and loss in the ionosphere been identified? What is the explanation of the changes in the E and F regions that take place during a solar flare? What are the physical processes acting on the ionosphere during magnetic storms? What causes and maintains sporadic E? How is the ionization in the polar regions distributed, and is it maintained by direct entry of solar plasma, transport effects, or by some other means? What are the roles of the ionosphere and magnetosphere in the production of aurora, and how are they mutually coupled? What can be deduced about the general and smaller-scale circulation of the high atmosphere? What can be deduced from radio and incoherent-scatter observations about the neutral high atmosphere—composition, temperature, natural chemistry, and dynamics as a function of height, geography, and time?

The military relevance of ionospheric and associated research is in the design and optimization of ground-based and satellite communications systems from ULF to UHF, in the estimation of nuclear weapons' effects, in the detection of ballistic misslery, and in satellite navigation and surveillance.

A visit was made to the Groupe de Researches Ionospheriques, a laboratory operated by the Centre National de la Researche Scientifique and located, with several others, near the Orleans University campus. The CNRS is one of the main French Government research operations and operates a large number of laboratories. The GRI laboratory used to be solely in Paris, but is being transferred to Orleans in a program of decentralization. The director of the laboratory is Dr. J. Hieblot. Dr. C. Beghin, of GRI and his group have been the first to transmit and receive VLF waves in space; transmission and reception being carried out between two stages of a rocket. The GRI have a cooperative program with the Russians to launch rockets from Kerguelen to inject electrons and ions into the magnetosphere to study wave-particle interactions. The GRI are designing ULF, ELF, and VLF transmitting and receiving equipment for operation on the European Space Research Organization Geos geostationary satellite to be launched 1974/1975. The purpose of the satellite is to make studies of the distribution of thermal plasma, energetic particles, fields and waves in the magnetosphere. The ULF equipment is highly sophisticated and the results should be of value for future experiments on wave-particle instabilities generated, for example, by cold plasma injection outside the plasmapause. The Max Planck Institute proposes to inject electrons from Geos to study their drift due to electric fields in the magnetosphere but no instability experiments are planned.

Radio probing of the ionosphere can be carried out by coherent scatter (moderate power) or by incoherent scatter (high power) techniques. In the first, the reflection process depends on the collective behavior of the electrons; in the second, on the scattering of waves from individual electrons. Incoherent scatter is sensitive to the properties of the ions in the ionospheric plasma, their temperature, concentrations, drift motion due to electric fields, and collision rate with neutral particles. Thus, these ionic properties, in addition to the density and temperature of electrons, can be obtained.

There are, at present, seven incoherent scatter radars in operation (Jicamarca, Peru; Arecibo, Puerto Rico; Chatanika, Alaska; Millstone, Massachusetts; Malvern, England; Nancay-St. Santin, France; Russia). There are proposals to construct new incoherent scatter radars in the New York State-Canada area and in Scandinavia (to be operated by Finland, France, Germany, Norway, Sweden).

A visit was made to the Nancay facility. Here a large radio astronomy antenna (20m × 100m) (oblique) is used in conjunction with an associated transmitter-antenna (vertical) system, separated by 300 km. Continuous wave signals, 75 kW at 935 MHz, are used instead of pulses. The height of observation is determined geometrically by setting the two antenna beams to intersect at the designed height, with a resolution of 3 km at 100 km to 30 km at 500 km. The system is operated several hours per week for ionospheric research and a wealth of data is being produced.

(Continued from Page 7 — NRL Acquires New Aircraft).

(pyranometer); a radio altimeter; and a radio transceiver for measuring the distance to oceanographic ships with which the Orion will be working.

These test data will be recorded continuously in digital form on magnetic tape by a special multi-channel recorder, and processed at the NRL Computer Center.

The Orion is the first research aircraft in NRL's history to be configured at the outset for general research use rather than just for a specific project.

Unmanned Arctic Research Submersible Successfully Tested by Navy

A remote-controlled craft called an Unmanned Arctic Research Submersible (UARS) has been successfully tested by the Navy under the Arctic ice. Its purpose is to survey the under side of the ice.

The nine-foot long torpedo-shaped vehicle was developed by the University of Washington under contract to the Office of Naval Research (ONR), with funding provided by the Defense Advanced Research Projects Agency (ARPA). The tests were conducted adjacent to T-3, the Arctic drifting research ice station operated by ONR's Naval Arctic Research Laboratory.

The UARS system includes an acoustic command control subsystem for navigation and data telemetry. Special ice hole-cutting techniques were developed to permit launching through deep multi-year arctic ice. The vehicle, which was a fiberglass hull, is retrieved through the hole after first capturing it in a lowered net.

The submersible has a speed of three knots and a ten-hour endurance. It has an effective range of 9000 feet from its launching hole and a depth capability of 1500 feet. During one four-hour period of operation the UARS was maneuvered in a series of figure-eight patterns that totaled 17 miles.

Previously, studies of the under side of the ice could only be made using fleet submarines or divers. The UARS can be fitted with a variety of instrumentation for oceanographic and acoustic research.

During these tests the submersible's precision upward-looking echo sounders recorded over 200,000 position-correlated measurements to produce an under-ice profile of a one-mile diameter area. The data disclosed some pressure ridge keels greater than 75 feet deep, although there were no obvious manifestations of these keels on the surface of the ice.

It is anticipated that the UARS will provide a means to enhance research capabilities under the ice of both the central Arctic basin and the surrounding marginal ice zones.

New Sensitive Ocean Noise Measuring Device

Scientists at the Naval Research Laboratory (NRL) have designed an extended-range hydrophone capable of broadband measurements of low level noise radiated by submerged submarines.

In response to the requirements of a Navy program, the hydrophone is highly sensitive to sound pressure, but insensitive of variations in temperature and hydrostatic pressure.

The NRL hydrophone can sustain hydrostatic pressure as great as 6.9 MPa. Its sensitivity is independent of temperature in the range of 10 to 30° C and is sufficiently high to permit acoustical measurements in ambient noise of Knudsen sea state zero.

Protected from seawater by a butyl rubber covering to ensure a long service life without corrosion and water migration, the NRL device is capable of making acoustic measurements in ambient noise of sea state zero in the frequency range of 10 Hz to 60 kHz and at depths to 700 meters. The nominal open-circuit crystal voltage sensitivity is −185 dB re $1V/\mu Pa$.

Holographic System for Crystal Growth Studies

Dr. Jerry Blodgett and Dr. Robert Schaefer at the Naval Research Laboratory (NRL) have developed a holographic system that enables them to study crystal growth from the molten state.

By studying microstructural development during solidification metallurgists can determine methods of producing stronger and more reliable metals for naval applications by revealing the significance of microstructural development during solidification.

In discussing their research, the scientists related that examination of the microstructure of metallic solids frequently indicates that the growth of the component crystals is a highly complex process. Because the opacity of metals severely limits the possibility of experimental study of crystal forms during growth, transparent substances have been used as analogs to metals in the solidification studies.

Previously, metallurgists have observed crystal growth in thin layers of material by normal microscopic techniques. But crystals grown under such conditions were found to differ from those grown in bulk liquid.

In the new NRL method, the scientists employ large crystal growth chambers to avoid the constraining influence of the container walls on diffusion, convection, and crystal geometry.

To record these crystallization events at unpredictable locations with high resolution, the researchers used a holographic system they developed with an off-axis reference wave. They employ an argon ion laser with an acousto-optic switch which allows the recording of a time sequence of holograms at rates up to 4 per second and with individual exposure times as short as 50 microseconds.

The reconstructed images permit the detailed study of sample volumes of a few cubic centimeters with a resolution as high as 400 cycles per millimeter. Interferometric techniques applied to the reconstructed images enable the scientists to observe in detail and measure the influence of grain boundaries and other crystal defects on the process of solidification.

(See Picture Inside Back Cover).

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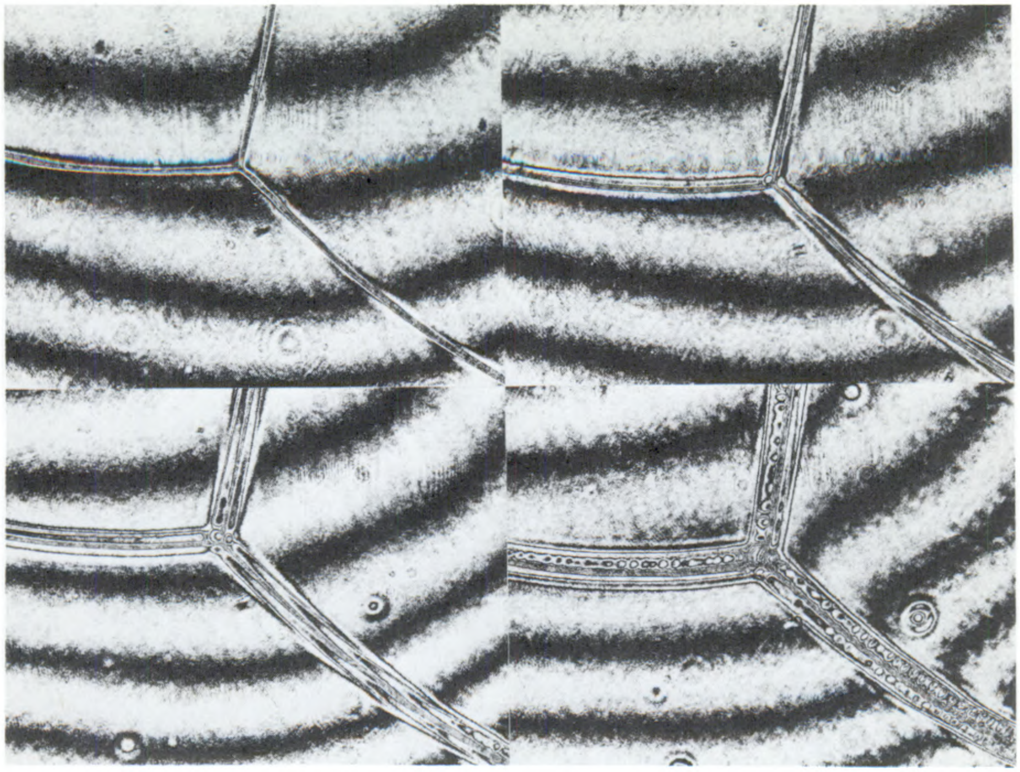

Holographic reconstruction of crystal growth in metallic analog — Interference fringes revealing development of features near a grain boundary tri-junction at a solid-liquid interface in camphene. The four holograms containing this tri-junction were taken at 15 second intervals.

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Artist's concept of Apollo 16 astronaut taking photographs with the new camera/spectrograph. *See page 1.*

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