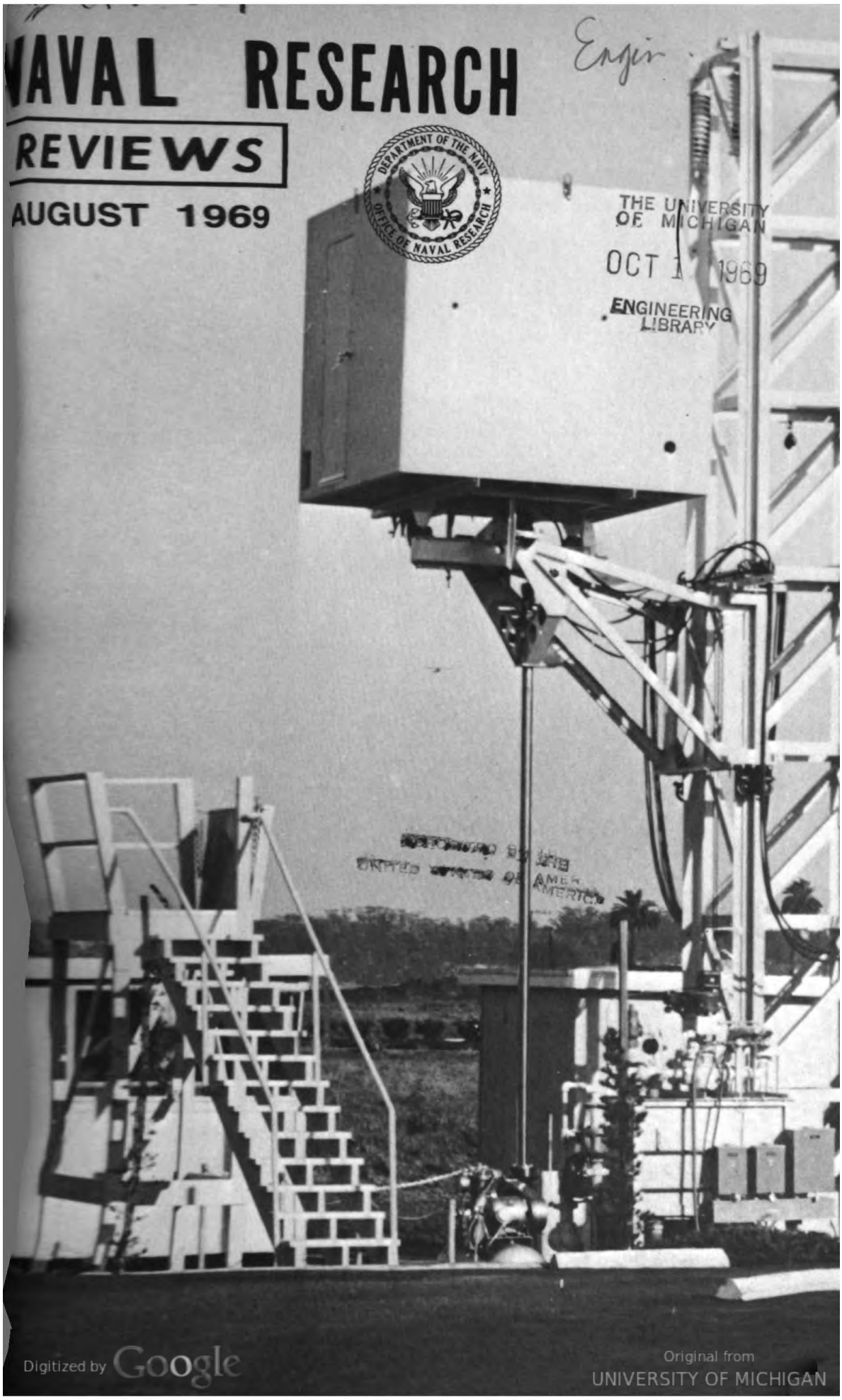


Portraits in Science

SINCE 1945 CAPT ASHTON GRAYBIEL, MC, USN (RET.), HAS CONTRIBUTED MUCH TO AEROSPACE MEDICAL RESEARCH AS THE DIRECTOR OF RESEARCH AT THE NAVAL AEROSPACE MEDICAL INSTITUTE (NAMI), PENSACOLA, FLORIDA. DR. GRAYBIEL RECEIVED HIS M. D. FROM HARVARD MEDICAL SCHOOL IN 1930; THEN HE STUDIED IN LONDON AND BOSTON. IN 1942 HE BEGAN HIS NAVAL CAREER. AFTER 26 YEARS ON ACTIVE DUTY AND 280 PUBLISHED PAPERS, DR. GRAYBIEL RETIRED FROM THE NAVY, BUT HAS CONTINUED HIS POSITION AT NAMI. HE IS AN INTERNATIONAL AUTHORITY IN THE MECHANISMS OF SPATIAL ORIENTATION AND HAS PARTICIPATED IN NUMEROUS ONR RESEARCH PROGRAMS. DR. GRAYBIEL RECEIVED THE NAVY LEAGUE'S ADMIRAL WILLIAM S. PARSONS AWARD FOR SCIENTIFIC AND TECHNICAL PROGRESS IN 1960 AND THE ROBERT DEXTER CONRAD AWARD IN 1965.

A Motion Generator for Sea Craft

Dr. Donald N. Buckner
Human Factors Research Inc.

CDR David D. Heerwagen, USN
Office of Naval Research

INTRODUCTION

Aeronautics Programs in the Office of Naval Research is studying the feasibility of using Short Take-Off and Landing (STOL) type aircraft for ASW missions. As the missions are presently conceived, the aircraft would land on the sea, and operators aboard it would monitor signals from several acoustic sensors for periods of from 10 to 60 hours.

The feasibility and utility of such an ASW system depend greatly on how well the ASW operators can perform their tasks in the rolling, heaving, pitching environment the air/sea craft concept implies. It seems probable that motion sickness will interfere with performance, or that motion, even without sickness, may result in impaired performance, so a vehicle design which damps out waterborne motions to an acceptable degree is a key part of concept feasibility.

Advances in aerodynamics, propulsion, and hydrodynamics are combining to make the concept of an operational air/sea craft or advanced water-based aircraft an attractive one. Possible combinations of jet flaps, canards, lift engines, leading and trailing edge-flaps, and retractable vertical floats attached to high-lift hydro-skis are some of the features that would allow advanced STOL seaplanes to take-off and land in seas up to sea states 5-6 (waves from 12 to 16 feet in height). In addition to the feasibility of landing and taking off in such seas, hydrodynamic damping and stabilization could permit on-station operation while lying-to for periods up to 60 hours.

An important consideration for this concept is human factors engineering, which is concerned with the performance of man as part of the man-machine combination. The trade-off between operator performance and vehicle seaborne stabilization is critical in selecting a design concept that minimizes weight, drag, and complexity of that part of the vehicular configuration that provides open-sea stabilization and damping.

It was in this context that research requirements for predicting operator performance in air/sea craft were analyzed in 1966. An extensive literature survey was first conducted to compile information concerning the effects of either motion sickness or of motion upon human performance.

Not surprisingly, motion sickness has a very long history of study and the literature is voluminous. The Romans and Greeks mention it

in several of their writings. Both Cicero and Caesar were susceptible, and Nelson, although he spent most of his life at sea, was a victim of seasickness most of the time. The surprising result of the survey was that there is virtually no pertinent, documented information concerning the effects of either motion sickness or of motion upon human performance. The majority of research literature has been concerned with the physiology of the non-auditory internal ear, with the characteristics of motion that induce sickness, or with drugs concocted to alleviate motion sickness.

Following this survey, the development of an experimental program was undertaken to provide data relevant to the ASW sensor operator's performance aboard a waterborne air/sea craft. With the results of the proposed test program and the calculated response motions of a damped air/sea craft afloat in high sea states as input requirements, the next task was to determine the specifications for a motion generator and then to survey the field to see if an appropriate machine existed to conduct an experimental program. Two generators with near-adequate characteristics were located that did not require major modifications. Unfortunately, problems were encountered in either scheduling or leasing these machines, making it more cost effective to procure a new generator—especially tailored for this type of experimental program.

MOTION SIMULATOR DESCRIPTION

In 1968, it was decided to design and build a motion generator. In March 1969, Human Factors Research, Inc. (HFR), in collaboration with Intergraphic, Inc., under ONR contract, completed the design and construction of a machine for generating the motions of different types of waterborne craft in various sea states that could be used to evaluate human operator performance. Intergraphic was responsible for the design and construction of the motion-generating equipment and HFR was responsible for the design and construction of the foundation, the operators' cabins, the motion-generating signals, controls, and control cabin.

Performance specifications were established by ONR, and the design goals were established jointly by ONR and the contractors. The established design goals significantly exceeded the performance specifications, and controlled performance tests showed that all design goals were met or exceeded.

The ONR Motion Generator has the following design performance capabilities in heave, pitch, and roll:

Heave Motion

Excursion ..... ±11 feet, plus safety overtravel

Velocity ..... ±8.7 feet/sec

Acceleration..... ±0.35 g

Frequency Response ..... D.C. to 0.5 cps

Pitch and Roll Motion

Excursion ..... ±15° plus safety overtravel

Velocity ..... ±21.5°/sec

Acceleration..... ±51.5°/sec²

Frequency Response ..... D.C. to 0.5 cps

The motion generator has a heave drive similar to that commonly used to drive an elevator. The heave-drive mechanism is a hydraulically-driven, cylinder-piston system. Roll and pitch motions are controlled by hydraulically-boosted servo valves and actuators.

The motion-generator system is located on the grounds directly adjacent to the main building of Human Factors Research, Inc., in the Santa Barbara Research Park, Goleta, California. As shown in Figure 1, the main components of the system consist of the motion generator, the moving cabin, the stationary cabin and the control cabin. The moving cabin is guided up and down in heave along a track attached to the 30-foot tower. As the moving cabin moves up and down in heave it is also subject to roll and pitch motions produced by hydraulic-positioning servo-mechanism systems.

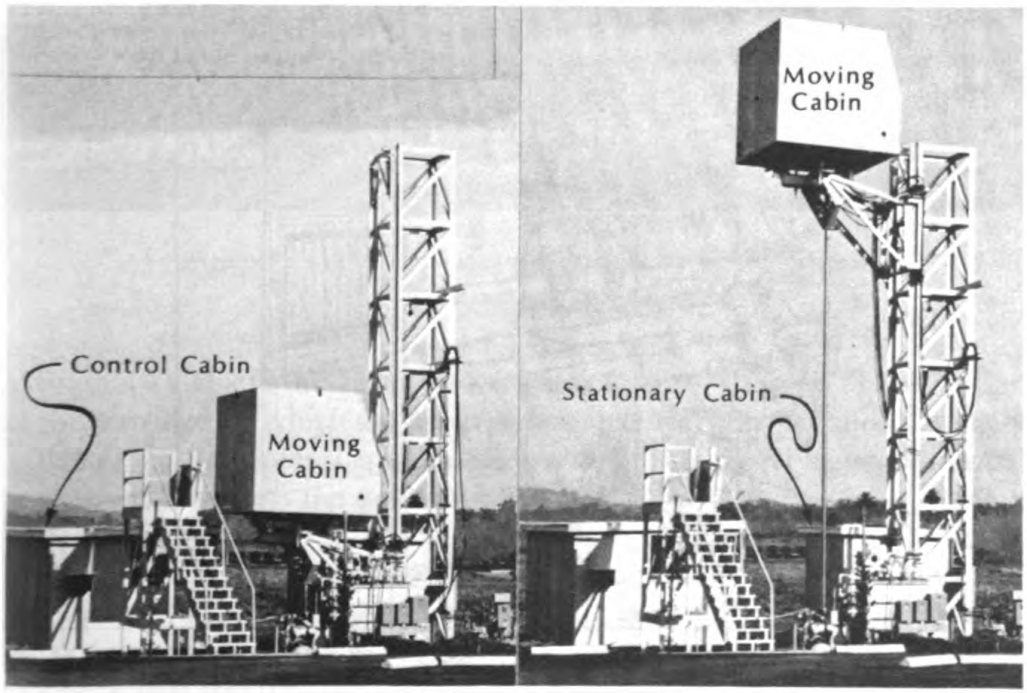
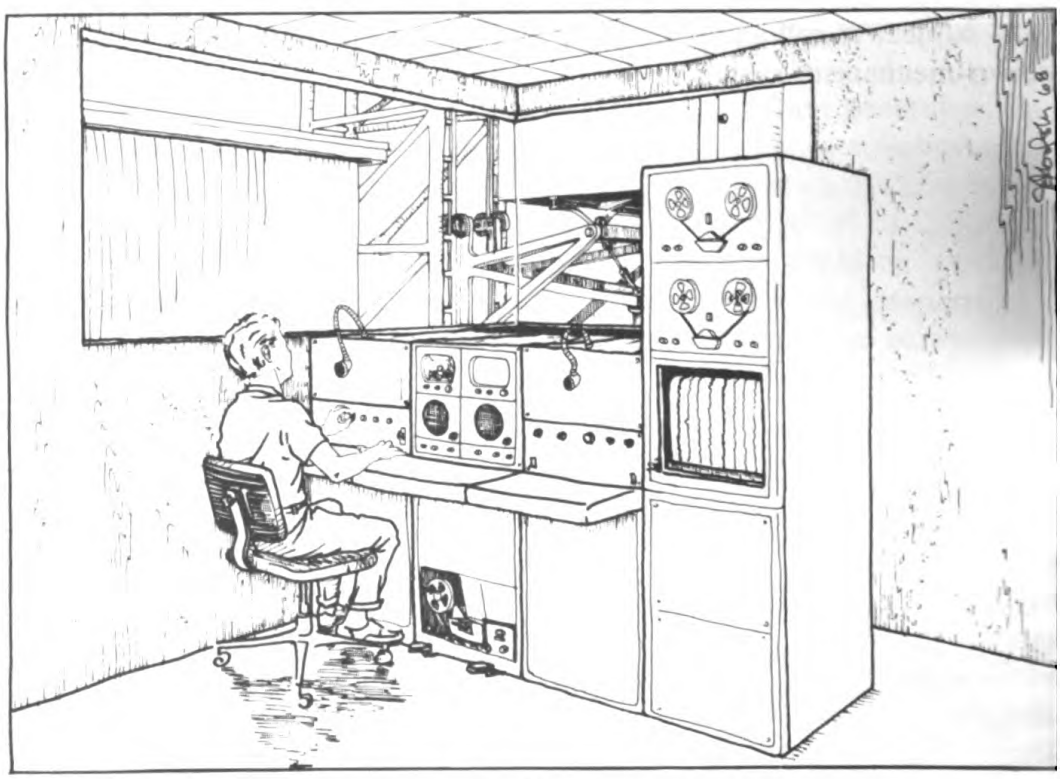


Figure 1 - Moving cabin at the maximum heave position

(a)



(b)

Figure 2 - (a) Wide angle view of inside of moving cabin.
(b) View from inside of experimenter's cabin.

The moving and stationary cabins are identical and are designed to house two men for missions up to 60 hours. Each cabin contains a toilet, sink, bunk, air conditioner, heater, and two aircraft seats. Figure 2 is a drawing showing the interior of the cabins. The purpose of having two cabins is to permit the collection of control data from the stationary cabin at the same time experimental data are being collected from the moving cabin.

Figure 3 shows the two cabins, with the moving cabin displaced in pitch and roll. Figures 1 and 3 also show the relative position of the control cabin to the motion generator. The control cabin contains one console for controlling and monitoring the motion generator and three consoles for performance-measurement equipment and for closed-circuit TV equipment which will be used to monitor the interior of the stationary and moving cabins.

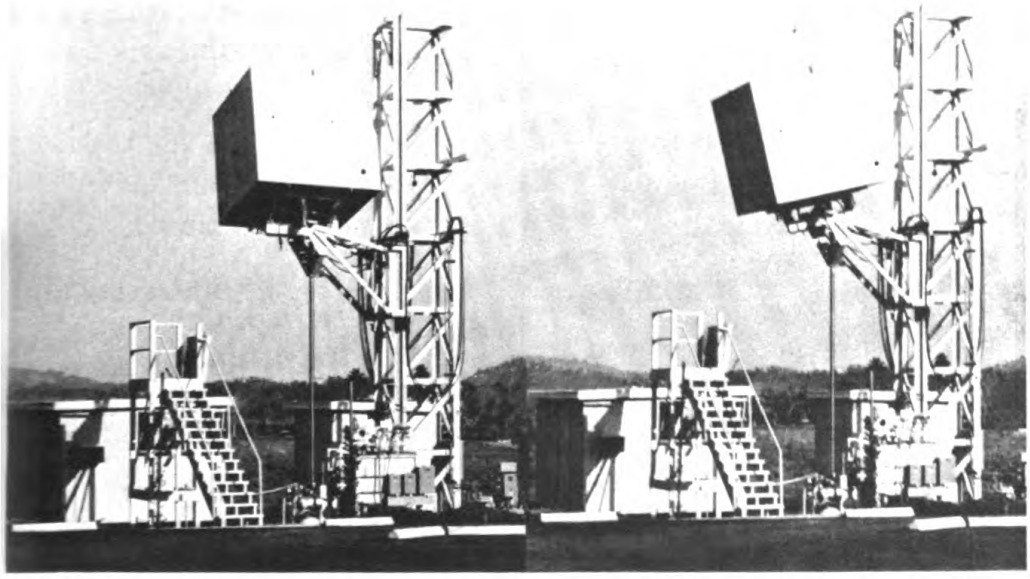


Figure 3 - Cabin at the maximum rolled and pitch positions

Figure 4 depicts the Motion Generator Control Console. The position of the carriage on which the cabin is mounted may be controlled manually with the 10-turn potentiometers, shown on the control console. In normal operation, however, the position of the cabin in all three axes of motion is determined by time-varying command signals, recorded on standard magnetic tape which is played by the four-channel tape recorder. Independent roll, pitch, and heave-motion commands can be fed continuously into the motion generator.

The actual and the commanded position of the cabin in any of the three axes can be recorded on a two-channel analog paper recorder for a

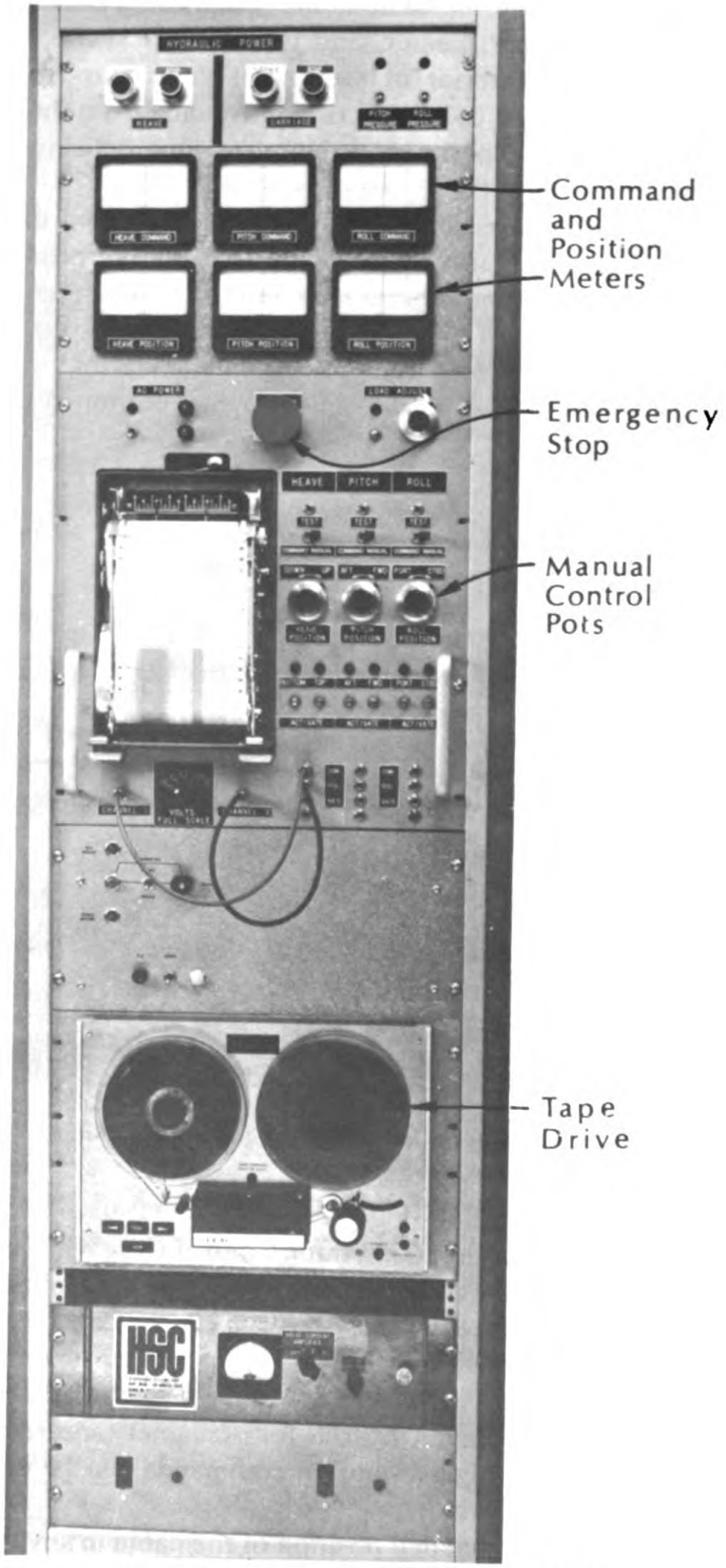


Figure 4 - Motion generator control console

permanent record of the system response. The position and command signals may also be read directly from permanently connected meters located on the main control console.

EXPERIMENTAL PROGRAM

Human Factors Research, Inc., under ONR contract, is now designing experiments and a test program for measuring human tolerance to waterborne, stabilized, simulated air/sea craft motions in seas up to and including sea state 5. In addition, this experimental program will be a first step in determining potential crew member capability of performing useful ASW-type tasks while subject to these motions. The motion generator will be used with approximately 80 test subjects over the next year in simulated air/sea craft missions having a waterborne phase of up to 60 hours duration.

Test subjects will be evaluated in their performance of tasks that are sensory, perceptual, and conceptual. Some of the tasks to be employed are the following:

(1) *Sensory Tasks:*

(a) *Target detection on active and passive sonar displays and on radar displays.*

One of these tasks will be similar to the operation of Jezebel-type equipment connected with passive sonobuoys in ASW in the LOFAR mode. Measurements will be made of performance efficiency in detection and analysis of targets.

(b) *Critical Flicker Frequency (CFF) Test.*

Psychophysical tests such as CFF are conceded to be a reliable indicator of the responsiveness (*i.e.*, degree of fatigue) of the central nervous system.

(2) *Perceptual Tasks:*

(a) *Harris Stress-Sensitive Perceptual Test (SST).*

This test, developed by HFR, has proved to be highly reliable as an indicator of the effect of stress upon perceptual performance. The test requires the interpretation of visual patterns having an information content that increases as a function of time, similar to interpretation of Jezebel signatures.

(b) *An auditory test, similar to making TURNCOUNTS with a passive sonar system and a test of auditory*

doppler discrimination, which is an important skill in classifying active sonar targets.

(3) *Conceptual Tasks:*

Several tests designed to test the ability to perceive relations and to comprehend given information will be employed.

The above tasks, and others, are considered to be representative of the types of skills and performances that are relevant to the ASW mission—the detection of weak signals and the perception of subtle signatures in visually displayed signals.

The motion generator will be useful in investigating preliminary design concepts of the air/sea craft. Its use over a period of time under controlled conditions with appropriate human subjects should also contribute to a basic understanding of the causes of motion sickness, the human tolerance to different types of water-vehicle motions and a more detailed description of their effects on human performance. The performance characteristics of the generator should also permit it to be used for studying similar types of human factors problems associated with traditional small craft of the Navy as well as far-advanced, high-speed craft during the low-speed part of their mission profile.

The long range results from this experimental program could easily outweigh some of its more immediate objectives. They will provide the start of a data base that relates to such fundamental questions as: what are the selected motions, their range of values, and their duration that cause motion sickness? Can man perform military tasks or any other tasks that require vigilance and perception while under the effects of severe ocean-induced motions and, if so, how well can he perform? The possibility that data collected from these tests could contribute not only to an understanding but to an ultimate cure for or amelioration of the effects of motion sickness would be welcome news indeed for the large number of would-be, leisure-time sailors who have been land-locked because of a weak stomach.

Hulburt Science Award

Charles Y. Johnson, an atmospheric physicist whose rocket-borne experiments have contributed significantly to knowledge of the earth's ionosphere, received the Naval Research Laboratory's top scientific award, the 14th annual E. O. Hulburt Science Award.

Mr. Johnson's rocket-borne experiments first revealed the distribution and species of the ions for which the ionosphere is named, disclosed the predominant role of nitric oxide ions in the ionosphere, identified the dramatic changes in composition of the undisturbed ionosphere at night, and discovered the metallic ion origin of dense mid-latitude sporadic-E. With his team he also discovered the ionizing ultraviolet radiations of hydrogen and helium in the night sky, thereby solving the long-time mystery of why the lower ionosphere is sustained throughout the night.

Navy Contract Experiments Probe Secrets of Metals

James L. Redding
First Naval District
Boston, Massachusetts

As the Navy constantly searches for better equipment, exciting new designs often must wait for improvements in materials to catch up.

Recent interest in high-output turbines for use in both aircraft and ships is an example. Here the problem is to develop metals which can withstand the tremendous temperatures and pressures they will be subjected to in high-output turbines. The blades of these turbines must retain their shape in environments which even the strongest alloys today cannot withstand without some form of distortion or failure.

Before these turbines can be built, a new way must be found to make blades with characteristics surpassing those of present products. The Office of Naval Research has been active in promoting research in university and industrial laboratories to find these new methods and materials. A typical research program of this type is presently being conducted under Navy contract at the engineering laboratory of Northeastern University in Boston, Massachusetts. Scientists there are attempting to answer basic questions about forming metals under extremely high pressure, which may lead someday to the production of ultra-high strength metals needed by modern technology.

Forming metal parts under high pressure promises to solve some of the problems. Most metals when subjected to high pressures become highly ductile, which means they can be molded and formed far beyond ordinary limits. Many metals, when formed by this technique, become considerably stronger and tougher than metals formed by conventional processes. One of the oldest and best known high-pressure processes is extrusion—the forcing of a material through a die opening.

Conventional extrusion (Figure 1), which is a method of shaping materials by forcing them under pressure from a ram through a small die opening, has been used extensively by industry for some time. Hydrostatic extrusion (Figure 2) is a relatively new process, in which a fluid under extremely high pressure replaces the ram to force the billet of material through the die. The billet, its nose shaped to fit into the extrusion die, is placed in a fluid which ideally acts as a good pressure transmitting medium and a good lubricant. The high-pressure plunger moves downward, pressurizing the fluid which in turn causes the billet to extrude. The liquid surrounding the billet also prevents it from touching the container walls thus eliminating friction between the walls and

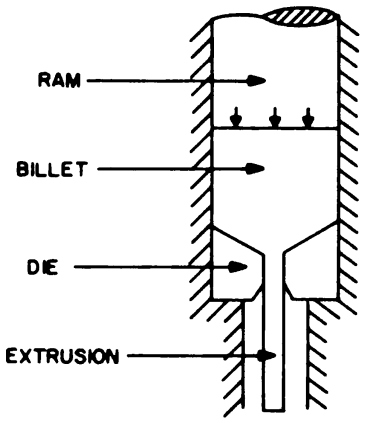


Figure 1 - Conventional Extrusion – Pressure from a ram forces the billet of material through the die opening. This method has been used by industry for many years.

the billet. In addition, the high pressure fluid can be made to surround the die walls to provide external support for the die.

Fluid-to-fluid extrusion (Figure 3) is like hydrostatic extrusion, but adds pressure to the exit-side of the die also. This back pressure allows much higher pressures to be applied to the billet and imparts greater ductilities to the materials, and thus metals which are normally brittle can be extruded by this process.

But before such methods can be utilized effectively by industry, research must be done to answer seemingly elementary questions about why metals behave the way they do under stress.

Fundamental research probes deep into the very heart of the behavior of metals. At Northeastern University, Professors Welville B. Nowak and Richard J. Murphy are studying what happens to materials during fluid-to-fluid extrusion.

While much activity goes on to develop production techniques for difficult-to-work materials using this process, extremely little attention has been paid to an explanation of the property changes which take place in the material.

Professors Nowak and Murphy are hoping to learn exactly why materials become stronger and more ductile when extruded by the

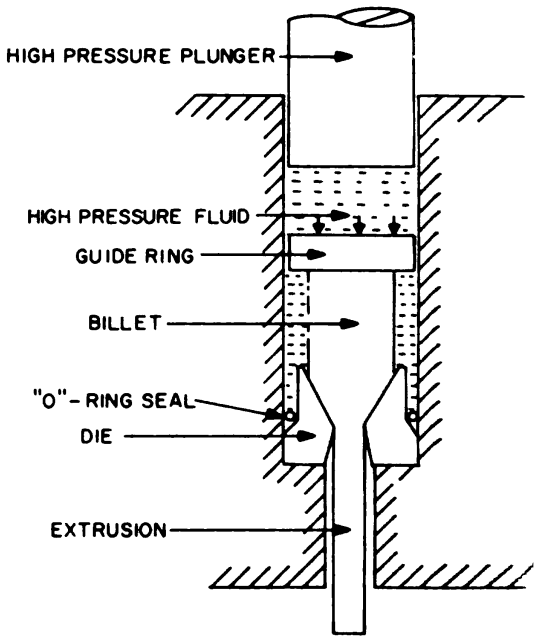


Figure 2 - Hydrostatic Extrusion – A relatively new process in which the ram is replaced by a fluid under extremely high pressure. The billet's nose is shaped to fit the die opening, sealing the chamber. A pressurizing fluid (either castor oil or pentane) is pumped in. The fluid acts as a pressure transmitting medium, a lubricant and also surrounds the die walls to provide external support for the die. Under pressure from the plunger the fluid forces the material through the die opening.

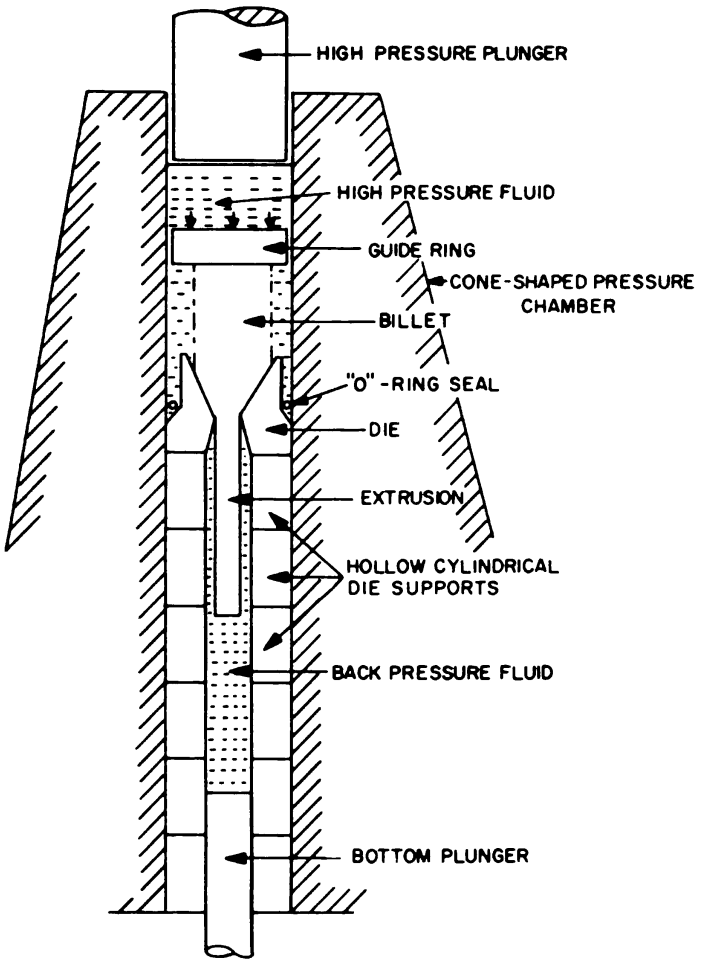


Figure 3 - Fluid-to-Fluid Extrusion—Similar to hydrostatic extrusion, but adds pressure to the exit side of the die, also. A bottom plunger pressurizes a fluid creating a back-pressure which allows much higher pressures to be applied to the billet and imparts greater ductility to the material. Metals which are normally brittle can be extruded by this process. The drawing shows the components as they are assembled within the cone-shaped chamber.

fluid-to-fluid process. To accomplish this, they extrude small pieces of salt crystal (NaCl) which has a molecular structure similar to many metals, but being transparent, the extruded salt crystals can be examined under a microscope with polarized light. This type of lighting produces birefringence, a phenomenon which visibly shows the local distribution of stresses after extrusion.

The origin of the increased deformability of extruded materials is still not completely understood. One suggestion is that ductility is due to the healing of microcracks in the material. But present research indicates that increasing of the flow property and decreasing the tendency to fracture is caused partially by the creation of a new "deformation mode" under extremely high pressure.

A deformation mode is the characteristic movement of regions within the material relative to each other which take place during the flow process. Specifically, it defines the crystallographic planes and directions on which the relative motion occurs.

A history of such block movements are easily visible by birefringence (Figure 4). The visible lines are known as traces of "slip planes" (the checkerboard patterns are intersecting slip planes). Using this technique, new deformation modes can be observed and studied.

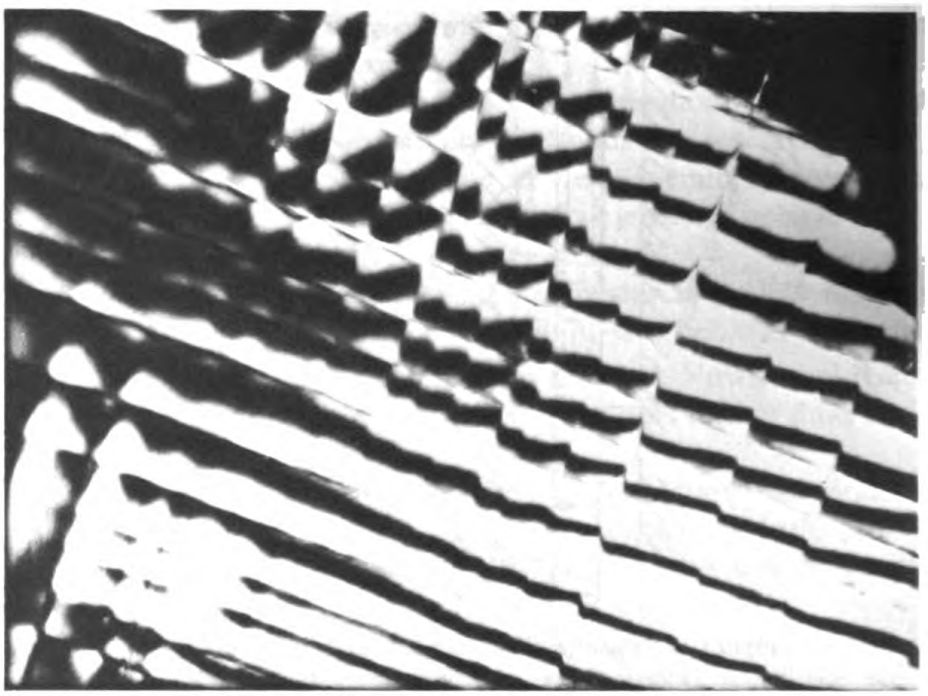


Figure 4 - Observed through a microscope using polarized light, the birefringent pattern of an extruded single crystal of salt shows traces of the slip planes which operated during the deformation. The crossed lines indicate intersecting slip planes.

Originally, Professors Nowak and Murphy tried extruding cylindrical billets of salt, but the slip patterns were too confused to be of use. Billets made from flat sheets of salt are now used with excellent results (Figures 5 and 6).

The experimental procedure begins with the fabrication of a die of epoxy-ceramic composite or of steel, and a tiny slab of salt crystal is then cut to fit the die. Finding a sealant to use between the die and the crystal has posed a problem for the researchers. Many materials that were tried broke down under the tremendous pressures applied to the billet, but beeswax has now been found to work surprisingly well.

The die, billet and a number of spacers are then assembled and placed inside a strong, cone-shaped cylindrical pressure chamber which is

Figure 5 - Examples of extrusions produced in the Northeastern University experiments. The pieces are (from left) partially extruded aluminum; partially extruded cylindrical salt crystal; extruded sheet of salt crystal and sheet of salt crystal before extrusion. Pencil at right shows relative size of objects.

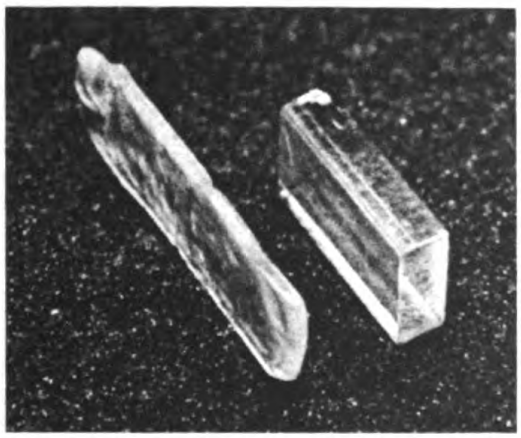


Figure 6 - A comparison of a single crystal of salt prior to extrusion (at right) and a crystal after extrusion shows that while the width remains the same, the length increases as the thickness is reduced.

placed at the bottom of the press (Figure 7). Then the constraining rings and high-pressure plunger are carefully lowered onto the cone (Figure 8). The operator finally places a heavy steel shield around the pressurized chamber, a pressurizing fluid (either castor oil or pentane) is pumped in and the extrusion process is ready to begin (Figure 9).

Standing behind a shield of thick plexiglass, the researcher carefully controls the pressure build-up by adjusting various valves on the control panel and with a hand switch (Figure 10). He monitors the process by watching the fluctuations of a fine red line, automatically penned

Figure 7 - After assembling the internal components (see Figure 3), the operator places the tapered high-pressure chamber in position to receive the constraining rings and piston from above

onto graph paper by an X-Y recorder which registers the variations of pressure and piston displacement.

Northeastern's press, built by Pressure Technology Corporation of America, can produce pressures up to 450,000 pounds per square inch. The enormity of this pressure is difficult to comprehend. In the Mariana Trench, the deepest yet-discovered part of the Pacific Ocean, some 36,000 feet of ocean weighs 15,000 pounds per square inch, which seems small when compared to the almost half a million pounds produced by the Northeastern facility, according to Dr. Frank F. Gardner of the Boston branch of the Office of Naval Research.

After the desired extrusion is accomplished, the salt crystal is removed and examined under a microscope to observe what changes have taken place in the material.

While it may seem like a long way from stretching tiny salt crystals to toughening turbine blades, experiments such as those being conducted at Northeastern University are a vital step toward developing the improved metals needed tomorrow.

Figure 8(a) - The operator carefully lowers the upper half of the press assembly which consists of the two constraining rings and the high-pressure plunger housing, onto the pressure chamber. Tubing carrying the pressurizing fluid can be seen entering the plunger housing located between the two constraining rings. Visible at the extreme lower part of the picture is tubing carrying the back-pressure fluid for the other plunger located in the base of the press.

Figure 8(b) - The operator carefully lowers the upper half of the press assembly onto the tapered pressure chamber (center) and the surrounding supporting posts. The two heavy constraining rings (only one visible in this picture) and the high-pressure plunger housing.

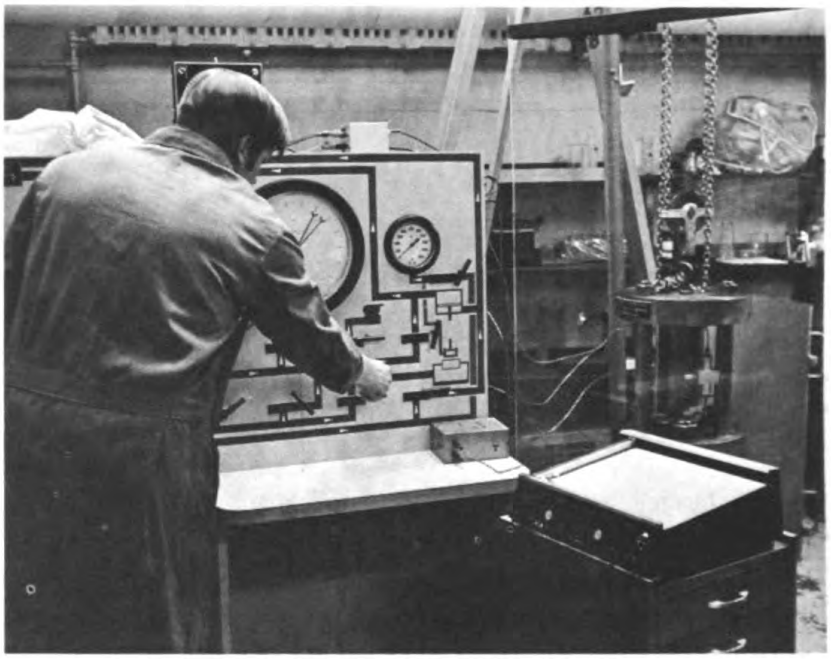


Figure 9 - As the pressurizing process begins, the operator makes adjustments on the control console. The X-Y recorder is at the right while the top part of the pressure chamber is visible in the background beyond the protective shield of plexiglass. The flow pattern of the pressurizing fluid is outlined on the face of the console. A schematic diagram of the top and bottom plunger is shown on the right side of the console.

Figure 10 - A research assistant at the Northeastern facility, controls the pressure build-up with a hand switch while monitoring the process on the X-Y recorder at the right. The pressure chamber is in the background, surrounded with a heavy steel shield. The flow pattern of the pressurizing fluid is outlined on the front of the control console. A schematic diagram showing the top and bottom plungers is at the right side of the console.

The Heat Pipe and Some Potential Naval Applications*

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Office of Naval Research
Washington, D.C.

An interesting and useful device has been developed during the last seven years that may substantially change the approaches to heat transfer and utilization. The so-called heat pipe seen in Figure 1 is a high heat conductance device that works on the principle of vapor heat transfer resulting from boiling a liquid in one end (evaporator) of a closed container—pipe or duct—and condensing in the cool end (condenser).[1] The pressure difference thus set up between the evaporator and condenser transfer the vapor and the heat energy to the cooler section where it condenses, releasing the stored energy in its heat of vaporization. The condensed liquid is returned by surface tension forces to the evaporator *via* a capillary structure or grooves adjacent to the outer surface without any external pumping action. This seemingly simple device can transfer extremely large amounts of thermal energy with a very small temperature drop. Working fluids include water, acetone, ammonia, cesium, potassium, lead, lithium, and silver. Heat transfer rates and operating temperatures are shown in Figure 2 for a one inch pipe, one foot long, with a mesh wick.

The theories of operation of the heat pipe are complex, but development has proceeded very rapidly in the past few years to the point where heat pipes can now be considered competitive for many naval applications, from the cryogenic to the 2000°C temperature region.

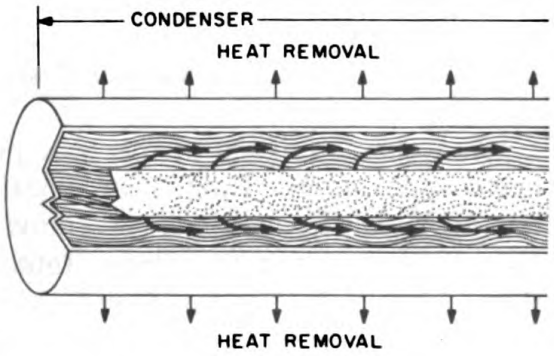

Figure 1—The principle of the heat pipe is an amazingly simple one. Phenomena involved are surface tension and the latent heat of the working fluid. There are no moving parts. Its effective thermal conductivity is hundreds of times more than solid conductors like copper and silver.

*ONR's initial interest in heat pipes was generated thru its thermionics and other power programs.

[1]K. Thomas Feldman, Jr. and Glen H. Whiting, "The Heat Pipe," *Mechanical Engineering*, February 1967, pp. 30-33.

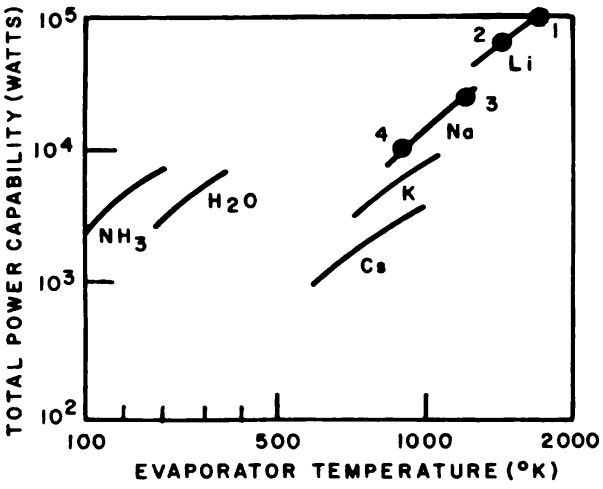

Figure 2—The operating temperature is determined by the choice of working fluid and to some extent by the pressure. Theoretically the heat pipe operates at a single temperature, that of the evaporator as shown here.

The desirable properties of a good working fluid are: boiling point and low vapor pressure in the desired operating range, high heat of vaporization, low density, and high surface tension. The principle of the heat pipe was first explored by R. S. Gangler of the General Motors Corporation for a refrigeration application in 1942, but it was never put into practical use until Dr. George Grover of the Los Alamos Scientific Laboratory independently discovered the device in 1963. Development has been rapid since then, with emphasis on space applications. Considerable work has been done both in this country and abroad, particularly at Karlsruhe, Germany, and the Euratom group at Ispra, Italy, in developing, optimizing and performing long life testing of structures, capillary materials and configurations. The Ispra group has proposed, a space nuclear thermionic power plant utilizing lithium heat pipes to transfer the heat (at 1600°C) from the nuclear core to thermionic converter emitters located outside the reactor. The collectors can be cooled in space by radiation using a sodium heat pipe operating at about 800-900°C. Combinations of working fluids and materials that appear promising are: lithium with tungsten, or TZM (molybdenum), or Nb-1 ZR (niobium—one percent zirconium; sodium with stainless steel or silicon carbide.

What characteristics of the heat pipe are particularly attractive for naval applications? First, heat pipes can have several thousand times the heat transfer capacity of equivalent size metal conductors. Dr. Grover reported at the Stresa International Thermionics Conference that 15KW/cm² was transferred axially with sodium as the heat pipe working fluid. The limit for lithium is much greater and is estimated to be 50KW/cm² or more. Second, the temperature drop down the length of the pipe is very small (less than 11°F down a one-inch diameter, two-foot pipe, operating at 2600°F and transferring 4.5KW of heat). This makes a heat pipe radiator very efficient and attractive for space system rejection of heat by radiation. Third, heat pipes have no moving

parts, are very reliable and can operate in a zero gravity field. The heat transferred at a constant temperature is a linear function of the inclination. Fourth, a heat pipe can be coupled to a nonuniform heat source, such as a flame, and still maintain a uniform temperature within 17° in the condenser. Fifth, the property to act as a heat transformer makes it possible to match widely varying sources and uses of heat. A 12:1 ratio is practicable. This property enables low power radioisotopes to be considered by concentrating the heat available. Conversely, in thermionic or similar devices with very high power densities (250 Watts/cm² input), the emitter can be heated, or the collector cooled, by this technique. Sixth, it is possible, by using a heat pipe, to separate the heat source from the sink; a high voltage source can be isolated from the heat rejection area, and barriers such as high radiation shields can be penetrated. Seventh, reliability of the system is increased by using separate heat pipes instead of a single closed loop system.

What are some potential applications for neat pipes in the Navy?

- High power, small space cooling requirements such as high power electronic tubes and rectifiers could be met by the heat pipe/radiator system.
- Leading edges of high speed aircraft, or vehicles, could be cooled by heat ducts which form the outer surface.
- Manned recoverable reentry vehicles that have heating rates in the hundreds of watts and a moderate "g" loading requirement could use the ducted heat pipe shell principle to reject the heat *via* the cooler rear surface by using a heat pipe/radiator system. The deceleration "g" forces assist in returning the condensed fluid to the evaporator section. This method adds heat vapor transfer to metal radiation and air cooling as a basic process and could permit reuse of the vehicle vis-a-vis an ablative shell.
- The same general approach could be used in cooling ballistic reentry vehicles. The feasibility of this method would require extensive evaluation as combination tests of very high heat input rates (KW/cm² surface heating) and high "g" forces are not believed to have been performed.
- Using the heat of reentry, a heat pipe connected to a thermionic or thermoelectric converter could furnish vehicle electrical power for terminal guidance and emergency power with no moving parts.
- Heat pipes can be used in conjunction with thermoelectric devices heated by radioisotopes or other heat sources. Heat pipes, for example, might be used to transfer heat from the converter cold plate to the space radiator to reduce weight and increase efficiency or to couple a cascaded thermoelectric device with unequal cooling and heating requirements.
- Use as a power-flattener. This scheme uses a reservoir of inert gas connected to the condenser end. Decreasing the rate of supplied heat

will effectively shorten the condenser area, and increasing the heat rate will increase it. By this method a constant temperature can be maintained over at least three isotope half lives to a thermoelectric, thermionic or other thermal load.

- Use as a high heat conductance device which combines high electrical resistance to remove heat from high voltage spaces.[2]
- Air conditioning and thermal control of ships and submarines.
- Cool the heat sink region of the thermoacoustic pipe.
- Use as a stand off heater by coupling the heat pipe through metal conductors to obtain the desired temperature drop. By this technique, water could be used as the coolant even though the heat pipe working temperature is well above the boiling point.

Even though the heat pipe appears capable of giving new alternatives, there are limitations that have to be considered and work is being done in these problem areas. There is a usable range of temperatures for each working fluid (Figure 2). Heat pipes have been tested from 83°K using liquid nitrogen to 2000°C (3600°F) with silver as the working fluid. Each designed system has its heat transport limit which is characterized by insufficient return flow of condensate, resulting in a drying out and rapid rise of temperature. Even though the limits are quite high (50KW/cm² or more for lithium), the limits must still be considered in very high heat flux designs. Nucleate boiling in the wick structure can produce burnout. This is similar to "pot" boiling limits and is treated in a paper by Werner and Carlson at Lawrence Radiation Laboratory.[3] This heat pipe radiator paper was presented at the 1968 IECEC Conference in which the relative superheats of different working fluids were calculated. For a given quantity of radial heat addition, the relative thickness of the flow channel for water is 1: potassium, 232; for sodium, 685; and for lithium, 1720. This makes it evident why sodium and lithium are such good heat pipe fluids. Of all elements with a vapor pressure of less than 10 atmospheres at 1600°C, lithium should be the best working material.

Another limit on the maximum axial flux is the sonic velocity of the working fluid vapor. This occurs due to choked flow at the exit of the evaporator. A practical limit is about 2/3 of the heat flux at sonic velocity. At 1000°C the practical limit for sodium is $2/3 \times 84 = 56$ KW/cm². Startup dynamics such as heat addition above the cutoff rate for proper operation of the heat pipe must be considered. This cutoff flux rate can be used to advantage, as a control or safety valve. Vapor-liquid interface effects resulting from entrapment of liquid in the counterflowing vapor

[2]G. Yale Eastman, "The Heat Pipe," *Scientific American*, May 1968, pp. 38-46.

[3]Richard W. Werner and Gustav A. Carlson, "Heat Pipe Radiator for Space Power Plants," *IECEC 1968 Record*, 487-503.

can also cause failure.[4] Practical application of high temperature (1500°C) heat pipes also depends strongly on whether mechanically reliable systems with long life times can be achieved. Below 900°C, long life times have already been demonstrated.

In summary, the heat pipe, with its unique properties, should find naval applications competitive with other techniques of heat control in advanced systems. Several companies and laboratories have very active programs in research and development on the heat pipe. It is estimated that normal development within the next few years will establish the heat pipe as a well-known engineering approach to solving some of the Navy's heat transfer and control problems.

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[4]G. M. Grover, J. E. Kemme, and E. S. Keddy, "Advances in Heat Pipe Technology," reprint from *Los Alamos Scientific Laboratory of the University of California*, pp. 1-14.

"Djakarta Detachment Proposed"

The Naval Medical Research Unit No. 2, Taipei, Taiwan, is planning to establish a detachment in Djakarta, Indonesia, to study diseases prevalent in Indonesia. NAMRU-2's relationship with Indonesia began last year when Central Java was again subjected to a plague epidemic with high morbidity and mortality rates during early 1968. After the U.S. Public Health Service Communicable Disease Center Team instituted control measures, the Indonesian Ministry of Health invited NAMRU-2 to conduct inter-epidemic studies of the ecology of plague in the Bojolali area, which suffers plague outbreaks every six to ten years. The mission of the three NAMRU-2 Plague Research Teams was to locate the reservoir of plague, define it, and explore the relationships between host, vector, pathogen, and habitat that make the perpetuation of plague possible.

Emphasis was on the capture of wild rodents and microbiologic analysis of body tissues and fleas for the presence of *Pasteurella pestis*. Animal inoculation and culture methods were utilized for plague isolation and identification.

Although plague was of primary concern, other diseases were investigated. Blood samples were obtained from both humans and animals to detect immunity to plague. A battery of other immunologic tests for the detection of immunity to various arboviruses, rickettsiae, and bacteria were done on these specimens. Blood smears were examined for trypanosomes, malaria, and other parasites.

The appreciation of the Indonesian Government resulted in another invitation, this time to establish a permanent detachment of NAMRU-2 in Djakarta. The Chief of Naval Operations has authorized negotiation for establishment to be initiated through the Department of State.

Now a temporary NAMRU-2 Detachment is operating in laboratory spaces provided by the Indonesian Ministry of Health and pursues an active program of field studies. While one field team is studying leptospirosis, a second NAMRU-2 team is surveying Sulawesi, one of the larger islands in the Indonesian archepellago, to investigate prevalent medical problems and the existing research potential in connection with these problems.

The Indonesian people have shown an intense interest in the United States; the local high school English Club often invites NAMRU-2 personnel to address their group. This friendly attitude extends to the highest levels of government, and is leading every day to a more rewarding relationship between NAMRU-2 and the Indonesian medical profession.

Research Notes

Edwards Wins Award

Mr. Earl A. Edwards, Chief of the Immunology Division of the Naval Medical Research Unit No. 4 in Great Lakes, Illinois, was selected as the Outstanding Federal Professional Employee of the Year for the Chicago Metropolitan Area. At the 13th Annual Federal Employee of the Year Awards Program held on 7 May 1969 at the Conrad Hilton Hotel in Chicago, Mr. Edwards ranked highest of over 78,000 employees from approximately 200 U.S. Government agencies. Competitors in the professional category were experts in such fields as biological sciences, physical sciences, medicine, mathematics, statistics, law, engineering, social sciences, architecture, and accounting.

Mr. Edwards is well known in the field of immunology and has authored 37 publications. Recently he devised serological methods of detecting genus-specific complement fixing and group-specific hemsgglutinating antibodies for *Neisseria meningitidis*, the organism responsible for spinal meningitis. These tests have been accepted by many laboratories concerned with the problem and have been acclaimed as highly significant. They allow improved studies of the epidemiology of the disease and of the role of carriers in relation to disease states. On the basis of animal experiments, certain antigens used in these tests have a strong potential for use in immunization against maningococcal disease.

"Philippine Capillariasis Study"

The Naval Medical Research Unit No. 2 (NAMRU-2) Taipei, Taiwan, is undertaking studies on a new disease in man caused by a species of *Capillaria* which occurred in near epidemic proportions in the Philippines in 1967 for the first time. That year two NAMRU-2 teams were invited to begin a collaboration with the Philippine Department of Health on this disease, which was thereafter called *Philippine capillariasis*. One team conducts epidemiological and field studies in Tagudin, Ilocos Sur Province, Northern Luzon, P.I., while a second group of NAMRU-2 physicians and technicians studies the clinical aspects of the disease at San Lazaro Hospital in Manila.

A wasting illness lasting several months, this disease appears to be caused by a 1-mm parasite which leads to major derangement of the human gastro-intestinal function, including chronic abdominal distress, diarrhea, hypokalemia, cardiopathy, and neuropathy, presumably due to severe malabsorption and enteric protein loss. Over 1300 human infections have been reported, associated with a significant mortality.

Epidemiologic field studies have included determinations of prevalence, incidence, age and sex preferences, and geographic distribution to determine the mode of spread and optimal means of control. Vertebrates and invertebrates found in the endemic area have been studied in an attempt to establish the possible intermediate and definitive hosts, although no leads have yet resulted.

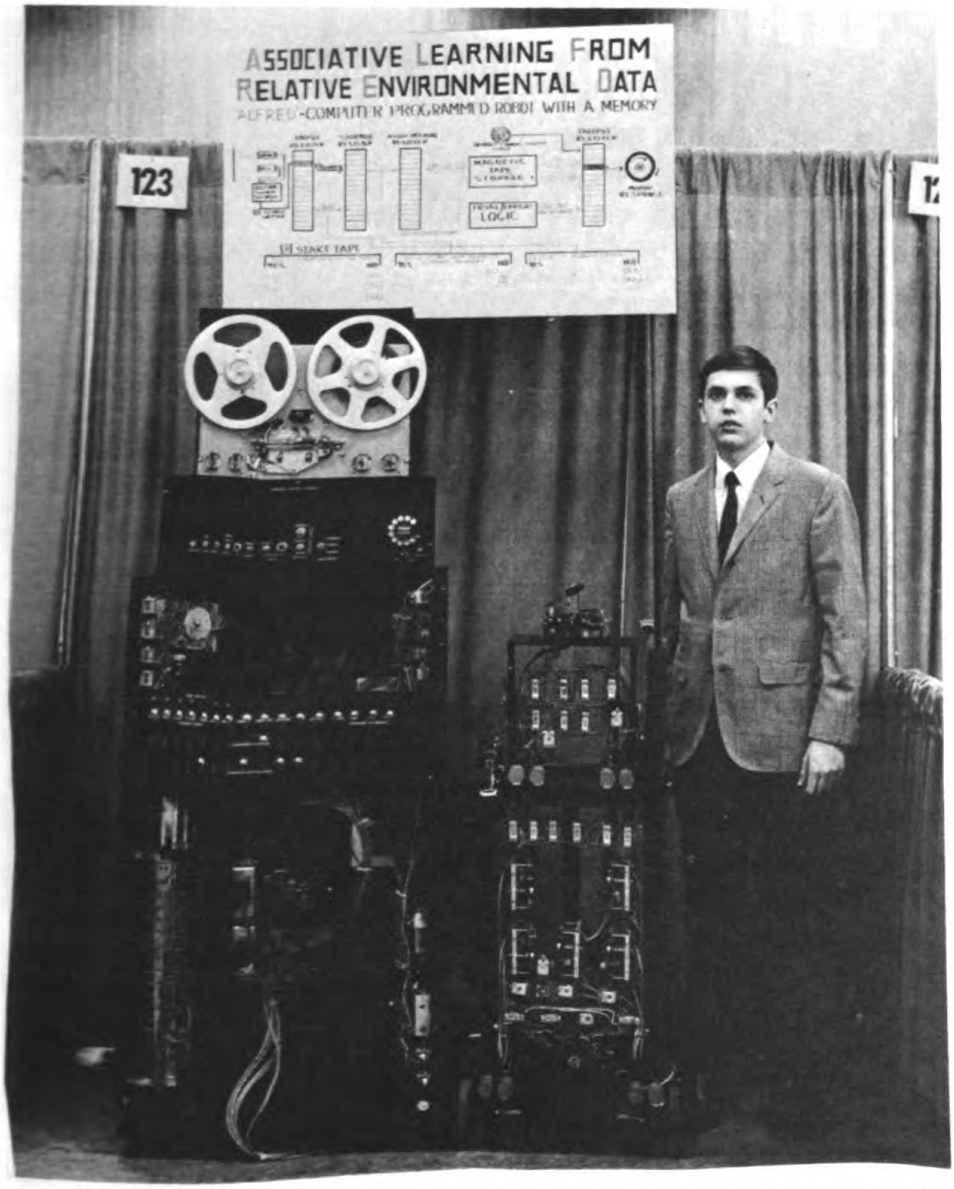
In Manila the pathophysiology and therapy of this disease are being studied. Complete clinical investigations include intestinal absorption studies and examination of biopsy specimens from all areas of the human digestive tract; pathological changes are noted. The finding of large numbers of parasites in the intestine, the presence of larval forms, and the existence of larviparous females suggest that autoinfection occurs in *Philippine capillariasis*.

To enable a comprehensive study of the life cycle and the relationship between the parasite and the host, attempts are underway to establish the parasite in the laboratory; to date, however, parasites have failed to develop in experimentally infected animals. Research is continuing into this new disease, with both NAMRU-2 and the Philippine Department of Health studying the problems presented.

Operation Cherry Blossom

Operation Cherry Blossom is a yearly program, begun in 1963, in which each of the three military services selects an outstanding student exhibitor at the annual International Science Fair and awards him or her an expense-paid trip to Japan where the winning exhibit is displayed at the Japan Student Science Exhibition. The selection of the three students to make the trip to Japan is based on the creativity and sophistication of their science projects and on personal characteristics which will reflect credit on the United States in a foreign country. The award of this trip, one of the most coveted prizes at the International Science Fair, is considered commensurate with the degree of the accomplishment.

Each year the Japanese sponsor of the Japan Student Science Awards Program, the Yomiuri Shimbun newspaper, has invited the Department of Defense to participate.



William Synhorst of Des Moines, Iowa, is standing beside his exhibit which was the Navy's winning exhibit for Operation Cherry Blossom

Cheryl Engleman of Hazelton, North Dakota, whose exhibit was the Navy's second choice, is the alternate for the trip to Japan

Although the Department of Defense sponsorship of the U.S. students is played down to those who are aware of DOD's part it demonstrates that the three military service are vitally interested in encouraging and supporting scientific research in fields othe than weaponry and warfare.

The program is a notable contribution to the people-to-people effort between countries It gives U.S. science students an opportunity to compare the facilities available to them for scientific study with those of another scientifically advanced country.

Mathematics Research Center at NRL

Dr. Alan Berman, Director of Research at the Naval Research Laboratory, has announced the establishment of a Mathematics Research Center within the Laboratory's Mathematics and Information Sciences Division. The move reflects the increasing importance of mathematics to Navy-oriented research.

The mission of the new Center will be to conduct research in areas of mathematics that are vital to a complete understanding of physical and scientific phenomena governing the naval environment. Among the initial areas of investigation will be functional analysis, ordinary and partial differential equations, special functions, approximation theory, functions of a complex variable, diophantine approximations, stochastic processes, control theory, and numerical methods.

When fully staffed, the Center is expected to consist of about 10 permanent members and an equal number of term appointees, primarily holders of sabbatical appointments from universities and other government laboratories. A limited number of term appointments will also be available to outstanding young Ph.D.'s.

Robert F. Acker Accepts Position at Northwestern

Robert F. Acker has been appointed director of the Office of Research Coordination and assistant dean of faculties for research at Northwestern University, effective June 1.

He is also being recommended to the Board of Trustees for academic appointments in the department of biological sciences in the College of Arts and Sciences and in the department of microbiology in the Medical School, Provost Payson S. Wild announced today.

Acker succeeds Lucius Gregg Jr., who has accepted a position as senior program officer at the Alfred P. Sloan Foundation, New York.

Acker has been director of the microbiology program, Office of Naval Research, since 1962. A diplomate of the American Board of Microbiology, he is a specialist in tissue culture, virology, and antibiotics, and is on the faculty of Georgetown University.

He is a member of the editorial board of Applied Microbiology and is the author of 25 research papers in microbiology and co-author of a microbiology textbook to be published this year by the Van Nostrand Publishing Co.

A native of Chicago, Acker received his B.A. in chemistry from Indiana University. After World War II service as a lieutenant in the U.S. Navy, he received an M. A. in bacteriology at Indiana and a Ph.D. in microbiology from Rutgers.

He was assistant professor of bacteriology at Iowa State University, 1954-59, and was assistant chief and chief in the departments of cancer chemotherapy, quality control, and cell and media production of Microbiological Associates, Inc., Bethesda, Md., 1959-62.

He has been a U.S. representative to the Organization for Economic Cooperation and Development, Paris, since 1965, serving since 1967 as chairman of the OECD committee on preservation of wood in the marine environment.

New Microscope Invented at NMRI

The first holographic microscope system intended specifically for biological studies has been designed and built in a joint effort by scientists at the Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland; the University of Michigan: Flint College; and Jodon Engineering Associates. To be employed primarily in the study of decompression sickness, known to divers as the "bends," the optical system will enable Navy scientists to observe where and how gas bubbles are formed in tissues and to possibly develop a treatment or prevention for the bends. The first prototype system was delivered this week to the Naval Medical Research Institute, where studies are underway to assess the advantages of holography *versus* microscopy when observing microscopic events in subjects exposed to extreme environments.

To make such observations scientists have needed a technique that would allow them to explore a greater volume of tissue with the same microscopic detail. The technique must also be suited to observation of the fast events that occur in living tissue. Both these problems have been solved by combining (1) a photographic technique called holography, the recording of optical information in three dimensions, and (2) a pulsed laser, which "stops" fast action. Events can be recorded exactly as they happen and then studied later.

Because of the large tissue volume recorded in the hologram, the method has great potential for the study of random events, such as blood clotting or hemorrhage.

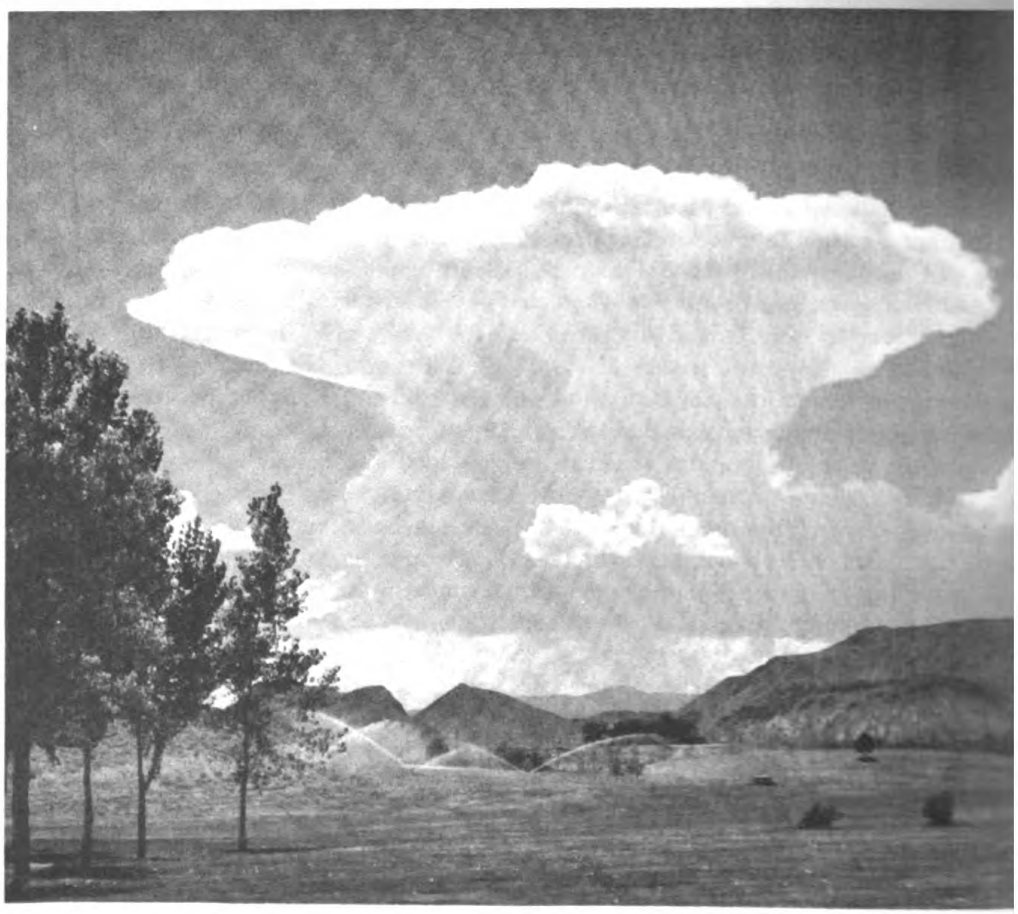
For the study on decompression sickness at Bethesda, the optical system has been attached to a high pressure chamber. Inside the chamber is a hamster, which is observed as the pressure increases. Since the cheek pouch of this animal is thin and filled with many blood vessels, scientists will be able to observe how these blood cells change with increased pressure and, particularly, how tiny gas bubbles form when the hamster is returned to atmospheric pressure.

The Holomicrography system was developed by a brother-sister team: Lieutenai Richard G. Buckles, MSC, USNR, a Ph.D. bioengineer in the Biophysics Division the Naval Medical Research Institute, and his sister, Mrs. Mary Cox, a University Michigan physicist. Doctor Cox provided the theory for the optical design and Doct Buckles determined the specifications necessary to adapt the general holographic syste for biological use. After they had specified the system parameters, they collaborated wi Jodon Engineering Associates in Ann Arbor, Michigan, under an Office of Naval Researc grant, in the development of the first prototype system.

Langmuir Laboratory

Langmuir Laboratory is an atmospheric research facility of New Mexico Institute Mining and Technology constructed with the support of the Office of Naval Researc and the National Science Foundation. The laboratory is located on top a 10,600 fo ridge in the Magdalena Mountains of central New Mexico. During the summer, isolate convective clouds often form, grow and finally dissipate directly over the laborator Scientists at Langmuir Laboratory study these clouds to understand the still puzzli process by which clouds make rain, lightning is produced, and how air moves in thunde storms.

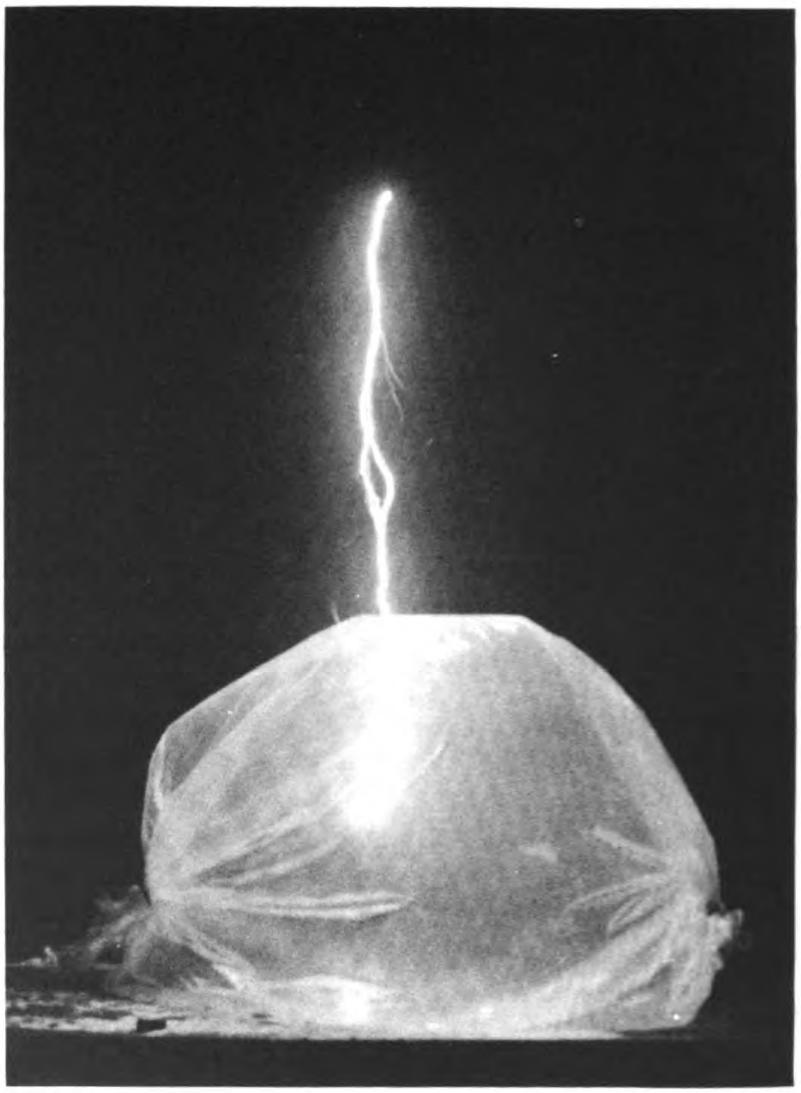
Summer thunderstorm over Langmuir Laboratory



Apparatus for artificial production of atmospheric space charge in concentrations similar to that found in thunderstorms

At Langmuir research is being conducted on how lightning may seed clouds. Ice crystals are often first noticeable in young thunderstorms at about the same time that the first lightning is detected; this association has been used to support arguments that ice in clouds is responsible for the charge separation resulting in lightning. On the other hand, lightning has also been observed in tropical clouds everywhere warmer than freezing so that the presence of ice can not be essential for all cloud electrification. The pressure variations associated with large explosions have been observed to cause condensation of clouds apparently as a result of the expansion and cooling of water vapor in the air. Perhaps a similar process might occur in the rarefaction portion of thunder which might cool a cloud of unfrozen water droplets to the temperature where ice might form and thus "seed" the cloud.

Radar examinations of thunderclouds indicate that natural seeding often occurs in the volume from which lightning has just come. Small sparks in laboratory cold boxes have also been observed to seed artificial clouds but this effect may be a result of metal evaporation from the electrodes. To separate the electrodes from a test cloud volume, experiments were carried out at the Westinghouse High Voltage Laboratory near Pittsburg with the 14-foot spark gap. In these preliminary experiments no seeding of a supercooled cloud



Long spark discharge through a supercooled cloud for studies of how lightning may seed clouds

contained in a balloon was observed at air temperatures as low as −15°C. The lowest air temperatures encountered during last winter never attained the −20°C threshold necessary for the expansion cooling to cause nucleation of ice. The lack of ice nuclei production indicates that the evaporation of the electrodes was not a source of cloud seeding in these last experiments.

ONR has sponsored studies which show that the collisions and coalescences of cloud droplets depend on the electrical state of the cloud. Equipment for the artificial modification of atmospheric charge has been constructed at Langmuir Laboratory. The apparatus consists of a surplus 1400 hp airplane engine mounted in a wind tunnel with an arrangement for making and charging an oil fog. The charged fog is expelled upward at a speed of about 100 mph carrying up to 1 ma of current which produces a vivid display of St. Elmo's fire and spark discharges into the air. When a natural cloud has covered the charger, radar echoes have been detected just down wind of the apparatus; this suggests that the growth of cloud drops has been greatly accelerated.

Biochemical Research May Unlock the Secrets of Life

A team of biochemists at Lehigh University is engaged in research which may help science to emulate nature's fundamental processes. In this scientific investigation, the Lehigh research team is hunting for a series of new enzymes, the tools science needs to work with proteins, often called the "Building blocks of life."

Enzymes are complex microscopic substances which hold the key to life's most intimate biochemical secrets. Therefore, such research could have profound medical, economic, and nutritional implications for the future of mankind.

Supported by a grant from the Office of Naval Research, the Lehigh investigation is being conducted in the chemistry department and the Center for Marine and Environmental Studies. It is directed by Dr. Joseph R. Merkel, professor of biochemistry.

While taking the basic approach, the Lehigh scientists are not overlooking the immediate practical and beneficial aspects of their research. It could, for instance, contribute to more economical production of protein-rich foods and essential amino acids required for a balanced diet.

Since enzymes are the catalysts that run the body, the Lehigh research could also contribute to medical breakthroughs. Certain enzymes are already in medical use in removing blood clots, healing wounds, and as anti-inflammatory agents.

In addition, there are many medical phenomena involving enzymes which have not been adequately explored, such as variations in blood pressure caused by the action of certain naturally occurring enzymes, and the controlled digestion of inactive proteins to yield active ones and vice versa.

The source of the enzymes with which the Lehigh scientists are working are specimens—some 500 of them—of marine bacteria collected by Dr. Merkel during the past six years from various parts of the Atlantic and Pacific oceans.

Bacteria are microscopic, single-celled organisms which exist everywhere. Some cause disease, but many others perform a useful service for mankind, such as transforming waste matter into plant food.

Dr. Merkel estimates that about 70 percent of the bacteria he has cultivated in the laboratory at Lehigh are capable of producing proteolytic enzymes and most of the cultures produce more than one such enzyme. A proteolytic enzyme is one which digests proteins. Meat tenderizers and pre-soak detergents used by housewives are good examples of such enzymes.

Dr. Merkel and his associates have not only been isolating and separating the proteolytic enzymes produced by their bacteria, but they have also been looking into the mechanics of enzyme action. To date they have discovered five enzymes which possess what is called "specificity."

"Specific" enzymes are those which attack, at certain points, the complicated arrangement of amino acids making up a protein molecule. Thus, they are the tools which enable biochemists to determine the structure of proteins.

Structure determination is the first step toward an understanding of the real nature of proteins that have enzymatic activity, and a prelude to their laboratory synthesis. In this way, such proteins as insulin and ribonuclease have been manufactured artificially.

Some of the enzymes isolated by the Lehigh team have gone through necessary stages of purification and may now be used by chemists to determine protein structure.

On the Naval Research Reserve

Flag Rank Selections

RADM Eugene P. Cronkite (MC), USNR (left) and RADM Frederick Wiggin, USNR (right) were recently selected to flag rank. RADM Cronkite, who is Adjunct Professor of Medicine, State University of New York at Stonly Brook, until recently was a member of NRRC 3-9, Upton, Long Island, New York. RADM Wiggin, who is an engineer for the Boeing Company, is a member of NRRC 13-1, Seattle, Washington.

Annual Naval Research Reserve Seminar

The 14th annual Naval Research Reserve Seminar was recently conducted at the Naval Research Laboratory. The two-week period was devoted to presentations by and tours of the scientific divisions at the Laboratory. These included the fields of applications research, electronics, radar, communications sciences, electronic warefare, acoustics, ocean sciences, ocean technology, solid state and plasma physics, mathematics and information sciences, space sciences, nuclear physics, chemistry, and metallurgy.

Two special meetings were planned for the Seminar by NRRC 5-9. They featured Dr. Robert A. Frosch, Assistant Secretary of the Navy (Research and Development) who addressed the group on "Navy Research and Development" and Dr. Donald B. Rice, Jr., Deputy Assistant Secretary of Defense Resource Analysis, OASD (Systems Analysis) who spoke on "Decision Making in the Department of Defense."

NRRC 3-8 Judges for Science Fair

This Spring five members of NRRC 3-8, New York, New York, judged the exhibits for the American Institute's 31st School Science Fair. The judges not only questioned but were questioned regarding the Navy's interest in science.

Activities of NRRC 4-4

To understand how public relations can help an organization become favorably received in a community, NRRC 4-4, State College, Pennsylvania, held a symposium on Navy Public Affairs. The public affairs symposium will help prepare the Company for a later symposium in which community organizations will participate; and NRRC 4-4 will examine its role in the community.

NRRC 8-1 Visits Research Ship Kane

NRRC 8-1, New Orleans, combined forces with the New Orleans Chapter of the American Society of Oceanography and the U.S. Military Sea Transportation Service to sponsor a program for which CAPT T. K. Tredwell, USN, Commander, U.S. Naval Oceanographic Office spoke on modern oceanography. Afterwards the group was taken on a tour of U.S. N. S. Kane which was at a nearby dock.

NRRC 8-3 Activities

NRRC 8-3, College Station, Texas, is preparing for a two week computer seminar which will be sponsored by ONR and Texas A and M University.

LCDR Robert M. Olson, LCDR Leo D. Berner and LT Charles E. Knowles were judges at the International Science Fair in Ft. Worth, Texas this Spring.

An Award of Excellence was presented to CDR Ronald Darby by the former Secretary of the Navy and Governor of Texas, John Connally at Austin, Texas. The Excellence Award is sponsored by ONR-Chicago Branch Office Director, CAPT E. D. Anderson.

NRRC 8-4 Sponsors Fourth Space Technology Seminar

NRRC 8-4, Houston, Texas, sponsored the Fourth Space Technology Seminar at NASA's Manned Spacecraft Center. Sixty-five reservists heard presentations by internationally known sicientists and engineers and toured the Apollo Mission Control Center. The seminar was organized principally for research companies in the Eighth Naval District. The co-sponsor was the National Aeronautics and Space Administration.

LCDR C. N. Coleman presenting 20-year plaques to CDR M. G. Gugenheim and LCDR J. D. Wyant

A ceremony was held during the seminar commemorating the 20th anniversary of NRRC 8-4. Plaques were awarded to CDR M. G. Gugenheim, Jr. and LCDR J. D. Wyant, who are orginal members of the Company when it was activated 15 April 1949.

NRRC 8-12 Participates in the International Science Fair

NRRC 8-12 was privileged to have six of its members among the 21 Navy judges for the Navy Science Cruiser Awards at the 20th International Science Fair held in Fort Worth, Texas.

Award Named in Honor of CAPT Behnke

CAPT Albert R. Behnke, Jr. MC, USN (Ret) known as the father of American diving medicine, was the first recipient of the award named in his honor, The Albert R. Behnke, Jr. Award. The presentation was made at the annual meeting of the Undersea Medical Society on 8 May 1969 by CAPT R. D. Workman, MC, USN, President of the Society and Head of NMRI's Environmental Stress Division. In presenting the award, CAPT Workman cited Dr. Behnke as a "physician, naval officer, scholar, and investigator who has given to diving medicine continuous enthusiasm and stimulation during the more than three decades of his contribution to the advance of undersea activities." Dr. Behnke retired from the Navy in 1959 and is currently Clinical Professor of Preventive Medicine at the School of Medicine of the University of California at San Francisco. He is also acting as a consultant with the Bay Area Rapid Transit System in the laying of the San Francisco-Oakland bay tunnel.

New Deputy for ONR

On July 1 CAPT Carl O. Holmquist, UNS, relieved CAPT H. E. Van Ness, USN, as Deputy and Assistant Chief of the Office of Naval Research. CAPT Van Ness has retired and taken a position at the National Aeronautics and Space Administration.

After graduation from the Naval Academy in June 1942 CAPT Holmquist was assigned to the USS Dunlap (DD384) as Gunnery Officer and kept the post until October 1944. He participated in the action at Guadalcanal, Marshall and Gilbert Islands, Saipan, Guam, Marcus and Wake Island, and received a Letter of Commendation with Ribbon and Combat "V" for outstanding service during the Battle of Vella Gulf.

CAPT Holmquist completed advanced aviation training and was assigned to Fighter Squadron 98 in July and August 1946. From September 1946 to June 1948 he was an aviator and Maintenance Officer of Fighter Squadron 20A, based on USS BOXER and at Alameda, California.

During the next five years he spent two years at the Naval Postgraduate School, Annapolis, Maryland, and three years at the California Institute of Technology, receiving a Masters degree in Aeronautical Engineering in 1951 and a Doctor of Philosophy degree in Aeronautics in 1953.

In March 1953 he reported to Flight Test Division of the Naval Air Test Center, Patuxent River, Maryland as Chief Engineer of Flight Test. In June 1957 he began a tour of duty in the Bureau of Aeronautics as Project Coordinator of the Aircraft Division. Following a brief tour in the Office of the Chief of Naval Operations, he was selected for duty in the Office of the Assistant Secretary of the Navy (Air). In 1959 he was assigned to the Office of the Assistant Secretary of Navy (Research and Development); and in August 1961 he was assigned duty at the U.S. Naval Ordnance Test Station, China Lake, California, as Experimental Officer.

CAPT Holmquist became Commanding Officer and Director of the Naval Training Device Center in June 1963 and Commander of the U.S. Naval Missile Center, Point Mugu, California in September 1964. Three years later he was ordered to the Naval Air Systems Command Headquarters as Executive Director for Research and Technology. Before coming to ONR he was Assistant Executive Director for Engineering in the Naval Air Systems Command.

In addition to the Commendation Ribbon with Gold Star, CAPT Holmquist has the American Defense Service Medal, Asiatic-Pacific Campaign Medal with one silver and two bronze stars (seven engagements), American Campaign Medal, World War II Victory Medal, China Service Medal (extended), Navy Occupation Service Medal, Asia Clasp, and the National Defense Service Medal.

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 109, Office of Naval Research, Washington, D.C., 20360. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.75 per year in the U.S. and Canada; $2.25 per year, foreign; $0.20 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

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IN THIS ISSUE

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Designed under ONR contract, the motion generator imitates the pitch, roll, and heave of an air/sea craft on the ocean surface. The moving cabin, which has accommodations for two crew men, is shown in its neutral position on the tower. *See story on page 1.*

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