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The Forward Wake

The existence of a wake that sometimes moves ahead of an object in a fluid, instead of trailing behind it, has been confirmed by experiments conducted at the California Institute of Technology for the Office of Naval Research. The disturbance, which might be called a "magnetic wake," appears only under certain conditions: when the fluid involved conducts electricity readily and when a magnetic field is present. Theoretically, the wake should occur both in the ionosphere and in the ocean, because both environments fulfill the requirements.

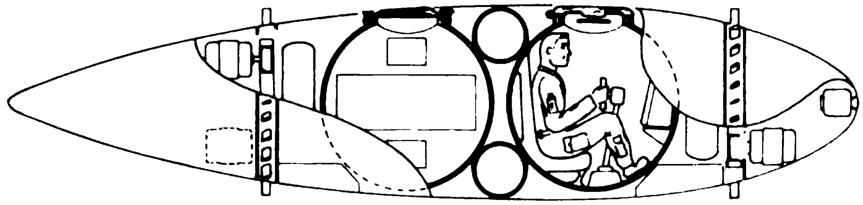
The experiments on the magnetic wake were carried out by Harlow G. Ahlstrom, a graduate student in aeronautics, who worked on the problem for his Ph.D. thesis in connection with a general investigation in the comparatively new field of magneto-fluid dynamics under the direction of Professor Hans W. Liepmann. "Greater understanding of this field may result in its application in producing electricity, in the control of nuclear fusion, and in plasmas," Dr. Liepmann has said. "It also may be useful in propelling and controlling missiles, as well as in controlling re-entry-type heating."

The magnetic wake is produced by the propagation of what are known as Alfven waves, which move along the lines of magnetic fields. These waves are named after the Swedish astrophysicist Hannes Alfven, who predicted their existence about 20 years ago. Alfven waves are somewhat analogous to sound waves that move ahead of objects traveling at subsonic speeds. But in addition to moving ahead of their source, Alfven waves produce vorticity and currents in the conducting fluid through which they propagate.

The magnetic wake stays in front of the moving object when the latter is traveling at a speed less than the speed of propagation of the Alfven waves. However, as the speed of the object increases, the object eventually catches and passes its magnetic wake. The wake velocity depends on the strength of the magnetic field and the density of the fluid. In Ahlstrom's experiments, the wave velocity was about 20 feet per second. In a plasma like the ionosphere, the velocity can reach much higher values.

Ahlstrom's waves were propagated in a device designed to generate the most pronounced Alfven waves possible so that their effect might be more readily detected. This device, called a magneto-fluid dynamic tank, is actually a stainless steel tube about 5-1/2 inches in diameter and 42 inches long that stands upright. It holds up to 1,000 pounds of mercury—the liquid selected for the experiments because of its combination of high electric conductivity and ease of handling. Used in conjunction with the tank and the mercury is a solenoid that produces a very strong magnetic field (up to 13,000 gauss; by comparison, the magnetic field of the earth averages less than one gauss).

In his experiments, Ahlstrom propelled a bullet-nosed plastic object at speeds of up to 10 feet per second through the mercury, while applying different magnetic-field strengths. In all instances, a distinct magnetic wake was observed to move ahead of the plastic object, markedly disturbing the mercury. The perturbations were the combined result of sound waves and Alfven waves.



Propeller of Promise

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Undersea Programs
Office of Naval Research

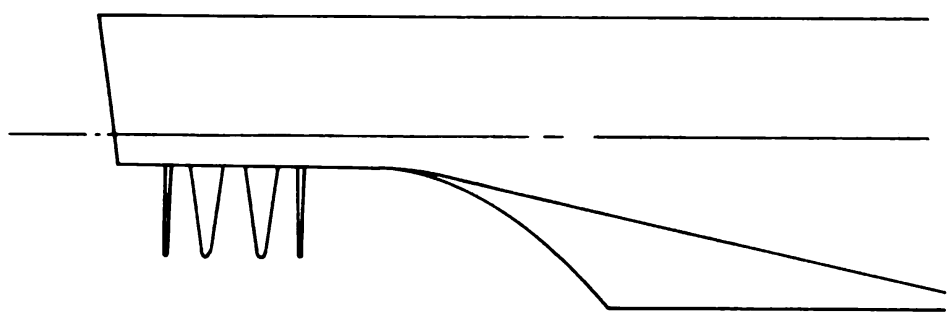
In the years just ahead, submarines of many types will be able to dive to the bottoms of the deepest oceans and carry out a variety of tasks with greater facility than submarines of today do at maximum depths of only a few hundred feet. These vessels will be able to travel swiftly in almost any water, and they will be able to slow down, stop, and maneuver readily at very low speeds, even close to the ocean floor.

Conventional submarines are not equal to these tasks now for several reasons, the most important of which is their method of maneuvering. This method depends upon a combination of planes and rudders for medium and high-speed control and upon change of ballast for extremely low-speed control. Although this system is simple and has reached a high state of development—having been built upon a backlog of more than 100 years of experience—it does not satisfy the important new requirement of precise control of attitude and motion while the submarine is hovering or moving slowly. This problem has been solved in the construction of some special-purpose vehicles by placing the propellers in unusual locations on the hulls and by using some of them specifically for maneuvering. The bathyscaphe TRIESTE, for example, has already proved that vessels can be built to descend to the deepest parts of the oceans and to maneuver to some extent over limited areas. And a number of other vehicles have been constructed or are planned in order to carry out special missions, such as picking up objects on the sea floor and making scientific observations on the bottom.

As the arrangements for controlling these special-purpose vehicles are basically simple, and the propellers used are of conventional types, which have well known characteristics, no outstanding problems have been encountered in designing and building them. However, such systems are costly in weight and power, primarily because of the use of separate propellers for different functions. Furthermore, in spite of the improved maneuverability provided, these vehicles do not possess the full six degrees of freedom which may be required in the near future.

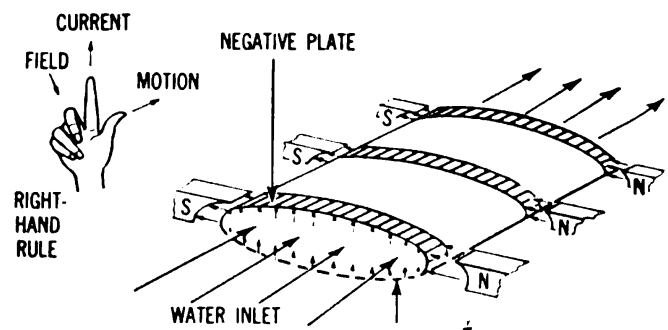
In order to close the gap further between the conventional and special-purpose vehicles, a number of unusual systems have been proposed. One of these is the vertical-axis propeller conceived by Dr. Kirsten of the University of Washington about 40 years ago. This system consists of a set of blades which revolve on a shaft that protrudes vertically from the hull of a ship (see profile). Because of this orientation, the blades turn in a horizontal plane, and therefore must be changed constantly in pitch to exert force against the water and cause the ship to move. Although ships propelled by this system are highly maneuverable in two dimensions (forward-backward and side to side), the system has the disadvantage of requiring constant changes of pitch of the blades while cruising, resulting in excessive mechanical wear and noise. Also, the vertical-axis propeller is less efficient than the conventional propeller.

Among other methods which have been devised to obtain better maneuverability are those based on concepts of electrohydrodynamics. The most exotic of these systems is the magnetomotive pump jet, which has no moving parts. This device consists of a thrust duct which carries a positive charge on one side and a negative charge on the other. When the duct is submerged, and salt water enters it, the water acts as a conductor, causing an electric current to move across the duct from the positive to negative sides. In the presence of a magnetic field, a force is exerted on the conductor, or water, to make it move—according to the principle known as the right-hand rule (see diagram). Unfortunately, the electric conductivity of sea water is too low to make the system economically feasible for most practical uses. Hydrodynamicists have become convinced, therefore, that in the foreseeable future at least, the propeller must be relied upon in one form or another to achieve propulsion efficiency.



Profile of vertical-axis propeller. Shaft projects vertically from ship's hull, so blades rotate in horizontal plane. Blades are made to exert a force against water, and thus propell the ship forward or backward, by changing their pitch constantly. To maneuver the ship, these pitch changes are varied.

Method of operation of the magnetomotive pump jet. Water entering duct causes an electric current to pass from positive to negative side of duct. When this happens in the presence of a magnetic field, a force is exerted on the water, causing it to move. Courtesy of Space/Aeronautics, Jan. 1960.



Because of the importance and magnitude of the problem of achieving efficient maneuverability, the Office of Naval Research has conducted studies of several new systems. One of these is called the tandem propeller. As the name indicates, and as is revealed in the illustrations on pages 4 and 5, this system utilizes a pair of propellers, one located near the bow and the other near the stern of the vehicle. Of particular significance, in addition to the positions of the propellers and the way in which they are mounted, is the fact that the pitch of the blades can be varied collectively as well as cyclically and that the propellers have been designed to rotate in opposite directions to each other.

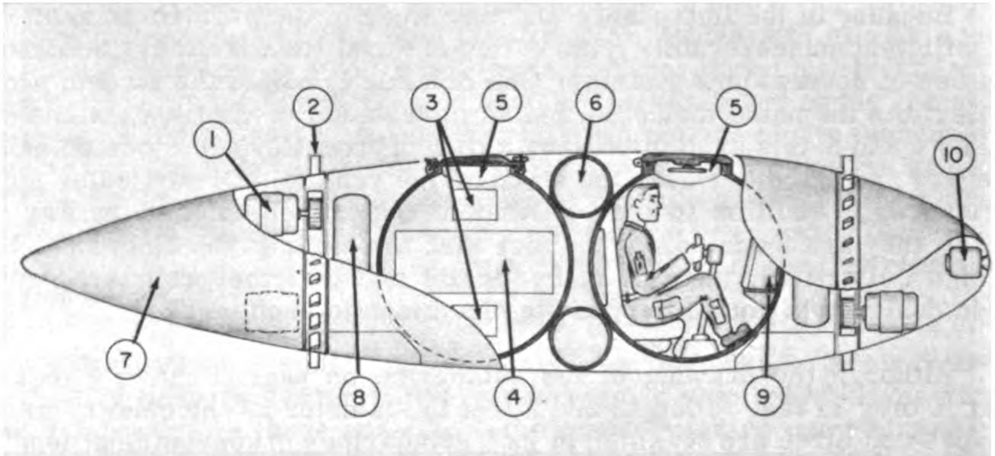
Although the drawing of the submarine on page 4 shows a vessel that is only 18 feet in length and 3 feet in diameter at the center, other shapes and sizes are feasible; in fact, submarines of conventional length and shape could be built utilizing this system, as is pointed out by the artist's concept on page 5. Also, the control units shown in the drawing need not occupy the exact positions indicated, but can be moved fore and aft over a rather wide range. Other rearrangements are possible, too.

Movements of the tandem propeller submarine forward and backward are achieved in the same way that they are by conventional changeable-pitch marine propellers. The only difference is that the propellers turn in different directions, the torque produced by one offsetting that produced by the other. To ascend or descend, the pitch of each blade is varied during each revolution so that on the downward half of the propeller's cycle, the pitch of the blades is greater than it is on the upward portion of the cycle. Thus, if the forward unit is rotating clockwise, its blades will have greater pitch while traveling down the starboard half of the vehicle than they do when traveling up the port side, and therefore will produce a force which will result in the upward movement of the vehicle. Obviously, the opposite situation is effected to move the vehicle down. (See drawings on next page.)

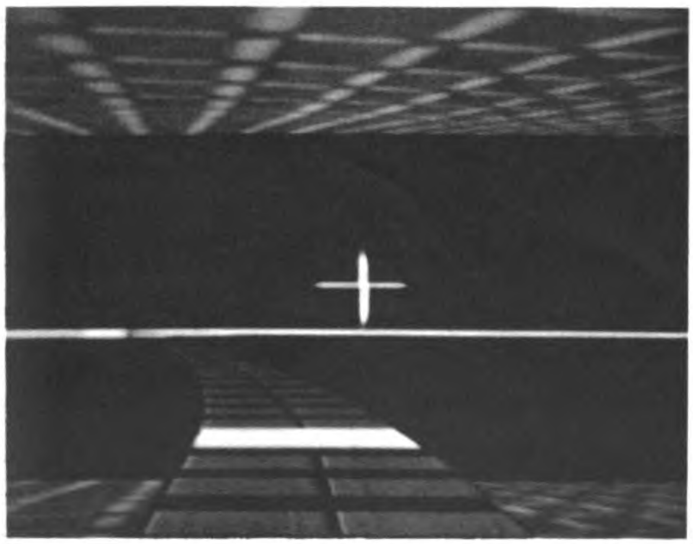
The vessel is kept on an even "keel" by programming the pitch variations of the blades so that each unit contributes equal torque. If this programming is changed, so that unequal torque is produced by the two propellers, the vessel will roll. It is not difficult to see that as many variations in roll are possible as are variations in other types of movement.

While cruising, the forward motor is feathered, and the sub is powered by the after propeller only. The vehicle can then be maneuvered according to the same forces that are applied in maneuvering a conventional submarine.

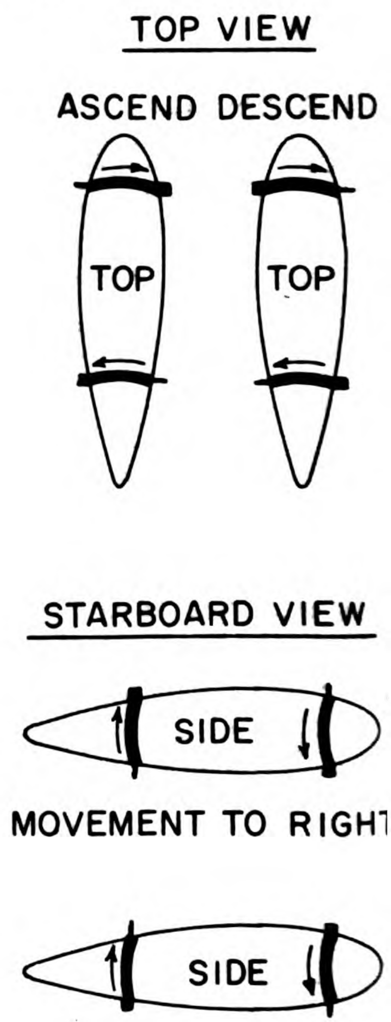
Although the motor utilized to turn the propellers is electrical, it is unique in that it is an inside-turned-outside version of the conventional motor—and the largest such version yet built. Thus the moving part, or armature, to which the propeller blades are attached, encircles the electric field (see cutaway drawing of motor on page 5). The motor is unusual also in that the propeller blades, blade motors, and the armature are immersed in ocean water. Consequently, the electricity which powers the motors turning the blades must be passed across the water medium. This is done by means of a rotary transformer.



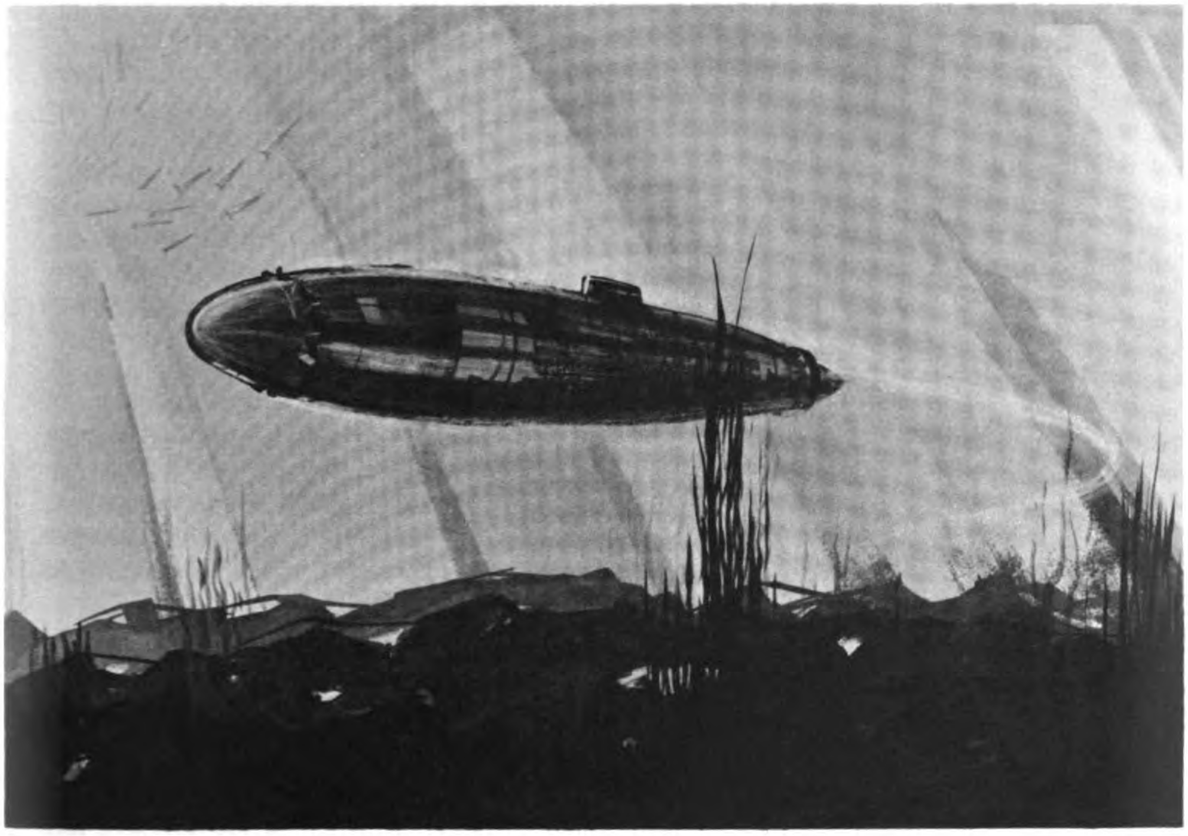
Artist's concept of an 18-foot tandem propeller vehicle. 1, D. C. oil-filled motor; 2, propeller and blades; 3, instrumentation; 4, batteries; 5, pressure spheres; 6, air tank; 7, superstructure hull; 8, ballast tank; 9, information display for operator; 10, TV camera.



"Roadway-in-the-sky" display to be used to maintain control of tandem propeller vehicles. Ocean surface and sea floor (or maximum depth to which sub is allowed to descend) are delineated by light-gray grids extending across top and bottom of display. Curving "roadway" indicates submarine's planned course; white cross designates sub's bow; horizontal white line indicates horizon; and white marker on "roadway" provides information regarding sub's speed.

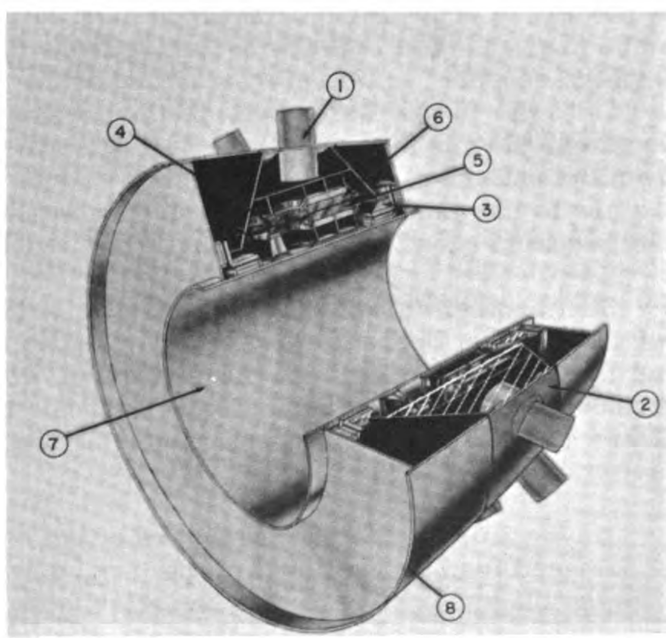


Demonstration of movements of tandem propeller vehicle up and d
and side to side while vehicle remains in horizontal position. For c
venience, only two blades are shown on each propeller.



Artist's concept of full size tandem propeller submarine.

Cutaway view of motor and propeller envisioned for full size tandem submarine. 1, individually controlled blade; 2, rotating structure (indicated by hatch marks); 3, water-lubricated friction bearings; 4, rotary transformer; 5, A. C. field; 6, armature; 7, pressure hull; 8, superstructure hull.



One of the advantages of the tandem propeller system which is immediately apparent is the versatility of movement which it affords. As a matter of fact, it permits maneuvers to be made that have never before been possible for any vehicle underwater. For example, the ship can drive sideways or nose upward into a vertical position and then stand on its "tail." At present, no tactical requirements exist for such "antics," but the needs may very well change in the future. As one may recall, when the first helicopters were being developed only a few decades ago, some pilots of fixed-wing aircraft questioned the usefulness of the apparently bizarre movements the new aircraft were expected to make. They were proved wrong.

The absence of a propeller or propellers on the extreme stern of the new sub gives the vehicle another kind of capability that modern submarines don't have. It enables the stern to be used for such important purposes as weapons launching, towing, and retrieval of objects in the ocean. Obviously, late-model nuclear subs, which employ a single propeller mounted at the apex of a conical stern, either cannot perform these tasks at all or cannot utilize the stern in doing so.

A third desirable feature of the new submarine is that its hull is not encumbered by control appendages such as rudder and stern planes. These projections, which add weight and mechanical complexity, are essential to the control of conventional subs at medium and high speeds, but are of little use at low speeds and of no use while the sub is motionless. On the tandem propeller vehicle, rudder and stern planes are not needed for either high or low speeds because control can be maintained simply by varying the cyclic pitch of the propeller blades.

Equipped with tandem propellers, Navy submarines could dive many times deeper than they are able to now. They could do so because they do not utilize propeller shafts, which must turn in rather large openings in the pressure hull that are becoming more difficult to seal as submarines go deeper. As the driving motor of the tandem propeller vehicle is immersed in sea water outside the pressure hull, the only penetrations that have to be made in the hull are for electric cables which run from the batteries to the motor in the 18-foot model and from the generators to the motor in the large unit shown on page 5. These lines are easily sealed because they are small in diameter and do not rotate.

Still another important characteristic of the tandem propeller is its relatively quiet operation—obviously vital to many research activities and to all missions carried out in time of war. Little sound is made because the propellers rotate slowly—at not more than 50 rpm—which means that the blades carry rather light loads and create little or no cavitation.

As the hull-encircling propellers of the new sub are more likely to be damaged than conventional propellers, a fixed shroud may be placed over the blades, particularly of the after unit. In addition to protecting the blades, this cover would increase the efficiency of the propeller because it would serve to distribute the flow of water more evenly among the blades and prevent excessive flow of water around the tips of the blades. Furthermore, like rudder and stern planes, an after shroud would serve to give additional stability to the ship when it moves at high speed.

Once ships of this type have been built, they are certain to be in demand to perform a wide range of tasks. One of the most important may be to serve as fleet ballistic missile submarines. A tandem propeller FBM submarine about equal in size to the conventional FBM ship would provide precise control of ship attitude during missile firing at zero and low speeds. Another application might be for reconnaissance—for example, to determine the locations of such enemy equipment as hydrophone arrays, cables, and mines. And these subs might be employed in the salvage of sunken ships, and in carrying out rescue operations at great depth or in ocean areas otherwise inaccessible to conventional rescue devices. In addition, the vessels might be used as undersea tugboats to move transducers and other heavy gear. Other assignments could include undersea research, the repair, adjustment, or replacement of research or military equipment underwater, and the refueling of ships and stations far beneath the ocean surface.

Obviously, the production of tandem propeller submarines equal to these tasks will require much additional research and subsequent development work. Although the concept has been demonstrated to be sound, further studies need to be made particularly of certain mechanical and electrical functions of the motors and propellers. For example, large-diameter water-lubricated bearings must be perfected to enable the propellers to revolve efficiently and quietly (see drawing on page 5), and the large inside-turned-outside electric motor called for by the new design must be refined. Important also is the problem of meeting the requirements of the human operator in controlling the submarine through the six degrees of freedom afforded by the system. As envisioned now, information will be displayed in large part by means of a "roadway-in-the-sea" picture (see photo, page 4) similar to the "pathway-in-the-sky" picture developed for aircraft control (see Naval Research Reviews, January 1960). Such displays convert most of the data needed by an operator to control his ship into constantly changing pictures which he can view and grasp the meaning of at a glance.

Investigators will reach a better understanding of some of these problems next summer when they will test an 18-foot all aluminum model of the vehicle. This craft, which will be designed both for remote control and for control by an operator aboard, is now under construction at the Netherlands Ship Model Basin in Wageningen, Holland. It will be completed next month, then will undergo preliminary testing in Holland before being delivered to the David Taylor Model Basin in Washington, D. C., where final tests will be made when schedules permit.

Many centuries ago, man dreamed hopefully of propelling ships through the water by oxen-powered treadmills. Although a great many advances have been made in the development of ship-propulsion systems since that time, man still goes on dreaming of better ones. His dream of today—a system that will enable him to reach the bottoms of the oceans in large, highly maneuverable submarines—is well on the way to realization.

An investigator prepares to photograph a porpoise to obtain information on the animal's swimming motions.

Calculating the Swimming Speeds of Marine Animals

If ships, boats, subs, missiles and other ocean vehicles could move through the water as efficiently as many marine animals do—in terms of their weight and power output—they would be able to glide much more swiftly on their way. Consequently, hydrodynamicists, who have known about the swimming prowess of ocean creatures for centuries, have looked upon them as models for improved hull designs. Of course, before they can obtain helpful information from the models, they must know as much as possible about them. In an attempt to elucidate some of their features, T. G. Lang of the Naval Ordnance Test Station, Pasadena, California, for several years has been making determinations of the speeds at which certain fish and cetaceans actually swim. During the early phase of this work he was supported by the Office of Naval Research.

Mr. Lang bases his calculations on various body sizes, weights, and power outputs. He is doing this for a wide range of exertion periods, for both laminar (streamlined) flow and turbulent flow conditions, and for animals ranging in weight from 2 pounds to 200,000 pounds—the latter being the weight of a large blue whale. The speeds which he thus assigns to the animals are then compared with the speeds at which the creatures have been reported to swim.*

*The reports of swimming speeds referred to in the following paragraphs were derived from the open literature.

Porpoises, for example, have been sighted swimming at speeds of 17 to 18 knots for periods of 8 to 25 minutes. The calculated top speed of the porpoise for this period, when swimming under the expected turbulent flow conditions, is only 11 knots, whereas it is 17 to 18 knots under laminar flow conditions. It would thus appear that either the porpoise's power is four times greater than expected or he achieves full laminar flow. The latter is probably the correct explanation.

Another interesting calculation was made of the speed of a killer whale 15 to 24 feet long. This animal was reported to approach a ship at about 30 knots, then swim around it for 20 minutes at a speed greater than that of the ship, which was 20.6 knots. As the expected speeds of this animal for periods between 15 minutes and 2 hours is about 16 knots (mostly turbulent flow) and 35 knots (laminar flow), the whale obviously had achieved either about 50 percent laminar flow or had utilized about 5 times the expected power. Again, the absence of substantial drag appears to have permitted the swimming feat.

A calculation of sustained swimming at high speeds was made of a school of black fish (a type of whale that is between 12 and 15 feet long) which was reported to circle a Navy ship traveling at 22 knots for several days. For these whales, the daily calculated speed is 9 to 10 knots (mostly turbulent flow) and 16 and 18 knots (laminar flow). For a 2-hour period, the speed attained with laminar flow would be 24 knots. This calculation indicates that the whales probably achieved full laminar flow. It also suggests that they have remarkable endurance, for by comparison, the finest specimen of man could continue a comparable activity (in terms of energy expended) for only 2 to 4 hours.

Mr. Lang's calculations indicate that although laminar flow is highly advantageous, it is not essential for fast swimming by large animals; nor are unusual power ratios necessary. In full turbulent flow, the 200,000-pound blue whale might travel at 18 knots all day long and 24 knots for 2 hours. For the same time periods, these speeds exceed those of any other sea animal weighing up to 1,200 pounds, even those swimming in full laminar flow. As a matter of fact, the blue whale could travel all day in turbulent flow at a speed about equal to that attainable by a 200 pound porpoise while swimming in full laminar flow for a period of 15 minutes.

In the course of studies such as this one, many hypotheses have been set forth by various investigators to explain the superior swimming abilities of sea animals. As might be expected, body shape and body undulations have figured prominently in these. According to Mr. Lang, however, one of the most reasonable hypotheses is one by Dr. M. Kramer that places emphasis on the effects of the resilience of the animal's skin. Because of this characteristic, tiny disturbances in the flow of water around his body that normally build up to cause turbulence are damped out, and laminar flow is maintained.

Mr. Lang is not alone in his effort to solve this difficult question. Another similar study is currently underway in the Department of Zoology at the University of California at Los Angeles. This research, which is supported by ONR and directed by Vladimar Walters, is concerned with large fish, such as tuna, mackeral, and skipjacks, instead of cetaceans primarily. Its purpose is to determine the relationships between the various shapes, sizes, and skin temperatures of these animals to hydrodynamic features.

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Cruise XVIII: The VEMA's Longest

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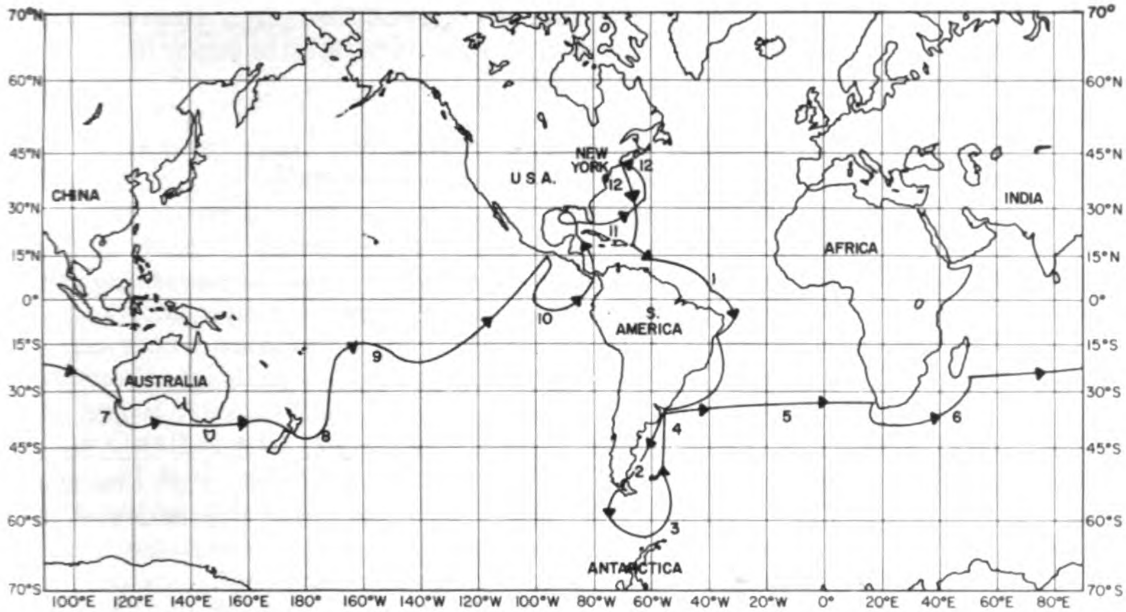
When the Lamont Geological Observatory's* research ship VEMA returned from her last voyage, in December, she had logged so much mileage that if one didn't know her calling, he might assume her to be a spacecraft. The ship had traveled 56,000 miles—equivalent to more than one-fifth the way to the moon—which is more the order of distance one associates with astronauts than oceanographers. But the fact that the cruise took place on the oceans and not in space makes it none the less valuable, for during the 373-day round-the-world journey—the VEMA's longest both in point of time and distance covered—her scientists gathered an unusually impressive quantity of valuable research data.

The VEMA's eighteenth scientific cruise began with the ship's departure from her home port at Piermont, New York, on December 1, 1961. and it ended with her return to New York on December 8 of the following year. During this period, the VEMA was at sea a total of 326 days. First she sailed southward to Bermuda and Puerto Rico, then passed down the east coast of South America, stopping at Recife, Brazil, and Buenos Aires, Argentina. For three months she conducted intensive geophysical investigations in the Argentina Basin, Scotia Sea, and Drake Passage, receiving considerable cooperation from Argentine and Chilean naval vessels.

After returning to Buenos Aires, she crossed the Atlantic to Cape Town, South Africa, and then went on to Port Louis, Mauritius, in the Indian Ocean. Here, the VEMA represented the United States in this country's first participation in the International Indian Ocean Expedition (Naval Research Reviews, August 1962), making a survey of a hitherto unexplored sector of this important body of water. Subsequently, she proceeded to Fremantle, Australia; Wellington, New Zealand; Pago Pago, Samoa; and Papeete, Tahiti; then crossed the Pacific and passed through the Panama Canal. Before returning to New York via the Bahamas and Bermuda, the VEMA visited several areas of interest in the Caribbean.

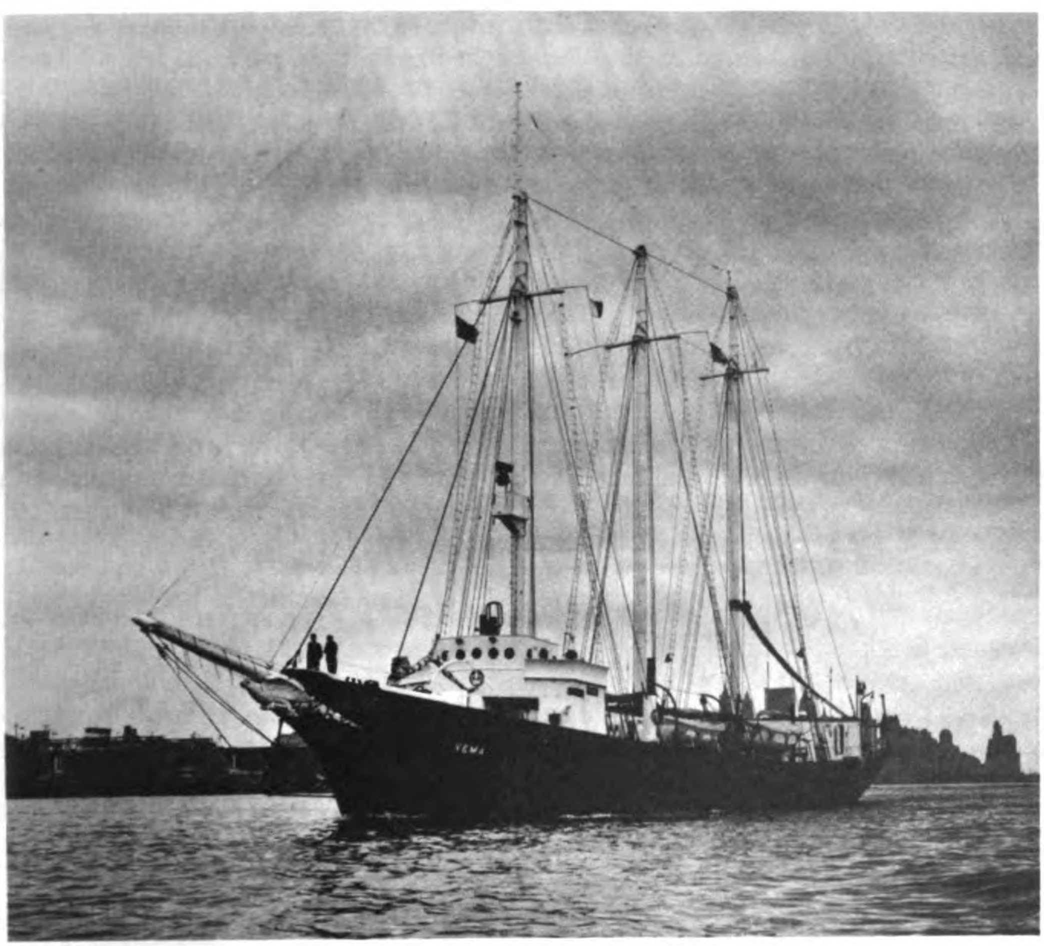
The scientific program included a comprehensive depth survey of the North and South Atlantic, the Indian, and the Pacific Oceans, and the Gulf of Mexico to delineate the bottoms of these bodies of water. Also, observations were made to obtain additional knowledge of the geophysical structure of the earth. Special emphasis was placed on the profiler method of measuring thicknesses of layers of sediment on the deep sea floor. This method consists of firing small explosive charges at short intervals and picking up their signals reflected from the bottom and

*The Observatory's activities are supported in large part by the Office of Naval Research.



Map showing track of VEMA on 56,000-mile voyage. Each number along track designates month the ship was at that location.

Lamont Geological Observatory's research ship VEMA.



from other reflecting material beneath the bottom by a hydrophone drifting aft of the ship. Recordings are made on facsimile paper similar to that used in precision depth recorders.

Other research included the first continuous circumglobal measurements of gravity in the Southern Hemisphere; extensive coring and dredging of the bottom; topographic studies of the trench north of New Zealand; additional investigatinns of the Middle America Trench in the Pacific off Central America; complete heat-flow measurements along many sections of the ship's track, using the Lamont Thermograd; Radiochemical analyses of large volumes of water to determine water ages and circulation rates; and examinations of a 45,000 mile continuous, branching crack which occurs along the top of the Mid-Atlantic Ridge in the Atlantic Ocean, runs around the Cape of Good Hope to the Indian Ocean and Red Sea, and extends into the Pacific Ocean as far as the East Pacific Rise. A total of 379 long, deep-sea cores was also taken during the expedition.

For biologists on the Lamont staff, numerous samples of macro- and micro-organisms were collected from the sea, from sediments and rocks taken from the ocean bottom, and from a number of islands that were visited. These samples were preserved, then shipped to the laboratory ashore for analysis. Variations in the distribution of the organisms—both with time and area—are determined, and cultures are made from some specimens as a first step in the unrelenting search for new sources of antibiotics.

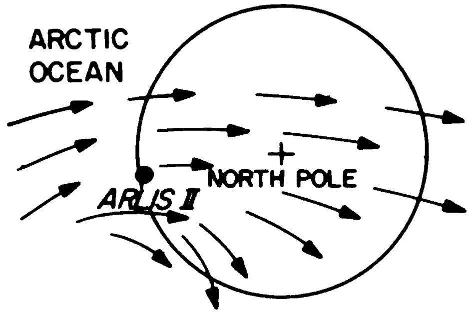
A veteran research ship, the VEMA made her eighteenth cruise in very nearly the same number of years that have passed since she was purchased for Lamont by Columbia University. She was built in Copenhagen, but during World War II was owned and operated by the U. S. Navy. Later she was acquired by the university. Since she began her research work, the VEMA has been utilized primarily to conduct geophysical studies intended to lead to an understanding of the geologic structure and acoustic properties of the ocean floor. However, a variety of other important research has been carried out aboard her, too.

Although the VEMA is now 38 years old—a ripe age for a vessel called upon to perform exacting research tasks—plans are being made for her further service during Cruise XIX. If the voyage completed in December is an example of the contribution she is still capable of making, then the VEMA has a highly productive life yet to live.

Nuclear Physics Contract Renewed

The Office of Naval Research has renewed its contract with the University of Chicago for continued fundamental research in nuclear physics. The amount of the renewal is $1,250,000.

During the decade following the establishment of the ONR synchrocyclotron laboratory at Chicago, the facility has been a highly productive source of information regarding the properties of the pion and muon. For this reason, much of the research that will be done under the contract in the near future will concern the properties of these particles.



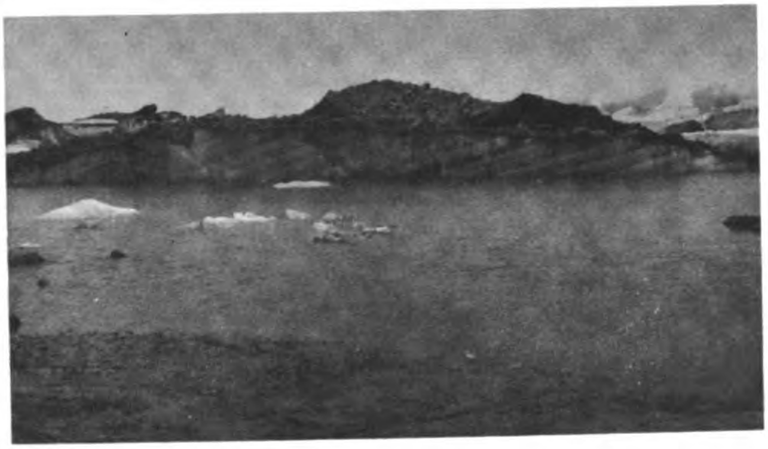
Ice Island at a Fateful Crossroads

Some of the northernmost islands of the Canadian Archipelago are covered by ice which flows as glaciers down deep valleys to the Arctic Ocean. Upon reaching the ocean, this ice flakes from the glaciers' terminal faces and joins the pack ice, which covers most of the ocean the year around. Usually, the chunks of fresh-water ice that enter the sea are relatively small, and so become virtually indistinguishable from the pack ice. But occasionally, very large masses—a mile or more long and 100 feet or more thick—are deposited in the sea. These bodies may jut well above the surrounding pack ice, appearing like small islands. The chief clue to their identity is that although they are here today, they may be gone tomorrow, drifting off with the constantly moving floe ice.

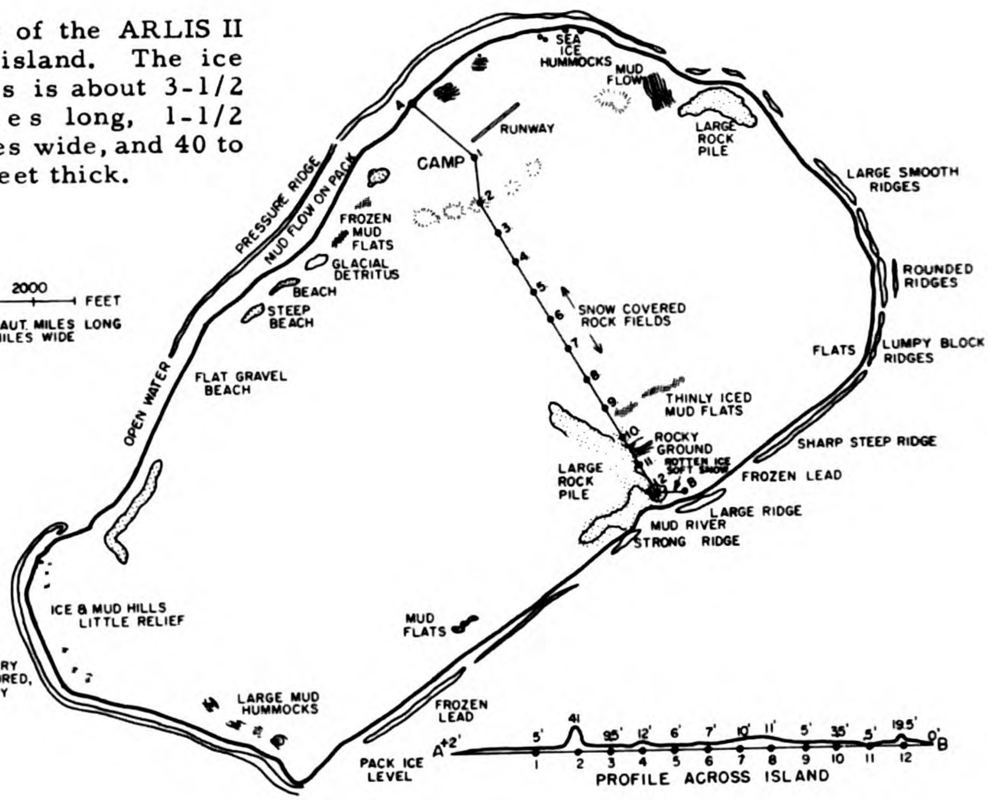
At some time in the past, a large mass of ice carrying part of a moraine (rock debris pushed into a large mound by a glacier), probably on the northwest coast of Ellesmere Island, separated from the glacier and joined the floe ice. The newly born "island" had flat "lands" covered by lakes and ponds, and mounds of rocks and boulders which accumulated as the original glacier passed through the highlands of Ellesmere. Continued ablation reduced the size of the ice island and left low ice-cored, rock-covered hills where the mantle of glacial debris was sufficient to protect the ice against melting and evaporation. A beach was added to the geography later on as the result of the island running aground on a mud flat, perhaps in the fiord at the mouth of the "mother" glacier, then moving off again, carrying the mud with it. Later, this fine material was exposed at the island's edges.

Along one side of the island, the ice weakened and fractured, allowing sea water to flow in and form bays. These bays froze solid, then were covered by layers of fresh-water ice produced by melting snow. Finally, the layers of salt and fresh-water ice were bent and folded by the flanking masses of glacial ice. Many other changes took place in the island as it moved away from Ellesmere Island and began drifting with the ocean currents and the pack ice southwestward toward the Beaufort Sea.

How long ago these events occurred is not known, but it is possible that the surface of this glacial ice is the peculiar one Dr. Frederick Cook reported crossing in 1908 on a journey over the Arctic Ocean. The large mass of floating ice could also be the "island" sighted by Admiral Peary on his famous sledge trip toward the Pole in 1909. And it might be "Takpuk," the mysterious island which disappeared off the northern coast of Alaska after being examined, photographed, and named by Eskimoes in 1931. Furthermore, the island fits the description of one sighted in April 1959 about 12 miles from Ellef Ringes Island, which lies southwest of Ellesmere Island. The 1959 discovery was made by



Vertical face of stratified bluish ice formed on ARLIS II, probably by the freezing of sea water.

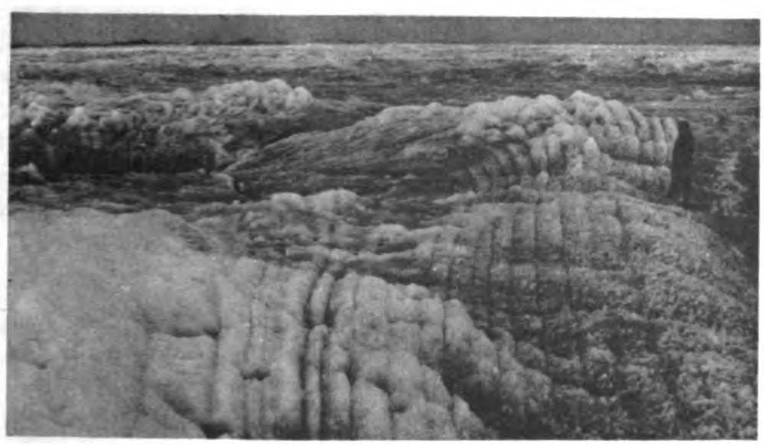


Map of the ARLIS II ice island. The ice mass is about 3-1/2 miles long, 1-1/2 miles wide, and 40 to 80 feet thick.

An outcrop of mud on ARLIS II. The mud layer lies beneath gray glacial ice. Apparently at one time in its early history the ice island ran aground, picking up the mud from the ocean bottom.

A Navy plane skims low over ARLIS II. In the background is a row of the island's rocky hills.

Workers set up one of ARLIS II's prefabricated insulated buildings.



Thick section of banded and folded fresh-water ice on ARLIS II.

members of the Canadian Polar Continental Shelf Project party led by Dr. E. F. Roots. This group set up a base on the floating glacial ice and conducted studies there during the following summer.

After the island was abandoned by the Canadians, it probably continued to move southwestward, a "forgotten" wrinkle on the vast surface of the pack ice. Then in May 1961, Max Brewer, Director of ONR's Arctic Research Laboratory, spotted what is almost certainly the same island while flying from Barrow across the Beaufort Sea toward an ice floe which had been selected as the site for a scientific station. The huge mass of glacial ice, about 1-1/2 miles wide and 3-1/2 miles long, with rock covered hills rising about 40 feet above the surrounding ice floes, was then about 1,000 miles from the location of the island which the Canadians had occupied in 1959. Because the glacial ice was much thicker than any of the floe ice (the island ranged from 40 to 80 feet in thickness), and was therefore much more substantial, Brewer immediately changed plans and decided to set up his new station here. Its name was agreed upon just as quickly, following a practice already established—"ARLIS II," for Arctic Research Laboratory Ice Station II (Naval Research Reviews, September 1961.) [ARLIS I, the first ice station established by ARL, had been set up on floe ice in September of the previous year. Between that time and May 1961 when it was abandoned, it had traveled more than 500 miles—to a point about 100 miles northwest of the new station (Naval Research Reviews, December 1960).]

Within about three weeks of the time Brewer sighted ARLIS II, about 146,000 pounds of equipment and supplies were flown to the island, fourteen 12-by-16 foot prefabricated buildings were set up, and about a dozen scientists were at work conducting a variety of studies of the Arctic surroundings and the forces at work there. The research concerned such subjects as underwater acoustics, marine biology, oceanography, geology of the island, magnetics, seismology, gravity, meteorology (including sea-ice micrometeorology), and strain effects on the pack ice. From the scientists' point of view the natural moving platform and the little-known region through which it traveled were an excellent combination. Only in one other way—by allowing a ship to be frozen into the pack ice—would it be possible to make such a long journey and still provide facilities for comfortable living and for carrying out many different research projects as well.

Whereas a powered ship has the advantage—at least during the summer—of maneuvering in and perhaps making its escape from the pack ice, if such is the desire, the massive ice island must remain a prisoner and go where the drifting pack ice will take it, regardless of the time of year. Thus, as the scientific work aboard ARLIS II went forward, so did the island—at an average drift rate of about one-tenth of a knot, moving from a few hundred miles off the coast of Alaska to about 350 nautical miles from the Pole, where it was located last fall. Insofar as this movement had taken the scientists to new areas for their studies, it was welcomed. But it had also stretched out the supply lines, which no one could be happy about.

The problem of supplying the island for the approaching winter—particularly with a large quantity of fuel oil—suddenly became serious last fall with the development of the Cuban crisis. During the critical month of October, while ARLIS II was more than 850 nautical miles from

Barrow, no U. S. aircraft of sufficiently long range was available to carry fuel oil to her; all had been alerted for assignments that might arise as a result of the tension in the Carribean. ARL's R4D aircraft, used to supply the island with food and light equipment, and to rotate personnel, could carry only a few drums at a time because of the distance to the island and the plane's small payload capacity.

Fortunately, the previous summer, the USS BURTON ISLAND had broken through the pack ice to Fletcher's ice island (T-3), which was then located about 450 nautical miles from Barrow, and had unloaded 640 drums of fuel oil. (On this voyage, the ship penetrated 120 nautical miles farther north than any ship had done previously under its own power.) Therefore, by flying to T-3 and picking up its load of fuel oil there, the R4D was able to carry a few more drums on each trip than it could by hauling the load all the way from Barrow.

In this way, the ARL plane kept the island supplied with oil until late October. Then it developed engine trouble and had to stay at T-3 until repairs could be made. As the days passed, the fuel supply on ARLIS II dwindled to a critical low.

Relief came from Canada. The RCAF, learning of the scientists' plight, dispatched a C-130 to Barrow for use as a supply plane. This aircraft carried 43 drums of oil and a new engine for the R4D. It flew to T-3, deposited the engine, then continued on to ARLIS II with the oil—another two weeks' supply, which provided time to arrange for the major resupply that was needed to carry the station through the winter.

Arrangements for the airlift were finally made through MATS. In a 12-day period, six C124 aircraft made a total of 15 flights to the island, carrying about 315 drums of fuel oil and aviation gas. The drums were dropped over the beleaguered camp, four to a chute. Of this total, only

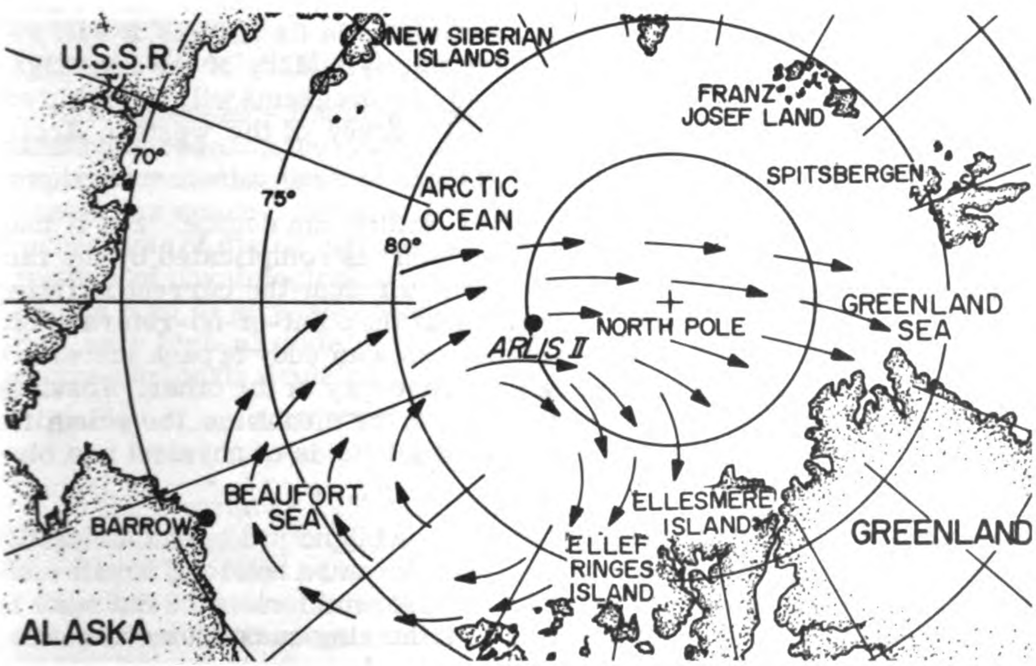


Chart of north polar regions showing location of ARLIS II and directions of ocean currents (indicated by arrows) affecting her course.

12 drums were not recovered, which was far below the percentage loss expected. The operation was completed on November 30, providing enough fuel to keep ARLIS II's research going through May 1963.

Of course, the same problem will arise again next spring. In fact, the logistics may become even more difficult to manage—depending upon the course the island takes during the next few months. The uncertainty exists because ARLIS II stands at an important crossroads. If it continues to remain under the influence of the clockwise current which sweeps the western Arctic Ocean, including the Beaufort Sea, it will turn southward again—back toward Ellesmere Island, its hypothetical "home." But it may also be affected by a strong current which branches from the clockwise current near the island's present location. This stream would sweep the island across the Pole into the Greenland Sea and possibly on into the Atlantic Ocean. (See map on page 17.)

If the island moves over the Pole, it will cross the great submarine Lomonosov Ridge, presenting U. S. scientists the best opportunity yet to study this feature, previously investigated only cursorily by this country. The structure, which extends more than 1,000 miles across the Arctic Ocean Basin from the continental shelf north of Ellesmere Island to the shelf north of the New Siberian Islands, divides the ocean region into two sub basins. Based on current interpretations of geophysical data, the ridge appears to represent an extensive belt of folded and metamorphosed sedimentary material. More detailed studies of the ridge would be advantageous. However, if the island takes this course over the Pole, the problem of supplying it will be much greater. Also, the over-the-Pole current could carry the island to its eventual destruction far southward in the relatively warm Atlantic Ocean.

If the island continues its circuit in the western Arctic, the supply problem will diminish gradually. Furthermore, the island will be preserved and, unless it runs aground somewhere in its travels, it will remain useful as a scientific station indefinitely. Many of the investigations now underway will be continued, and new programs will be initiated, with the advantage that a more complete survey of the western Arctic will be obtained.

Which way will ARLIS II go? Only Nature can decide. But it may take its time about doing so. The "decision" is complicated by the fact that the wind is likely to be more of a factor than the current in fixing the island's eventual course. The arrival at the point-of-no-return could also be delayed by the island being drawn into an eddy of pack ice where it will twirl for months before being swept one way or the other. Possibly by spring her destination will be apparent. In the meantime, the scientific work will continue, with studies in almost all fields of physical and biological science.

Scientists do not know how long the ice island has been touring the Arctic Ocean, and they are not able to say for sure how long it will continue to do so—assuming it survives the present "crisis." But what is more important, because of it they are fathoming numerous other Arctic secrets—many of them far more valuable for man to learn.

—R. D. O.

Research Notes

Oxygen Rationing Underwater

How the alligator is able to "hold its breath" underwater for long periods of time and survive—even though it is equipped with respiratory and circulatory organs similar to those of land creatures—has been explained by Dr. Harald T. Andersen, a physiologist at the University of Oslo, Norway. Dr. Andersen studied the question with Dr. Per F. Scholander, Professor of Physiology at the Scripps Institution of Oceanography, with the support of the Office of Naval Research and the National Science Foundation.

After performing a series of physiological tests on 14 American alligators (mississippiensis) acquired from the San Diego Zoo, the two investigators found that this animal can submerge for about two hours because it employs certain physiological mechanisms which ration the supply of oxygen to important organs and tissues. For instance, Dr. Andersen determined that lactic acid, which forms in the muscles during diving, does not appear in the animal's blood until after it emerges from the water. This suggests that the flow of blood through the muscles is greatly reduced, or even shut off, while the alligator dives.

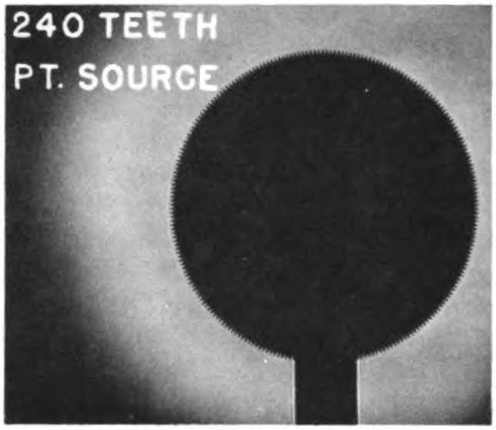
The alligator's heart, which slows to just two or three beats a minute, may be the only muscle which receives oxygen during the period of submersion. Such slowing of the heart's activity is an adjustment made by all other diving animals, too.

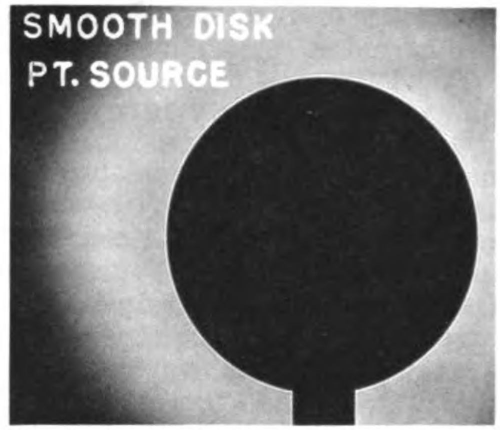
Another determination made through the study was that as much as one-half of the alligator's oxygen supply is consumed during the first 20 minutes of a two-hour dive. Nevertheless, the alligator remains conscious throughout the remaining 100 minutes of his dive—until his oxygen is almost depleted. Then he returns unharmed to the surface.

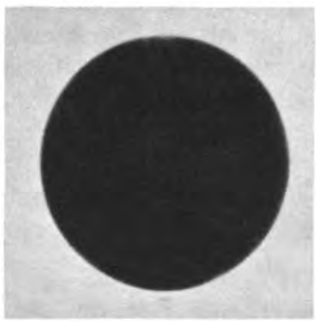
Dr. Andersen's findings constitute a valuable addition to the understanding of respiratory systems. Until they were made, knowledge of the respiratory mechanisms of "cold blooded" divers—of which the alligator is one—was scarce. Information on this subject—and on the respiratory mechanisms of diving birds—is of value to the Navy as part of a general program of physiological study particularly because of the Navy's need to adapt man to stressful conditions, such as may exist beneath the sea or at very high altitude if the oxygen supplies carried to support him become seriously depleted.

Correction

In the December 1962 issue of Naval Research Reviews, announcement was made of the appointment of Dr. Gerald M. Clemence, scientific director of the Naval Observatory, to the chairmanship of the Division of Physical Sciences of the National Academy of Sciences—National Research Council. Through an error, the title of the announcement indicated that Dr. Clemence was leaving the Observatory to assume the new duties. Actually, he has not left, but will take on the new responsibilities in addition to those which he now has as scientific director of the Observatory.







Improved Coronagraph

Short-exposure photographs of shadows cast by sawtooth and smooth occulting discs (above) and long-exposure photographs showing amount of light which creeps into the disc shadows (below). In the photo at lower right, streaks are caused by minute nicks on edge of disc; a concentration of light occurs also at center; wedge-shaped area is produced by support. Note absence of light in shadow at lower left.

From the ground, the outer solar corona can ordinarily be studied only at time of total eclipse, when the moon blots out the solar disc (leaving only the corona visible) and also reduces the sky brightness to nearly a night-time level. For satellite-borne solar "observatories," the skylight is absent; and if the bright surface of the sun is eclipsed by artificial means, such as by an opaque disc placed at some distance in front of the telescope aperture, the corona then stands out clearly against the black sky of outer space and becomes visible (and thus measurable) in the field of the telescope. A telescope used in such a way is called a coronagraph.

Although the earth satellite has made the corona accessible for continuous observation, the observation itself is still very difficult. The limiting factor now—instead of skylight—is the very bright light of the solar disc itself. A smooth-edged occulting disc diffracts sunlight into the coronagraph, and special methods had to be developed to prevent any sunlight from entering, since it is desirable to measure a brightness which is one billion times dimmer than the sun.

Scientists at NRL have solved the problem by modifying the occulting disc of the coronagraph. Saw teeth have been cut around the edge of the disc so that light diffracted from the edge is redirected away from the aperture of the coronagraph. The disc presently being used has a total of 240 teeth around the edge, each about 0.7 millimeter high, with an angular spacing of 35 degrees.

The observed coronal pattern is never the same from eclipse to eclipse, and the changes which occur are extremely large. In addition to the long-term changes, there are no doubt day-to-day and even hourly changes, though little about these is known. Continuous observations of the corona will do much to increase our knowledge of these processes occurring in the sun. NRL's improved coronagraph will provide this increased coverage. After being tested in two separate rocket flights, it will become part of the instrumentation included in NASA's S-17 Orbiting Solar Observatory.

Four-Engine Research Plane Readied

A four-engine C-54 airplane capable of taking scientists and equipment to any part of the world's oceans is now being converted for use by the Woods Hole Oceanographic Institution. The new plane, which normally will carry a scientific party of eight men and a crew of 5 men, will be used primarily for meteorological studies. However, it will also be equipped for tracking scientific buoys, taking temperature readings, and for conducting geological and geochemical investigations. Its first major expedition will be to the Indian Ocean in May.

The Office of Naval Research has arranged for the C-54 to be loaned to the Institution on a continuing basis.

Measuring Mercury Poisoning

The almost universal use of mercury in industrial and research laboratories has resulted in numerous poisonings—primarily through the saturation of the atmosphere by the element. The poisoning of workers in the hatting industry that gave rise to the "hatter's shakes" is a classic example of the toxic effects that mercury can have. Although such large-scale poisoning is now largely a matter of historical interest, the fact remains that mercury is still dangerous, mainly because it is so commonly used that workers tend to let their "familiarity breed contempt" and thus ignore its subtle toxicological hazards.

Realizing that a major contributing factor to the laxity which has existed in dealing with this problem is the time lag which occurs between exposure and analysis, the medical and analytical-chemistry staffs of the Naval Research Laboratory have cooperated to develop a rapid and sensitive method for measuring mercury ingestion by human beings.

The method devised at NRL permits the measurement of very small quantities of mercury in urine. Potassium permanganate is used to destroy the organic solids in the test sample, permitting the mercury to be precipitated from the sample as part of a sulfide. After the precipitate has been collected, it is subjected to quantitative examination by X-ray and Geiger-counter techniques, which reveal the amount of mercury present—30 counts per second for every 30 micrograms of mercury in the sample.

Determinations of mercury concentrations as low as 6 micrograms per 100 milliliters of sample can be completed within an hour of the time a sample is collected. Considering that it is generally agreed that clinical symptoms of mercury poisoning do not occur when the concentration of the element is less than 30 micrograms per 100 milliliters of sample, the method is more than adequate for the purpose. Due to this fact and to the simplicity of the procedures involved, the method should prove useful as a means of monitoring persons working in mercury atmospheres.

ONR Medical Scientist Wins Young Scientist Award

Dr. Joseph F. Saunders, ONR's branch head for medicine and dentistry, has earned the distinction of being the first ONR employee to be named for the Arthus S. Flemming Award. This award is given annually by the Washington Junior Chamber of Commerce, to 10 outstanding men in the Federal Service who are under 40 years of age. Five must be scientists or engineers. The awards, suitably engraved plaques, were presented at the Junior Chamber annual banquet on February 14.

Dr. Saunders has become widely known, both in the United States and abroad, for his organization and direction of the Navy's highly successful research program in the field of cryobiology—the study of tissues at extreme low temperatures. This program has evolved practical techniques for freezing whole blood and tissues so they can be stockpiled, or "banked," in cold storage.

A native Pennsylvanian, Dr. Saunders graduated from Pittsburgh's Duquesne University and did his graduate work (M.S., Ph.D.) at Georgetown during off-duty hours from his job at ONR. He is only 35, well within the qualifying age for the Flemming Award. (See also "People on the Way Up," SatEvePost, August 11, 1962, and "Cryobiology" NavResRev, November 1961).

Oceanographic Instrumentation Center

The Oceanographic Instrumentation Center, a new addition to the Naval Oceanographic Office, has gone into operation in Washington, D. C. The Center's staff of about 100 persons will be engaged in a broad program of development, testing, calibration, evaluation, and standardization of information-gathering instruments for the Naval Oceanographic Office and other government agencies and private organizations.

New instruments currently under development at the Center include improved electronic bathythermographs, shipboard wave recorders, shipboard survey instruments, submerged buoy systems, and sound velocimeters.

On the Naval Research Reserve

Marine Science Seminar Planned

Naval Reserve Research Company 1-2, Providence, Rhode Island, will conduct a Marine Science Seminar at the Naval Air Station, Quonset Point, Rhode Island, during the period June 9-22, 1963. For the past several years, ONR Boston has held a seminar for research reservists of that naval district. This year, because of the great interest in oceanography which now exists, the sponsoring company has offered to open the seminar to reservists from other naval districts. The tentative program of the seminar includes some of the most eminent east coast scientists and educators associated with oceanography. Also on the agenda are field trips to Raytheon, U. S. Underwater Ordnance Station, and to a Navy antisubmarine warfare squadron. Limited BOQ space will be available.

New Training and Liaison Officer Reports for Duty

CDR Langdon

CDR Frank H. Langdon, USNR, reported to the Office of Naval Research for duty as Training Officer and Research Reserve Liaison Officer for the Fifth and Sixth Naval Districts on January 21. Prior to reporting to Washington, CDR Langdon was Training Officer at the Naval Air Station, Willow Grove, Pennsylvania.

CDR Langdon received his B.S. degree in electrical engineering at the University of New Hampshire in 1939. He enlisted in the Navy in February 1942, was appointed an aviation cadet in August 1942, and received his wings in January 1943.

During World War II, CDR Langdon served in a torpedo squadron aboard the USS SUWANNEE, participating in the invasions of Tarawa, Kwajalein, Hollandia, Saipan, and Leyte. He has been an operations officer, assistant for aircraft in the Torpedo Branch of the Bureau of Ordnance, and has had duty at the Naval Air Station, Atlanta.

Seminar Postponed

The Research Reserve Seminar in Submarine and Diving Medicine scheduled to convene at the Navy Medical Research Laboratory, New London, Connecticut, on March 17, 1963, has been postponed until fall. The new convening date is October 6, 1963. Postponement of the seminar was necessary because quarters will not be available at the Medical Research Laboratory in March due to the heavy schedule of activities planned for that time.

Research Reservist Wins Award

LT Harold D. Wallace, USNR, Commanding Officer, Naval Reserve Research Company 6-4, Gainsville, Florida, has been named the recipient of the American Feed Manufacturers Association Nutrition Council's $1,000 Research Award for his outstanding work in swine nutrition. The lieutenant—Dr. Wallace as a civilian—is a University of Florida professor of animal science and animal nutrition. His work on animal nutrition was judged by the American Society of Animal Science to be the most outstanding in the field during the past three years.

W. T. Diamond, Treasurer of the American Feed Manufacturers Association, presents award to LT Harold D. Wallace, USNR (center). Dr. L. S. Pope of Oklahoma State University, chairman of the Awards Committee of the American Society of Animal Science, looks on.

Full Charge

The large background of research experience with lead-acid batteries that has been built up over the years at the Naval Research Laboratory has been applied to the solution of a serious problem which arose in the use of the lead-calcium storage battery--an important component of nuclear powered submarines (see photograph on front cover). Since the time these cells were first developed for submarine use, they have failed to operate under the required float conditions, which means that they will not charge continuously--so as to maintain the battery at full charge--without overcharging. Although a procedure was developed to permit the batteries to be used, it did not permit them to be used in the desired manner.

After an exhaustive investigation conducted at NRL, it has been shown by electron as well as optical microscopy that a considerable difference in morphology exists between the active material of the electrode of a cell which will float satisfactorily and one which will not do so. This valuable information is now being placed in the hands of the battery manufacturer in order that modifications in the active material of the electrode can be made to permit the batteries to be floated as required.

Measuring Water Vapor in the Stratosphere

In order to learn more about the absorption of solar and earth radiation by the stratosphere and about the circulation of air in this outer region, a knowledge of the distribution of water vapor at high altitudes and its changes with the seasons is very important. To obtain this knowledge, investigators at the Naval Research Laboratory are measuring water vapor in the stratosphere with a special frost-point hygrometer carried aloft by balloon. A silver mirror in the instrument is automatically controlled to stay at a temperature such that a given amount of frost will be retained on it; the temperature of the mirror is then measured and telemetered to a ground receiver. From the recorded temperature it is possible to calculate the amount of moisture in the atmosphere at a known altitude.

The NRL scientists have launched the hygrometers at several locations in the United States and also in tropical regions of India. These flights have pointed up the difficulty of obtaining accurate measurements of the moisture in the stratosphere because of the problem of obtaining an air sample whose water vapor content has not been altered by the presence of the balloon and instrumentation. If proper precautions are not taken, moisture carried by the instrument and balloon will contaminate the air sample; the amount of moisture contained in the sample will then exceed the amount normally present in the dry portions of the stratosphere, which is approximately one one-millionth of that on the ground.

Some of the measurements made so far indicate that the amount of water vapor increases with altitude between 50,000 and 100,000 feet. If this finding is varified by additional measurements, the determination of its cause will be of great importance to meteorology.

IN THIS ISSUE

\VAL RESEARCH Reviews publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington 25, D. C. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price: $1.50 per year in the U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this publication was approved by the Secretary of the Navy on March 1, 1961.

EDITORS: A. T. Drury and Richard D. Olson

NAVEXOS P-510

Framed by the huge cables of a submarine battery cell is Jeanne Burbank, an NRL chemist, who is testing the cell to determine why it has not charged properly. Such tests are conducted as part of research aimed at improv-