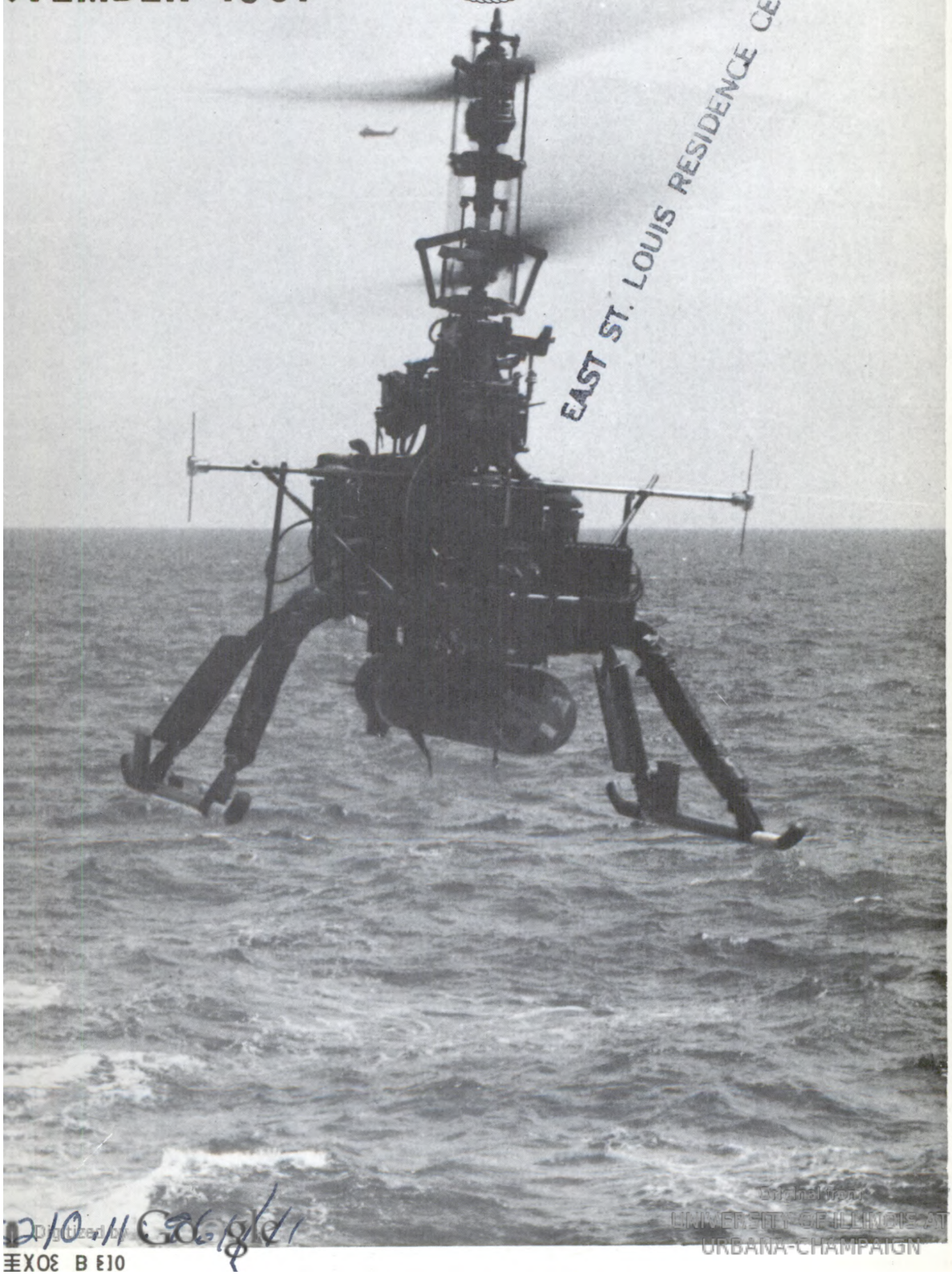
AVAL RESEARCH

REVIEWS

OVEMBER 1961



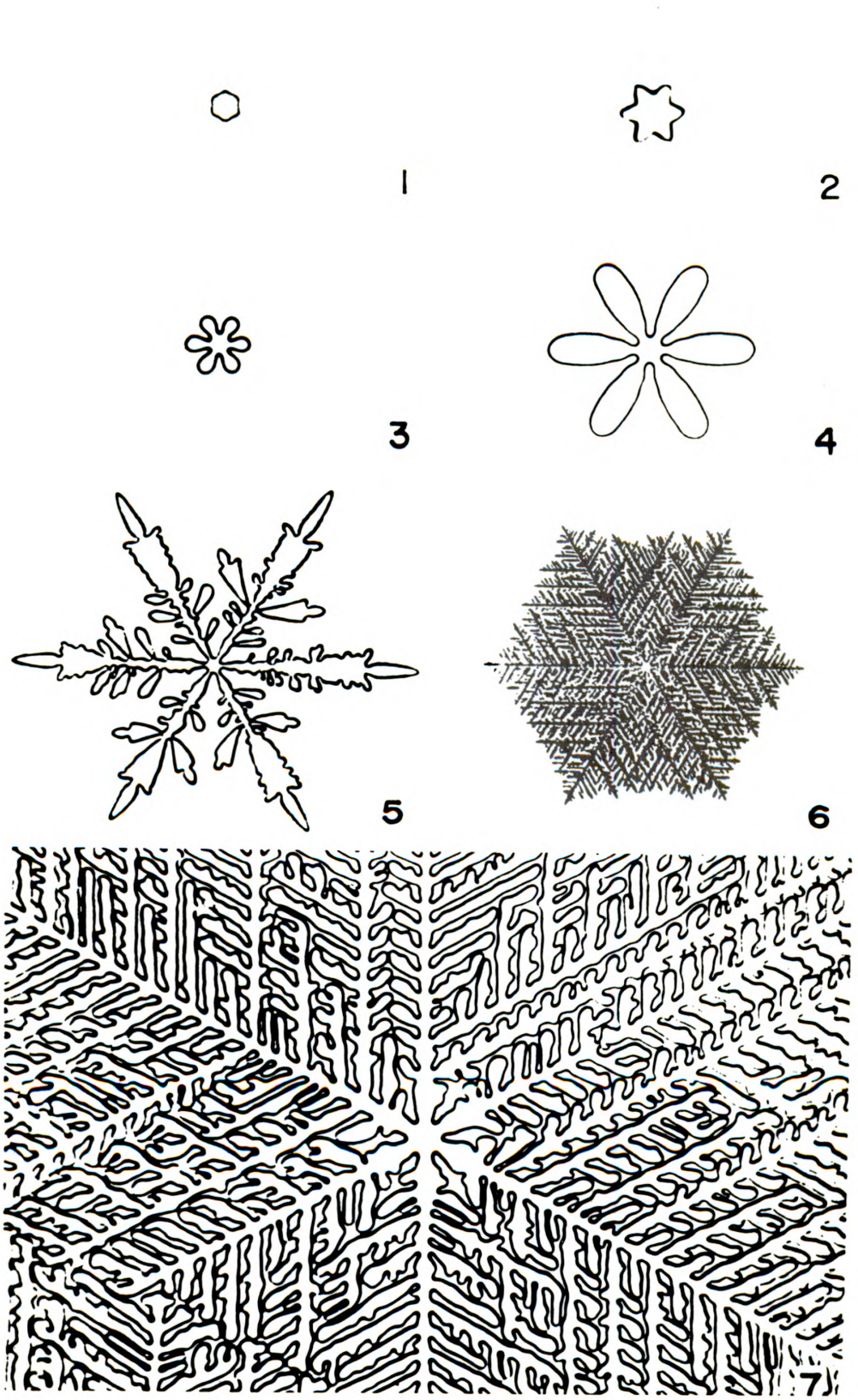


Figure 1 - Stages in the growth of a hexagonal ice crystal. 1: hexagonal disc; 2: star; 3 and 4: rosettes; 5: branching rosette; 6: skeleton; 7: enlargement of a portion of the skeleton shown in 6. (Courtesy of B. J. Luyet)

Cryobiology

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Cryogenics* has made tremendous strides in the past decade in applications to such fields as missiles, electronics, and gas liquefaction. On the other hand, the latent possibilities of the new field of cryobiology† have hardly been touched. For the past few years, the U. S. Navy, foreseeing the tremendous applications of cryobiologic research (in blood and tissue preservation‡ for treating traumatic injuries in peace and war, for example), has been fostering basic and applied research in this field.

Until recently, man's interests in biologic freezing appear to have been focused primarily on his defense against it (such as the prevention and treatment of frostbite). Very little attention had been given to the possible beneficial effects of cold—particularly as a practical tool in biologic research. As long as 300 years ago, the eminent chemist Robert Boyle published a series of essays on the effects of cold on knights in armor. He was also perhaps the first to show that frogs and fish remained viable even after being encased in ice for as long as two days. Since then, researchers have established the fundamental fact that many living plant and animal tissues can be exposed to the lowest available temperatures (-455° F) without being killed. Today, cryobiologic research is directed along two principal lines: studies of the uses of low temperatures for the preservation of individual cells, lower organisms, and the tissues of higher animals; and studies of the effects of temperature reduction in warm-blooded animals, such as occurs during physiologic hibernation and experimental hypothermia. (Hibernation is the normal physiologic response of certain species of animals when exposed to the seasonal lowering of their environmental temperatures. Hypothermia, on the other hand, is the induced lowering of the body temperature produced by a cold environment, such as the chilling of a patient's body prior to surgery.)

THE MECHANISMS INVOLVED

Although animals and plants, from the simplest microorganism to Homo sapiens, are extremely complex when viewed in their entirety, each basic entity (such as the single cell) may be likened to a simple machine. Cells as well as machines are energy-consuming units subject to the physical law of conservation of energy! The natural mechanism that functions to conserve energy during periods of cold is, of course, hibernation.

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*A branch of physics dealing with the generation of low temperatures (near absolute zero degrees or about -455° F) and their effects on various materials.

†A branch of physical biology dealing with the effects of low temperatures on living processes in biologic systems. It covers a wide range of temperatures (32° F and below) and includes such things as immersion foot, hiberation, and other forms of "suspended animation."

‡See the June 1957 issue of NavResRev for further details.

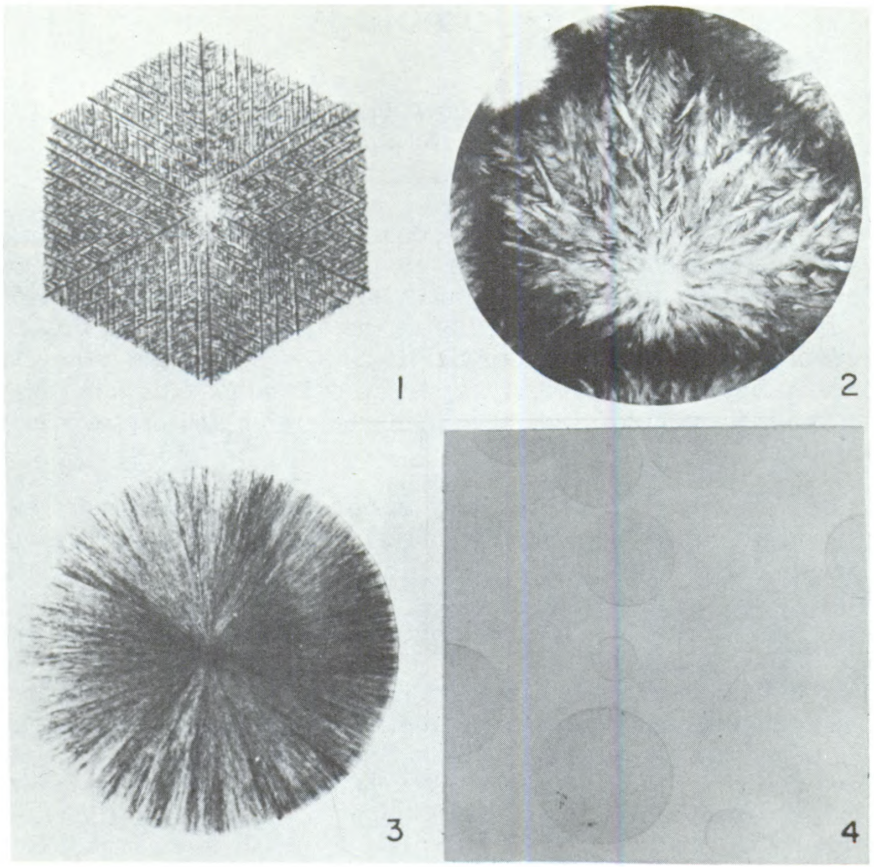

Figure 2 - The four basic types of ice crystal formations. 1: hexagon; 2: irregular dendrite; 3: coarse spherulite; 4: evanescent spherulite. (Photo courtesy of B. J. Luyet)

A serious deterrent to the advance of biologic research is the perennial problem of the long-term preservation of living cultures of cells, tissues, viruses, and bacteria. The answer to this dilemma may be a new freeze-thaw technique already useful in preserving human blood for long periods.

In surviving the freeze-thaw process, however, living organisms must undergo cooling, freezing, and existing for an indefinite period at subfreezing temperatures, as well as warming and thawing. The effects of freezing stem basically from two physical phenomena associated with the process: ice crystal formation (Figures 1 and 2) and its attendant dehydration. Variations in the end results depend on either or both of two factors: differences in the rate of freezing or thawing and variations in the physical characteristics of the material to be frozen.

The following describes briefly the effects of different rates of freezing on groups of living cells. (For further details, see February 1958, NavResRev).

Rate of Freezing	Effect
Slow	Few, large ice crystals form in the extracellular (interstitial) spaces. But, when forming, these crystals withdraw pure water from both outside and inside the cells. Result: large crystals with dehydrated cells squeezed between.
Faster	More numerous, but smaller ice crystals form. At first all the crystals form outside the cells, but as the freezing rate is speeded up, the crystals also form within the cells. An optimum point is reached when the crystals become evenly distributed, thus preserving the cells with a minimum of distortion.
High	The ice crystals become more numerous and smaller as the rate of freezing increases, until a point is reached when they finally vanish entirely. The resulting ice is solid and glassy. (This occurs near -200° F.)

Maximum usefulness of low-temperature preservation in the biological sciences and medicine can be achieved by preventing the occurrence of various detrimental reactions. For example, since ice crystal formation and growth are time-dependent phenomena, the more rapidly the temperature can be lowered to a point at which reaction rates are negligible, the less will be the risk of damage to the biologic system. This consideration applies even more to rewarming and thawing. Furthermore, damage to cells attributable to ice crystal

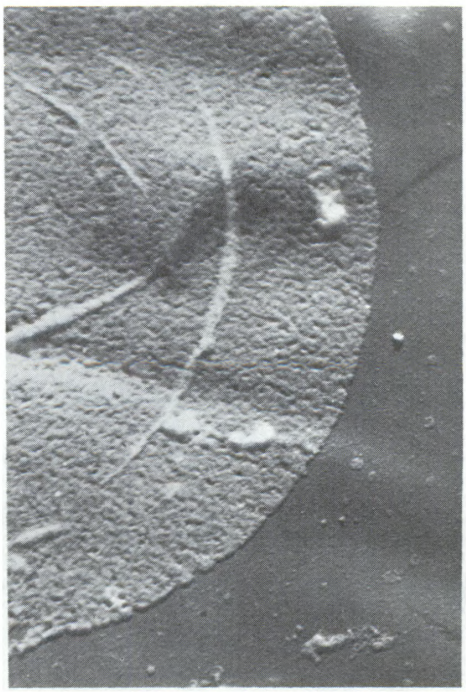

Figure 3 - Portion of a frozen red blood cell on the surface of a droplet of blood after direct freezing with liquid nitrogen. Magnified 17,400 times. (Photomicrograph courtesy of the Linde Co.)

Figure 4 - Equipment for studying the effect of low temperatures on storage of blood, tissues, etc. (Photo courtesy of the Linde Co.)

growth can be prevented only by storage at a temperature below the recrystallization point of ice (between -184° and -200° F). Protective substances can be added to biologic materials—such as blood—which are inherently susceptible to damage due to rapid changes in temperature (Figure 3). Additives now in use for this purpose include glycerol, glucose, other sugars, and certain low-molecular-weight polymers (dextran, polyvinylpyrrolidone).

Today, many investigators believe that the death of cells from freezing results not from the freezing process but rather from a slow warming and thawing process during which ice crystal growth (recrystallization) can proceed rapidly. When ice crystal formation is absent, most cells are not harmed by low temperatures.

BLOOD-PRESERVATION RESEARCH

Ever since the technique of therapeutic blood transfusion was developed, early in the 20th century, scientists and physicians have been working toward a method of preserving blood for long periods. To justify the practicality of this effort, one merely needs to mention that blood valued at more than $10,000,000 is wasted annually in the United States alone because the blood could not be used for transfusion within the currently prescribed storage period of 21 days. The demonstration in 1937 that cadaver blood could be used for transfusion, without the addition of anticoagulants, paved the way for stimulating interest in blood preservation. Blood banks were established in hospitals as early as 1937. With the widespread adoption of the blood-bank system, the study of the effects of various preserving methods on blood constituents gained new impetus. Numerous studies were made on the effects of various additives, anticoagulants, and varying temperatures.

The classical work of Luyet in 1949 paved the way for experimentation with the low-temperature preservation of blood. He showed that

70 percent of the red cells in smears of oxalated ox blood remained viable when cooled at a rate of some 200 degrees per second by immersion in liquid nitrogen and then rewarmed at about the same rate. In 1950 Dr. A. U. Smith (of the Institute for Medical Research in England) became interested in the protection of red blood cells during freezing and discovered that a 15 percent glycerol solution protected rabbit and human red blood cells from death during freezing at temperatures of -109° F and -313° F. With the foundation thus laid, considerable research followed. Pioneers, such as Sloviter, Mollison, Lovelock, and a host of others, contributed to the development of a method whereby glycerolized blood could be frozen, thawed, deglycerolized, and used for transfusion. It was shown that about 70 percent of the cells had a normal life span in the recipient. Later this process got a firm foothold when it was adopted by the group at the Protein Foundation, Cambridge, Massachusetts. Then in 1955 Meryman (of the Naval Medical Research Institute) successfully preserved, thawed, and transfused blood that had been frozen in liquid nitrogen by using a "droplet" method.

The prime example of cryobiologic research sponsored by the Office of Naval Research is the program on the low-temperature preservation of blood. The work on this two-year-old project is being done under contract by the Linde Company (a Division of Union Carbide Corporation) of Tonawanda, New York. This company is developing a freeze-thaw method (Figure 4) of processing human blood for indefinite storage at liquid-nitrogen temperatures (on the order of -320° F). The goal is to achieve a simple, economical, speedy process of blood preservation, storage, and transfusion without any intermediate steps in the process from donor to recipient.

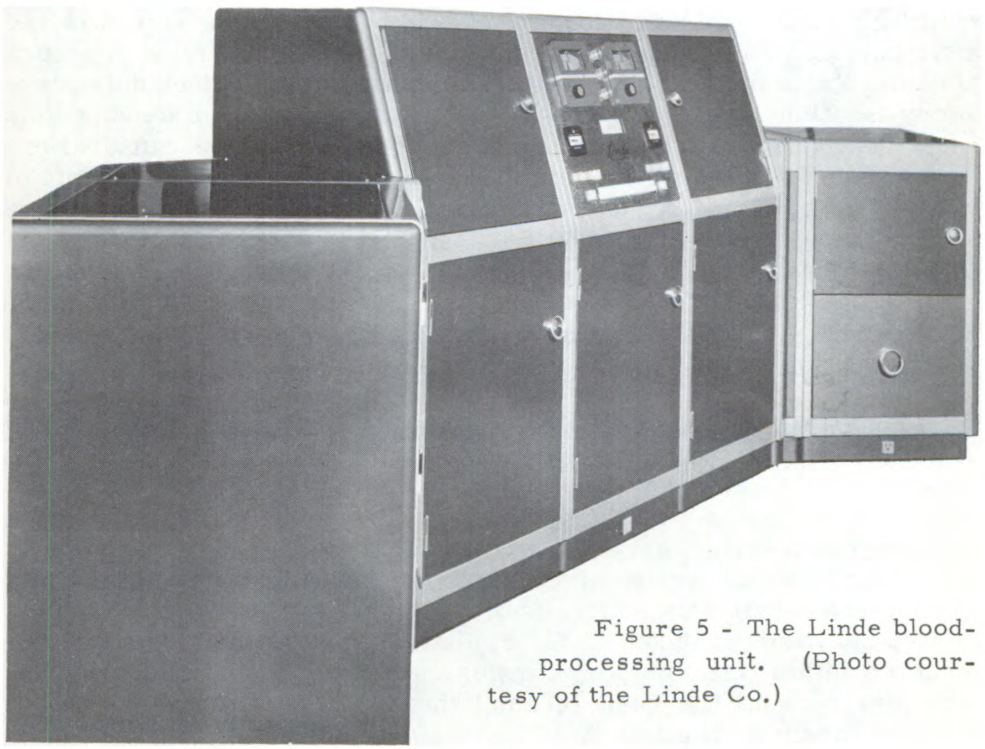

Figure 5 - The Linde blood-processing unit. (Photo courtesy of the Linde Co.)

Toward this end, the Linde Company has already achieved a major breakthrough in biologic engineering by developing blood-processing equipment for use in their new rapid-freeze procedure (Figure 5). With this equipment, a pint of blood can be frozen or thawed in one minute or less. From the standpoint of research, such apparatus is an important feature, for it permits a rapid study of procedural variations in blood processing, such as changes in freezing or thawing rates, or the frequency of shaking.

The current steps in processing a pint of fresh blood with this unit are as follows:

- A special container, shaking at 200 cycles per minute, is frozen in liquid nitrogen for about 45 seconds (Figure 6).

- Thawing proceeds at about 115° F for about 35 seconds at 200 cycles per minute.

- The thawed blood is stored in an ice bath at 32° F until it is needed. Once the frozen blood is thawed, it can be stored for as long as three weeks in the blood bank refrigerator. Although considerable work needs to be done, the potential of this process for establishing a simple freeze-thaw blood-preserving technique is great. Already, there is a growing international interest in the process.

RESEARCH IN OTHER FIELDS

Although cryobiologic research has been principally centered around finding optimum blood-preservation techniques, low-temperature research on other biologic systems has not been entirely neglected. Spermatozoa were successfully frozen and revived as far back as 1938. And in 1952, A. U. Smith worked on a freeze method of preserving fertilized rabbit eggs and found that one percent of the eggs survived after thawing. Although one percent is not a very high rate, it is enough to demonstrate that even a cell in such an unstable state does not necessarily succumb when exposed to low temperatures. Extending this phenomenon to microorganisms, scientists have found that survival can vary tremendously, depending on the temperatures involved, the rate of cooling and rewarming, and the nature of the medium in which they are suspended during exposure.

The problems involved in freezing highly organized animals, such as mammals, however, become more complex and perhaps appear insurmountable. Until a few years ago, it was thought that an adult nonhibernating animal, such as a rat, could not survive cooling to a deep body temperature below 69° F (at this point the respiration and heart beat cease). Yet, the emperor penguin not only supports life but contrives to incubate eggs and care for its chicks in Antarctic temperatures as low as -76° F. The old ideas regarding the tolerance of mammals to freezing, however, were recently blown to bits by Radoslav Andjus of the University of Belgrade who by using special methods, demonstrated that rats, mice, and dogs could be revived after cooling to deep body temperatures of 32° F. Rats so treated showed no impairment of either memory or learning capacity. These are only a few examples of what has been accomplished so far and serve to indicate the vast potential ahead.

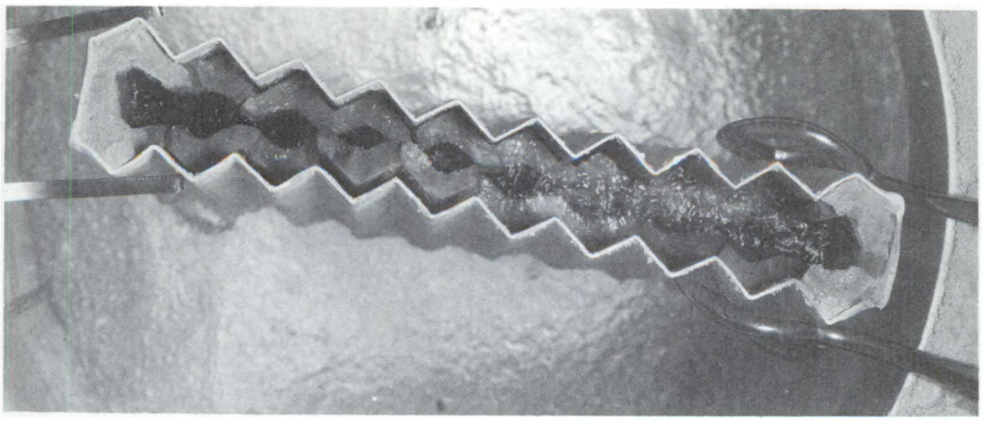

Figure 6 - Section through metal container used in freezing a pint of human blood in liquid nitrogen. During freezing, the blood migrates to the sides of the container leaving a central void. (Photo courtesy of the Linde Co.)

THE FUTURE

The expression "Where there is no vision, the people perish" is applicable to basic research in biology and medicine. Just as some of the infectious diseases fell before the onslaught of the army of broad-spectrum antibiotics, so may others succumb through further progress in biologic research aided by the valuable research tool, cryobiology.

There is no doubt that there will be many applications for the preservation techniques developed through cryobiologic research. In the area of "cryofixation," for example, low-temperature preparation techniques could be utilized to permit stabilization of the macromolecular matrix of biologic specimens for permanent preservation of their fine structure for study. Even relatively large specimens, such as whole brains of vertebrates, could be preserved intact with a minimum of chemical fixation. Looking further ahead, we foresee the long-term preservation and storage of live bacterial and cell or tissue cultures. A further advantage in preserving such cultures would be the elimination of the present laborious day-to-day transfer of a strain or colony to keep it going. One can also visualize the long-term banking of antibiotic-producing organisms as well as their products—a new development that would eliminate the terrific expenses of today's continuous production and waste loss due to the unstable or short-lived nature of many antibiotics. In fact, some organisms die off even before evaluation and testing of their products is completed. Long-term preservation would eliminate the present "start again from scratch" routine necessary to study such organisms completely.

Another important area of application could be the arresting of chemical and other life processes, in disease as well as in health, for future study. Important enzymes, for example, could perhaps be preserved without loss of function. If this were possible, then more

accurate studies of cells and tissues could be made without the hinderance of autolysis (literally self-destruction). Then too, the study of transient phenomena, through the preservation of time-labile characteristics (such as the transient state in a biochemical reaction or unidentifiable but important intermediates) may enhance molecular biology. And the ecologist and geneticist could preserve present generations of organisms for later comparison with future generations. Also, tissues affected by a present-day disease process or metabolic disturbance could be preserved and then compared with diseased tissues in existence, say 10 years hence. Thus changes in disease and genetic patterns possibly could be detected.

Looking far into the future, one might visualize the preservation of live flora or fauna to prevent the imminent extinction of a species. Museums might become interested in this possibility. Such an application cannot be dispelled as being impossible or fantastic, for, theoretically, life virtually does experience a temporary halt at temperatures around and below the liquid-nitrogen range.

The foregoing are only possibilities, we must admit. But they serve to illustrate the vast potential of cryobiology in the general fields of biology and medicine.

An ONR contractor, Dr. Frank Halden of Stanford Research Institute, has developed an arc-image crystal grower that provides extremely pure growing conditions in addition to atmosphere control over a wide range of oxidizing and reducing conditions. A description of this grower was published in the January 1960 issue of the Review of Scientific Instruments. As a result of Dr. Halden's research, several laboratories, including the Albany Metallurgy Research Center of the U. S. Bureau of Mines, the U. S. Army's Diamond Ordnance Fuze Laboratory, and the National Aeronautics and Space Administration Lewis Research Center, have now announced plans for building similar crystal growers. In addition, the Institute has received many inquiries from government and industrial laboratories regarding the possibilities of growing crystals from materials that have high melting points and from materials that are highly reactive at elevated temperatures.

During the recent conversion from black oil to aviation fuel of four large fuel-storage tanks in the Fourteenth Naval District (Honolulu), a problem developed. For the conversion involved not only cleaning and sand-blasting the interior, but also finding a sealing material that would protect the welds against fuel permeation and the fuel against contamination from microscopic rust particles.

So an extensive search was conducted to find a tank coating that would be capable of withstanding the solvent action of all types of fuel—in particular, aviation gasoline rich in aromatics. The lining material finally selected was a plastic one developed by the U. S. Naval Research Laboratory particularly for this purpose. The material consists of a system of polymers that has been under development for about three years and makes use of one of the newest polymers to become available for forming films that are almost completely inert to a broad spectrum of solvents.

Oceanography and Food

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The people of Southeast Asia, already burdened by an exploding population whose food-growing space is being reduced through conversion of rice paddies into urban areas, are turning increasingly to the sea for additional food. Even though fishing in parts of the adjacent waters is already intense, it is believed that modern science can find ways to exploit still further the resources of the sea.

The Naga Expedition,† sponsored by the International Cooperation Administration (ICA), was established as an exploratory program to survey and develop the marine food resources in the Gulf of Thailand and the South China Sea. Under the leadership of the Scripps Institution of Oceanography and in cooperation with representatives of Thailand and South Vietnam, a program for an oceanographic and biologic study of these two bodies of water was arranged in order to determine the food-producing capacity of both. Scripps personnel, officers from the Thai Navy, scientists of the Thai Fisheries Department, students and teachers attached to Chulalongkorn University, and technical personnel from the Oceanographique Institut Nhatrang of South Vietnam were among those who participated in the expedition.

To study the physical properties and life processes of the ocean, members of the cooperating agencies made a series of cruises in the RV STRANGER (Figure 1), a well-equipped Scripps Institution oceanographic vessel. The cruises utilized a network of oceanographic stations established throughout the Gulf of Thailand and the South China Sea. Water samples were collected for the determination of salinity, oxygen, and phosphate. Nets were towed through the water to collect plankton, and dredges were towed along the bottom at some locations to collect pelagic (open-sea) and benthonic (deep-dwelling) organisms. Numerous valuable data covering the entire annual life cycle were collected on the 10 cruises made in both bodies of water.

LIFE CYCLE

How was the marine food potential of the Southeast Asia region studied? Since the important fish-producing areas were not clearly defined, they had to be sought principally by indirect methods, i.e. by locating and mapping environments likely to produce food for fish and other valuable marine life.

A study of the food supply of marine animals involves a study of its life cycle (Figure 2). The cycle begins with nutrients, one of the factors

*Former senior scientist on the Naga Expedition.
†Hindu serpent-genii of the waters.

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Figure 1 - The RV STRANGER in the Chao Phraya River in Bangkok. (Photo by the author)

needed by plants in the process of photosynthesis. The nutrients are water soluble and consist chiefly of chemicals, such as phosphates, nitrates, and silicates, plus a few trace elements and vitamins. These plants provide food for the small marine animals, (zooplankton which include the larvae of most fish). Zooplankton, in turn, are eaten by larger animals (which include the adult forms that are of primary interest as human food). All of this living matter eventually dies and and is decomposed by bacterial action. The resulting nutrients are redissolved in the water (especially in the deeper layers of the sea), thus completing the life cycle. "If any one of the steps in this cycle could be singled out and its areas of concentration determined," the scientists of the Expedition reasoned, "then potential food-producing areas could be established." Since the concentration of nutrients is the key to the whole life cycle, finding these areas became the basis for the procedures used by the Naga Expedition in the Southeast Asia area.

ECONOMY OF THE SEA

The major supply of marine plant nutrients flows from the land into the sea through river drainage and runoff. This process is analogous to fertilization. Some of the nutrients spread out temporarily on the surface of the sea, but most find their way to the bottom layers. The runoff observed in the Gulf of Thailand is extensive.

The vertical movement of water is a powerful factor in introducing nutrients to the zone of light penetration (euphotic zone) where the plants are found. To gain a fuller understanding of the factors involved in the regional sea-life food economy, the pertinent vertical water movements of the area were classified and observed:

- Fronts: The leading edge of a border separating unlike water masses is called a front. Fronts can occur not only between water masses of different salinity but also between those differing in other properties, such as temperature. These fronts raise water of higher nutrient content to the surface. In addition, the fronts tend to concentrate floating fish food in adjacent areas.

- Wind Mixing: The storms indigenous to Southeast Asis were found to be severe enough to mix the surface layer with water from considerable depths. Such mixing and churning of the water may raise nutrients up from the depths.

● Convection: Convection currents, set in motion whenever the surface water layer becomes heavier than the layers beneath (either through evaporation or cooling), also bring nutrients up from the depths. This condition was observed during the winter in the northeast part of the Gulf of Thailand.

● Shoals: Observation revealed shoal borders to be favorite fishing grounds. Here, nutrient replenishment may be effected through the vertical circulation and turbulence created when water flows over a shoal.

● Islands: Off the leeward side of islands, the subsurface water layers may rise to higher levels through eddying and limited upwelling, thus furnishing a method of localized nutrient replenishment. This process was noted in the western part of the Gulf of Thailand.

● Upwelling: Surveys by the Naga Expedition in the Southeast Asia locale showed that nutrients were brought almost to the surface by near-shore upwelling. Here the twin factors of coastal orientation and persistent wind direction combined to make upwelling a principal source of nutrient replenishment.

RESULTS

From the data gathered, combined with a knowledge of regional wind direction and speeds, it was possible to establish the most

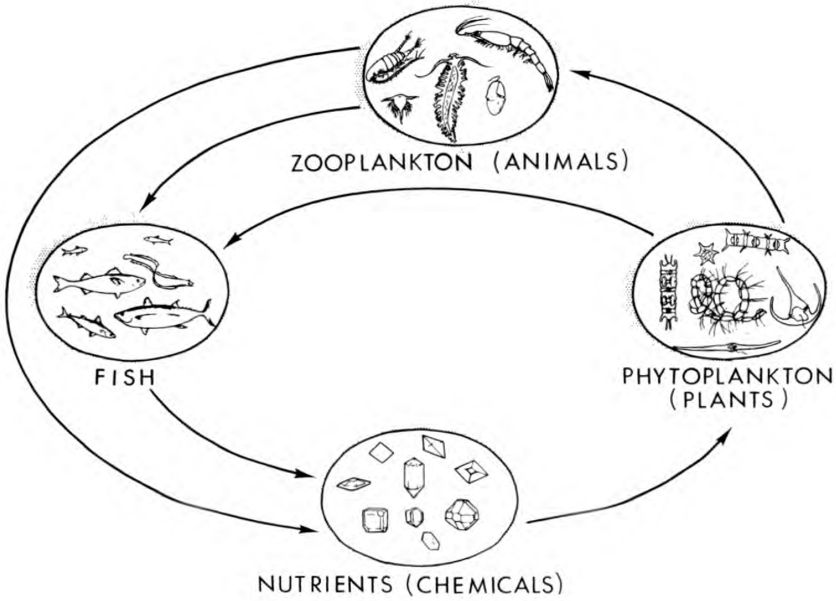

Figure 2 - The life cycle of the sea. Nutrients (in the presence of sunlight and other favorable conditions) furnish the plants with the materials necessary for photosynthesis; the plants are then eaten by the small animals (zooplankton), which are in turn eaten by the larger animals, such as fish. All of this life eventually dies, and the constituent chemicals are redissolved in the water.

Figure 3 - Areas of offshore upwelling and high organic production in Southeast Asia. Areas 1 and 2 are sites of major summer upwelling. Area 3 is the site of a weakly developed winter upwelling. Area 4: A frontal area, rich in plankton, between two water masses of differing temperatures. Area 5: A probable winter area of upwelling predicted as a result of the conditions found in the areas to the east.

probable current or motion patterns in the Southeast Asian region. It was determined that during the summer, when southwest monsoon winds prevail, the current flows northward up the South Vietnam coast in the South China Sea, and a large clockwise eddy forms in the upper Gulf of Thailand. In winter, when northeast winds prevail, the circulation nearly reverses, with a southward flow off South Vietnam and a counterclockwise eddy in the upper Gulf. The other seasons, transition periods between the extremes of summer and winter, have variable circulation patterns. A description of the principal areas where upwelling was found follows.

Southwest Monsoon Upwelling: The strongest and most persistent winds in Southeast Asia are the summer southwesterly monsoons. These blow the surface water away from the coast on the west side of the Gulf (see No. 1 in Figure 3) and cause the colder, higher-nutrient water in this region to well up to a subsurface level of less than 20

meters, but not completely to the surface. In this region, however, other factors, such as the impinging of currents on islands and strong winds, are also capable of forcing the nutrients to the euphotic zone.

During the early part of the southwest monsoon season, wind action off the South Vietnam coast was such as to induce surfacing of the lower sea layers. This causes colder patches of surface water to develop off the north coast of South Vietnam (see No. 2 in Figure 3). Later in the season, the upwelling zone moved somewhat south and offshore. This was observed to be a region of high organic production. The careful delineation of this phenomenon is important for the development of fisheries in the South China Sea.

Northeast Monsoon Upwelling: Evidence of upwelling on the northeast coastal sector of the Gulf appears in winter, when northeasterly winds prevail. This creates another seasonal area of high nutrient content, with resultant planktonic production (see No. 3 in Figure 3). A fish tagged in the summer upwelling region on the west side of the Gulf (No. 1) was caught on the east side during the winter upwelling (No. 3). The fish was probably following the food supply, or region of upwelling.

A significant discovery of the Naga Expedition was a water-mass boundary near Paulo Obi, between the waters of the Gulf of Thailand and the China Sea (see No. 4 in Figure 3). This boundary, caused by temperature differences, showed an abrupt rise in temperature just north of Paulo Obi. Here, for miles, the water was very turbid from a concentration of plankton. This proved to be a zone of high organic production.

Scientists of the Naga Expedition theorized that upwelling should occur off the Thailand coast in the Andaman Sea (see No. 5 in Figure 3). Although not studied, the area was postulated as an upwelling zone for two reasons: in winter the monsoon winds, blowing from the northeast, should displace the coastal waters seaward and cause upwelling; and the zone is a vital fishing area worked intensively by local fishermen. These men, by trucking small boats across the narrow peninsula, fish in the Andaman Sea in winter and in the Gulf of Thailand in the summer.

SUMMARY

Though many factors unknown to science still exist in the life cycle of the marine organisms that are moved by sea motion and subjected to environmental hazards, scientists of the Naga Expedition found a strong planktonic concentration at the edge of the Gulf of Thailand. This was in accord with predictable nutrient-distribution and circulation patterns. Upwelling of deep, cold, nutrient-rich waters, which influences distribution and abundance of plankton, was found to follow the changing seasonal wind system. The species of plankton inhabiting the Gulf of Thailand showed discrete and meaningful patterns of distribution. Still other relationships will no doubt evolve with further analysis of the data.

Through oceanography, the Expedition began a practical course of action to identify the marine resources and increase the food supply. In the opinion of the Asian and American scientists who participated, the program was so well conceived and executed that it can serve as a model for similar expeditions in the future.

New Paint for Submarine Interiors

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A new semigloss acrylic-latex paint, recently developed at the U. S. Naval Research Laboratory, is free from the air pollutants that seriously cut down the time submarines can spend under water.

The use of paint on nuclear submarines, as on any other Navy vessel, is essential in protecting the hull and machinery from corrosion. Almost equally important is the use of paints for sanitary and decorative purposes. In today's nuclear submarines, prolonged undersea voyages without a change in surroundings for the crew present a psychological problem. To ease the situation, the interior "scenery" of the submarine is sometimes partially modified between voyages by changing the color of the paint above the bilges. But frequent painting can have a deleterious physiological effect of greater import than any psychological benefits, because volatile organic solvents in the paints are released into the submarine's atmosphere long after the paints have dried. These often are compounds of appreciable toxicity. They generally pose no problem when applied in well-ventilated spaces, but in the confined spaces of a submarine the cumulative effect of these "poisons" must be reckoned with.

For over a decade, chemists at NRL have been working on the problem of improving the habitability of nuclear submarines. Most of the studies have dealt with the chemical composition of the submarine atmosphere and with the development of methods and equipment for maintaining the atmosphere during submergence in a condition as close as practical to "country-fresh" air.

EARLY WORK

Late in 1958, after extensive research had proved that much of the hydrocarbon contaminants in a submarine atmosphere could be traced to the slow evaporation of residual solvents in oil-based paints, NRL began a research program on the suitability of water-thinned paints for submarine interiors. Initial work centered on measuring and identifying the small amounts of volatile components—other than water—from a number of commercial latex paints. This was done by force-drying samples of the paint and trapping the volatiles. The identity, amount, and rate of evaporation of these volatiles was then determined by gas chromatography and other methods. Recommendations based on the results of this work guided the Bureau of Ships in authorizing the use of a commercially available latex paint for submarine interiors. The matrix of this paint was polyvinyl acetate. Although highly satisfactory in many respects, the paint was still not entirely free from volatile components. These included traces of resin monomer and small amounts of additives which are necessary for proper film formation, package stability, inhibition of biologic attack, etc. Because of these volatiles, submarine painting had to be restricted to 30 days before departure for sea or after the last dive on patrol.

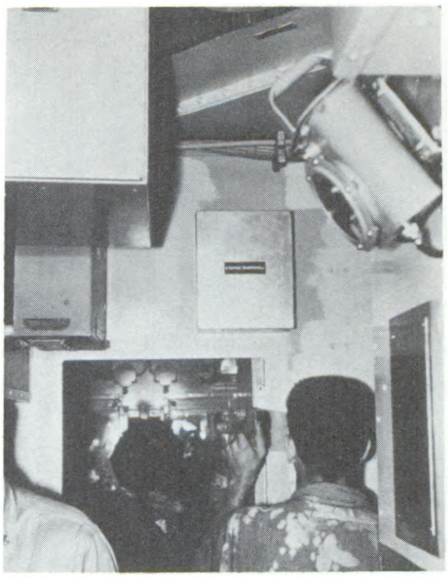


Figure 1 - NRL's latex paint being applied to the forward passageway of the USS TRITON. (Photo courtesy of BuShips)

Some time after this latex paint was authorized for use on submarines, another unsatisfactory feature came to light: because of its extreme flatness, the coating was easily soiled. (On the semigloss aklyd paint ordinarily used, soiling either was not apparent or could readily be removed). So NRL scientists decided to develop a semigloss latex paint which would be more suitable for painting submarine interiors during submergence.

DEVELOPMENT OF SEMIGLOSS LATEX PAINTS

Although latex paints with gloss equal to the alkyd paints could not be found on the market, several formulations for such paints have appeared in the literature. These served as a starting point in the search for a product of adequate gloss, durability, drying rate, and freedom from volatile atomosphere contaminants. In the course of this research, some seventy formulations were made, tested, and compared with each other and with five commercial latex paints. We will present only a summary of the important points.

The three types of latex pants were examined. The styrene-butadiene type was quickly eliminated from further consideration because gloss finishes were difficult to obtain. So attention was focused on the other two types: polyvinyl acetate (PVAc) and acrylic. Although paints made from these two vehicles appeared to be equal in hardness, scrubability, cleansibility, resistance to soiling, gloss, and weathering, the PVAc paints were less intricate to formulate, so the chemists worked mostly with them. But after several months, these latter paints began to decrease in gloss. The acrylic paints, on the other hand, were found to have excellent gloss retention, therefore, the research effort was turned toward improving their formulation. The formula finally developed afforded excellent hiding ability, gloss, and leveling, as well as good scrubbability and resistance to soiling. The resulting acrylic-latex paint, for use on both bulkhead and deck, has been tested extensively in the laboratory and aboard a nuclear submarine. A description of these tests follows.

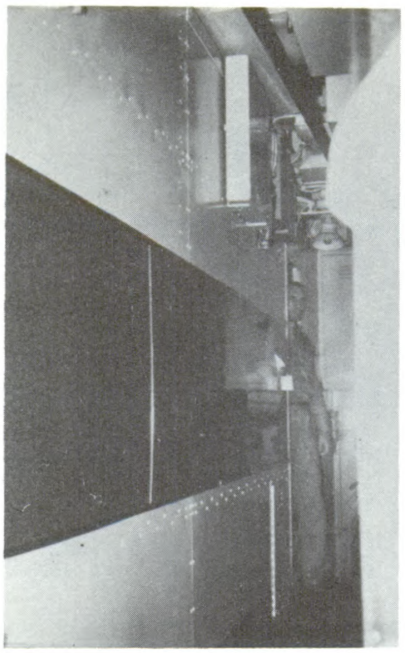


Figure 2 - The finished paint job. (Photo courtesy of BuShips)

LABORATORY TESTS

Scrubbability and Cleansibility

A cleaning and scrubbing test, in accordance with specifications outlined in Circular 767 of the Scientific Section, National Paint, Varnish, and Lacquer Association, Inc., was made using a "Gardner Model 105 Straight Line Washability and Abrasion Machine." The paint to be tested was applied with a 10-mil-clearance film caster over an undercoat (fire-retardant alkyd enamel MIL-P-17970B) on a plate-glass panel. After a specified cure time, various types of soiling materials were applied to the paint film. The panel was then scrubbed on the tester with a hog-bristle brush treated with water and grit soap. After 100 oscillations of the brush the panel was examined for soil removal. The same panel was then scrubbed as before, but with a one-percent detergent solution, until a break in the paint film indicated its failure. After 96 hours of drying, the NRL coating showed excellent soil hold-out and removal and, further, had not failed, even though it had received 8000 scrubs.

Roof Weathering

Although the NRL paint was not subjected to a roof-weathering test, similar formulations have been so tested at NRL. These were applied over five different standard primers and exposed at an angle of 45° on racks facing south. The tested paints did not show any failures during a 13-month exposure period.

Salt-Spray Test

In a severe test, a number of latex paints were applied over primed steel panels and exposed continuously, until failure, to salt spray in a chamber at 100° F. The latex paints, however, are not very effective

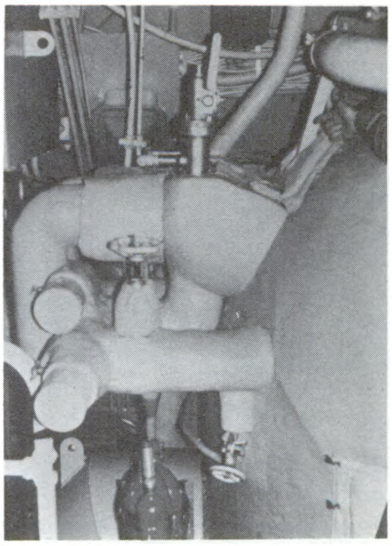


Figure 3 - Latex paint on steam-pipe installation. (Photo courtesy of BuShips)

in keeping out salt spray and hence their performance in a salt-spray test depends largely on the corrosion resistance of the primer-undercoating. Therefore the paint failure in this test was due to the quality of the primer rather than the latex topcoat. Included in this test was an experimental, commercial, water-dispersible, zinc-chromate primer which apparently withstood corrosion as well as the alkyd zinc-chromate primer (JAN-P-735) now authorized. The best paint-primer combination was the NRL paint on top of the water-dispersible zinc-chromate primer. This combination withstood 550 hours of exposure before any perceptible failure.

TESTS ABOARD THE USS TRITON

During a 26-day submerged voyage of the TRITON (August 22 to October 2, 1960), six gallons of the NRL acrylic-latex paint and one gallon of the water-dispersible zinc-chromate primer were applied to various areas of the ship. Figure 1 shows a pastel green being applied to the forward passageway. Figure 2 shows the finished job and the paint's gloss. The difference in color between the new and old paints was due to a deposit of dirty yellow aerosols (mostly from tobacco smoke) on the bulkheads. In this area it was also noticed that the new paint lacked proper adhesion and could be removed by scratching it

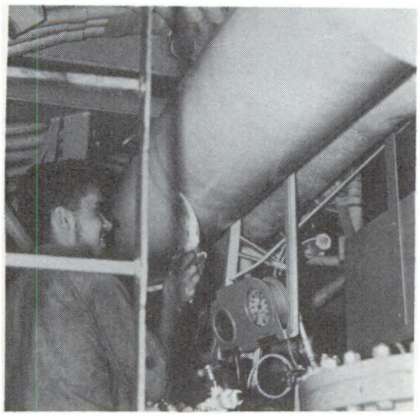


Figure 4 - Latex paint being applied to starboard screw shaft while it was turning. (Photo courtesy of BuShips)

Figure 5 - Latex paint on floor mat. The paint exhibited only slight wear after one month of service. (Photo courtesy of Bu-Ships)

with a coin. The reason is that the resin particles in emulsion paints and those composing an aerosol film are of equal dimensions—ranging in diameter from 0.1 to 1.0 micron. Therefore, the resin particles are unable to penetrate the aerosol film to establish adequate contact with the solid substrate on which the aerosol film rests. This problem can be solved by washing such areas clean before applying the latex paint.

To evaluate its durability on warm and hot equipment, the acrylic-latex paint—which contains a thermoplastic vehicle—was also applied to a steam-pipe installation (Figure 3) having surface temperatures ranging from 90° to 300° F. At temperatures above 200° F, the paint was found to be soft when scratched with a coin. And between 200° and 170° F, the paint was slightly soft but not tacky. Because of these findings, this paint was not recommended for application on surfaces which would reach temperatures above 160° F. Paint was also applied to the starboard screw shaft (Figure 4). Since the previous coating was black, two coats were necessary for adequate coverage.

The paint was also tested on certain deck surfaces. Floor mats under the hatchways to an engine room were painted pastel green (Figure 5). Abrasion resistance was very satisfactory, especially since the mats had no special cleaning before the paint was applied. In fact, the paint was superior to a solvent-type, synthetic-rubber deck paint applied under the same conditions.

CONCLUSIONS

The acrylic-latex paint developed at the Naval Research Laboratory compares favorably with enamel in gloss, resistance to soiling, and ease of cleaning and is superior in ease of application, freedom from odor, and level of toxicity. The paint is also comparable in hiding power, adhesion, and resistance to heat and abrasion. Under ordinary conditions, it is dry to the touch in 20 minutes and may be scrubbed after 24 hours. The small percentage of high-boiling organic constituents in the paint film that evaporates slowly for weeks following application can be removed from the atmosphere by the submarine's catalytic-combustion and carbon-absorption facilities as fast as the volatiles are released.

Although Navy Bureau of Ships specifications will be written around the present NRL formulation, NRL paint research will continue to be directed toward improving the paint in general, with special emphasis on the qualities of leveling (smooth flow) and thermal resistance.

Thermodynamic Properties Listed

To fill an interim demand, the following publication has been reprinted: "Selected Values of Chemical Thermodynamic Properties, Part I, Tables, and Part II, References," by F. D. Rossini, D. D. Wagman, W. H. Evans, S. Levine, and I. Jaffe. National Bureau of Standards Circular 500, Part I, reprinted July 1961, 828 pages, $2.50; Part II, reprinted July 1961, 481 pages, $2.25. (Order from the Supt. of Documents, U. S. Govt. Printing Office, Wash. 25, D. C.) A revised set of tables may be available in about two years. This project was conducted in part under the sponsorship of the Office of Naval Research.

New Nonmagnetic Alloy Developed

The U. S. Navy has recently developed an important class of new nonmagnetic alloys that promises to benefit a wide range of people, from the underwater demolition expert working on mines to the housewife working in her kitchen. The alloys, based on the intermetallic compound NiTi (nickel and titanium), have been named "nitinol" by their developers in the Magnetic Materials Division of the U. S. Naval Ordnance Laboratory of White Oak, Maryland.

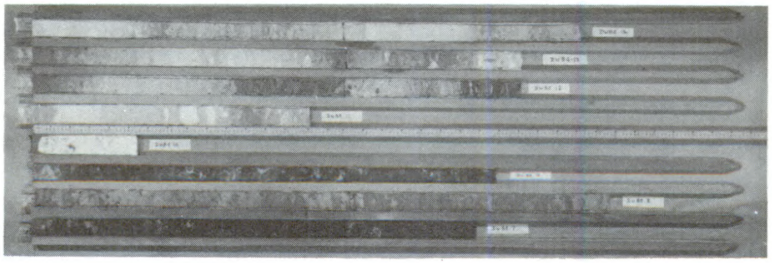
Nitinol's properties, many of which are unusual or unique in nonmagnetic materials, make it potentially useful to a broad range of applications. For example, its excellent nonmagnetic properties plus it resistance to corrosion and the fact that it is tough and can be hardened and welded make it an excellent material for the nonmagnetic tools needed in mine-disposal and other underwater ordnance work. Many of these same properties will also give it varied applications in mine sweepers as well as in sweeping and servicing gear. In addition, nitinol exhibits marked changes in mechanical-vibration damping characteristics with changes in temperature—a property that might make it useful in temperature-sensing devices. Also, the fact that it offers lower density coupled with toughness and strength over a wide temperature range, resists oxidation, and can be welded easily makes it an ideal alloy for many space and aircraft components.

Back in the kitchen, the housewife who uses nitinol cutlery will find that the beautiful lustrous finish (that can be easily obtained in manufacture by buffing or polishing) will not stain or tarnish. In addition, the sharpness of the knives should last almost indefinitely.

Scripps Deep-Sea Core Collection

Marston C. Sargent
Office of Naval Research, Pasadena Branch
and
William R. Riedel
Scripps Institution of Oceanography

The preliminary MOHOLE operation, completed in April 1961, had as its principal objective testing methods rather than obtaining material. Nevertheless, the operation produced 110 feet of core—some of it from a depth of 600 feet below the surface of the sea bottom. Also in April, RV ARGO of the Scripps Institution brought home 1500 feet of core obtained during an eight-month cruise. Preserving this and other core material from the Pacific and adjacent oceans, in a satisfactory condition for distribution of portions to interested geologists all over the world, is a responsibility which the Scripps Institution of Oceanography has assumed.



Core halves photographed for identification and study after splitting and before storage. (Scripps Institution photo).

Cores are of interest because they preserve a record of the past expressed as a sequence of layers of different particle size, chemical and mineralogical composition, and fossil content. Interruptions of such sequences are themselves indicators of past events, such as unusual currents, changes in marine fertility, lava flows or ash falls, etc. The sea bottom is the only place where thick sediments (and thus long cores), preserved under conditions close to those when the sediments were first laid down, can be obtained. Before the preliminary MOHOLE operation, cores as long as 100 feet had been claimed by the Russians, and sediments deposited as far back as the Eocene (70,000,000 years) have been cored. Besides yielding these records of the remote past, cores also give information about the superficial layers of deep-water sediment, which are becoming important as we begin to operate vehicles on the bottom, plant structures on it, dispose of radioactive waste, and work with long-range sonar. Obtaining cores has thus been a major objective of many a recent oceanographic expedition.

CORING TECHNIQUES

Techniques for getting long cores (ten feet or more) in deep water have developed rapidly in recent decades. The most-used devices, all

fundamentally very much alike, fall in two classes. Gravity corers are steel tubes or pipes with a sharpened cutting nose on the lower end. They are heavily weighted, so that when they are lowered on a cable to within 10 or 20 feet of the bottom and are automatically triggered so as to fall freely (attached only by a slack pendant), they penetrate the bottom. While these devices are uncomplicated, they have the disadvantage that the friction of the core barrel compresses the core material and distorts its layered structure. Piston corers overcome this difficulty by exerting on the top of the core a negative pressure (suction) equal to the friction. When possible, core-barrel liners of transparent plastic are used so that the core in its liner may be handled with a minimum of disturbance.

A good long core taken in a remote part of the ocean is precious. It may be a long time before anyone goes there again and is lucky enough to get a good core. Under the most favorable conditions, getting a core in deep water takes hours. But if, during this procedure, the corer hits a rock or a resistant layer, the hours of work then will produce nothing more than a bent core barrel. Therefore, deep-sea cores are treated and stored with great care.

At the time a core is collected, the position of the ship is noted both by latitude and longitude and in relation to any nearby prominent features on the sea bottom. The water depth, measured (and recorded) just before the corer is lowered, is used partly as a guide to handling the corer on its way down. The recovered core is carefully extruded from the barrel (ideally in its liner) so as not to disturb the strata, mix different portions of the core, or lose any portion. After this, immediate tasks include measuring its length and measuring the depth of penetration as shown by sediment adhering to the outside of the barrel. A geologist writes a thumbnail description of the core, mentioning general appearance and any conspicuous features. At this time samples may be removed aseptically for study of microbial populations. The core (and liner) is then cut into convenient lengths, usually 5 or 10 feet, and the ends of the liner or the ends and seam of a plastic wrapper are sealed with masking tape. Finally, the core is stored in a refrigerator at a few degrees above freezing.

Once ashore, a core in its core-barrel liner is made accessible by splitting. First the liner is cut longitudinally by passing it twice over a bench saw set to penetrate just the liner wall. Then a wire cheese slicer is passed through the core. One half is promptly sealed again and put into prolonged storage as the "archive half," while the other, "working half," is prepared for more immediate use. The working half may be utilized without delay by the man who supervised collecting the cores to make a set of observations pertinent to the cruise. He may be interested in such things as thermal conductivity, chemistry of interstitial water, or foraminifera (tiny shells). The archive half, on the other hand, may not be used for several years, say by somebody from the British Museum who is interested in measuring calcium carbonate content.

The working halves in their plastic semicylinders, suitably labeled, are photographed in groups lying on a table (see cut). The first

function of the photograph is to provide positive identification of the core by recording its gross features, like a person's fingerprints. Also from the photograph it is possible in some cases for a distant scientist to select portions of special interest as if he were using a Sears Roebuck catalog. Third, a photograph can be used to record the exact locations from which samples have been removed.

Very small samples may then be removed at strategic points along the working half for preparation for viewing on microscope slides. The remainder with its liner is slid into a plastic tube with a D-shaped cross-section. The ends are sealed with tape or plastic caps, and the labeled core is slid into a rack in a refrigerator. These plastic tubes with D-shaped cross-sections were originally manufactured as diffusing elements for the sides of fluorescent lighting fixtures. Scripps first picked them up as surplus items when they were becoming obsolete and, on contacting the manufacturer, found that he still had the dies and would be glad to fabricate batches of the tubing on order. Compared with cylindrical cases, the D-shaped containers have two advantages: they indicate at a glance which side is right side up for the core and they take up less space. Cores must be kept relatively undisturbed and cool (between 32° and 40° F) and must retain their original moisture content. Any disturbance to the cores, especially if they are dry and brittle, can destroy the laminar structure and hence remove any possibility of learning the time sequence recorded in the original core. Low storage temperature inhibits the development of microorganisms whose metabolic products can destroy even the calcareous remains of small fossils.

The microscopic slides prepared from selected levels in the core are examined for major minerals and readily identified fossils. The fossils indicate the ages of the different levels, and both the fossils and the minerals are guides to the conditions prevailing at the various established dates. This information supplements the photograph, the original thumbnail description, and the data on position and bottom depth as a guide to the composition of the core throughout its length.

The cores in the archives are catalogued by geographical position and cross-indexed by nature and age. From time to time mimeographed copies of new catalog sheets are distributed to people known to be interested, or to those who have asked for them. Core samples are exchanged with other institutions so that the Scripps scientists have ready access to material from many sites never visited by a Scripps ship or geologist. The archives collection is available to any interested scientist. The sites of cores wholly or partly in the Scripps collection are plotted on a large wall map. The Pacific Ocean shows 1500 stations, or about one core per 40,000 square miles.

The University of California, recognizing that the collection needs space to accommodate growth, has allocated $50,000 for a building. As most of the interior will be refrigerated, it is proposed to take advantage of the insulating properties of soil by burrowing into one of the steep-sided canyons on the Scripps campus. Like Fort Knox, the core archives will contain, in one hole in the ground, valuable material obtained from other holes.

Research Notes

Cyclotron Used to Treat Brain Tumor

A powerful 160-million electron volt proton beam generated by the Navy-sponsored cyclotron at Harvard University has been used in a pioneering effort to treat a deep-seated human brain tumor.

The new procedure, utilizing the "Bragg peak" of the proton beam to produce controlled lesions was described in a paper presented October 16 by Dr. Raymond N. Kjellberg, a neurosurgeon at Massachusetts General Hospital, at the Second International Congress of Neurological Surgeons in Washington, D. C. The patient was a two-year old girl who last March was found to be suffering from a brain tumor that doctors considered inoperable and fatal.

Since January 1960, Dr. Kjellberg and Dr. William H. Sweet, Chief of Neurosurgery at Massachusetts General, have been investigating the possibilities of employing a proton beam to treat human brain tumors. In the case of the young girl, the penetrating power and range of the proton beam generated by the Harvard cyclotron was considered suited to treating her particular type of tumor. The cyclotron, built with Navy funds, is regularly utilized by Harvard nuclear physicists to bombard atomic nuclei in a study of the interaction of nuclear particles. This work is supported by the Office of Naval Research, which authorized the use of the cyclotron for the special treatments.

During a six-week period last May and June, the beam was focused three times on the tumor. Since then, the growth has shrunk 80 percent. The child has now gained eight pounds and is now back at home where, according to Dr. Kjellberg's report, she "plays happily with other children and has an emotional and motor performance compatible with her age." The only symptom that remains is a mild visual defect. However, because it is the first of its kind, the final outcome of the procedure cannot be determined a complete success until the child has been under observation for some time. The child will be X-rayed again in about four months to see if there has been further reduction in the size of the tumor.

Dr. Kjellberg already predicts that the therapeutic use of the proton beam, which circumvents the surgical hazards of bleeding and blood poisoning, will have very broad future applications.

The protons in the beam are accelerated to such high energies by the cyclotron that they penetrate deeply into tissues. However, the characteristic of the proton beam which makes it suitable for treating brain tumors is that the largest concentration of energy is deposited at the end of the range of the beam. This concentration is known as the Bragg peak. X-ray and gamma-ray beams do not behave in this manner. Further, the radiation of the proton beam, unlike X-ray and gamma-ray beams, can be controlled so that it does not penetrate beyond the target area. All this means that the normal tissue, through

which the beam must pass on its way to a deep-seated tumor, is spared from the effects of the full force of the beam.

The use of a proton beam eliminates the necessity of opening up the skull and exposing the brain. Prior to the actual treatment of the young patient, test irradiations were made using a radiosensitive chemical in a wax model of her brain. The model was specially developed by Dr. Majic Postsaid of the Massachusetts General Hospital.

Collaborating with the neurosurgeons are Dr. William H. Preston, Director of the Cyclotron Laboratory at Harvard; and Mr. Andreas Koehler, Assistant Director of the Laboratory and in charge of the operation of the cyclotron. Research on the use of the proton beam for intracerebral lesions is supported by the National Institutes of Health.

When notified of the girl's progress, RADM L. D. Coates, Chief of Naval Research, said: "The Navy is pleased to have played a modest role in this first attempt to use this method in the treatment of a brain tumor. We are naturally delighted at the initial success of the procedure but recognize that a long period of careful evaluation must precede any regular application of this technique. At the same time, this should encourage the application of the cyclotron to biomedical research as well as bring physicists and biologists into a closer working relationship."

Harvard University and Massachusetts General Hospital plan to submit a joint proposal to the Office of Naval Research and other government agencies for support to continue using the cyclotron on a part-time basis to explore further the use of the proton beam in biomedical applications. The giant cyclotron itself was built in the early postwar years at a cost of $1.5 million with funds provided by ONR and the Atomic Energy Commission.

Green Turtle Airlift

A unique Navy operation, in which humanitarian and scientific objectives are being served simultaneously, commenced in mid September when a Navy seaplane began to deposit between 20,000 and 30,000 green-turtle hatchlings throughout the Caribbean Ocean area. The aim is to replenish the rapidly diminishing population of green turtles (Chelonia mydas), which has been the main source of meat for natives of the area for past centuries. At the same time, the Navy is studying the homing instincts of this sea-going reptile, which is considered to have superior navigational abilities on the same order as the salmon.

The planting operation was a cooperative venture of the Navy and the non-profit Caribbean Conservation Commission (CCC). Professor Archie Carr of the University of Florida was in charge of the field activity and is also the director of the research project with ONR's Biology Branch. The freshly hatched turtles were transported in plastic bags by a Navy Grumman seaplane from the green-turtle hatchery operated by the CCC at Tortuguero, Costa Rica, about 50 miles north of Limon—one of the few areas in the Caribbean where green turtles

are still plentiful. The baby turtles were flown to British Honduras; Cartagena, Colombia; Barbados, Grenada, and St. Lucia in the Windward Islands; Antigua and St. Kitts in the Leeward Islands; and Puerto Rico.

The operation is based on the theory (which has received preliminary confirmation from earlier work by Carr) that green turtles return to their spawning grounds three years later to lay their eggs, similar to the return of the salmon to spawn. By transplanting the baby green turtles just after they have been hatched, it is hoped that they will accept their new location as their spawning ground and return there to lay their eggs rather than to Tortuguero where they were hatched. If the turtles return to the various places in the Caribbean where they were planted, then natives of those areas will be provided eventually with an abundant supply of meat for the first time in many years, thus solving a critical problem of protein deficiency.

Professor Carr and his fellow biologists are trying to find out, first, if they can identify the "clues" the turtles use for pinpoint navigation across thousands of sea miles, and second, whether those clues guide the turtles to the sand hole where they were hatched or to the spot where they first entered the sea. ONR has also under consideration a research study to be conducted by Professor Carr to determine how baby green turtles, which are spawned well inland and usually behind dunes, unerringly find their way to the sea which they have never seen. This would throw more light on their navigation mechanisms. Plans also exist for developing a system of marking baby green turtles—which are about the size of a half-dollar—so that as they grow to their huge adult size they can be located and identified at intervals throughout their migration period.

ONR's study of green turtles is part of a broad, long-range, Navy program in biological orientation (see NavResRev, Aug. 1961, pp. 11-14). Through it, the Navy hopes to improve its navigation and long-range detection devices by learning how birds and marine animals can navigate with remarkable accuracy over long distances to reach destinations over unfamiliar routes.

Navy DASH System

The U. S. Navy has a new, long-range antisubmarine weapon system under development named "DASH" (Drone AntiSubmarine Helicopter). This drone would provide a destroyer a long-range striking capability heretofore unknown in surface escort antisubmarine warfare. DASH is a compact, coaxial-rotor, weapon-carrying helicopter designated Modes DSN-1 (see cover photo), and is developed and produced by Gyrodyne Company of America, Inc., of St. James, Long Island, New York. On August 12, 1960, the DSN-1 made the world's first free flight of a completely unmanned drone helicopter at the Naval Air Test Center, Patuxent River, Maryland.

Modern destroyer sonar gear can pick up a submarine many miles away and deep below the surface, at which point the submarine is not apprehensive of attack. The addition of a drone helicopter will extend

a destroyer's attack capabilities virtually to the limit of its sonar range and will enable the destroyers to strike at the submarine with homing torpedoes long before the submarine has begun to expect hostile action.

The DSN is a remotely controlled, unmanned drone which can be flown from the deck of a destroyer in any weather without risk to a pilot's life. With a payload of homing torpedoes, it can fly to the area where sonar gear has detected the presence of a submarine, hover there until instructed to drop its weapons, and then fly back to the parent ship for rearming. Being unmanned, it could be expendable if for any tactical reason it should not be recalled. The vehicle is a small, two-bladed coaxial helicopter with a rotor diameter of 20 feet, and is powered by a 72 horsepower Porsche reciprocating air-cooled engine. The production version of the drone helicopter will be powered by a more powerful Boeing turbine engine and will operate from both modernized and newly built destroyers.

Monitoring Secondary X-Radiation

A fresh coconut and a Plexiglass cell filled with animal bone meal take the place of a human skull very nicely for secondary dental X-ray monitoring purposes.

After much experimentation, an industrial hygienist (Mr. Herbert Worsham) at the U. S. Naval Air Station, Norfolk, Virginia, has found that such items produce scattered X-radiation values comparable to those obtained from a few human volunteers. He uses a 2.5 inch-square, 3/8-inch-thick Plexiglass cell filled with Armour's steamed bone meal and attaches it to the side of an average-sized fresh coconut. Then the cone of the X-ray machine is placed one inch from the Plexiglass cell. Although this invention is interesting and fulfills a need, the real problem, according to Mr. Worsham, lies in standardization.

One of the concerns of industrial health specialists is minimizing the exposure of medical personnel to X-radiation. The specialists use ionization-chamber survey meters to measure the effectiveness of the protective barriers used to shield operating personnel. But these instruments are not fast enough (i.e., a three to four-second exposure-time is needed with the "cutie-pie" type of meter Mr. Worsham has available) to register during the fraction-of-a-second medical X-ray examinations commonly in use today. So to obtain the necessary readings, investigators have been faced with two possibilities: either subjecting human volunteers (acting as patients) to the fairly long exposures necessary to obtain meter readings, or finding materials that would satisfactorily simulate the X-ray-scattering qualities of various parts of the human body. The second one is obviously the better choice. To this end, many substances, such as cocounts, hot water bottles filled with water, plywood of various thicknesses, rubber, and plastic have been used to simulate parts of the human body.

Today the Navy is attempting to evaluate scattered radiation from medical X-ray units at many of its establishments. Here's where the

problem of standardization comes in, for, in the absence of a standardized procedure for accurately measuring scattered radiation without exposing humans, the results obtained cannot be correlated or compared. A research project aimed at establishing such a procedure needs to be undertaken by an organization having adequate testing facilities and equipment. The method devised, however, should permit the use of materials and instruments available to field activities.

Navy Inventors Take Note

Navy civilian-employee inventors will benefit from a recent change in NCPI 450 regarding cash awards for patentable inventions. As of 4 August 1961, Section 4-14 of the Instruction now requires heads of activities to establish procedures which will: encourage employees to disclose inventions, provide for patent review of all inventions, and insure that inventions will receive award consideration. Under these procedures, inventions will receive both patent and award consideration regardless of whether they arise out of employee contributions (suggestions and superior accomplishments) or are brought to light as disclosures submitted directly to the patent authority for consideration. Detailed instructions for processing employee contributions for patient consideration and for processing inventions for award consideration are contained in the change to the Instruction, which was released under Cover Sheet 81.

Highlight of the plan is the provision for an initial award of $50, which may be granted for inventions which are considered valuable enough to require protection under the U. S. patent laws. At the time the patent is finally issued, the invention is again reviewed for further award consideration. The amount of this award is based on the total value to the government of the invention. All inventions receiving initial approval for patent application or final patents on or after 4 August 1961 are eligible for award consideration under the change.

Computers in Teaching Machine Systems

The potentials for the use of digital computers in automated instruction were discussed in scientific papers presented at the Conference on Application of Digital Computers to Automated Instruction. The meeting, held in Washington, D. C. from October 10 to 12, was cosponsored by the Office of Naval Research and the System Development Corporation of Santa Monica, California.

The use of teaching machines in the fields of education and training has recently generated great interest among scientists and educators. Such machines generally provide the student with an automatic program of self-instruction, thereby pre-empting many classroom functions now performed by teachers. The mechanical teachers usually start out by presenting a question or problem, and after the student has given the answer, the machine indicates the correctness of the student's answer and often programs further questions on the basis of the answer.

Invited papers were presented by a number of scientists and educators from research organizations and educational institutions. In delivering the opening address on "The Challenge of Automation in Education," Dr. L. F. Carter, Vice President and Director of Research at System Development, pointed out that the use of computer-based teaching machines would permit teachers to devote more attention to other aspects of the child's development, such as training in thinking and creativity, developing skills and techniques, and providing opportunities for social and physical development.

A discussion of "intrinsic" and "extrinsic" programming was presented in a paper by Dr. N. A. Crowder, Technical Director of the Education Science Division of U. S. Industries, Inc. In intrinsic programming, the student's response determines the next material he sees, while in extrinsic programming, the order in which the questions are presented to the student is determined in advance. Either intrinsic or extrinsic programs may require elaborate instrumentation. However, Dr. Crowder feels that, at this point, more effort should be directed toward the improvement of programmed materials than toward development of more elaborate instrumentation.

Dr. A. A. Lumsdaine, Professor of Education at the University of California, Los Angeles, gave a paper dealing with some of the theoretical and practical problems involved in the use of computers in automated instruction programs. Dr. Lumsdaine outlined some of the areas in which computers can perform valuable functions and cautioned against the use of computers when simpler devices might be more appropriate.

A paper describing the uses of the digital computer in a freshman program was given by Dr. A. J. Perlis, Director of the Computation Center at the Carnegie Institute of Technology in Pittsburgh, Pennsylvania. In such a course, students learn to program the computer in addition to a machine simulated on it. The student's progress in understanding is measured by programs within the machine, which compares the student's answers to those of previously provided standards.

The applications of automated computers in programmed teaching systems was discussed in a paper by Dr. H. D. Huskey of the University of California, Berkeley. Dr. Huskey pointed out that the computer has two roles in the field of automated teaching: one in the actual control of teaching machines and one in the preparation of scrambled teaching materials. In a computer-controlled system, scrambled material would involve the presentation of more detailed material on the basis of answers to previous questions.

Fish Watch Stars

Migrating sockeye salmon may navigate by the stars. According to the Associated Press, Canada's Fisheries Research Board station at Nanaimo, British Columbia, has reported that the fish follow definite ways in clear weather but travel in random directions when under artificial covering or overcast skies.

On the Naval Research Reserve

Brookhaven Seminar

The Ninth Annual Naval Reserve Nuclear Sciences Seminar was held from Sept. 17 to Sept. 30 in Brookhaven National Laboratory, Upton, New York. This seminar was sponsored by the Office of Naval Research in conjunction with the Atomic Energy Commission and the Brookhaven National Laboratory. It was arranged and conducted by Naval Reserve Research Company 3-9, of Brookhaven National Laboratory with CDR J. C. Austin, USNR, CO of the Company serving as Seminar Chairman. Thirty-eight Reserve officers of the Navy, Army, and Coast Guard attended.

The theme of this year's program was "Effects of Radiation on Human Populations; Civil Defense and Management of Nuclear Casualties." RADM L. D. Coates, USN, Chief of Naval Research, took note of this problem in his message in the seminar brochure when he stated, "In exploring the problem of treating nuclear casualties, we must first determine the effects of fallout on the introduction of nuclear material into the human body. We are then presented with the challenge of improving and increasing the effectiveness of treatment methods." The program was concerned with the organization and selection of special details to meet radioactive fallout and accident situations within the Naval Establishment and was planned for officers whose duties may make them responsible for counter-measures to radioactive exposure.

The seminar was opened by RADM George Wales, USN, Commandant, Third Naval District; Dr. Maurice Goldhaber, Director, Brookhaven National Laboratory; and RADM Coates. During succeeding sessions of the seminar the conferees were privileged to hear presentations from authorities in their fields from Brookhaven National Laboratory; Oak Ridge National Laboratory; U. S. Naval Radiological Defense Laboratory; U. S. Atomic Energy Commission; Office of Civil and Defense Mobilization; Bureau of Medicine and Surgery; American Institute of Biological Sciences; Lovelace Foundation, Albuquerque, New Mexico; and Los Alamos Scientific Laboratory. The afternoon sessions of the seminar were devoted to tours of the major research facilities of the Laboratory including the following: graphite reactor, cosmotron, alternating gradient synchrotron, medical research center, gamma irradiation field, hot laboratory, and radiation-monitoring and waste-disposal facilities.

On the final day of the seminar, CAPT J. W. Jochusch, Jr., USNR, Special Assistant to the Chief of Naval Research for Research Reserve, discussed the Research Reserve Program. A review of the seminar program and a question and answer period conducted by CAPT E. P. Cronkite, MC, USNR, and CDR W. W. Shreeve, MC, USNR, concluded this highly successful seminar.

Report on DASA Courses

This year two courses were opened for the first time to Research Reservists for AcDuTra by the Defense Atomic Support Agency, Albuquerque, New Mexico (see NavResRev, June 1961.) These atomic weapons training courses are: (1) National Atomic Weapons Capabilities Course (NAC), open to CDRS and CAPTS; and (2) Navy Nuclear Weapons Officers Course (NNWO), for LCDRS and below.

One of the first Research Reservists to attend this course was CDR Charles O. Smith, USNR, a member of Naval Reserve Research Company 6-3, Oak Ridge, Tennessee. CDR Smith attended the National Atomic Weapons Capabilities Course which is designed to familiarize senior officers with the effects and factors affecting employment of atomic weapons and with the management of stockpiles. CDR Smith reported that the course was presented through lectures and by participation in operational-type problems. He further commented that the course was well organized and extremely well presented, and highly recommended this tour of active duty to any qualified officer.

Uniform Regulations

Recommendations of the National Naval Reserve Policy Board and the action of the Secretary of the Navy on these recommendations were published some months ago. One of these recommendations concerned the wearing of the uniform and the payment of the uniform maintenance allowance to Ready Reserve Officers. The Board recommended that all Ready Reservists in a pay status be required to wear the uniform at drills. It was stated that these Ready Reservists are paid because they have special duties setting them aside from other members and that, because of these duties, the uniform should be worn.

The Secretary of the Navy approved this recommendation of the Policy Board and the Bureau of Naval Personnel has issued instructions concerning this requirement in the Bureau of Naval Personnel Manual. Article H-31501 states in part "Reservists on inactive duty shall wear the uniforms of their grades or rates when ... associated with or attached to a Specialist Reserve Company, Naval Reserve Officer School or Composite Company in a pay status and attending a drill."

New ONR Reserve Assistants

CDR Franklyn L. Jones, USN, reported on 1 August 1961 for duty as Executive Officer and Assistant for Research Reserve at the Office of Naval Research Branch Office, Boston. He previously served as Executive Officer of Fleet Tactical Support Squadron 21, N.A.S. Barbers Point, Hawaii.

A veteran Naval Aviator with 9500 hours, CDR Jones was commissioned as Ensign after flight training in May 1941. His various

CDR Franklyn L. Jones, USN

LCDR William F. Cooper, USNR

assignments have included duty as: CO of Utility Squadron 15, Executive Officer of VW-2, Officer-in-Charge of ATU-601, two tours in Air-Transport Squadrons, and three years in BuAer. During World War II he piloted "Liberators" under the operational control of the Coastal Command in England.

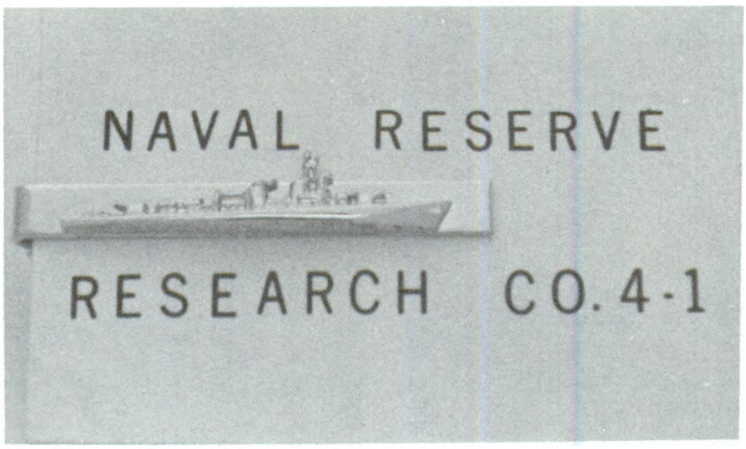
LCDR William F. Cooper, USNR, relieved LCDR Herbert A. Wellemeyer, USN, as Research Reserve Assistant, Office of Naval Research Branch Office, San Francisco, California, on 10 August 1961. LCDR Wellemeyer retired after 22 years of active naval service. LCDR Cooper's last billet was as CO of the U. S. Naval Reserve Training Center, Sheboygan, Wisconsin, where he served for three and a half years.

LCDR Cooper enlisted in the Navy in June 1937 and served in the engineering department of USS PENNSYLVANIA (BB 38).

In 1942 he returned to active duty in USS YMS 121, and in 1944 was commissioned an Ensign and served the remainder of the war as Engineer Officer of LST 392. Active reserve duty followed.

He served during the Korean War aboard LST 1077 and LST 1083, assuming command of the latter from 1952 to 1954. Following two years of shore duty, he returned to Korea for a year as advisor to the ROKN Shipyard Commander at Chinhae. Welcome aboard to you both!

Gift For Speakers



Tie clasp presented by NRRC 4-1

Speakers at company meetings of Naval Reserve Research Company 4-1, Princeton, New Jersey, are now receiving a small token of appreciation in the form of a gold-plated destroyer tie clasp attached to a card imprinted with the name of the company. These tie clasps can be obtained at Naval Uniform Shops at a nominal cost of $.65 each. "People like them" says CAPT Frederick J. Trost, USNR, staff member of NRRC 4-1.

In Memoriam

It was with regret that the Research Reserve learned of the death of LCDR Homer T. Gittings, Jr., USNR, a charter member of Naval Reserve Research Company 8-9, Los Alamos, New Mexico. LCDR Gittings was killed in an automobile accident on 7 September 1961. LCDR Gittings was employed at the University of California Los Alamos Scientific Laboratory. During World War II LCDR Gittings served at the Naval Ordnance Laboratory, Navy Yard, Washington, D.C.

Oak Ridge Seminar Postponed

The Research Reserve Nuclear Sciences Seminar, originally scheduled to convene on 27 November 1961, has now been postponed. The new dates will be announced later.

Dr. Waldo K. Lyon, internationally known polar research scientist, has been named to head the newly created Submarine and Arctic Research Division at the U. S. Navy Electronics Laboratory in San Diego. This the new division was formerly a branch of the Special Research Division.

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Great Names of Science in a Historic Photograph

This remarkable photograph brings together many of the great names of science, including many Nobel Prize winners. The occasion was the Fifth Council of Physics held in Brussels on October 1927. Many of these scientists have been associated with the Office of Naval Research at one time or another. In fact, Leon Brillouin (extreme upper right corner) has an ONR contract at the present time.

In the front row (left to right) are: Irving Langmuir, U. S. chemist; Max Planck, Germany, developer of the quantum theory which is the foundation for some of the most spectacular advances of modern physics; Madame Marie Curie, France, discoverer of radium and polonium; Hendrik A. Lorentz, Holland; Albert Einstein, Germany, formulator of the theory of relativity; Paul Langevin, France; Ch. E. Guye, Switzerland; Charles T. R. Wilson, Great Britain, known for his cloud chamber work; and Sir Owen T. Richardson, Great Britain.

In the center row are: Peter J. W. Debye, Holland, chemist; Martin Knudsen, Denmark; W. I. Bragg, Britain; H. A. Kramers, Holland; P. A. M. Dirac, Great Britain; Arthur H. Compton, U. S. X-ray specialist; Prince Louis Victor de Broglie, France; Max Born, Germany; and Niels Bohr, Denmark, "father of the atom."

In the top row are: Auguste Piccard, Belgium; Emile Henriot, Belgium; P. Ehrenfest, Holland; Edouard Herzen, Belgium, chemist; Theophile De Donder, Belgium; Erwin Schroedinger, Austria; Jules F. Verschaffelt, Belgium; Wolfgang Pauli, Austria; Werner Heisenberg, Germany; Ralph Howard Fowler, Great Britain; and Leon Brillouin, France.

IN THIS ISSUE

NAVAL RESEARCH reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $1.50 per year in U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. Changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. The issuance of this publication approved by the Secretary of the Navy on 1 March 1961.

The Navy's new DASH drone helicopter hovers with a homing torpedo aboard. (See pp. 25 and 26)