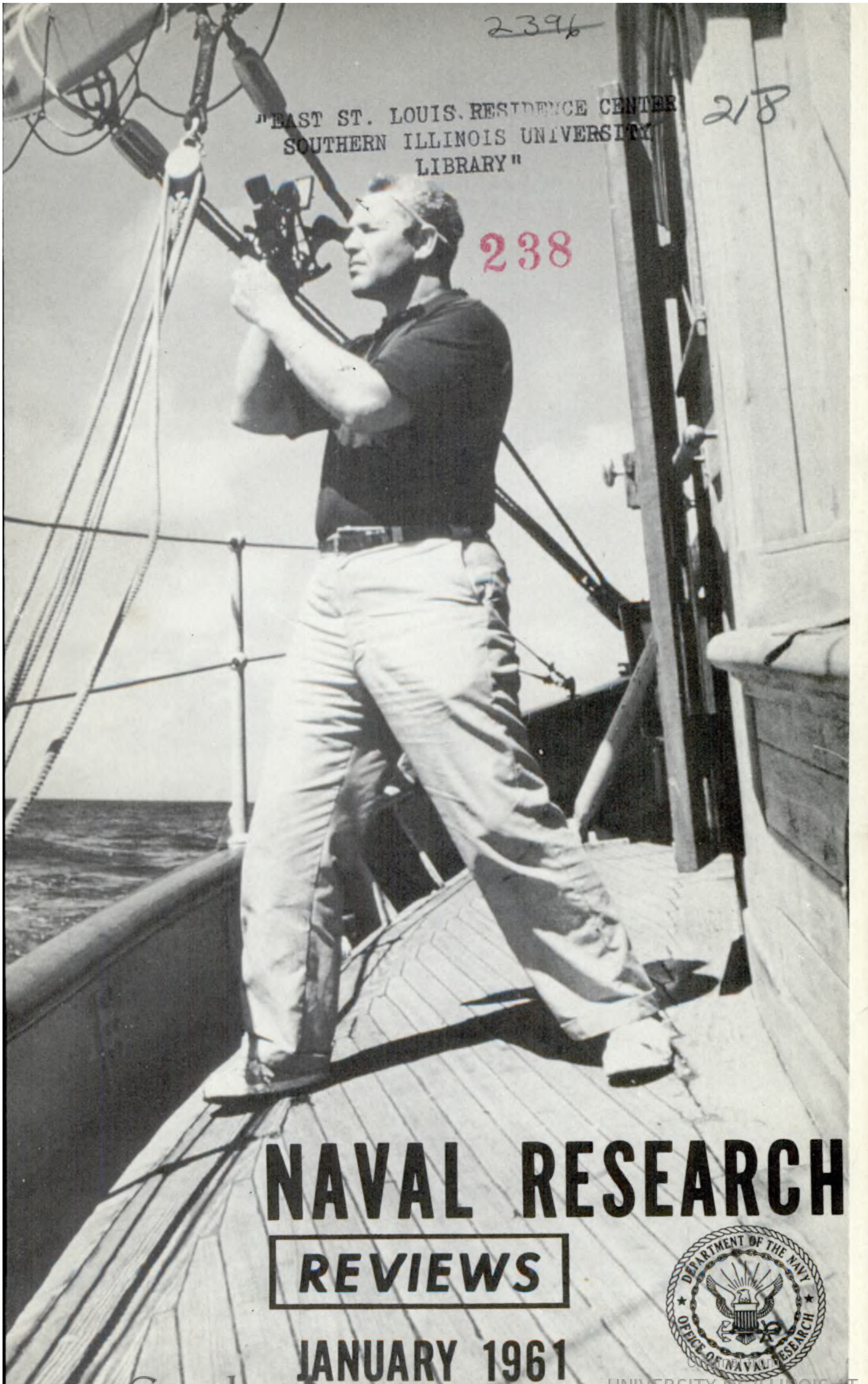


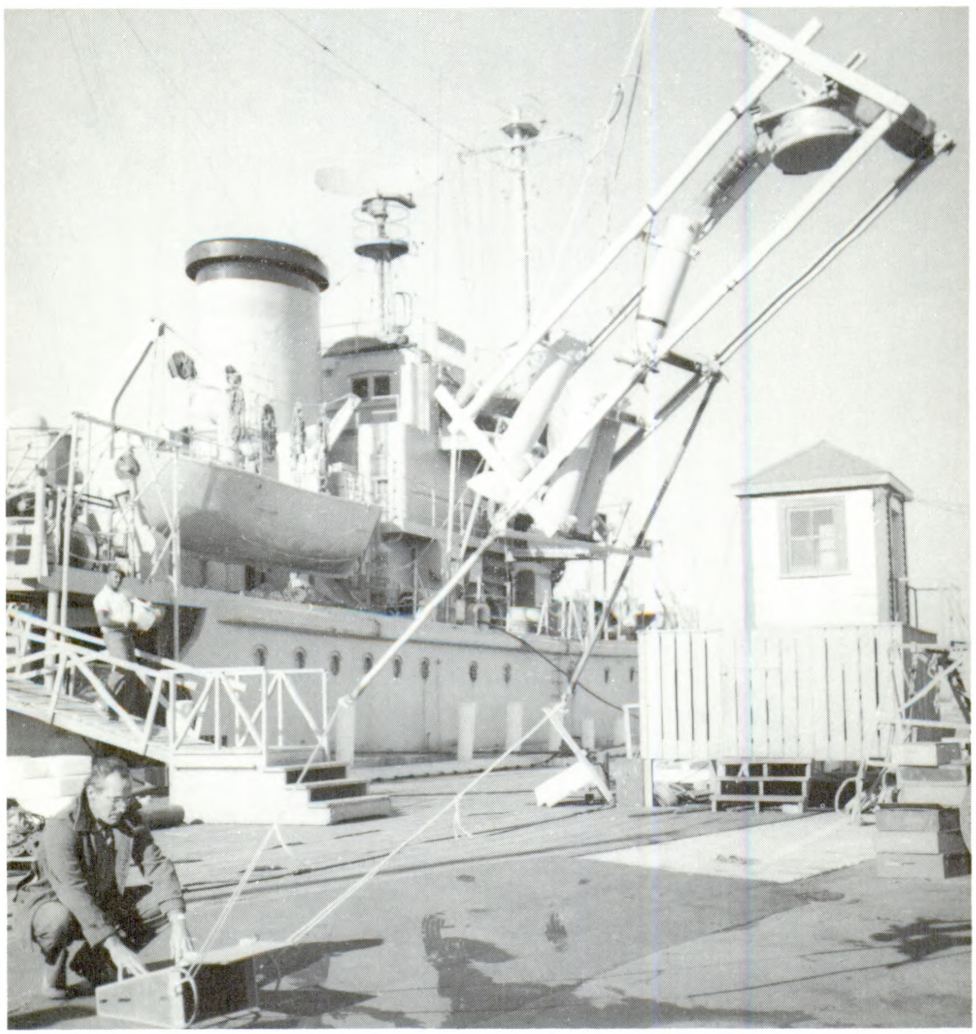
NAVAL RESEARCH

REVIEWS

JANUARY 1961

AVEXOS P-510

ATLANTIS and water plume produced by a shallow explosion used in seismic reflection studies. (Photo by Jan Hahn)



Edgerton bottom camera, upper right, with an experimental sampling dredge attached. A similar camera was used during IGY cruises. The RV CHAIN is in the background. (Photo by Jan Hahn).

Seismic Crustal Studies Beneath the Ocean

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and

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Against the ravaging effects of such physical events as earthquakes, man may seem helpless. Nevertheless, he can acquire the ability to minimize the effects of such disasters by improving his knowledge of their nature and by ascertaining the likelihood of their occurrence and probable magnitude in particular locations. Seismological investigators have long been cooperating on an international basis in an effort to obtain the kind of information which would enable scientists to predict and warn of disasters similar to the one which occurred recently in Chile.

The International Geophysical Year permitted seismologists to extend their investigations of the earth's crust and deeper structure below the various oceanic and continental areas of the world. The results described here concern those obtained from the marine program.

Three U. S. scientific institutions collaborated in carrying out the US-IGY marine seismic program: The Scripps Institution of Oceanography of the University of California, the Lamont Geological Observatory of Columbia University, and the Woods Hole Oceanographic Institution. The program was helped materially through the cooperation of similar institutions in other nations, including Argentina, Brazil, France, the United Kingdom, and the Union of South Africa, who provided scientists, ships, and instruments.

TECHNIQUES AND INTERPRETATION

Seismologists are confronted with the limited usefulness of naturally occurring earthquakes for making detailed studies of the earth's crust because neither the time nor the place of occurrence can be reliably predicted. Therefore, a controlled explosion technique which generates "artificial" seismic waves has been developed to provide our most reliable information about the earth's crust and the underlying mantle—the layer directly beneath the crust. By using this technique, in which the exact location and time of the explosion are known, it is possible to determine both the physical nature and thickness of the earth's outer layer. The resulting seismic waves, reflected or refracted by the interfaces between rock types of different density and compressibility, are detected by an array of seismometers located at known distances from the "shot point." The records obtained can then be used to compute travel times and wave velocities in the various crustal layers penetrated by the waves. These, in turn, are used to calculate the thickness of the layers and to estimate their density and composition.

In the deep ocean, where it is not feasible to lay out a series of seismometers at known distances from the shot point, two ships are used. One acts as a moving shooting platform and the other as a stationary receiving station with one or more hydrophones suspended 100 feet or more below the surface. The principal technical problem is "quieting" these hydrophones in order to record the weak waves propagated through the crust. Distances are usually computed from the time required for sound pulses to travel through the water between the ships. This technique requires numerous shots at varying distances up to about 100 kilometers in order to obtain adequate data for measuring the local crustal thickness. Energy refracted along the interface between rock layers and later returned through the water is the basis for nearly all the oceanic crustal measurements of the past, including those made during the IGY. However, the energy reflected from these same interfaces (and others) is proving increasingly useful. At present writing, modern reflection techniques are used mostly for studying shallow sedimentary structures in comparatively shallow water. However, these techniques are being steadily extended and offer great promise. This development, although commencing well before the IGY, was given a considerable boost by the opportunities offered by the IGY program.

Two basic types of elastic waves are generated in the earth by earthquakes and explosions: compressional or "P" waves, and shear or "S" waves. P waves, also termed longitudinal waves because particle motion is parallel to the wave's direction of travel, can be produced by explosions or by dropping large weights. S waves, also referred to as transverse waves because particle motion is at right angles to the direction of travel, are produced primarily by the shearing or tearing motion of earthquakes. Since S waves are difficult to produce artificially and are not transmitted through liquid material, the artificial seismic technique depends almost entirely upon the use of P waves. At several places the seagoing seismologists have observed waves which started out as P waves, were converted to S waves during part of their travel through the crust, and then were reconverted to P waves before reaching the hydrophones.

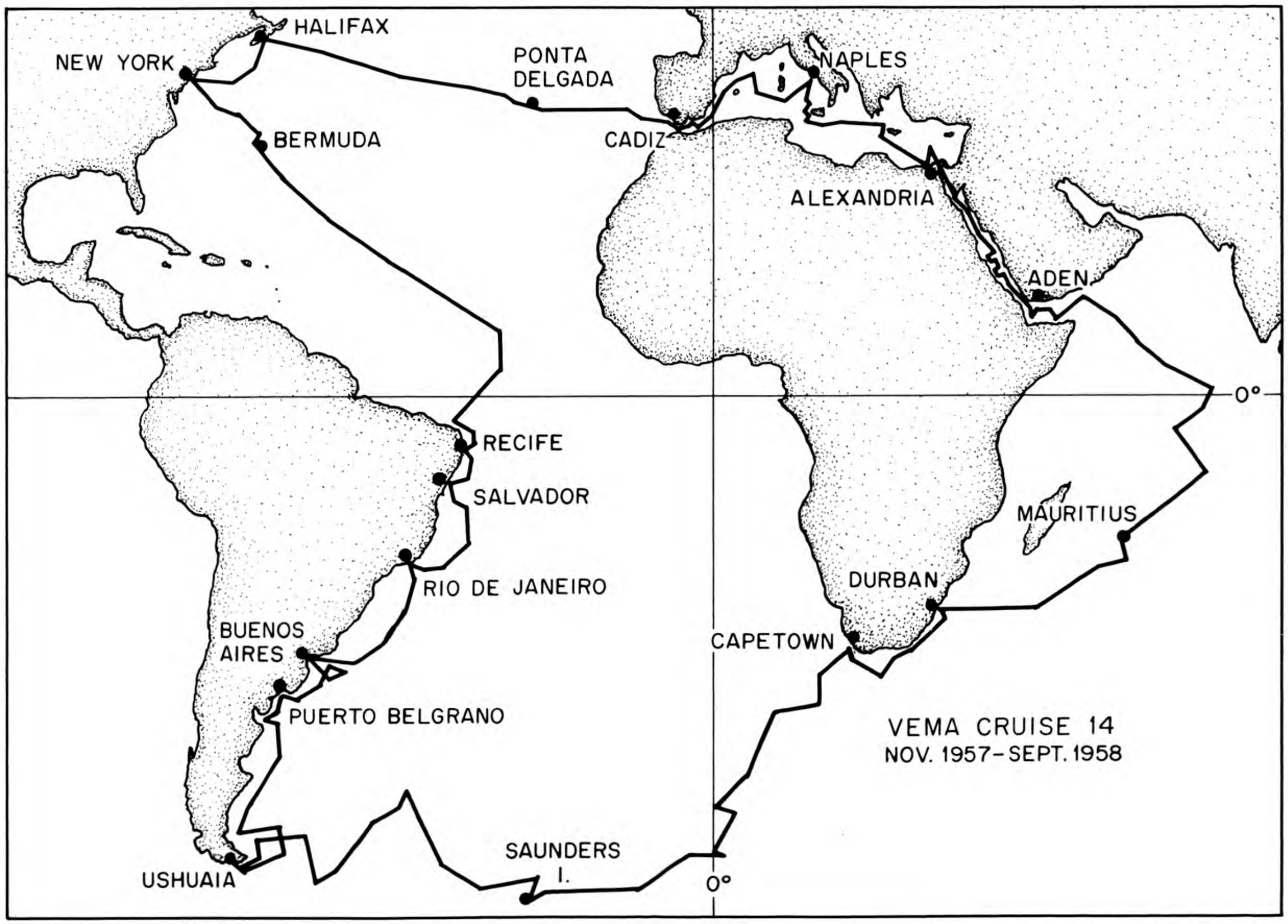
Seismic studies of the earth's crust in various parts of the world have shown the average crustal thickness to be about 38 kilometers beneath the continents and about 5 kilometers beneath the oceans. In general, the continental crust is thicker beneath major mountain systems and thinner under island arcs and mid-oceanic ridges. The thinnest crust is found under the open ocean basins 5000 to 6000 meters deep.

The crust is regarded as consisting of two principal layers by most seismologists: an upper, essentially granitic layer, in which seismic-wave velocities are generally in the vicinity of 6.0 kilometers per second; and a denser, presumably basaltic lower layer, with seismic-wave velocities varying from 6.5 to over 7.0 km/sec. Though in some continental areas it appears the crust may have a three-layer structure, the thickness of the crustal layers varies greatly from place to place, and the upper, granitic layer appears to be absent beneath most oceanic areas. Overlying the crust in most continental regions are layers of unconsolidated and semiconsolidated sedimentary materials, a few kilometers thick at most, in which P-wave velocities are lower than in the crust. In the oceans, the sedimentary materials range from about 0.5 to 1.0 kilometer in thickness. In the upper part of the earth's mantle, just beneath the crust, the seismic wave velocities are about 7.9 to 8.3 km/sec. The seismologist's definition of the base of the crust is the surface or region where the P-wave velocity changes from a value below 7.5 km/sec to about 8 km/sec. This interface is called the Mohorovicic discontinuity, after its discoverer, but the ponderous term is usually simplified to MOHO. The earth's mantle is commonly said to consist of peridotite, but its chemical and mineral composition are only conjectural, and will not be known until the MOHO Hole project (NavResRev, Jan., 1960) has been completed.

MARINE PROGRAM RESULTS

About one-fourth of the seismic measurements in the marine program included the entire crustal thickness above the MOHO. The other measurements were confined to a study of the bottom sediments overlying the crust and to the crustal material immediately beneath them.

Cruises of the marine seismologists during the IGY missed being truly global only because they avoided northern latitudes. These had received some attention previously, whereas the southeastern Pacific, the South Atlantic, the southern ocean surrounding Antarctica and the Indian Oceans had received little or no attention. One question to be answered was: "Would the generalizations about oceanic crustal structure inferred from studies of the central Pacific and the North Atlantic (discussed above) be confirmed in other ocean areas?" Scientists also wanted to know about the southern extension of the mid-Atlantic ridge, and whether the island arc of the ocean area and the great submerged plateau east of Argentina were structurally similar to superficially similar regions that had already been studied in the northern hemisphere. Furthermore, the earlier crustal studies, some of which had been made deliberately in these far-off places, had not always included measurement of the depth of the MOHO in areas of abnormal oceanic depth. It was especially important to find out whether the MOHO could be reached by using the most recent procedures, or whether some peculiarity of the local crust could make observations difficult or impossible. The Puerto Rico Trench, the Indian Ocean, and the Mediterranean Sea were part of this list. Their deepest parts should be checked. In a general way the nature of the structures spanning the transition from ocean basin to continental margin was known, but in only a few places. Before hypotheses about global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RIO DE JANEIRO
DURBAN
BUENOS AIRES
CAPETOWN
PUERTO BELGRANO
VEMA CRUISE 14
NOV. 1957-SEPT. 1958
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tectonics could be given solid foundation, considerably more work was required. It was scarcely hoped to accomplish all of these objectives during the IGY, but cruise plans were laid out so that, given reasonable luck with the weather and with the cooperation of the little people (gremlins, nisse, or other meddlesome elves of laboratory or engine room), the scientists would be well ahead with most, if not all of these problems.

Seismologists from the Scripps Institution of Oceanography concentrated on the southeastern Pacific between French Oceania and the coast of South America. Lamont Geological Observatory scientists made the first of what has become an impressive series of expeditions with their ship VEMA to high southern latitudes, working cooperatively with ships and scientists of Argentina and the Union of South Africa in their "home" waters. Explosion seismology on the VEMA was carried out mainly on the continental shelf of the east coast of the two countries and in the island arc area between South America and Antarctica. Originally VEMA was scheduled to make rendezvous at Capetown with ATLANTIS of the Woods Hole Oceanographic Institution, so as to make an intensive study of the crust beneath the western basins and ridges of the Indian Ocean. However, engine-room gremlins were so vicious aboard ATLANTIS that year that much of her cruising had to be curtailed. She eventually sailed through the Mediterranean and Red Seas to meet VEMA north of the Seychelles for a few "refraction profiles" just before the monsoons of July 1958 struck the Gulf of Aden. Both ships retreated in good order, by going northwest through the Red Sea and the Mediterranean, shooting refraction profiles as they went, as far as the Pillars of Hercules. (By this time VEMA had been away from home over nine months!) Another Woods Hole group aboard the USCGC YAMACRAW supplemented the refraction-shooting of VEMA and ATLANTIS with a series of reflection studies in the western Mediterranean. The following year (still IGYish), the Woods Hole group returned to the Mediterranean to follow up the findings of 1958 by doing both refraction and reflection studies from the newly converted USNS CHAIN. The refraction shooting was carried out in cooperation with a French group from the Musée Oceanographique de Monaco aboard the Monacan ship WINNERETTA-SINGER. The Caribbean area, which has been a focal point of geophysical exploration since the early measurements of gravity by Meinesz, Ewing, and Hess, has been visited repeatedly both by Woods Hole and Lamont ships working together and separately throughout the years from 1949 to date, including the IGY.

At this writing, two years after the expedition, many of the IGY findings have been published, while nearly all the rest have been analyzed and are being prepared for publication in scientific journals. The broadest generalizations about the contrast between continental and oceanic crust (thick under the continents, thin under the oceans) still remain intact. The island arc between South America and Antarctica appears to be similar to the Caribbean, and the east coast of Argentina was found to be bordered by a shelf with an underlying sediment-filled trough somewhat similar to that already known off the coast of northeastern U. S. and Canada, two significant similarities. The apparent rule of correspondence between deep water and thin crust seems to hold over comparatively small basin areas, even in places surrounded in close proximity by continental platforms. Thus the crust was found to be approximately oceanic in character in the center of the Algiers-Provencal Basin of the western Mediterranean (the work of the Swedish seismologist Båth indicates a similar structure for the eastern Mediterranean basin). Oceanic structure also was found in a deep-water embayment in the Tuamotu Island platform (southeastern Pacific), even though the surrounding platform is a shallow-water area where the crust might be expected to have a greater thickness. On the other hand, the well-known deep trenches off the island arcs and along the western coast of South America do not fit this general rule. In the Puerto Rico trench, particularly, there is a considerable thickening of all crustal layers, whereas the deep crustal structure off western South America seems not to reflect the presence of the Peru-Chile Trench. There, results suggest only a normal thickening of the crust from ocean to continent.

Elsewhere in the results there are intriguing correlations to be made with other geophysical findings: measurements of heat flow from the interior of the earth on the Easter Island rise are five times as high as normal, suggesting that abnormal crustal and mantle velocities are to be anticipated; and in the Red Sea and Gulf of Aden the seismic results suggest the intrusion of high-velocity (presumably high density) material, possibly from the mantle, to shallow depths in the crust. Another exciting extension of previous thinking made possible by these IGY cruises was the continued support, from echo-sounding and earthquake-seismology data, for the idea that the central rift-valley of the mid-Atlantic Ridge is a major rift of the crust which may be traced from the South Atlantic across the Indian Ocean into the Pacific. None of these exciting new correlations is thoroughly established, nor will their true significance be known for some time. Meanwhile, the recent IGY program of international scientific group-cooperation, direct governmental support, and stimulation for continuing studies has greatly deepened and broadened the interest and scope of oceanic geophysical research.

Correction in Hydrofoil Story

In the November issue an article on the XCH6 hydrofoil craft, designed and built for the Office of Naval Research by Dynamic Developments, Inc., contained the statement that it was "the first installation of a gas turbine engine in a hydrofoil craft." We have since learned that the information given us on this point was incorrect. Actually, it is the first occasion that a gas turbine engine has been combined with supercavitating hydrofoils in the operation of a hydrofoil craft. The first use of a gas turbine engine in a hydrofoil vehicle was the HALOBATES, a converted Navy landing craft powered by a Lycoming T53 gas turbine engine, which made its first flight in September 1958, more than a year before the XCH6. The HALOBATES and another installation of the Lycoming T53 on a hydrofoil craft in 1959 established the practicality of gas turbine-powered hydrofoil vehicles.

Human Quality Control in Naval Air Training--1960

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Training programs resemble industrial production processes. Raw material is selected in accordance with some minimum standards of quality and put through a series of processings which change it progressively, in specified ways, until a desired end product is reached. Usually, at several levels of the sequence, the product is measured to determine the probability that the end product will be within the quality tolerances necessary for its market. In industry these measurements may be made by the use of gauges, by chemical or mechanical tests, or by visual, optical, or electronic inspections. The procedures are commonplace and they are part of what is known as product quality control.

In training programs, whether the trainees be military (aviators, technicians, submariners) or civilian (engineers, physicians, teachers), similar quality control requirements exist. Candidates for the training first should be screened to eliminate those who are likely to fail in training. In addition, minimum training standards that will prevent the graduation of potential job failures should be imposed at appropriate levels of the training process. This is human quality control.

During the past five years, the Department of Psychology of the Naval School of Aviation Medicine has been instrumental in the development and application of such human quality control techniques and processing for the Naval Air Training Command. As in industrial quality control, the procedure had to begin with a knowledge of the product quality level acceptable to the consumer. For this reason, a survey of the fleet squadrons was first conducted early in 1956 and was repeated at intervals of about 18 months thereafter. The purpose of these surveys was to single out men who could be considered unsatisfactory products of the training program. Included were all graduates killed in pilot-error accidents, all men who had been grounded or transferred to less hazardous flying duty, and all men whom squadron commanders felt should not have been permitted to graduate, either because of poor flying ability or because of inadequacies as an officer. Approximately half of all squadrons were covered by each survey.

After the satisfactory and unsatisfactory graduates were identified, it was then possible to review statistically the training grades and ratings and the selection-test scores of the graduates in order to determine new minimum standards which would have reduced the number of unsatisfactory men reaching the fleet. The first fleet-survey revealed that half of the lowest 7 percent of the students (in terms of their pre-solo flight grades: the grade for the man's first 12 flights) had failed to graduate, and half of those who did graduate proved to be unsatisfactory in the fleet. Furthermore, a study of the accident records of these men revealed a pilot-error accident frequency that was twice normal, both in training and in the fleet; and a fleet casualty-rate that was three times normal. These data were confirmed on the second survey.

It was shown that the immediate removal of these men would have resulted in an annual saving of about 7 million dollars in training costs and also a reduction of about 20 percent in the number of unsatisfactory men reaching the fleet.

In the second fleet survey, experimental peer ratings of officer-potential – made by the man's section mates during the eighth week of training — were available. It was found that only three in eight of the men who had received ratings in the bottom 7 percent had graduated. Of thirteen such graduates in the squadrons visited, only two were satisfactory both as officers and pilots. A later sampling revealed that three out of four such low-rated men had dropped out through attrition before graduation. As a result of these findings, the eighth-week peer rating was adopted as a regular procedure. Low peer-rating scores are not treated as minimum standards in themselves. However, a man who has received a low peer-rating is dropped if he encounters any difficulty — whether it be academic, disciplinary, or in flight – for the evidence of inadequacy is considered to corroborate the judgment of his peers.

Comparisons of the early training performances of men who were unsatisfactory in fleet squadrons equipped with various types of aircraft (jet vs. prop, single-engine vs. multi-engine, and the like) have made possible the establishment of standards for differential assignment to the training pipeline. These standards now make possible the highest probability of both training and fleet success.

Since students are subject to personnel actions based on the grades that they make, it is important that the grades be as accurate as possible. In order to provide for a maximum standardization of grading policies, members of the Department of Psychology, assisted by training staff personnel, developed a manual on grading which was adopted by the Naval Air Training Command and published and distributed to all instructors and administrators. Furthermore, a manual for training administrators, based upon various studies of the relationships of selection test scores and early grades and ratings to later failures in training and in the fleet, was developed. This manual shows the probability that, for each score level on each measure, a man will graduate and that a graduate at that score level will be successful in the fleet. The manual is used to assist in reaching decisions regarding failing students. In order to keep the manual current and also to provide "instant" data for selection and training research studies, procedures have been established which provide for routinely punching all student-selection test scores and grades into IBM cards as the students complete each major stage of training.

Present findings indicate that the quality-control procedures already adopted should reduce the number of unsatisfactory men reaching the fleet by about 50 percent. In addition, these procedures are resulting in substantially more efficient use of training dollars because men with a high probability of later failure are dropped earlier in their training; thus more aircraft and instructors are made available to students who have better chances of success.

Effects of Typhoon Ophelia on Jaluit Atoll

Whirling in from the east without warning, a typhoon named Ophelia roared directly over Jaluit Atoll in the southern Marshall Islands on January 7, 1958. It produced wind speeds of more than 125 knots and flooded some islets to a depth of six feet, changing the islet morphology and soils and damaging the vegetation and buildings. The storm then moved in a west-northwest direction, seriously damaging Ponape, Truk, and the Hall Islands in the Caroline Group, and finally died out in the Philippine Sea.

By April 24, 1958, a field party of seven scientists* was conducting an intensive investigation of the changes on Jaluit Atoll wrought by the storm. This study was sponsored jointly by the Pacific Science board of the National Academy of Sciences—National Research Council, the Office of Naval Research, and the Trust Territory of the Pacific Islands. The U. S. Navy provided transportation and logistic support. A periodic re-examination of the atoll was planned, so three scientists† made a 10-day resurvey of the scene, under the same sponsorship, in October, 1960.

In general, the worst damage was sustained along the narrower parts of the islets along the eastern side of the atoll, for these areas were swept by water, as well as by wind. All native buildings and most others were destroyed.

Out of a total Jaluit-Atoll population of about 1200, only 16 Marshallese died as a result of the storm. So few were killed because the storm did not completely inundate Imroj, the most populous islet; because about 150 natives of hard-hit Mejatto Islet happened to be visiting Imroj Islet when the storm struck; and because the natives of heavily damaged Jaluit Islet were able to take refuge in sturdy, Japanese-built concrete-block buildings. These buildings were the only structures on the atoll to withstand the storm. Buildings of board and corrugated iron blew apart, while native buildings of grass, fibre, and pandanus blew down. The native buildings, however, were easily put back up and reinforced after the storm.

Trees and other vegetation, normally very dense, were completely stripped away on the narrower eastern islets, while 20 to 50 percent of

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*These men were: Drs. David Blumenstock, U. S. Weather Bureau Pacific Area Climatologist; A. H. Banner, director of the Marine Biological Laboratory, University of Hawaii; J. L. Gressitt, chairman of the Entomology Department, Bishop Museum, Hawaii; Harold J. Wiens, professor of geography at Yale University; F. R. Fosberg, botanist, and Edwin McKee, geologist--both with the U. S. Geological Survey; and Mr. J. B. Mackenzie, now Agricultural Development Officer for the Marshall Islands.

†Drs. David Blumenstock and F. R. Fosberg, and Mr. C. G. Johnson, geologist, U. S. Geological Survey.

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Scene of devastation in coconut grove, 1958. (Photo by Gressitt)

the trees on the western islets were uprooted or snapped off. Of the trees, Pemphis, Cordia, Calophyllum, Casuarina and Bruguiera stood up better than Pandanus, Terminalia catappa and breadfruit.

Much information was gained on the mode of adaptation of some of the important atoll and strand plant species to survival and recovery from a typhoon. After 2-1/2 years, the tree species Pandanus, Cocos, Bruguiera, and Pipturus had mostly replaced themselves by seedling reproduction, while Pemphis, Artocarpus, Terminalia, Pisonia, and Cordia had sprouted from the remains of the typhoon-damaged plants. Scaevola and Tournefortia have recuperated both by sprouting from old stumps and by producing new plants from seed.

All of the terrestrial animal species of the atoll seem to have survived the initial onslaught of the storm. Of the fauna, the rats, soil insects, grasshoppers, and scale insects appeared to have suffered the most, while sea and shore birds, lizards, brackish-water shrimps, amphipods, land crabs, and spiders seem to have suffered little. Four months after the storm, certain insects, such as house flies, Culex mosquitoes, moths, and hemipterans, were found breeding in large numbers because of an increase in favorable habitat.

During the initial survey, it was discovered that the typhoon had created rubble bars composed of 75 percent fresh reef material lifted from the reef-front along the ocean side of the eastern islets. The storm had also deposited thick sheets of coral gravel across large sections of the eastern islets and had scoured out channel-ways, some reaching entirely across these islets to the lagoon. As might be expected, about 75 percent of the soils on the eastern islets that were

Bar-like ridge of coral boulders thrown up on reef flat by 1958 typhoon waves. Material is from undersea reef slope, Jaluit Atoll. (Photo by Fosberg)

Islet in 1958 with coconut palms swept clean and the soil buried under gravel sheets. (Photo by Gressitt) awash were either buried under a 5 to 30-inch sheet of coral rubble or swept away. The eastern lagoon fish life and bottom below the low-low tide level seemed to be unaffected by the storm, although some new gravel bars were noted near shore.

A discovery made by McKee and Fosberg during the initial survey may be of special interest. In a well at a depth of about three feet, they found an undisturbed soil profile overlain by coral rubble. Typhoon Ophelia produced a similar situation by spreading rubble over soil. This discovery suggests that it might be possible to date those typhoons of past centuries that were sufficiently intense and sufficiently "on target" to spread gravel sheets on atoll soils.

During the 1960 resurvey of the atoll, the scientists observed that many of the typhoon-produced changes had been modified or partly eliminated, although some effects of the typhoon were still evident on all the islets. For one, the gravel bars lying off the ocean side of the eastern islets either had been removed, had migrated landward, or had spread out. Scour pits and channels within the tide zone had become partly filled, but those lying above the influence of tides and waves showed little change.

The difference in soils between wave-swept and non-wave-swept areas was still conspicuous after 2-1/2 years. In the wave-swept areas, whether the soils were buried by gravel or removed, little new soil development has taken place beyond the addition of some surface litter and a small amount of roots and humus. However, beneficial effects of the typhoon on areas still retaining the original soil were noted, for the storm added large quantities of organic debris to this soil. This debris has since decomposed making the soil loose, friable, dark, and rich in organic matter.

Before the storm the chief export was copra but, because of the widespread devastation of the coconut trees, this industry has almost vanished. The U. S. Trust Territory Government has instituted a program of replanting of coconut palms to provide a cash crop in the years ahead. Coconuts are still the chief subsistence crop, although breadfruit, pandanus, pumpkins, bananas, sweet potatoes, and taro root are also cultivated. At present the principal exports are trochus (mother of pearl) shell and handicrafts, neither of which provide a substantial cash income.

Though progress has been made, it is thought that it will take at least a decade before the atoll has fully recovered economically from the effects of the storm. C.E.F.

Forty-three NRL employees are sharing a $5000 Navy Incentive Award, presented 20 December, 1960, for their part in the development of the Space Surveillance System — a series of transmitting and receiving stations for detection and tracking non-radiating earth satellites. The first station became operational in August 1958, and all six stations have operated 24 hours a day since February 1959. This is the largest group ever honored under the Incentive program.

Induction Plasma Torch

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and
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Plasma has been aptly described as the "fourth state of matter," adding another condition to the traditional threesome of solids, liquids, and gases. It resembles a gas in a highly excited state but with large amounts of electrical energy stored as charges on its particles. Nearly equal amounts of both positive and negative charges are stored on the particles. The plasma is generated and maintained by some source of mechanical, thermal, or electrical power, and is commonly found in stars, lightning bolts, meteor trails, fluorescent light bulbs, and various other forms. It can often be recognized by the radiant energy it emits.

A simple and ingenious new method of generating and maintaining a stable plasma at temperatures that will melt or vaporize any known material was described by its inventor, Dr. Thomas B. Reed of the M.I.T. Lincoln Laboratory, during the Gaseous Electronics Conference held in Monterey, California, at the U. S. Navy Post Graduate School. This method has been put to use in a new device, called an "induction plasma torch," which is expected to have important research and industrial applications.

The apparatus required is surprisingly simple — a conventional radio-frequency power supply and solenoid coil, a source of the desired gas, and tubes to direct and control the gas flow in the vicinity of the electromagnetic field from the coil. The gas in a tube is ionized into a plasma by the field, and a jet of high-temperature plasma projects from the open end of the tube, resembling a torch. The source of heat in the torch is, of course, the plasma itself. Since power is coupled from the coil into the plasma by induction, the name "induction plasma torch" identifies the major features of the device and its operating principle.

The torch, shown in Figure 1, is an early developmental model; a more recent model, using a flat "pancake" coil, is shown in Figure 2.

Temperatures as high as 20,000° K (or 20,273° C) — almost four times as hot as the surface of the sun — are easily generated by using this new method by using only three kw of power from a moderate-sized power supply of the type widely used for radio-frequency (above 15,000 cps) heating applications. The experimental unit currently in use employs a conventional radio-frequency power supply operating at 4 Mc, with a maximum rated output of 10 kw. As little as 500 w is necessary to maintain the induction plasma, and any desired gas or mixture of gases (nitrogen, oxygen, hydrogen, argon, etc.) may be used, whether they have reducing, oxidizing, or inert qualities.

High temperatures are of vital importance to the electronics industry and to scientific research in the production of crystals for

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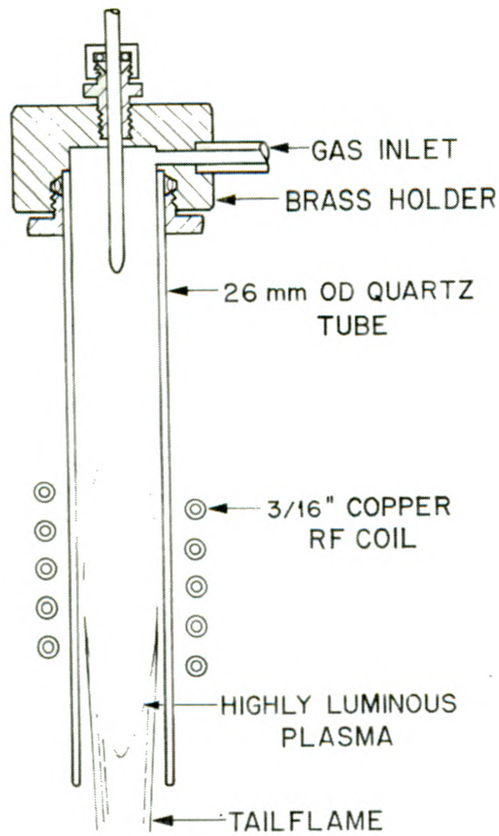

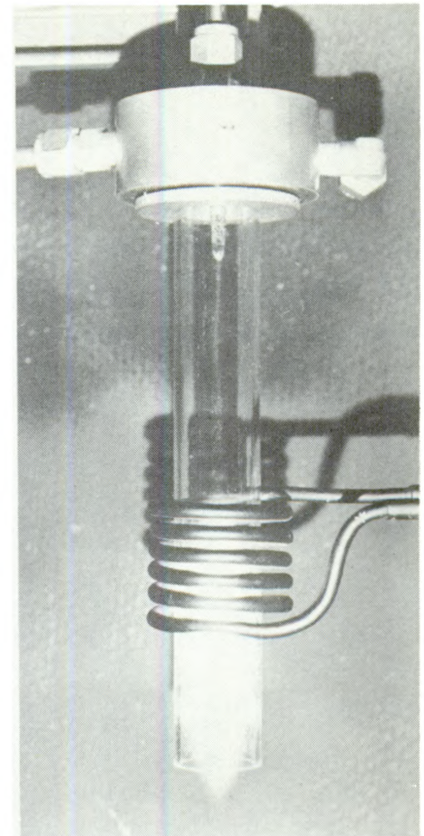

Figure 1--The induction plasma torch (early model).

electronic devices, such as transistors, diodes, and masers. Artificial germanium and silicon crystals for electronic devices are now in large-scale production. Furthermore, artificially grown sapphires are now widely used for phonograph needles, but sapphires and rubies also have valuable electronic properties. Crystals of many other materials, important for research and possible commercial applications, cannot be produced by present conventional methods because it has not previously been possible to maintain the very high temperatures required.

Many crystals with useful electronic properties now are grown and purified in a molten state at high temperatures. Silicon and germanium, for example, can be grown from a melt in a crucible. One of the reasons why these two materials are so commonly used for transistors, diodes, and other solid-state electronic devices is that they can be produced economically, in crucibles, at temperatures below 2000°.

Other types of crystals, such as rutile and ruby or sapphire, cannot be produced in crucibles because the best available crucible materials either melt or they contaminate the material from which the crystals are to be grown. Crystals of some of these materials can be produced by an ingenious technique, called the "Verneuil method," in which the material itself serves as its own crucible. A torch, flame, or arc is used to melt a "puddle" at the center of a large piece of material, or to melt a "drop" on the tip of a rod of the material (as shown in Figure 2). The crystal is grown from the molten region.

Figure 2--A later model of the torch melts the top end of an aluminum oxide rod to grow an artificial sapphire.

The disadvantages of present conventional torches are that they unavoidably contaminate the melt with combustion products, that only a few combinations of combustible gases can possibly be employed, and that the gas-flow velocity must be rather high in order to supply adequate heat to maintain high temperatures. Electric arcs and direct-current plasma torches are free from some of these limitations, but the electrodes that are necessary for their operation can produce contamination.

The induction plasma torch avoids all of these advantages and is ideally suited to crystal production by the Verneuil method: it uses any desired gas or combination of gases; contamination is eliminated, for there are no combustion products or electrodes; and the gas-flow velocity need not be great enough to stir up or spatter the melt. Furthermore, since the high-temperature region is not confined to any one focal point, it is completely accessible for the introduction or manipulation of materials to be heated.

It appears to be quite feasible to generate still higher temperatures, approaching 100,000°, without excessive power requirements — if a suitable method can be developed to contain the plasma. In the torch illustrated, the quartz tube melts at higher power levels.

High-Energy Particles Tracked by University of Minnesota Scientists*

A team of University of Minnesota scientists† were kept busy night and day for 5 days beginning November 12 as they kept track of "one of the greatest solar storms ever"—that filled space with high-speed particles, capable of killing any unwary or nonshielded space traveler. At approximately 7 a.m. (Minneapolis time), on November 12, a great number of sunspots began spewing forth huge tongues of hot gas, thousands of miles in extent. These solar flares produced vast clouds of magnetically charged gas and great streams of invisible high-energy particles, energizing the void between earth and sun. Long-range radio communications all over the world were disrupted in probably the worst global communications predicament and the worst sun-spawned magnetic storm in a decade. Also visible in the night sky was a display of the familiar "northern lights"—excited, dancing atoms.

The high-energy particles, or solar cosmic rays, were contacted 20 to 30 miles over Minnesota via geiger counters and film traps sent aloft in 22 unmanned balloon flights. Directing the flights were Drs. Edward P. Ney, John R. Winckler, and Phyllis S. Freier. They were assisted by Mr. Thomas C. May and Mr. Andrew J. Masley—in what may be man's most fruitful study of sun-produced cosmic particles. Working as a team for some time now, Drs. Ney, Winckler, and Freier discovered the existence of and nature of solar storms as a part of their balloon work in May 1959. They learned that these storms start without any warning, for not all sunspots produce them. Since May 1959, solar storms have been recognized as one of the greatest obstacles to space travel. (See "Threat to Manned Space," Malcolm D. Ross, Air Programs, Office of Naval Research—NavResRev, Oct. 59, inside front cover.) There have been about 35 such storms since May 1959, about two per month. The Minnesota scientists reason that space travelers might make short flights without encountering solar storms, especially during years when sunspots are at a minimum. On long flights, lasting weeks or months, they would have to rely on shielding. "This would help them during many of these events," said Dr. Winckler, "but a storm of the intensity of the present one, with particles in the billion-volt energy range, is another matter. It would just be impossible to fly a heavy enough shield for protection. A man in an unshielded vehicle might get a dose of 5 to 10 roentgens of radiation an hour. These particle storms usually continue for about 10 days, so a man might very possibly get a fatal dose."

The sunspot group causing the recent storm was spotted by the University of Michigan's McMath Observatory at 7:25 a.m. November 12. Dr. Winckler was phoned that morning by the U. S. Coast and Geodetic Survey's Observatory at Fredericksburg, Va., which monitors magnetic disturbances, and also by the University of Alaska's Geophysical Station. In addition, an alert was received from the International

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*Adapted from an article in the Minneapolis (Minn.) Morning Tribune.

†Most of whose work is supported by ONR and the National Science Foundation.

University of Minnesota team launching high-altitude
thin plastic balloons.

Geophysical Warning Headquarters at Fort Belvoir, Va., via teletype communications to the outer office of Drs. Winckler and Ney. At the same time, a new neutron monitor, atop the roof of the University of Minnesota's physics building, registered a great increase in radiation.

Upon receiving these signals, the Minnesota scientists responded by getting their balloons aloft—beyond the earth's atmosphere which prevents 999 out of 1000 primary cosmic rays from reaching the earth, although secondary cosmic rays reach the earth continually. The scientific team is reputedly better equipped than any other team in the world to fly thin plastic balloons above 98 to 99 percent of the earth's atmosphere—and they do so on short notice without outside help.

Between noon on November 12 and noon on November 13, they sent up 10 balloons that were carried by westerly winds over eastern Wisconsin. The flights were then ended by preset timers, so that the payload of geiger-counter and film-trap data could be recovered before the balloons dropped into Lake Michigan. Three more flights were made on November 13. The solar storm subsided, and the team thought it was over—Dr. Ney had even left Minneapolis for a consultants' meeting at NASA in Washington. Then at 8 p.m. on November 14 the second sun flare burst forth. Again, high-level solar activity brought out the balloons. Detailed results of the solar-activity studies will be possible because of the continuing work of the three physicists and their assistants at the University of Minnesota.

Cromwell Current

The November 1960 issue of NavResRev (p. 24) had a short account of the Cromwell Current, which is thought to be a sort of shallow ''oceanic subway'' of the Pacific that transports fish from the East Indies to the South American west coast. A recent note from the U. S. Fish and Wildlife Service adds the following information:

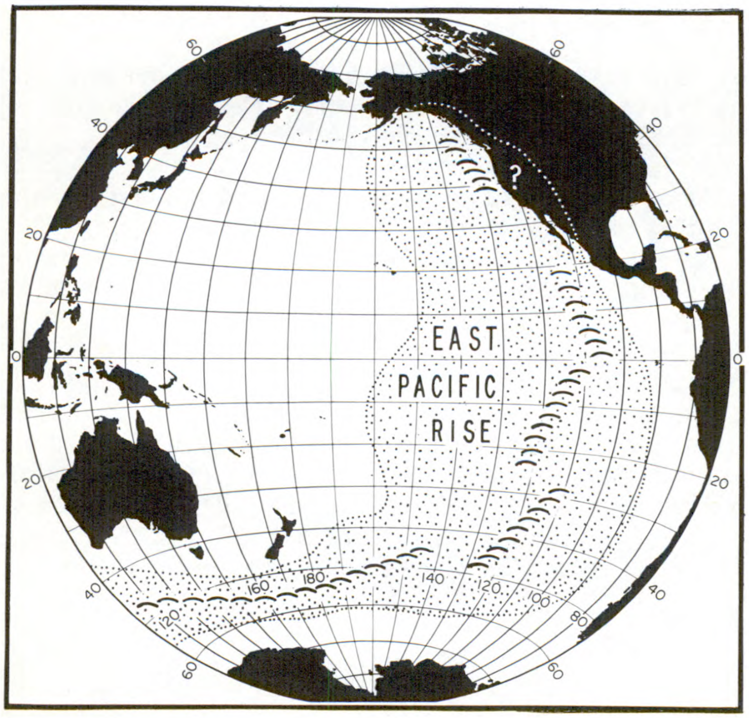
It is often forgotten in referring to the newly discovered Cromwell Current that the original discovery was made by Mr. Cromwell while he was a member of the staff of the Bureau of Commercial Fisheries of the Fish and Wildlife Service. The existence of this current was recognized when he, as a scientist fishing with tuna longline gear on a research vessel, realized the significance of the surprising fact that the vessel was drifting in one direction while the gear went in quite the opposite way. Later, in collaboration with the Scripps Institution of Oceanography, the detailed structure of the Current was charted.

This Bureau has made a number of significant contributions to our understanding of the oceanography of the central and northern Pacific Ocean. Their laboratory at Honolulu, Hawaii, in particular, has done much pioneer work in the tropical central Pacific.

Research Notes

The East Pacific Rise

One of the largest physical structures on earth has been discovered in the eastern Pacific area by scientists on Expedition Downwind.* Called the East Pacific Rise, † the crustal bulge has been traced 8000 miles in an arc extending from New Zealand to the Mexican coast. It may extend another 2000 miles if, as some scientists now think, it continues under western North America and along the Pacific coast of Canada to Alaska.



Dotted area in the Pacific Ocean shows the extent of the East Pacific Rise. The dotted lines over western North America indicate a possible extension of the Rise under the Western continental area.

The crest of the bulge lies 1-1/2 miles below the ocean surface, except where volcanic islands, such as Easter Island, thrust upward to the ocean surface. If the Rise really extends under North America, then Salt Lake City and Easter Island are a part of the same geological structure.

The Rise is part of a system of shoal areas found in all the oceans. The steep, jagged Mid-Atlantic Ridge and the Mid-Indian Ridge

*Expedition Downwind of the Scripps Institution of Oceanography, University of California, was an American contribution to the International Geophysical Year.

†Much of the work on the Rise has received support from the Office of Naval Research.

in the Indian Ocean are parts of this same system. In contrast to the steep western slope of the Mid-Atlantic Ridge, the East Pacific Rise slopes gently downward from the California coast to Hawaii. The Hawaiian Islands, however, lie somewhat off the western edge of the Rise.

Four characteristics of the Rise are especially intriguing to scientists:

- It is intersected by at least 11 narrow mountainous belts called "fracture zones." These zones run almost due east-west and contain most of the active and extinct volcanoes of the eastern Pacific. One zone even lines up exactly with the great volcanoes of Mexico.

- Under the crest of the Rise, the crust thins out to a thickness of two miles, as compared with the three miles of typical ocean basins and the possible 20 miles under the continents.

- The heat-flow rate through the crest of the Rise is as much as eight times that of the deep ocean floor or on land.

- As in other ocean ridges, it is the site of many shallow earthquakes.

To explain the origin of the Rise, scientists hypothesize that in geological terms it is a fairly recent feature of the earth's crust, akin to such ancient rises as the one in the central Pacific upon which the Hawaiian Islands are built. They say that perhaps the earth's crust was bowed upward by a vertical current in the hot materials of the earth's mantle, in a sort of convection cell below the Mohorovicic discontinuity (or MOHO). This also helps to explain the curious pattern of heat flow.

The sharply defined fractures zones are of particular interest, for other evidence of such features, if they have existed elsewhere, have been erased by time, except perhaps in China. These fracture zones mark abrupt changes in the direction of the crest of the Rise and also in its elevation. By using maps showing patterns of magnetic anomalies, the scientists have concluded that blocks of land as big as the state of Texas have moved bodily for several hundred miles along the sea floor off the coast of California. Crustal movements on this scale are unknown on land.

On Page 1 of the article "Activities of Naval Laboratories in Space Medicine," that appeared in the November issue of NavResRev (by CAPT. C. P. Phoebus, Director, Astronautical Division, U. S. Navy Bureau of Medicine and Surgery), we incorrectly captioned the photo. It actually shows the entrance to the Slow Rotating Room at the U. S. Naval School of Aviation Medicine at Pensacola, Florida instead of the "Entrance to the World's Largest Human Centrifuge," which is located at the Aviation Medical Acceleration Laboratory, Johnsville, Pa. Also, we incorrectly referred to CAPT. Phoebus as Director of the Aeronautical Division, U. S. Navy Bureau of Medicine and Surgery.

On the Naval Research Reserve

Navy Day in Idaho Falls, Idaho

NRRC 13-6, Idaho Falls, Idaho, commanded by CAPT Thomas J. Wadsworth, USNR, carried out several activities, as follows, in connection with the observance of Navy Day on 27 October.

● Delivered a 15-minute program, "U. S. Navy—Flexible Force for Freedom," over the Idaho Falls TV station. Appearing on the program were LT T. Scott, USNR, Surface Officer; LT T. Bloom, USNR, Submariner; and LT T. Stickley, USNR, Naval Aviator. They discussed the status of the Navy, the effectiveness of the Fleet aircraft carrier, nuclear-powered submarines, antisubmarine weapons, and the purpose of the Naval Reserve Research Program.

● Arranged a talk before the Idaho Falls Explorer Scouts by LCDR F. M. Mueller, USNR.

● Sponsored a Navy Day window display in the Rogers Hotel—in cooperation with an Electronics Reserve company.

Presented a 15-minute radio program over the Idaho Falls station. Participants were LCDR M. Baum, USNR, LCDR J. E. Rein, USNR, and LCDR J. E. Van Hoomissen, USNR.

● Organized the Idaho Falls Chapter of the Naval Reserve Association.

● Published news releases in the Idaho Falls newspapers.

● Held a special drill meeting on the theme, "Naval Customs, Traditions, and Etiquette."

Navy Day Exhibit at Idaho Falls, Idaho

Roster of Research Reserve Companies

ALABAMA

AUBURN
NRRC 6-2
Room 318, Ross Chemistry Laboratory
Alabama Polytechnic Institute
1900, 1st and 3rd Monday
LCDR James E. Land

HUNTSVILLE
NRRC 6-17
Naval Reserve Training Facility
Canal and Barnett Street
1900, 2nd and 4th Tuesday
CDR Charles A. Buist, Jr.

ARIZONA

PHOENIX
NRRC 11-6
USN&MCRTC, 2042 West Thomas Road
2000, 2nd and 4th Thursday
LT Selden B. Spangler, Jr.

TUCSON
NRRC 11-7
USN&MCRTC, 1100 South Avernon Way
2000, 1st and 3rd Thursday
LCDR Robert L. Voigt

CALIFORNIA

LOS ANGELES
NRRC 11-1
USN&MCTRC, 851 Chavez Ravin Road
2000, 1st and 3rd Tuesday
CDR Thomas J. Ayres

PASADENA
NRRC 11-2
USNRTC, 2727 Paloma Street
2000, 1st and 3rd Thursday
LT William F. Roberts

LOS ANGELES
NRRC 11-3
Room 2147, Life Science Building
University of California at Los Angeles
2000, 1st and 3rd Monday
LCDR Eric L. Nelson

COMPTON
NRRC 11-4
USN&MCRTC, 600 North Alameda
2000, 2nd and 4th Wednesday
CDR Howard F. Dostal

SAN DIEGO
NRRC 11-5
USNRTC, Camp Decatur
1930, 2nd, 3rd and 4th Tuesday
LCDR Nathan L. Wener

POINT MUGU
NRRC 11-8
Building 351, Pacific Missile Range
1645, 1st and 3rd Wednesday
CDR Elmer M. Holk

AZUSA
NRRC 11-9
Aerojet-General Corporation
2000, 2nd and 4th Wednesday
LCDR Gerald L. Starrh

VENTURA
NRRC 11-10
A6, Ventura College
1930, 2nd and 4th Wednesday
CDR William B. Plum

SANTA MONICA
NRRC 11-11
USN&MCRTC, 3400 Airport Avenue
2000, 1st and 3rd Monday
LCDR John N. Harvey

SAN FRANCISCO
NRRC 12-1
1000 Geary Street
1930, 2nd and 4th Monday
CAPT Ray H. Parker

LIVERMORE
NRRC 12-2
Room 216, Building 143
Radiation Laboratory
University of California
1645, Every other Wednesday
CDR Carl E. Schweickert

STANFORD
NRRC 12-3
Room 100, Physics Lecture Hall
Stanford University
1930, Every other Wednesday
CAPT Clifton A. Smith

FRESNO
NRRC 12-4
Room 119, Agriculture Building
Fresno State College
2000, 1st and 3rd Wednesday
CDR Clayton R. Tidyman

BERKELEY
NRRC 12-5
Room 147, Cory Hall
University of California
1930, 2nd and 4th Wednesday
CDR Harold G. Ries

DAVIS
NRRC 12-6
Room 9B, Poultry Husbandry Library
University of California
1930, 1st, 2nd and 4th Thursday
CDR Stanley F. Bailey

MONTEREY
NRRC 12-8
Room S-136, USN Postgraduate School
2000, every other Wednesday
CAPT Willard E. Bleick

COLORADO

FT. COLLINS
NRRC 9-12
Room 220, Chemistry Building
Colorado A & M College
1900, 2nd and 4th Thursday
LCDR Dale D. Maag

BOULDER
NRRC 9-17
University of Colorado
1900, 1st and 3rd Wednesday
LT Walter E. Johnson

CONNECTICUT

HARTFORD
NRRC 3-5
Hartford Electric Building
176 Cumberland Avenue
Wethersfield, Connecticut
2000, 1st and 3rd Thursday
CDR Robert A. Evans

NEW LONDON
NRRC 3-12
USNRTC, Building 137
US Naval Submarine Base
2000, 2nd and 4th Tuesday
LT James W. Parker

DELAWARE

WILMINGTON
NRRC 4-5
USN&MCRTC, 3920 Kirkwood Highway
2000, Alternate Mondays
CAPT Donald MacCreary

DISTRICT OF COLUMBIA

NRRC 5-8
National Academy of Sciences
2102 Constitution Avenue, N.W.
2000, 1st and 3rd Thursday
CDR James R. Patton, Jr.

NRRC 5-9
Building 28, NRL Auditorium
4555 Overlook Avenue, S.W.
July: 1630, 1st and 3rd Wednesday
Aug: 1630, 1st and 3rd Wednesday
Sept: 1st Wednesday and 3rd Thursday
2nd, 3rd, and 4th quarters:
1630, 1st and 3rd Friday
LCDR Charles F. White

FLORIDA

GAINESVILLE
NRRC 6-4
USNRTC, 1300 N.E. 8th Avenue
1915, 1st and 3rd Tuesday
CDR Robert S. Bolles

ORLANDO
NRRC 6-8
USNRTC, West Livingston Avenue
1930, 1st and 3rd Tuesday
CDR Donald T. Hawley

CORAL GABLES
NRRC 6-10
Processings and Research Building
2030, 1st and 3rd Thursday
Research, 2nd and 4th Thursday
CDR Norman R. Buchan

FT. WALTON BEACH
NRRC 6-15
Choctawhatchee High School
Shalimar, Florida
1900, Alternate Tuesdays
CDR Ralph B. Coe

MELBOURNE
NRRC 6-16
Conference Room, Building 425
Patrick Air Force Base, Florida
1630, 1st and 3rd Tuesday
CDR Charles A. Hoffman

GEORGIA

ATLANTA
NRRC 6-1
Conference Room
Engineering Experiment Station
Georgia Institute of Technology
2000, 1st eight Thursdays of 2nd, 3rd, and
4th quarters
CDR Robert R. Brewin

ATHENS
NRRC 6-9
US Navy Supply School
1930, 1st, 3rd, and 4th Monday
(Some months all four Mondays)
CDR John C. Craig

IDAHO

IDAHO FALLS
NRRC 13-6
USN Reserve Training Facility
Tautphaus Park Armory
1930, 2nd and 4th Thursday
CAPT Thomas J. Wadsworth

ILLINOIS

CHICAGO
NRRC 9-1
Navy Pier Campus
University of Illinois
1900, 2nd and 4th Tuesday
LCDR Walter A. Bohan

URBANA
NRRC 9-2
"E" Law Building, University of Illinois
1930, 2nd and 4th Tuesday
LCDR Wylie H. Davis

EVANSTON
NRRC 9-10
Elder Hall, Northwestern University
1800, Alternate Tuesdays
LT Karl Henize

DECATUR
NRRC 9-18
USN Reserve Training Center
2nd and 4th Wednesday
LCDR Clarence E. Taylor

FOREST PARK
NNRC 9-23
Naval Ordnance Pland
7500 West Roosevelt Road
1930, 2nd and 4th Wednesday
LCDR Remo Puricelli

INDIANA

LAFAYETTE
NRRC 9-7
Purdue University
Purdue University
1900, 2nd an d 4th Tuesday
CDR William J. Stadelman

IOWA

AMES
NRRC 9-5
USNROTC Building
Iowa State College
1900, 1st, 2nd and 3rd Wednesday
LT John E. Nutty

DES MOINES
NRRC 9-13
USN&MCRTC, Ft. Des Moines
1930, Every Wednesday
LCDR John V. Gebuhr

IOWA CITY
NRRC 9-19
Room 270, Medical Laboratory Building
University of Iowa
1930, Every Monday
LT William J. Hausler, Jr.

WATERLOO
NRRC 9-24
USNRTC, 200 Riverside Drive
1930, 1st and 3rd Wednesday
CDR Warren W. Klos

KANSAS

LAWRENCE
NRRC 9-20
104 Military Science Building
University of Kansas
1930, Alternate Tuesdays
CDR William P. Albrecht

LOUISIANA

NEW ORLEANS
NRRC 8-1
USNROTC Building
Tulane University
1930, Alternate Tuesdays
LT Arthur J. Rhodes

MARYLAND

FREDERICK
NRRC 5-3
Building 426, Ft. Detrick
1930, 2nd and 4th Tuesday
LCDR William G. Roessler

BALTIMORE
NRRC 5-4
School Board Administration Building
3 East 25th Street
2000, 1st and 3rd Thursday
LCDR Elza F. Tate

BETHESDA
NRRC 5-10
Auditorium, NMRI
Naval Medical Center
2000, 2nd and 4th Tuesday
CAPT George Z. Williams

ANNAPOLIS
NRRC 5-11
Auditorium
USN Engineering Experiment Station
2000, 1st and 3rd Tuesday
(No meetings during July & Aug.)
CDR Warren F. Anderson

MASSACHUSETTS

CAMBRIDGE
NRRC 1-1
Room 4-270, M.I.T.
77 Massachusetts Avenue
1930, 1st and 3rd Monday
CAPT Paul H. Flint

AMHERST
NRRC 1-3
Room 10-11, Gunness Laboratory
University of Massachusetts
1930, 1st and 3rd Tuesday
LCDR Edgar E. Lindsey

WORCESTER
NRRC 1-5
Stratton Hall
Worcester Polytechnic Institute
2000, 1st and 3rd Monday
(No meetings during July and Aug.)
LCDR Samuel Coes

WOODS HOLE
NRRC 1-8
Woods Hole Oceanographic Institute
1930, 1st, 2nd, and 3rd Thursday
CDR Robert J. Tilden

MICHIGAN

ANN ARBOR
NRRC 9-3
112 North Hall, University of Michigan
1930, 1st and 3rd Monday
(Varied dates July, Aug., and Sept.)
CDR Frank R. Bellaire

MIDLAND
NRRC 9-15
Midland Library
1900, 2nd and 4th Tuesday
LCDR Walter C. Broad

EAST LANSING
NRRC 9-16
Room 313, Electrical Engineering Building
Michigan State University
1930, 1st and 3rd Monday
CDR Walter F. Johnson

MINNESOTA

MINNEAPOLIS
NRRC 9-6
Room 211, Mechanical Engineering Building
University of Minnesota
1930, 2nd and 4th Monday
CDR Allan E. Hassinger

MISSISSIPPI

GULFPORT
NRRC 6-5
USN&MCRTC, Broad Avenue
1930, 1st and 3rd Wednesday
CDR John S. Howkins, Jr.

MISSOURI

ST. LOUIS
NRRC 9-8
Webster Groves Public Library
Webster Groves, Missouri
2000, 2nd and 4th Wednesday
LCDR Earle F. Palmer

NEBRASKA

LINCOLN
NRRC 9-22
Agriculture Engineering Building
University of Nebraska
1930, Wednesdays
LT Norris P. Swanson

NEW HAMPSHIRE

HANOVER
NRRC 1-7
Wentworth Hall, Dartmouth College
2000, 1st and 3rd Tuesday
(No meetings during July and Aug.)
CDR George Z. Dimitroff

NEW JERSEY

PORT NEWARK
NRRC 3-13
USN&MCRTC, Building 23
Naval Reserve Industrial Shipyard
1930, 1st and 3rd Wednesday
LCDR Norton L. Jeffers

PRINCETON
NRRC 4-1
10 Guyot Hall, Princeton University
2000, Alternate Wednesdays
CDR Charles W. Logan

NEW MEXICO

ALBUQUERQUE
NRRC 8-7
USN&MCRTC, 1805 Yale Avenue, S.E.
2000, 1st and 3rd Wednesday
LCDR Jack M. Houston

LOS ALAMOS
NRRC 8-9
Lecture Room, Administration Building
Los Alamos Scientific Laboratory
1700, 1st and 3rd Tuesday
CDR Alvin R. Lyle

NEW YORK

NEW YORK
NRRC 3-1
3rd Floor, 663 Fifth Avenue
1930, 2nd and 4th Thursday
CDR Evans Kahn

LONG ISLAND
NRRC 3-2
Engineering Building
USN Training Device Center
Port Washington
1930, 2nd and 4th Monday
CDR Alphonse A. Chester

BUFFALO
NRRC 3-3
USN&MCRTC, 3 Porter Avenue
2000, 2nd and 3rd Monday
LCDR Eugene S. Hiller

ROCHESTER
NRRC 3-4
Harkness Hall
University of Rochester
2000, 1st and 3rd Tuesday
LT Kenneth W. Kimpton

SYRACUSE
NRRC 3-6
General Electric Company
Electronics Park
1945, 1st and 3rd Monday
LCDR John B. Simeone

SCOTIA
NRRC 3-7
USNRTC, Scotia
2000, 2nd and 4th Thursday
CDR Arleigh H. Markham

NEW YORK
NRRC 3-8
285 Madison Avenue
1900, 2nd and 4th Tuesday
CAPT Edgar O'Neil

UPTON
NRRC 3-9
Brookhaven National Laboratory
1930, 1st and 2nd Thursday and
2nd and 4th Wednesday
CDR Jere C. Austin

MASSENA
NRRC 3-10
St. Lawrence Seaway
Development Corporation
1930, 1st and 3rd Monday
CDR John R. O'Connell

KINGSTON
NRRC 3-14
I.B.M. Conference Room
1800, 1st, 2nd and 3rd Thursday
CDR James D. Quale

NEW YORK
NRRC 3-15
90 Church Street
1845, 2nd and 4th Tuesday
CDR P. M. Randazzo

NORTH CAROLINA

CHAPEL HILL
NRRC 6-6
Physics Building, Duke University
1800, 1st, 2nd and 3rd Monday
2nd, 3rd, 4th quarters
2nd quarter, Chapel Hill Naval Armory
3rd quarter, Ralwigh, NRTC
LCDR Quentin W. Lindsey

OHIO

COLUMBUS
NRRC 4-7
Ohio State University, Research
Foundation, 1314 Kinnear Road
1930, Alternate Thursdays
(No meetings during Aug.)
LCDR Daniel Howland

CLEVELAND
NRRC 4-8
USN Finance Center
1901 E. 13th Street
2000, Alternate Mondays
CDR Viktor Schreckengost

DAYTON
NRRC 4-9
US Armed Forces Training Center
410 Gettysburg Avenue
1930, 2nd and 4th Monday
LT Jean C. Cassel

CINCINNATI
NRRC 4-11
Room 54, Albers Hall
Xavier University
1900, 2nd and 4th Tuesday
CDR Louis J. Pecora

OKLAHOMA

BARTLESVILLE
NRRC 8-8
American Legion Building
1930, 1st and 3rd Tuesday
CDR E. O. Box, Jr.

STILLWATER
NRRC 8-13
Room 2, Union Building
Oklahoma State University
2000, 2nd, 3rd and 4th Thursday
CDR Roy W. Jones

OREGON

PORTLAND
NRRC 13-4
USN&MCRTC, Swan Island
2000, 2nd and 4th Tuesday
LCDR Edward J. Warchol

CORVALLIS
NRRC 13-5
Room 132, Agriculture Building
Oregon State College
1930, 2nd and 4th Monday
CDR William J. Kirkham

PENNSYLVANIA

PHILADELPHIA
NRRC 4-2
Franklin Institute
20th Street and Parkway
1930, Alternate Thursdays
(No meetings during July and Aug.)
LCDR Peter F. Suffredini

PITTSBURGH
NRRC 4-3
Room 1112, Engineering Hall
Carnegie Institute of Technology
2000, Alternate Thursdays
CDR Frank M. Fellows, Jr.

STATE COLLEGE
NRRC 4-4
303 Wagner Hall
Military Science Building
Pennsylvania State University
1900, Alternate Mondays
LCDR Robert E. Clark

BETHLEHEM
NRRC 4-6
USNRTC, Rodgers and Lewis Station
1930, 2nd and 4th Tuesday
LT Donald R. Hindmarch

WILLOW GROVE
NRRC 4-12
Technical Training Building
US Naval Air Station
1930, Alternate Tuesdays
(No meetings during July and Aug.)
CDR John W. Pobst

RHODE ISLAND

PROVIDENCE
NRRC 1-2
102nd Air Control and Warning Squadron
1930, 1st and 3rd Wednesday
CDR Peter F. Merenda

SOUTH CAROLINA

CLEMSON
NRRC 6-11
103 Physics Building, Clemson College
1930, Wednesdays
CDR Tate J. Lindsey

AIKEN
NRRC 6-13
Red Cross Building
Laurens Street
1900, 2nd and 4th Thursday
CAPT Loren T. Palmer

SOUTH DAKOTA

BROOKINGS
NRRC 9-11
Room 330, Agricultural Hall
South Dakota State College
2030, 2nd and 4th Wednesday
(Varied Dates July and Aug.)
LCDR Gerald B. Spawn

RAPID CITY
NRRC 9-11
Chemistry Building
South Dakota School of Mines
1600, 1st and 3rd Wednesday
LCDR Clyde L. Harbison

TENNESSEE

OAK RIDGE
NRRC 6-3
Room 225, Oak Ridge High School
1930, 2nd and 4th Wednesday
LCDR Harry C. Francke

TULLAHOMA
NRRC 6-12
Conference Room, Arnold Engineering
Development Center
1930, 2nd and 4th Tuesday
LT Gerald Ewell

NASHVILLE
NRRC 6-18
Physical Education Department
21st Avenue South
Peabody College
2000, 1st and 3rd Monday
CAPT Solon B. Sudduth

TEXAS

COLLEGE STATION
NRRC 8-3
Biological Science Building
Texas A & M College
CAPT Richard H. Ballinger

HOUSTON
NRRC 8-4
USNRTC
1945, Alternate Wednesdays
LCDR James D. Wyant

AUSTIN
NRRC 8-5
Experimental Science Building 137
University of Texas
1900, Mondays
LCDR Robert L. Hunter

DALLAS
NRRC 8-12
USN&MCRTC, 9638 Bachman Boulevard
2000, 1st and 3rd Tuesday
CDR Daniel W. Wildfong

UTAH

LOGAN
NRRC 12-7
Room 212, Union Building
Utah State University
2000, 1st and 2nd and 4th Thursday
CDR Dean F. Peterson

VIRGINIA

HAMPTON
NRRC 5-1
USN&MCRTC, Warwick Road and Essex
1930, 1st and 3rd Tuesday
CDR Charles M. Cox

BLACKSBURG
NRRC 5-2
310 Agricultural Building
Hutcheson Hall, VPI Campus
2000, Monday
LCDR David P. Barnett

RICHMOND
NRRC 5-5
2 North Conference Room
Department of Biology and Genetics
Medical College of Virginia
1700, 2nd and 4th Monday
CDR Charles M. Preston

WASHINGTON

SEATTLE
NRRC 13-1
US Fish and Wildlife Service
2725 Montlake Boulevard
1930, 1st, 2nd and 3rd Monday
CDR Julius Rockwell, Jr.

RICHLAND
NRRC 13-2
2nd Floor Headquarters Building
Camp Hanford
1900, 2nd and 4th Tuesday
LCDR Linton W. Lang

PULLMAN
NRRC 13-3
Room 412, Holland Library
Washington State University
1930, 2nd and 4th Monday
CDR Irven O. Buss

WEST VIRGINIA

CHARLESTON
NRRC 5-6
USN Reserve Training Center
1930, 1st and 3rd Thursday
RADM Edwin N. Blackwood

WISCONSIN

MILWAUKEE
NRRC 9-4
USN&MCRTC
2000, 2nd and 4th Tuesday
CDR Robert A. Hoehne

MADISON
NRRC 9-14
119 Babcock Hall
University of Wisconsin
1930, Alternate Monday
CDR Marshall W. Keith

U.S. GOVERNMENT PRINTING OFFICE: 1961 O - 579856

Admiral Bennett Relieved as Chief of Naval Research

RADM Rawson Bennett, II

After five years as ONR's Chief, RADM Rawson Bennett, II, announced his departure from command as of 2 February 1961. He was appointed Chief of Naval Research in January, 1956, and was reappointed for a second term as CNR in January, 1959--a measure of performance in the billet that speaks for itself.

He was of the Class of 1927 at the U. S. Naval Academy. His early career was the typical round of a young line officer—heavy on sea duty—until the mid 1930's, when he began to specialize in electronics, graduating from the Naval postgraduate school in 1934 and from the University of California (with an M. S. in E. E.) in 1936. Thereafter his career was largely devoted to electronics—radio communications, radar, sonar. During World War II he earned the Legion of Merit for his accomplishments in sonar design. He was Director of the Navy Electronics Laboratory during the period of its expansion to become a major laboratory. When appointed as the Chief of Naval Research, he was Assistant Chief of the Bureau of Ships for Electronics.

He is a Fellow of the Institute of Radio Engineers, the American Institute of Electrical Engineers, the American Association for the Advancement of Science, and the Acoustical Society and an honorary Fellow of the American Rocket Society.

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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.

Skipper Scott Bray "shooting the sun" from aboard the oceanographic research ketch ATLANTIS, See article beginning on page 1. (Photo by Tom Stetson).