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REVIEWS

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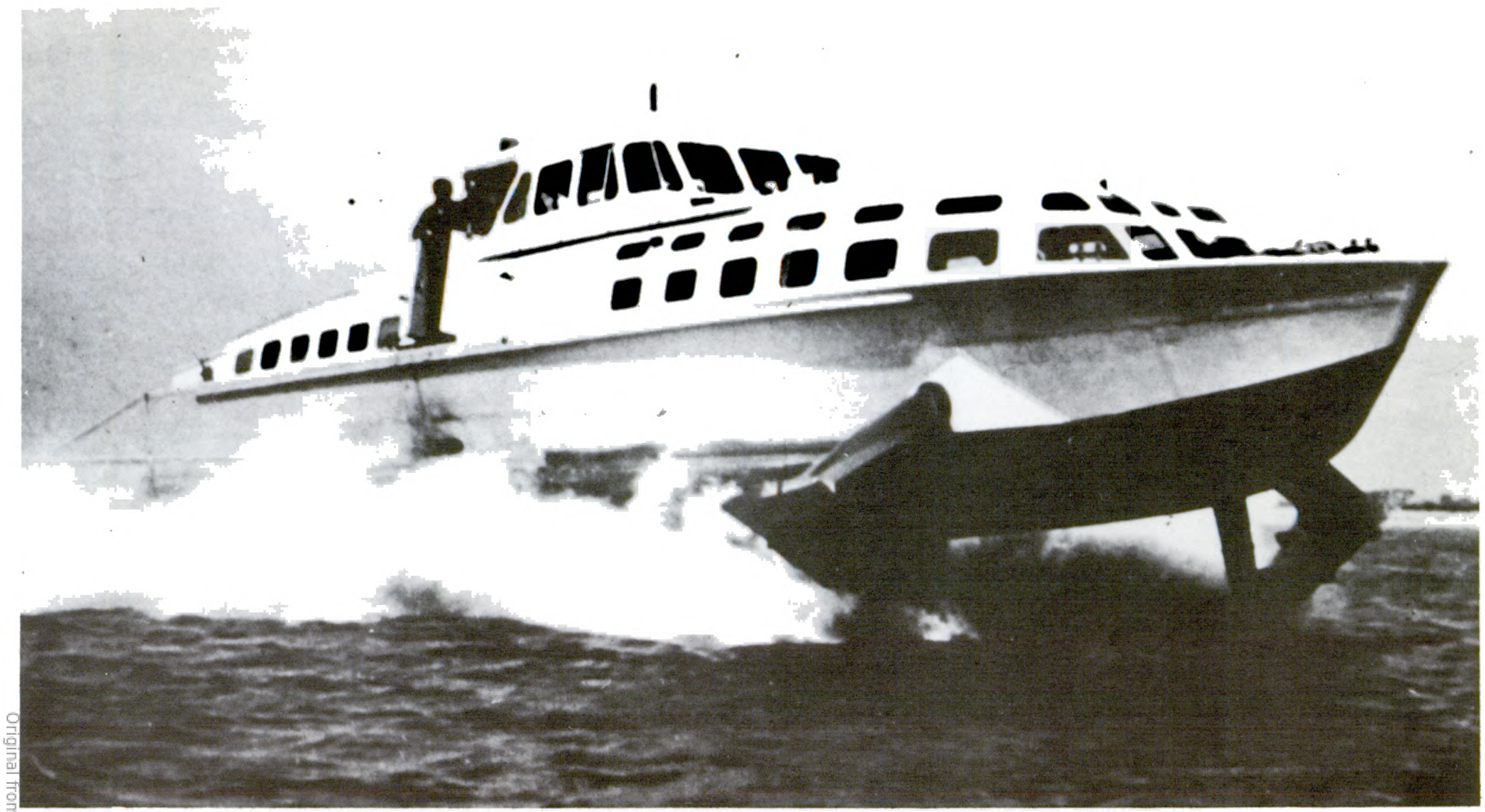

The Supra-Mar PT-20 Hydrofoil, an example of European commercial application.

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High-Speed Ships

CDR H. B. Keller, USN
Fluid Dynamics Branch, ONR

From canal boats to barge lines, from seven-masted schooners in their day to 50-thousand-ton liners in this, ships have generally been slower than other forms of transportation. There has been much banter over the years because of their lack of speed, but in this age of jets and superjets, it's no longer a joke; not to the Navy, anyway. In considering what to do about it, there are four basic problems right at the start: Gravity waves, a major component of resistance; cavitation, a limitation on powering; seakindliness, or maintenance of full usefulness in heavy seas; and port speed, which involves cargo handling and service time. There is hope for solving some of these difficulties, but they require vigorous research and bold development. The approach to problems of high-speed ships, of course, is encumbered by a number of physical facts, complex attitudes, and the variations between commercial and military purposes.

SCIENTIFIC BACKGROUND

The period of the American Civil War began an outstanding era in the development of ships. Sail gave way to steam and wood yielded to steel. Less understood is the fact that during this same period, significant scientific advances were made at a time when the leading scientists recognized the importance of shipping. The new techniques of transport required estimates of installed power and fuel capacity, and these new requirements led to basic research in the physical resistance to ship motion. Contributions to this analytical and experimental research included work by J. Scott Russel, Sir Geo. G. Stokes, W. J. M. Rankine, Osborne Reynolds, William Froude, Lord Kelvin, Sir Horace Lamb, and our Navy's own David W. Taylor. Many of these great minds are famous for other scientific endeavors.

Perhaps the most significant research work into the resistance to ship motion was done by William Froude (1810-1879), an English engineer who pioneered in ship model techniques. An appreciation of his contribution may be enhanced by the following, perhaps overly simplified, explanation. Available to him were the powerful ideas of Newton who lived some 150 years before him, among them the familiar formula,

$$\text{Force} = \text{mass} \times \text{acceleration},$$

and perhaps to a lesser degree, the law of linear superposition, which states that the effect of a number of effects is equal to the sum of the individual effects.

The forces involved in resistance to ship motion are basically, first, pressure forces perpendicular to the hull, and second, viscous or sheer forces parallel to the surface of the hull. A number of effects are related to each of these forces. And, significantly, they obey different laws of dynamic similarity—that is, they require different

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relationships for scaling models in tanks to actual ships. In general, viscous forces must be scaled in such a way that the "Reynolds number" (VL/μ) is held constant while pressure forces scale in a manner which requires the "Froude number" ($V/\sqrt{gL}$) to remain constant. (In these numbers, V = ship speed; L = ship length; μ = kinematic viscosity; and g = gravitational constant.)

To complicate the calculations even further, the movement of a ship through water requires progressive movement of water out of the volume to be occupied. Displacing this mass of water also gives rise to pressure forces. Two important effects arise from this local pressure. One of these effects, the wave-making resistance barrier of classical naval architecture, can be illustrated by using a crude analogy to the monometer, which is a simple device used to measure pressure differences. When a pressure is introduced at the base of a variable column of liquid, the surface of the liquid will rise against the force of gravity until the weight of the column balances the pressure force. So it is with the water surface near the pressure disturbances associated with ship motion. The elevation of this water requires energy, and the earth's gravity tends to cause the water to regain a stable even surface. The motion results in an oscillating overshoot which explains the initiation of the wave system which we observe as the ship glides through the water. This wave system carries away energy which is not recoverable by the ship.

A second effect, associated with pressure or its potential energy, is that which arises from viscous dissipation in the flow around the ship. When a rapidly moving ship pushes the water aside, the fluid hasn't enough kinetic energy to return quickly and fill the volume vacated by the ship. The resulting confused flow-velocities prevent the reformation of a pressure system at the stern equal to the pressure system at the bow. Thus, there is a "drag" on the ship that must be overcome by energy from within the ship.

Froude's experiments with thin flat planks of negligible volume led to his formulation of a method of estimating the "resistance" or necessary power for a ship which is to be constructed. In abridged form the method consists of measuring model towing force, estimating the viscous portion of this force by reference to a standardized experience curve, scaling each component up to ship size by the appropriate scaling law and recombining the resultant force components to yield the estimated resistance at each speed. The viscous resistance is called "frictional resistance." The other component containing all other remaining resistance forces is called "residual resistance," or more commonly, "wave resistance."

Froude's work reveals that at higher speeds, energy is carried away in gravity waves generated by the motion of conventional surface ships. At speeds presently attainable by fast destroyers, increasing power results in larger waves but with a slight increase in speed. This is the same as the wave resistance barrier of classical naval architecture. Does this mean that ships cannot expect to cross the seas at speeds in excess of 35 knots? Are ships indeed limited in speed by these facts of nature?

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Whenever limitations are met, some thoughtful person inevitably asks, "Are these true boundaries, and if so, how can we get around them?" A case in point is offered by the teacher who asked his plane geometry class to arrange six toothpicks to form four equilateral triangles. No one in the class could do it because each student had needlessly imposed a nonexistent limitation upon himself, nothing having been said about working in a single plane. Taking advantage of the freedom of space, a solid arrangement of four equilateral triangle faces was readily constructed using the six toothpicks.

From Froude's day and even to the present time, inventors have sought to reduce the frictional or shear resistance to ships operating on Archimedes' principle of buoyancy—by introducing air between the ship and its supporting water. The viscosity of air, or its internal frictional resistance, is much less than that of water. This attractive possibility has not been successfully exploited. In other words, there has been no success in "lubricating" a displacement hull with air.

The greater portion of resistance to ships movement at moderate speeds, 20 to 40 knots, has been shown by Froude to be associated with gravity waves generated in the free surface. It follows then to explore the possible advantages to be gained by moving away from the troublesome surface of the water. What is to be gained from moving up into the "continuum" of the atmosphere or down into the water may be outlined as

<u>Up</u>
The Hydrofoil,
The Ground Effects Machine (GEM), and

<u>Down</u>
The submarine,
Deep submergence, and
Shallow submergence.

Other areas deserving attention in relation to ship speeds are (1) weather and the effects of stormy seas and (2) idle time in ports, intrinsic with service and cargo handling.

The ideas of fluid dynamic lift—provided by planes in water that function in much the same way as aircraft wings do in air—has been known for centuries. In more modern times applying this principle to support a useful vehicle above the surface of the water has met with increasing success. As early as 1909, an Italian aviator used hydrofoils to assist landing and takeoff of seaplanes. Eight years later Alexander Graham Bell and his associates achieved 70 miles per hour in a hydrofoil-type boat. The failure to develop these successes was probably due to inadequate materials and unsolved stability problems which have been overcome by U. S. Navy research during the past 12 years. It is significant too that numerous small developmental craft have demonstrated successful configurations, stabilizing systems, and applications.

The hydrofoil craft is worthy of pursuing because of the probability that it can sustain speed while riding <u>above the surface</u> of rough

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water. The importance of this ability is readily appreciated by those who have experienced the violent impacts of planing boats operating on the surface of choppy water. One striking characteristic of a foil (or a wing) moving through a fluid is the creation of a pressure difference between its upper and lower surfaces. Proper design can achieve both pressure increase on the lower surface and reduced pressure on the upper surface. These effects are additive, resulting in an average pressure difference which acts over the area of the foil to produce useful lift. Associated with this lift is the drag or force which is required to produce the lift. To overcome drag or to produce the desired motion, power must be expended. The ratio of useful lift to its associated drag (lift-to-drag ratio) is an important relationship which indicates roughly what must be expended in power to attain lift. When lift equals the boat weight, the system will fly in a stable attitude, and the hull volume will be clear of the troublesome surface. The lift of a foil system is related directly to the density of the fluid in which it moves. And because water is 800 times more dense than air, the "wings" of a hydrofoil are far smaller than those required for airplanes. The associated frictional resistance is attractively low since it is proportional to wetted area. The wave-making energy of this system is also low because the foil volume is slight and because most of it operates below the free surface and at a high speed.

Hydrofoil craft, like an airplane, is supported on a wing, and its operational use will be weight sensitive. Useful lift-to-drag ratios of seven to one for a complete boat, including supporting struts and the propulsion system, are commonly achieved in small boats. But the unanswered question is how large can hydrofoil craft be built? It appears, however, that there exists a size beyond which hydrofoil support becomes impracticable. Our inability to answer the question of maximum useful size has been a great deterrent to useful application of foils to naval craft. The operator has legitimate interest in this question because he must have useful payload, operational endurance, and range. He must also anticipate a reasonable probability of weathering seas which on occasion are indeed large scale.

THE GROUND-EFFECT MACHINE (GEM)

A new idea toward achieving high speed over water is the Ground Effects Machine (GEM). See Figure 1. The deliberate design of a machine to take advantage of the proximity of the "ground surface" (actually water surface) for efficient lift is implied by its name. Recently, modest development and research successes have attracted active military and commercial interest, and a number of demonstration machines have been built. Also, a limited amount of competent research, experiment, and analysis has been completed and reported. A preliminary analysis indicates that unlike the hydrofoil craft, GEM can be expected to improve with size. Doubtlessly, the larger models will prove to be more efficient.

Ground effect may be categorized as (1) air bearing (or levapad), (2) plenum chamber, and (3) annular jet. The air-bearing idea has been used for quite some time by machine-shop operators to aid in positioning heavy casting on machine tool beds. The principle is well

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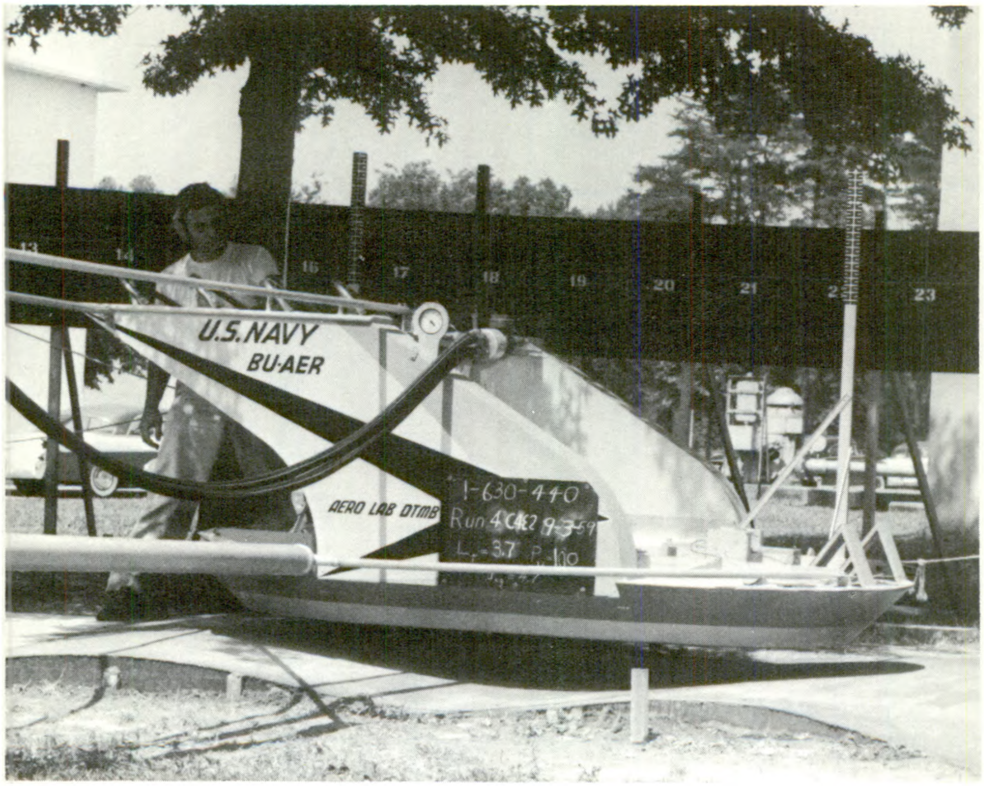

Figure 1--U. S. experimental Ground-Effects Machine (GEM).

developed for use in special slider and journal-bearing applications. Its use in vehicles, of course, would depend upon smooth stable-surface roadways. Plenum-chamber demonstrations machines have successfully operated over both land and water. Possibly the most practical system is the annular jet (or augmentation) system. Analytical and experimental programs to establish an understanding of the interacting effects are underway. A three-step concept of this principle is of value. In Step A, a solid jet of air impinging on a surface will turn and flow out in all directions as a thin boundary layer. Example: Blowing through pursed lips onto a tabletop. In Step B, a similar jet through a long slit will flow outward, left, and right over an interfering surface. In Step C, the bending of this sheet jet into a closed cylinder makes possible a trapped flow of air under the craft, above the surface of the water, and within the jet curtain. See Figure 2. The velocity of the flow of air is converted to pressure as it is trapped. This augmented pressure makes possible the altogether desirable lift which is utilized to raise the craft, thereby displacing it clear of the water. The anticipated advantage of the annular jet is that it move sufficiently fast to achieve low wave drag, as would be the case of a displacement ship if it could somehow reach the ideal speed. However, the existing displacement ships have not yet attained adequate speeds.

Problems requiring research to better understand GEM and its potential have been recognized. Examples are dynamic pressure effects on the air curtain, stability and control, spray and wave effects over water, and the air-pumping system losses. Careful research analysis

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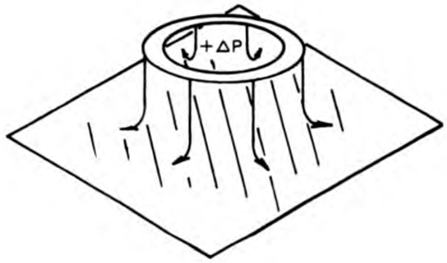
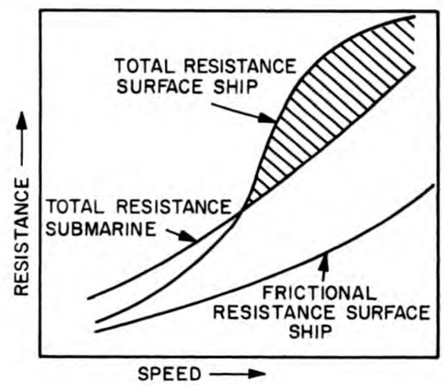


Figure 2--The annular jet (or augmentation) principle.

Figure 3--High-speed advantage of the submarine over the surface ship.



and experiment loom, which may develop a useful GEM. The basic research has only begun.

Having discussed the possibility of high-speed operation and the troublesome surface—abandoning the principle of buoyancy, let's prod into another direction. First we will look deep, then shallow.

HIGH SPEED UNDER THE SEA

Nuclear power has completed the development of the true submarine, as conceived by Jules Verne but only partially achieved by Holland. It is common knowledge that the new submarines are fast. Let's see why, briefly, and then review suggested ways to take advantage of the facts as best we understand them.

The 800-to-one relationship between the density of water and air gives rise to Froude's wave-making barrier to speed of displacement ships operating on the surface. The submarine, like the airplane, flies in a continuous medium. When it is remote from the surface, there is little density discontinuity to form waves involving mass motions with accompanying accelerations and power losses. Pressure effects occur in any given motion involving fluid flow, but in the absence of density variations no gravity waves can form. For the deep submarine, however, wave-making resistance is not important. The wetted surface area of a ship form is approximately doubled when it is submerged, which means that frictional resistance is also doubled. As shown in

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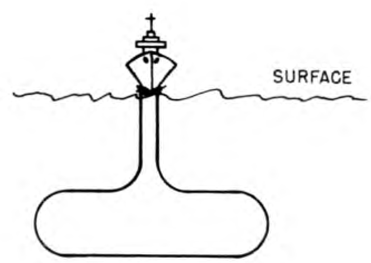
Figure 3, the total resistance to a submarine's speed will be higher than that of the surface ship at low speeds where the surface ship wave-making resistance is not extreme. However, at high speeds—of interest here—the fully submerged hull has an advantage represented by the shaded area in Figure 3. It follows that at low speed the submarine will have higher resistance than the equivalent surface ship, and at high speed the advantage is with the submarine.

At a given speed and proximity to the surface, the pressures associated with the movement of a submarine through the water will have time to react with the surface and form waves. Analytical and experimental results indicate that from 1-1/2 to 3 diameters clearance below the surface is sufficient to reduce this effect. These observations suggest the possibility of redistributing the displacement of a surface ship away from the troublesome surface. Configurations similar to the one shown in Figure 4 are experimentally attractive. Problems associated with these ideas include structural strength of the long thin strut, the demand for constant control of depth, extensive ballast and machinery systems associated with displacement control and storm sea operations. The configuration retains the advantages of conventional surface navigation and air-breathing engines; however, it loses the military advantage of concealment and three-dimensional maneuvering.

Figure 4--A shallow-submergence ship concept.



THE NATURE OF THE SEA

To understand and thereby deal more intelligently with the problems of operating at sea, we must first know something of the sea itself. Until the very recent development of a stereophoto technique of measuring the sea, we indeed had no reliable measurement worthy of a numerical description. Recent application of statistical techniques has developed, for the first time, an analytically useful description of the confusion presented by the surface of the windswept sea. To emphasize the difficulty of estimating the height of waves at sea, a recent experience is of interest. The author had occasion to cross the Adriatic Sea in company with three British Towing Tank Scientists aboard a hydrofoil craft, and they were all experienced hydrodynamicists who realised the problem of estimating a sea. The group made individual estimates of wave height. Estimates of wave height were made by these laboratory men, well aware of pitfalls involved; they came up with a scatter from 11 to 30 feet. One can imagine how this scatter factor would be affected as scale increased to proportions involving psychological effects in a stormy sea.

The new statistical technique has minimized this difficulty. The validity of the results have been checked experimentally and are well

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accepted. Two avenues of development are greatly assisted by this new system. First, it is now possible to superimpose analytically the hydrodynamic forces resulting from speed and ship motions and obtain stresses of a known probability for use in the new design work. Second, we now have the ability to use probability in the design of devices to control ship motions. In relation to ship speed, the waves of a wind-swept sea operate in three distinctly negative ways:

- Psychologically, men reduce ship's speed in heavy seas.
- Power requirements increase in rough seas.
- Structural stresses are greatly increased.

The motion of a ship may be studied in six parts:

- Roll—angular motion about a longitudinal axis.
- Pitch—angular motion about a transverse axis.
- Yaw—angular motion about a vertical axis.
- Heaving—vertical linear motion.
- Sway—transverse or sidewise linear motion.
- Surge—longitudinal linear motion, such as fluctuations in speed.

There is little hope—or need—to control the translatory motions. Yaw is reasonably controlled by the helmsman. We are left with two angular motions, rolls and pitch. Both are well understood and have been successfully dealt with in various ways. Ship's roll is the more amenable to control. Commercial stock designs using activated fins are available. A method reported before the Society of Naval Architects in 1947 uses wing tanks with pumps transferring ballast. The control of pitch is more difficult than ship's roll for structural reasons. The moment arm involved is the ship's length, usually five to eight times the beam. Effective experiment with a small fixed fin at the bow has reduced pitching as much as 40 percent. Pitch control involves tremendous forces and is not yet commonly attempted.

The loss of speed in a seaway is real because of the dynamics involved. Analytical expressions for added resistance have been developed. Full-scale and model estimates have been found to be accurate. The change in resistance is proportional to wave height and the effect is maximum in waves near ship's length. A 600-foot ship in waves 20 feet high may have to use power for 10 knots in order to stand still. To maintain 12 knots, she must increase from 65 to 100 percent power. Recent developments in wave forecasting have had practical results when applied to weather routing of ships. Wave areas which do not limit speed are sought and considerable gains are reported.

PROPULSION

Today the marine propeller is designed with foil sections. Increased efficiency through the mechanical and hydrodynamic improvements are not likely to be great or rapid. However, if we are to achieve very great increases in speed of advance, it will be necessary to deal effectively with the fluid phenomena of cavitation.

Everyone is familiar with the boiling or formation of vapor bubbles when water is heated. At sea level boiling occurs at 212° F, and boiling temperatures are less at altitudes because pressure is lowered. When this phenomenon takes place through reduction of pressure, we

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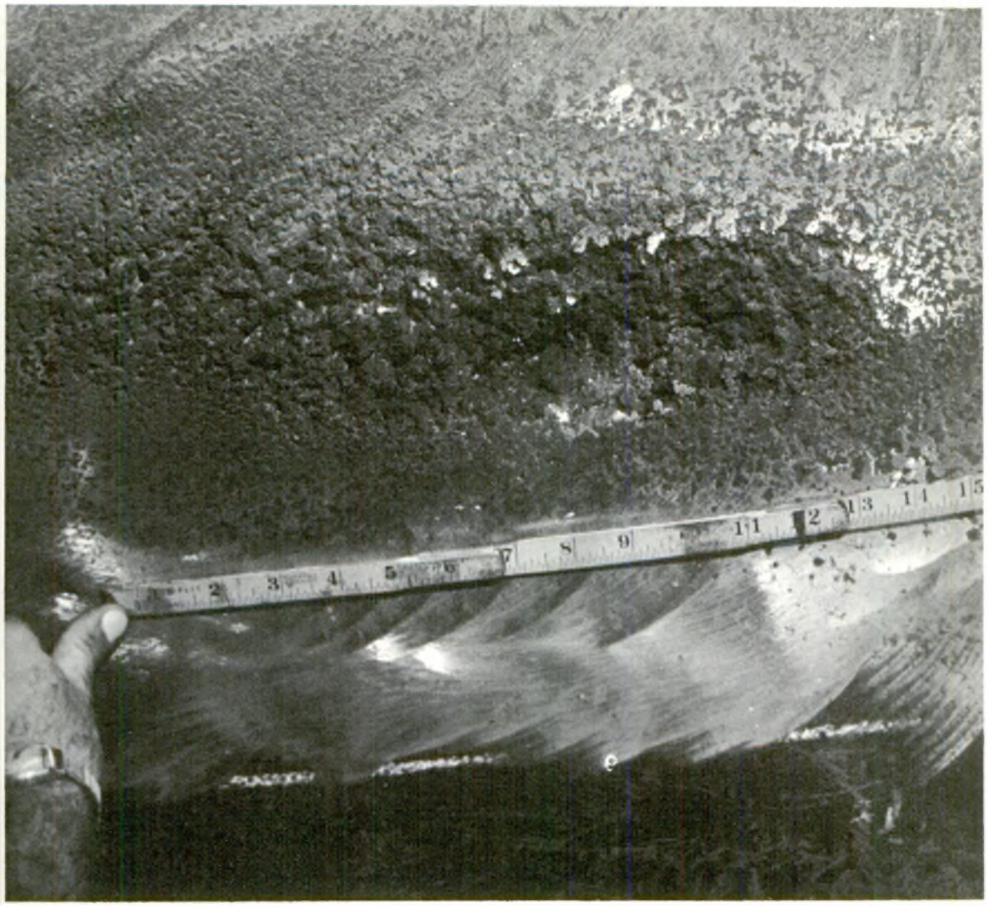

Figure 5--Metal erosion of a high-powered ship propeller.

call it cavitation. Although cavitation involves liquid and gaseous states, this phenomenon is not completely understood. Two aspects of cavitation are of importance in high-speed propulsion: Propeller efficiency falls off at high speeds and metal erosion is rapid and dramatic. See Figure 5. Discussion of propeller efficiency as related to cavitation is simple as we look to foil theory and relate it to the propeller: Fluid flow over a foil with an angle of attack produces lift and associated drag. As velocity is increased, lift increases rapidly until the pressures above the foil become too low. When this occurs the onset of cavitation takes place and destroys lifting capacity of the foil.

Recent theoretical work has resulted in extension beyond experiment into the characteristics of a cavitating foil. It also theoretically maximized the foil form for lift. Today this theory and its simplifying assumptions have been justified by limited experimental work. We are now able to drive foils efficiently at much greater speeds while maintaining useful lift. This work promises to be significant in propeller theory. It may be possible to extend the speed range of the efficient use of marine propellers. This work is known as the Supercavitating Propeller. Figure 6 shows sections of conventional and supercavitating propeller blades. There are no supercavitating propellers at sea. None will drive conventional 10- to 15-knot ships, but it may be that experience in the 30-knot ships will encourage us to believe that naval

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architecture may request greatly increased thrusts required for high-speed propulsion and expect to actually get it.

COMMERCIAL SHIP

In commercial practice, ship speed may logically be divided into two areas: sea speed and port speed. The typical cargo ship spends more than one-half her time tied securely to a pier—not by choice but by the requirements of cargo handling. A general cargo of a 10,000-ton ship may be expected to be composed of 300,000 items. It is easy to dismiss longshoremen with contempt, but a look into insurance adjustments convinces one that each longshoreman is a highly skilled craftsman. Like good health, he isn't appreciated until he is not available. Cargo handling includes the tasks of receiving, accounting, storing, stowing, and providing security for many items from numerous sources destined to many consignees. These items of diverse size require various, special segregated stowages and are consigned to various ports of call. If the cargo were standard and if its flow into the port from land and sea were controllable; and if . . . But things are in fact not ideal.

Our proper question here is what could be the commercial effect of doubling ships sea speed? Without major improvement in port and freight control, it would simply mean that the costly ship would be tied to a pier two-thirds of the time. This is the inevitable result of decreasing sea time and accepting established port time. It is probable that increased speed in commercial shipping can be most easily accomplished through improved port facilities and methods.

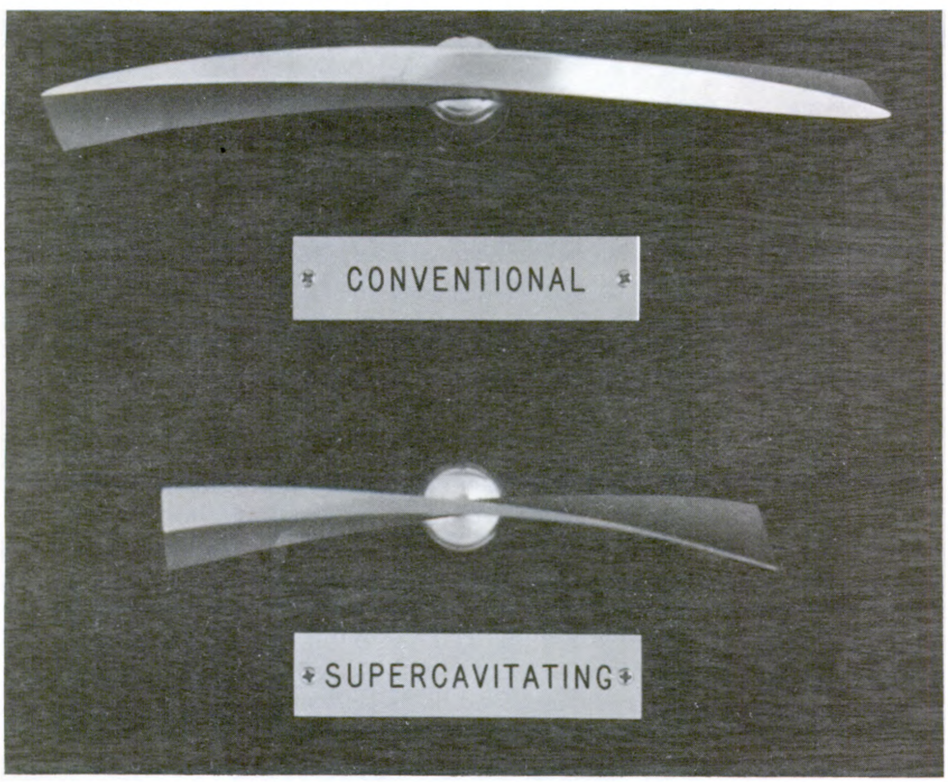

Figure 6--Propeller blade sections: conventional and supercavitating.

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Nose cone of the Aerobee-Hi Rocket after recovery at White Sands, New Mexico. The spectograph containing the "Lyman alpha" profile camera was found elsewhere, having separated from the nose cone.

Navy Scientists Report on Space Discoveries

Two Navy scientists made news last month when they presented some interesting new facts about the sun and the sun's environment at a meeting of the American Astronomical Society in Cleveland, Ohio.

The new work, relating to the existence of a great quantity of relatively cool hydrogen between the earth and the sun, was reported by Dr. Richard Tousey and James D. Purcell of the Naval Research Laboratory, Washington, D. C. Their paper, read to the society by Tousey, described discoveries made as a result of an Aerobee-Hi rocket fired from White Sands, New Mexico, July 21, as part of the United States effort in the International Geophysical Cooperation, 1959. (IGC is the followup program of IGY.)

In an experiment last March, researchers obtained photographs of the sun in the light of the penetrating ultraviolet Lyman alpha spectrum line of hydrogen which showed the presence of intensely emitting clouds of hydrogen scattered over the face of the sun. Analysis of the July experiment resulted in obtaining what the scientists term "highly

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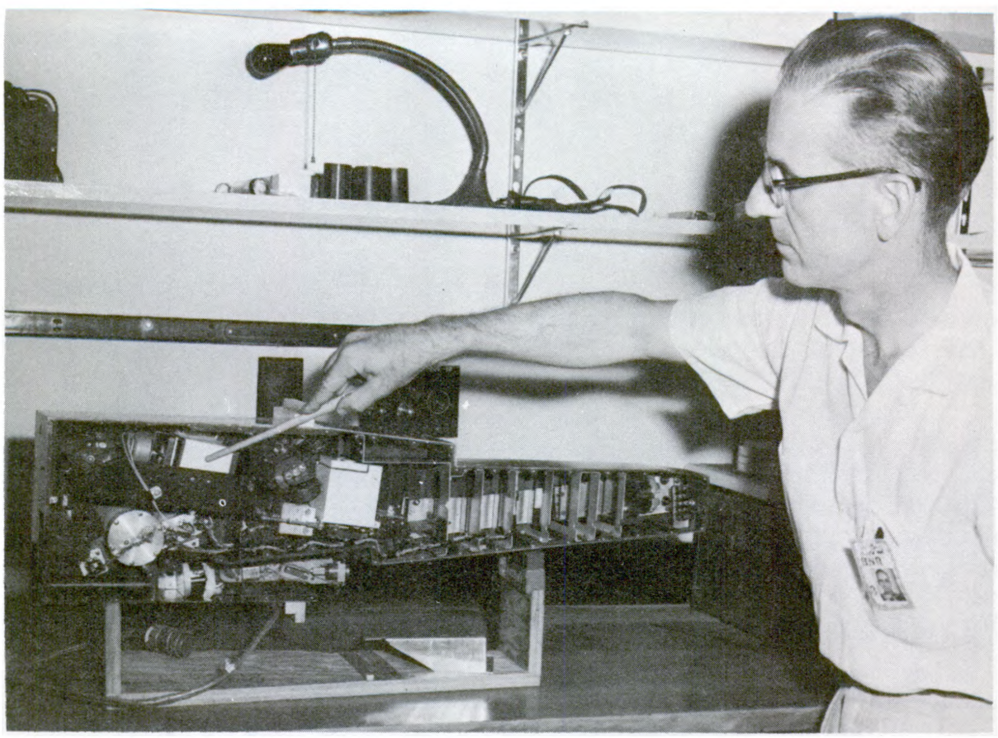
significant" spectra of the Lyman alpha line. In previous spectrum photos, the entire range of extreme ultraviolet wavelengths was covered but with rather low resolution. The Lyman alpha line was bright enough, but little or nothing could be said about its shape. In the new spectrum, only this line is photographed and it is magnified about 100 times so that its profile can be seen. It turns out that the Lyman alpha line is considerably wider than previously believed and includes many different frequencies, both higher and lower than ever come from hydrogen atoms in the laboratory.

Purcell and Tousey explain this phenomena as resulting from the Doppler effect of the high temperatures in the sun where hydrogen atoms, electrons, and protons are moving outward at speeds up to a million miles per hour while others are moving inward at similar speeds. Just as the pitch of a locomotive whistle is increased as it approaches, and decreased when it recedes, these rapid motions cause the Lyman alpha spectral line emitted by the atoms to be increased and decreased in frequency and so to spread over a wide frequency range.

The width of the line which measures about 2 Angstroms calls for a temperature of the order of 40,000° C, according to the astrophysicists who took part in analyzing the data. This means that hydrogen atoms continue to exist in the sun far out in its chromosphere where the temperature is extremely high. A little farther out, as the temperature rises still more, these atoms become broken up into protons and electrons and then boil off into space. This forms the "solar wind" that a



NRL Scientist Purcell points to the "Lyman alpha" profile camera inside the spectograph, a component of the Aerobee-Hi Rocket.

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day or two later reaches the earth and becomes trapped into the Van Allen belts, discovered during 1958 by satellites.

As soon as the films recovered after rocket impact were developed, it was discovered that there was a strong dark line at the very center of each spectral image of the Lyman alpha line—that is the center of the line was nearly completely missing. This finding told the scientists that there is a great bank of relatively cool hydrogen between the earth and the sun. Hydrogen there is too cool to emit radiation itself but acts as a filter, absorbing the radiation from the sun on its way to the earth. From the width of the dark absorption core, the temperature of the hydrogen cloud was inferred to be between an approximate 1000 to 2000° C. The degree of blackness of this core gives the first direct measurement of the amount of hydrogen between the earth and the sun. Dr. Phillip W. Mange, also of NRL, who worked with Tousey and Purcell on this aspect of the analysis, estimates that there are about 10 million million atoms in each long column (of one square inch area) imagined to extend from the flying rocket to the sun.

Some of these hydrogen atoms probably come from the sun, but most of them come from the earth. Marsh gas, escaping into the atmosphere, from decaying matter, gradually rises and eventually reaches rocket altitudes, and some water vapor does also. Here the molecules become broken down by sunlight—thus releasing atoms of hydrogen. When the very light hydrogen atoms reach the 300-mile level, more or less, some are traveling fast enough to escape from the earth's gravity. They shoot off into interplanetary space, taking their own orbits around the sun, and form a sort of satellite cloud around the earth.

The presence of a hydrogen cloud was first suspected by NRL scientists as a result of rocket experiments in 1955. They made measurements of the sky at night and saw that it was brightly aglow in Lyman alpha. This glow could only mean a cloud of atomic hydrogen. And now the cloud has actually been seen against the sun by screening out its ultraviolet emission. The view with ultraviolet light (Lyman alpha) is comparable to what one sees with his eyes during a dust storm; then the sky looks intensely bright and the disc of the sun can barely be seen. But there is this difference: The hydrogen is so high above the earth that even during night the gaseous cloud is still bathed in sunlight and emits ultraviolet rays with great intensity; of course this radiation—being outside the visible spectrum—could not be seen even if it were able to penetrate the ground. Material particles in space have the ability to scatter visible light in a somewhat analogous fashion. The zodiacal light is partially accounted for by scattering from fine dust particles concentrated toward the ecliptic plane.

Dr. J. J. Nassau, director of the Warner and Swazey Observatory, Cleveland, Ohio, was honored in October when he received the 1959 Case Achievement Award from the Case Institute of Technology in Cleveland. The Observatory's new station near Cleveland bears the name of Dr. Nassau and is known as the Nassau Station of the Warner and Swazey Observatory. Work by Dr. Nassau has been supported by the Office of Naval Research since 1948--one of the first researchers to receive ONR support.

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Phosphorous and Tooth Decay

Robert S. Harris, Ph.D.
and
Abraham E. Nizel, DMD

Massachusetts Institute of Technology, Cambridge

The authors made the provocative discovery in 1950 that diets containing New England corn and milk caused 40 percent more decayed teeth and 50 percent more decayed dental surfaces in hamsters than similar diets containing Texas corn and milk. Later they found that this difference in tooth decay was due to a decay-producing factor or factors in both New England corn and milk rather than to decay-inhibiting factors such as fluorine in Texas corn and milk.

Pursuing the possibility that this decay-producing (cariogenic) factor might be attributable to a trace element, they ashed the two diet mixtures and added the ashes to equivalent amounts of the diets, thereby doubling the content of trace elements not volatile at the ashing temperature of 550° C. When the ash-supplemented diets were fed to hamsters in comparison with the unsupplemented control diets, a marked reduction in the incidence and severity of dental decay (caries) resulted. Evidently, the cariogenic factor in New England corn and milk was overpowered by one or more trace elements in the ash supplement.

On the basis of spectographic and chemical analyses of these natural ashes, a salt mixture was prepared using chemically pure oxides and a phosphate of 12 measurable elements. Hamsters fed this salt mixture in the diet—this was in 1955—showed a 95 percent reduction in caries in comparison with the unsupplemented control diet. Thus, the salt mixture was fully as decay inhibiting (cariostatic) as the natural ash which it duplicated. In a concurrent experiment, the cariostatic activity of the salt mixture was completely lost when the phosphate compound was omitted. Actually, the phosphorous-free salt mixture increased the cariogenic activity of the diet. This effect of phosphorous was unrelated to the calcium-phosphorous ratio of the diet because diets of the same calcium-phosphorous ratio varied greatly in cariogenicity. Only those control diets which contained doubled phosphorous content were found to be cariostatic. In these experiments, the phosphorous content of the diet was doubled by adding 0.53 percent phosphorous (potassium acid phosphate) to the salt mixture. A similar effect was attained when the phosphorous content of the diet was doubled by using metaphosphoric acid sticks.

The authors, in their most recent report, found no caries in hamsters fed on a caries-producing diet in which the phosphorous content had been increased threefold by the addition of metaphosphoric acid pellets. The features of the molars were strikingly different in the phosphate group. Viewed laterally (from the cheek to the tongue), the molars of the phosphate-fed group had cusps (protuberances on the grinding surfaces) that were blunter and shorter, as measured from tip

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of cusp to bottom of fissure. The radius of curvature of the fossae (the concave or inner surfaces) was much greater and the inclined planes of the opposing cusps were farther apart from each other. The molars, when viewed occlusally (looking at the grinding surfaces), appeared flatter, the fossae smoother, cleaner, and more lustrous. Since no exposed dentine was evident, this change in features was perhaps due to normal wear. The teeth of the phosphate-supplemented group were less carious (decayed) either because of some chemical change in the tooth which decreased its solubility or some physical change in the tooth which reduced the tendency for food or debris to accumulate in the fissures.

Studies are now under way or planned (a) to determine whether this effect is related to the structure of the phosphate ion or solution pH of the phosphate or to the particular cation accompanying the phosphate; (b) to establish whether this effect is local or systemic; (c) to explain why tooth enamel becomes translucent; and (d) to determine whether the feeding of phosphates affects other tissues, organs, or metabolic processes. These results may shed light on the reports of other investigators who reported that additions of food ash or salt mixtures reduced caries in rats.

This observation that phosphates are potent cariostatic agents is not new. Several investigators have presented evidence that the phosphates of iron, sodium, or calcium exert cariostatic effects when fed in the diets of rats, hamsters, cotton rats, and even children. Others have shown that phytates—the phosphorous-rich compounds in plant tissues—may be responsible for the cariostatic effects of refined cereals and sugar cane juice. Still others have shown that a low level of phosphorous or calcium in the diet may be a prerequisite for the production of caries or rickets in experimental animals.

The present evidence indicates that a cariogenic diet can be made cariostatic for experimental animals when the diet is supplemented with phosphorous compounds. The optimal level of phosphorous feeding and the best type of phosphoric compound has not yet been determined.

Awarded Letter of Commendation

CDR Newell A. Atwood, USN, has been awarded a letter of Commendation by the Secretary of the Navy for outstanding performance of duty as Navy European Contact Research Program Officer in London, England, from January 1957 to August 1959. The award also authorizes CDR Atwood to wear a bronze star in lieu of his second Commendation Ribbon, his previous citation being received in 1946.

As the first officer assigned to the Navy European Research Contracts Program, CDR Atwood directed the initial operation of the program of contracts negotiated with European scientific facilities, filling the gaps in the United States research and development over-all program. The citation states that CDR Atwood's efforts assured the program's success and that he was largely responsible for its establishment on a permanent basis. CDR Atwood is presently assigned as International Aid Assistant, BuShips; previous assignments have been with the Naval Research Laboratory, the Office of Naval Research, the Norfolk and New York Naval Shipyards, and CINCNELM in London.

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Fuel Fungi

John M. Leonard
U. S. Naval Research Laboratory
Washington, D. C.

To say that the jet age—like every other age—has its problems, is to use a tired old cliche. But there is novelty in the suggestion that jet airplanes may have a biological problem. Specifically, their kerosene-like fuel supports growth of bacteria and fungi to an extent that exceeds mere physiological interest. The biggest problem is not the simple loss of hydrocarbon fuel through metabolism but the bacterial pellicles and the fragments of fungus mycelium. They are highly effective in clogging the various filters and strainers of the aircraft as well as those of the several storage and transport facilities through which the fuel passes. There is evidence too, that the problem is aggravated by the microbes (or their metabolic products) acting as stabilizers of some rather bizarre emulsions of water and fuel.

In analyzing the problem, one essential factor is the demonstrated ability of the organisms to utilize jet fuel for their own nutrition. Figure 1 shows an experiment which demonstrates the point. The 20-liter bottle shown had been inoculated with a mixture of bacteria from contaminated fuel storage tanks. The only source of carbon is the jet fuel which overlays an aqueous phase of mineral nutrients. A thick scum of bacteria can be seen at the interface; slime-stabilized emulsions are plainly evident on both sides of the boundary.

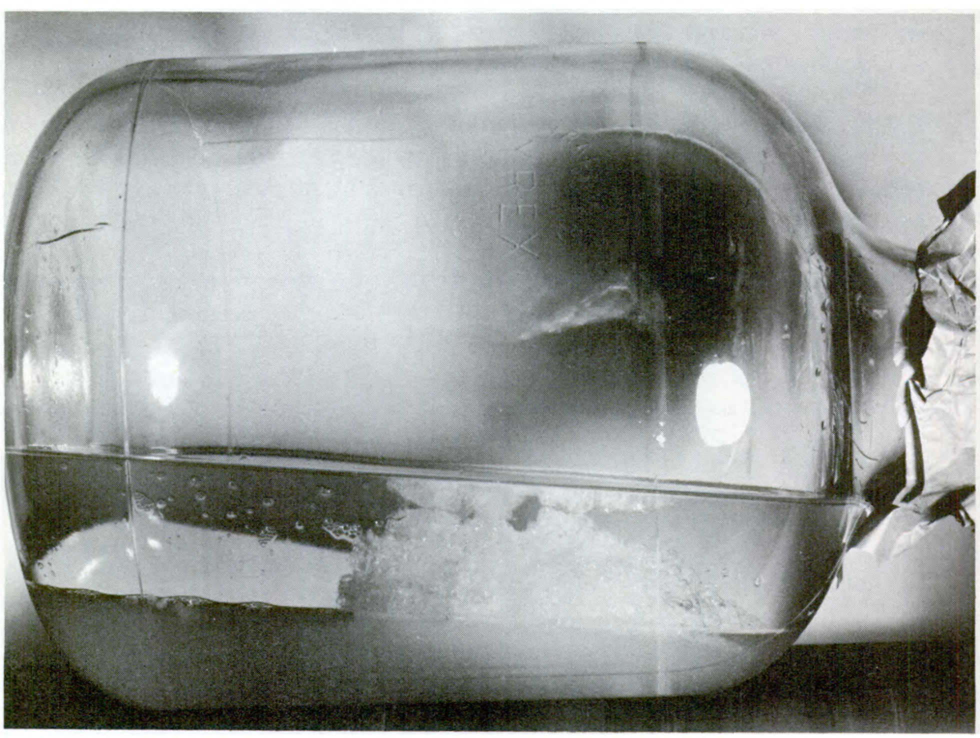

Figure 1--Bacterial growth in jet fuel.

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A second factor is the common occurrence of water in fuel-handling systems. Large storage tanks located in the ground are especially vulnerable to the seepage of ground water and, to a lesser extent, to the entrance of rain and surface water. In many installations water is introduced deliberately; fuel-transfer systems operating by water displacement are an example. So, by accident or design, hydrocarbon-water interfaces are common. It is at such interfaces that growth occurs. The point has been vividly brought out in many inspections of emptied tanks. The zone of slime on the walls sharply defines the range of movement of the fuel-water interface. And it is easy to believe that the interfacial material would be easily broken up by internal disturbances, such as pumping and convection currents, and that the fragments would be conveyed along with the fuel.

Storage tanks in the earth are not the sole source of difficulty, although the basic principles are best exemplified there. Any place—including the aircraft itself—where water and fuel can remain in contact is a potential trouble spot. And water will get in, even in the airplane. Usually, there is no single fuel tank but a labyrinth of interconnecting cells with numerous low points where water can pond. In many military aircraft, at least, the interiors are practically inaccessible for cleaning or flushing.

Since gasoline and kerosene are chemically similar, why didn't the problem come up long ago in connection with gasoline-powered aircraft? Part of the answer lies in the jet engine's enormous rate of fuel consumption—more than 1000 gallons per hour. A very low concentration of suspended matter quickly becomes a troublesome amount of residue. Jet fuel moreover, has a much higher viscosity than gasoline, which tends to stabilize water-in-fuel emulsions. That fungi figure importantly in the problem is not so well known. But that such is the case has been repeatedly demonstrated at the Naval Research Laboratory from examinations of contaminated fuels. Shown in Figure 2 is a typical storage-tank sample of contaminated fuel; the material at the fuel-water interface is largely fungal.

In principle, at least, the solution is simple enough: rigorous exclusion of water. This solution is probably beyond practical realization, but the mitigation of the difficulty would most assuredly be a function of how nearly we approach the goal of dry fuel. The need for supplementary methods of biological control will depend on how far short we fall. It is implied that there must be more efficient systems of filters and water separators, properly operated. In certain operations there is evidence that usages thwart, to a considerable extent, the full cleanup potentialities of existing equipment.

Serious attention has been given to a microbial inhibitor for the fuel. Such an inhibitor must not compromise any important functional characteristics. NRL experiments have indicated that none of the customary additives of jet fuel are sufficiently inhibitory, at practical concentration levels, at least. At present, NRL is evaluating several gasoline additives which are believed to be compatible with jet fuel.

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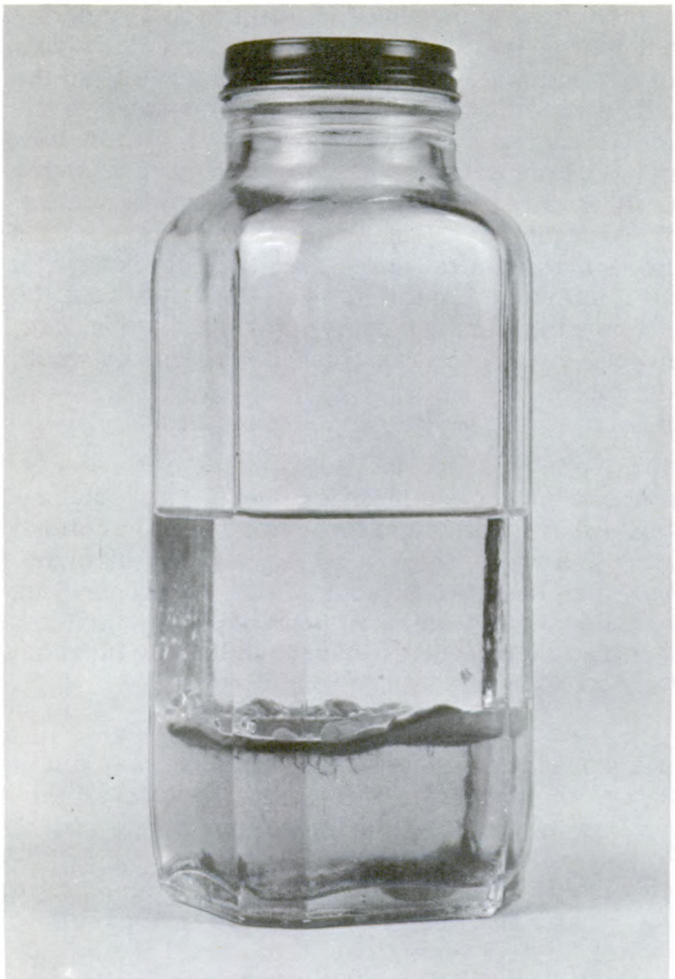

Figure 2--Typical storage-tank sample of contaminated fuel. The material at the fuel-water interface is largely fungal.

Preliminary experiments indicate that two of these may be sufficiently toxic at practicable concentrations. It has been suggested that a water-soluble, fuel-insoluble inhibitor be employed. This might be feasible, even necessary, in water-displacement systems where the aqueous phase is deliberately maintained. But an intolerable amount of inhibitor could get into the fuel through emulsification. In systems where the introduction of water is a highly variable happenstance, a water-soluble inhibitor is scarcely feasible.

A proper assay of the problem will entail studies of microbial nutrition, physiology, and ecology, in order to understand more clearly the circumstances under which the infestations develop. Some interesting interactions of bacteria and fungi have already been noted at NRL and these must be more thoroughly explored. The precise roles of moisture in the deterioration process must be elucidated. With sufficient fundamental information we may learn—among other things—to what extent and in what direction our standards of fastidious housekeeping may be safely relaxed.

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Research Notes

The Cascadia Channel

Off the Oregon coast, near the mouth of the mighty Columbia River, lies another stream that is longer and much deeper and has never been seen by man. This is a 1000-foot-deep channel gouged into the sediments of the sea floor in times long past. It stretches for 1500 miles, one-fourth of the way across the northern Pacific Ocean.

Until four years ago, the existence of the channel was unknown. Today it has become probably the most exhaustively studied ocean trench in the world. Other such channels are known in all the oceans, but the Cascadia Channel, as it is called, lies in an area frequently visited by the vessels of the U. S. Coast and Geodetic Survey and the University of California's Scripps Institution of Oceanography. On each crossing, soundings have been taken. At Scripps, Graduate Research Geologist Robert H. Hurley has examined these tens of thousands of individual observations to draw a detailed picture of the channel. Starting in the sediment fan that lies off the Strait of Juan de Fuca, the Cascadia Channel travels about 200 miles southward and then breaks through a pass in a range of rocky ridges off Cape Blanco, Oregon, to turn almost due west. It is still traceable at longitude 145° west, almost due south of Kodiak, Alaska. Hurley has calculated that the channel is five to 10 times larger than that of the Mississippi River. It starts in waters almost two miles

The Cascadia Channel, a continuation of the Columbia River, is calculated to be five to 10 times larger than the Mississippi River.

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deep and has been traced to waters almost four miles deep. In some reaches, natural levees have built up on both sides of the channel. He believes the channel was cut by undersea rivers of suspended sediment—turbidity currents. The shape and size of the channel tell him that the currents may have reached great speeds. "These could have been 20 to perhaps even 40 knots," Hurley says, "as opposed to one-half a knot or so observed in oceanic currents nearer the surface."

A moot question is whether these mighty streams of sediment still roar down the channel. Hurley believes they may not; that the feature may be a relic of the ice ages. The problem is difficult to settle because it requires that oceanographers collect sediment samples from the channel bed. Sampling techniques are still so crude and the weather in the area so bad that oceanographers are not certain their instruments have actually reached the channel bed, although it is at some points a mile and a half wide.

Hurley says it is probable that these channels on the sea floor are continuations of the rivers of the land and actually carry the same sediment that the streams empty into the oceans, far out away from the land. "While these streams of sediment-laden water may be continuous," he says, "there is some evidence to suggest that they are occasional events of catastrophic proportions. It has even been suggested the material carried down to the abyssal depths by the currents may be significant in providing food to fish and other animals living in the depths of the ocean."

This study of the channel is part of a larger effort to uncover the processes that build, shape, and destroy the hills and plains of more than half of the earth that is covered by the waters of the oceans. Studies of the channel have received support from the Office of Naval Research.

Senior Navy Mathematicians Visit U.S. Naval Training Device Center

The U. S. Naval Training Device Center, Port Washington, N. Y., was host in November to a group of Senior Navy Mathematicians in connection with the Third Conference of Senior Navy Mathematicians.

CAPT Edw. C. Callahan, USN, Commanding Officer and Director of the Training Device Center, welcomed the group. During the course of their visit, the mathematicians received first-hand knowledge of the Center's mathematical developments and participated in a whirlwind tour of the Center's facilities.

John F. Bodenburg, the Center's Technical Director and moderator of the conference, discussed NAVTRADEVCEN's Technical Program. In addition, Vincent Amico, Chief Special Projects Engineer, discussed mathematical problems involved in flight simulation; William Herzog, Electronic Scientist, discussed Mathematical Demonstrators, and Milton Fischer, Head of the Computer Division, explained the Center's Computer Program.

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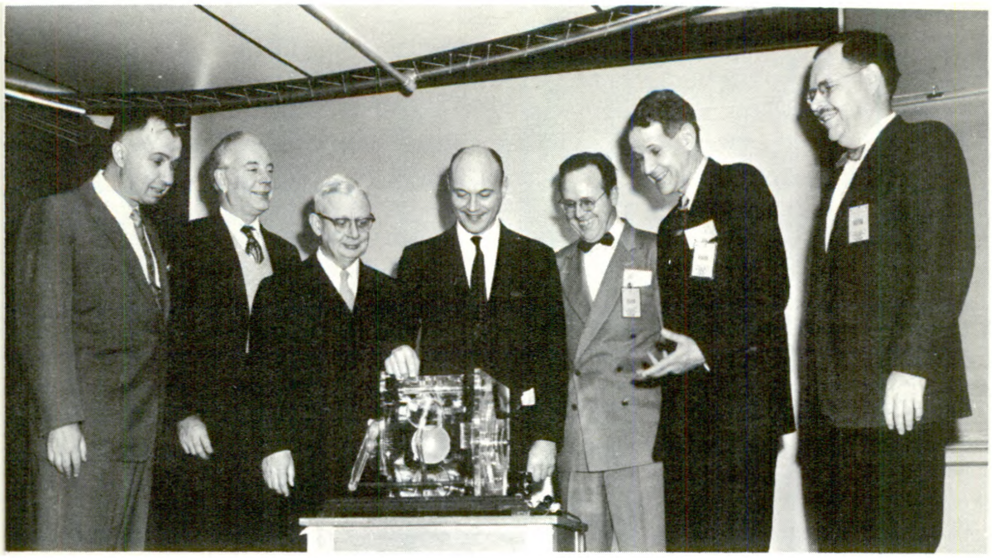

John F. Bodenburg, NAVTRADEVCEN Technical Director, shows a Component Integrator Demonstrator to visiting Senior Navy Mathematicians. On his left--H. Polachek, David Taylor Model Basin; J. D. Trent, Jr., Naval Air Training Center; R. S. Burington, Bureau of Ordnance (BuWeps). On his right--C. J. Thorne, U. S. Naval Ordnance Test Station, China Lake, Calif.; F. J. Weyl and F. D. Rigby, both of the Office of Naval Research.

The Culprit: Air Shock Wave

Explosives testing at the Naval Ordnance Laboratory, White Oak, Md., is carried on as quietly as possible. To help insure that a minimum of noise reaches nearby communities, test areas are located among the woods and hollows of the back section of the 876-acre reservation.

But in spite of all precautions, an occasional explosion may be cause for disturbance. Although investigations of complaints about explosions show no structural damage to homes, NOL strives to prevent even minor annoyances.

In the fall of 1957, NOL undertook to minimize the occasional disturbances caused by firing explosive charges. C. C. Matle, a physicist in the Air-Ground Explosions Division, was assigned to the technical job of finding the facts and recommending what, if any, action might be taken to reduce the disturbing effects. His search of literature relating to the subject, visits to other laboratories having similar problems, and experimental work developed the following information.

The air shock wave is the culprit. Ground shock is attenuated rapidly and is of no consequence for the explosive weights used and the distances involved. It is well known that at the same distant location, identical explosions can be very loud on one day and barely audible on the next day. This phenomenom can be explained by the refraction, or bending, of sound waves and shock waves by certain wind and/or temperature gradients existing in the atmosphere at the time of the shot.

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Wind and temperature gradients can refract the shock wave emanating from the explosion in an upward direction away from the earth, or in a curved path back to the earth. In the former situation, the explosion will be nearly inaudible to a listener located at a distance. However, if meteorological conditions cause the shock wave to bend toward the earth, the explosion could sound unusually loud to a distant observer. There is also a conceivable set of meteorological conditions with certain combinations of positive and negative wind and temperature gradients that could result in focusing the shock wave in a local area much in the same way as a lens will focus the rays from the sun on a spot. If this should happen, the explosion at the focus could sound very loud.

It is very fortunate, however, that for most of the normal working hours meteorological conditions minimize disturbances. There are times—especially in winter and during the early morning hours—when weather conditions indicate that NOL explosions could be disturbing to the countryside. When these conditions exist, NOL bans all firing operations except those that involve less than one-eighth pound of explosive fired in the open and less than one pound of explosive fired in the bombproofs.—Report, U. S. Naval Ordnance Laboratory, White Oak, Md.

Medical Considerations of Exposure to Microwaves (Radar)

Considerable interest in the biologic aspects of exposure to radar beams has been generated by widespread publicity of an alleged case of human death occurring after brief exposure to an unknown quantum of microwaves. The incident served to direct attention to this relatively new agent, and questions naturally arose concerning the extent of the hazard, if any, to persons working with radar transmitters and to those who might be exposed in some manner to the energized beam.

It is not generally known that apprehension over the biologic potentials of microwaves dates back to the early days of World War II, when Daily performed his original studies on U. S. Navy personnel engaged in the operation and testing of relatively low-powered radars. Although this study revealed no evidence of radar-induced pathology in human beings, numerous reports have since appeared indicating that tissue injury and animal death can occur under certain experimental conditions. These studies indicate that cataracts, corneal opacities, testicular degeneration, and hemorrhagic phenomena have been induced in anesthetized, small, furry, test animals by exposure to microwaves in the frequency range of 2800 to 9000 megacycles for various time exposures.

Boysen, using a transmitter with a frequency of 300 megacycles, exposed rabbits in a wave guide and produced damage to the central nervous system, degenerative changes in the kidneys, heart, liver, and gastrointestinal tract, and hemorrhagic changes in the respiratory tree. The power density measured in the wave guide was in excess of 0.1

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watts per square centimeter. The animals were exposed for periods of 7 to 10 minutes, and all whose rectal temperatures exceeded 44.5° C (112.1° F) died.

Because of these findings and the apprehension engendered by their publication in scientific journals, the medical department of an airframe manufacturer, coincidentally installing, testing, and servicing the most powerful airborne transmitters, instituted early in 1954 a comprehensive medical surveillance program for its several hundred employees working with radar or those who might be exposed to the energized beam. This program constitutes one of the longest continuous medical surveys of radar-exposed personnel in the United States.

The objectives of the program were (1) to detect any cumulative biologic effects of long-time exposure to microwaves of varying frequency and power output in persons who had taken minimal precautions; (2) to observe possible effects on persons working for short periods with or near extremely high-powered airborne radar with pulsed wave emissions; and (3) to establish correlation between objective findings and units of exposure expressed in time-powered density factors with the highly idealized objective of establishing safe maximum exposure standards.—U. S. Navy Medical News Letter.

Pacific Basin Heat Flow

Along a 3000-mile rise beneath the sea floor in the southeastern Pacific Ocean, heat is flowing through the crust of the earth at a rate eight times more than the average for the rest of the earth.

Oceanographers from the University of California's Scripps Institution of Oceanography, who discovered and plotted the area, believe that further study of the region may offer science new insights as to how continents and mountain chains are formed. Known as the East Pacific Rise, the area extends southwestward off the South American Continent. Lying on it is Easter Island.

Over most of the oceans, the heat flow is about equal to that in the continents, that is, one-millionth of a calorie per square centimeter per second. But along the crest of the Rise values are so high that the first measurements—made in early 1953 by Arthur E. Maxwell, former Scripps student, now with the Office of Naval Research—were thought to be isolated anomalies. Further investigations, however, indicate that the entire region has a high flow, ranging from two to three times average at the ends of the rise to seven times at the center.

Curiously, on either side of the Rise, heat flow measurements are very low, less than one-half the average values, with some one-fiftieth of the values along the crest of the Rise. This pattern has been attributed to a giant convection cell in the mantle of the earth in that area, rising beneath the crest of the ridge and descending on either side.

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NBS Adapts Two Simple Dynamic Techniques

The National Bureau of Standards, in a study sponsored by the Navy Bureau of Aeronautics (now Bureau of Weapons), has adapted two simple dynamic techniques to the determination of the thermoelastic properties of metals and alloys. One method utilizes a pendulum assembly to test wire specimens, the other a sonic vibration apparatus for rods and prisms.

Information derived with this equipment, designed by H. C. Burnett of the Bureau staff, may be used to develop improved alloys for spring materials. The elevated temperatures attained in the power plants of modern aircraft have created a need for metal springs that maintain stable deflection characteristics over a wide range of environmental conditions. However, to design alloys for these springs, basic data are necessary on the elastic constants of materials suitable for spring fabrication.

The equipment used in the pendulum method consists of an oven, photoelectric cell and lamp, timer, counter, and electronic temperature recorder. A frame about the oven supports a 3-foot long, 0.5-inch-diameter steel rod that extends vertically through a hole in the top of the oven into the heat chamber. The wire specimen is suspended from a chuck on the lower end of the rod. Another chuck, firmly fixed to a 6-inch-diameter brass disk, grips the lower end of the specimen. When a small amount of twist is applied with a starting arm fitted to the upper portion of the rod, the pendulum oscillates about the axis of the specimen.

The photoelectric cell and lamp, mounted just outside the rear of the oven, are alined with two holes in the oven wall. Once in each half cycle of oscillation, light from the lamp strikes a small mirror attached to the pendulum assembly, and is reflected back to the cell. The cell, thus energized, operates the counter and timer until a predetermined number of oscillations is registered. The shear modulus of the wire is then computed from the resonant frequency derived for the specimen and the dimensions and masses of the pendulum assembly. The frequency range of this test is from a fraction of a cycle to 10 cycles per second. Test temperatures up to 525° F are shown on the temperature recorder.

In the sonic vibration method, either a rod or a rectangular prismatic bar specimen, approximately 6 inches long, is suspended from an electromagnetic driver by two asbestos strings and enclosed in a furnace which operates at temperatures up to 1,000° F. The specimen is excited to its resonant frequency by the driver and a variable audio oscillator. A crystal pickup detects the vibrations which are shown as an expanded wave on a cathode-ray oscilloscope. The frequency of the oscillator is then adjusted to the frequency of the specimen, indicated by the amplitude of the oscilloscope trace, and this adjusted frequency is measured with an electronic events-per-unit-time counter.

From the measurements thus obtained, Young's modulus can be computed for rod specimens. In using the apparatus for tests on rectangular prismatic bar specimens, the prisms can be made to vibrate either in tension or torsion, so that both Young's modulus and the shear modulus may be determined without changing the mode of suspension.

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On The Naval Research Reserve

Gun Barrel Makes Ideal Radition Shield

CAPT J. S. Medd, USNR
and
LCDR J. S. Robertson, USNR

Naval Reserve Research Company 3-9, Upton, N. Y.

When Brookhaven National Laboratory's Medical Department needed steel for use as a massive shield for a low-level radiation detection device, the Navy "lept to the breech" by making available a 4-foot, 7000-pound section from the tube of an 8-inch rifle—providing 9 inches of steel shielding on all sides. The heavy shield is needed to reduce the background counting rate due to cosmic rays and other environmental radiations.

The illustration shows the equipment in use in a Medical Department isotope-counting room. The large cylinder is, of course, the gun barrel. The ends of the bore are fitted with removable steel plugs. The technician is shown holding a plastic tray which holds five samples and which slides into position within the shield for counting. After the tray is in position, the small hole is plugged with the upright cylinder. (See the illustration.) Counting is done by the use of five pancake-type Geiger counters which may be operated independently or simultaneously. Between the Geiger counters and the shield is a ring of nine 2- by 24-inch proportional counting tubes connected in an anticoincidence circuit to further reduce the background. With this arrangement, the background counting rate is only one count per minute.

Low-level beta counter radiation shield made from a section of the barrel of an 8-inch gun, as installed for use at Brookhaven.

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A person might assume that the gun barrel came from a heavy cruiser, but this would not be true. It was actually an unused barrel, cut and machined for Brookhaven at the Naval Weapons Plant, Washington, D. C. Since it was made from prewar steel, it is especially satisfactory as a shield because it does not contain any fission-product radioactivity, as some batches of new steel do. Surely this "beating of swords into ploughshares" is a splendid example of cooperation between the Navy and other establishments in promoting the peaceful uses of atomic energy.

New Assistant Reserve Assistant at ONR, Chicago

LTJG Lawrence A. WITUCKI, USNR, reported for duty as Assistant Reserve Assistant at the Office of Naval Research Branch Office, Chicago, on 4 January 1960. LT WITUCKI relieved LT Christopher S. LARDIS, USN, who has reported to Commander, Destroyer Squadron Three, Long Beach, California, as Staff Engineer.

LTJG Witucki

LTJG WITUCKI, a native of Edgar, Wisconsin, is a graduate of Wisconsin State College at River Falls, Wisconsin, with a B. S. degree in Agricultural Education. After graduation in 1955, he taught vocational agriculture for a year. LTJG WITUCKI entered the naval service in 1956 when he reported to Officer Candidate School at Newport, Rhode Island. He completed Damage Control and Atomic, Biological, and Chemical Warfare School in 1957. His first duty station was aboard the USS ERBEN (DD 631) as First Lieutenant. When the ship was decommissioned, he was assigned to the U. S. Naval Air Facility at Oppama, Japan. Here he filled billets as Personnel and Special Services Officer for 21 months prior to reporting to ONR, Chicago.

Research Reservist Wins Award

LT Donald F. Spencer, USNR, a member of Naval Reserve Research Company 5-8, Washington, D. C., was one of the recipients of a joint award for introducing a radical no-test-equipment concept in the BULLPUP guided missile program. Mr. Spencer, BULLPUP electronics engineer and coordinator for the BULLPUP missile guidance and avionics system development and evaluation, shared honors with R. D. Ginter, BULLPUP Senior Project Officer. Mr. Spencer is a member of the staff of Dr. Herbert F. York, the Defense Department's Director of Research and Engineering in the office of James M. Bridges, Director of Electronics. RADM W. A. Schoech, USN, Deputy Chief of the Bureau

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of Naval Weapons, presented the joint award of $4500 on 18 January 1960. Mr. Spencer received $1350 and Mr. Ginter received $3150.

In making the awards to Mr. Spencer and Mr. Ginter, they were recognized for their originality of thought and attention to the detail required to implement such a plan which resulted in the most reliable U. S. guided missile weapon system at its initial introduction into Service use. The resultant weapon system is simple, and its over-all costs were not only drastically reduced upon Fleet introduction, but the over-all cost savings will continue to compound throughout its Service life.

LT Spencer

In other operational guided-missile weapon systems, a large amount of time, manpower and money is spent in the performance of special functional tests before flight to insure that each missile will operate properly. The ability to eliminate these tests and treat a complex guided missile as a "round of ammunition" and yet retain high reliability will save the Navy not only the obvious direct costs, but also the many hidden costs normally associated with a missile program, such as missile test equipment, facilities and installation costs to house shipboard and shore-based equipment, training costs, and spares for maintaining missiles and test equipment after overhaul and repair.

Last August an initial award of $150 was given to Mr. Spencer and $350 to Mr. Ginter. RADM Stroop, USN, Chief of the Bureau of Naval Weapons, originally recommended that a total joint award of $8160 be made, based on the reported first year's savings to the Navy of more than $7,500,000. If the pending recommendation is approved by both the Department of Defense and the Civil Service Commission, who must authorize awards in excess of $5,000, these two engineers will receive still another sum of $3160 to be divided between them.

The BULLPUP system is the only U. S. guided missile to achieve the distinctive no-test position. The U. S. Air Force has purchased a quantity of BULLPUP missiles from the Navy and plans to make them standard weapons in the Tactical Air Command. The Air Force has also adopted the no-test-equipment philosophy. Information on savings which will accrue within the Air Force in following this precedent is not yet available; however, it might well be assumed that their eventual order of magnitude will be similar to those experienced by the Navy.

Now that the precedent has been set and proven, it is expected that other missile systems will be disposed to look toward this concept as a feasible philosophy.

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Supplemental Information

Rapid Hypothermia—An Improved Extracorporeal Method

(Naval Research Reviews, December 1959)

The illustration facing page one of the above article was intended to be a photograph of a display developed jointly by the Naval Medical Research Institute and the Naval Research Laboratory. Since the inadvertent cropping of the photograph eliminated information essential to the completeness of the article, the entire photograph is reproduced on the inside back cover.

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As a result of an editorial error, the title of the display was used as the title of the article. Had we retained the author's suggested title: "NRL Provides an Assist to Safer Surgery," it would have been clear at the outset that NRL's contribution was the adaption of a novel heat-transfer technique to a blood-cooling requirement developed by NMRI.

Regrettable Errors

On page 6, December issue of Naval Research Reviews, Dr. Clinton H. Maag was erroneously identified as Head, Physiological Psychology Branch, ONR, whereas Dr. Richard Trumbull is Head of that Branch. Dr. Maag is Assistant Head. The correction is gladly made in an effort to rectify false impressions involved.

Those two missing lines atop page 4 of the December issue are: "Another advantage is that the method of heating or cooling is entirely safe and can be precisely controlled. Blood will not tolerate..." The omission on page 10 (paragraph 2, line 7): "...experimenter (C.H.M.) on the outside. The total..."

Those associated with editing the December issue regret these errors and others not specifically mentioned.

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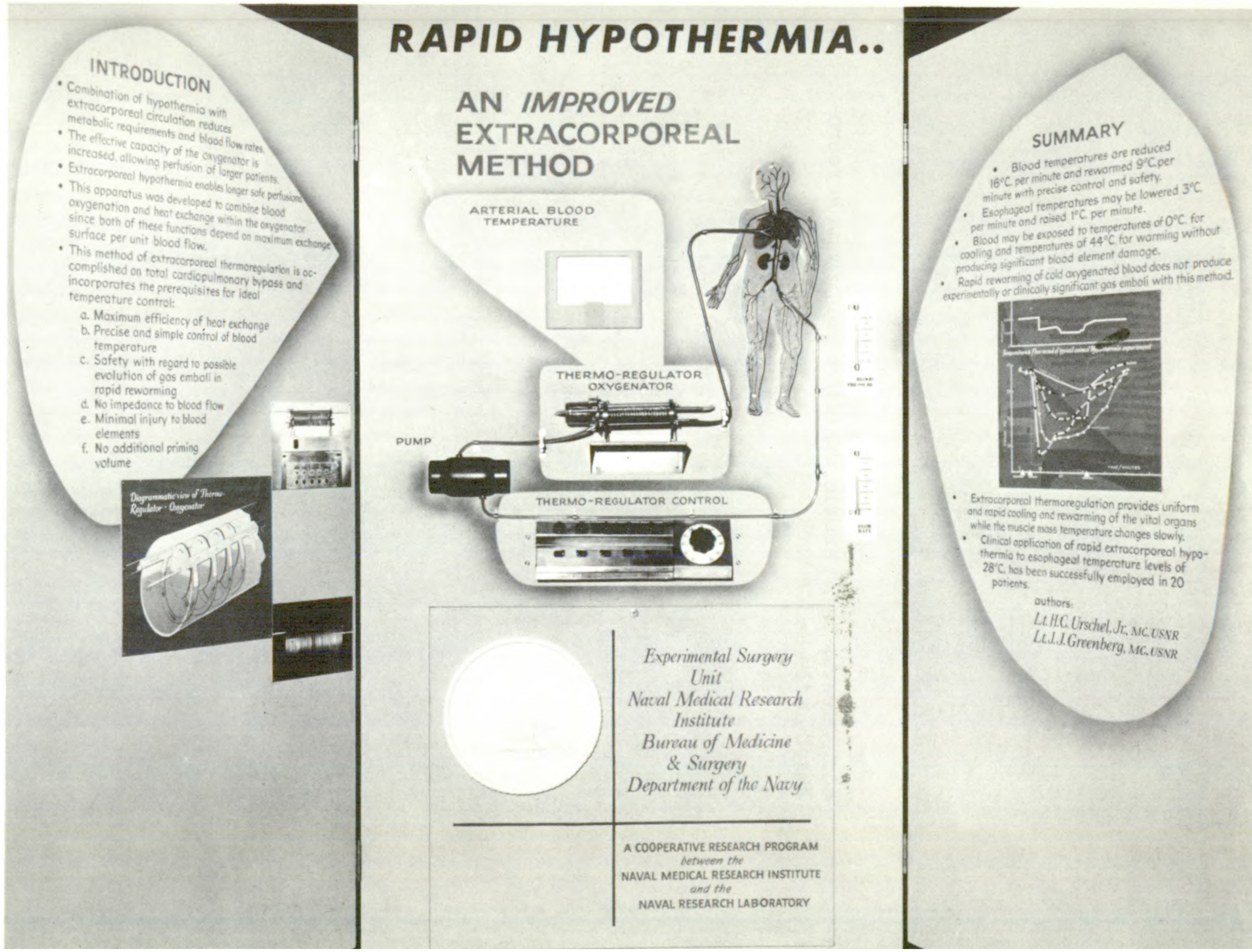

IN THIS ISSUE

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. Use of funds for printing this publication was approved by the Director of the Bureau of the Budget, February 12, 1958.

USS CONY (DD-508) approaching the fantail of the USS VALLEY FORGE during high seas. (See story beginning on page 1.)

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