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RESEARCH REVIEWS

Ships With Wings

NAVEXOS P-510

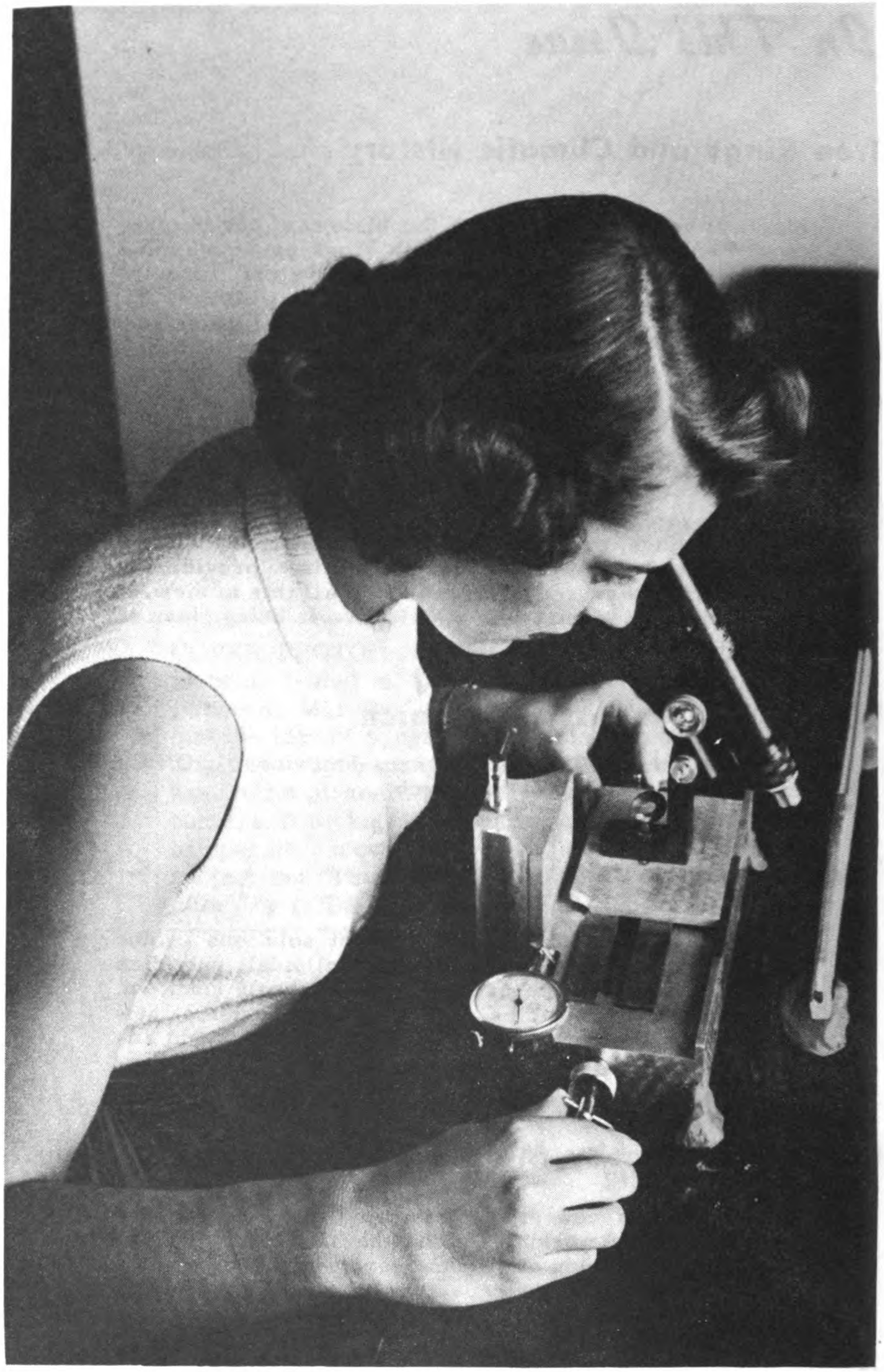
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: This hydrofoil research craft is being tested at the U.S. Naval Air Station, Patuxent, Maryland. Most people do not know that the idea of wings for ships is as old as the airplane. Now, many of the difficulties which have beset pioneers in the field are being overcome, and we know that hydrofoils can be made to operate successfully. For more about the subject, see "The Navy Experiments with Hydrofoils" by LCDR R. J. Johnston on pages 7 to 13.

Research Reviews endeavors to report briefly highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C.

Approved by Bureau of the Budget, 14 February 1952

In This Issue



Mrs. Helen Fahy measures ring-widths to .01 millimeter with the Craighead-Douglass micrometer. The moving stage carries the microscope and activates the dial gauge at the right, which may be quickly reset to zero by the clutch bar visible at the left of the stage.

Tree Rings and Climatic History

Edmund Schulman

. . .at the Tree Ring Laboratory of the Univ. of Arizona since 1932, is on leave as Professor of Dendrochronology at the California Institute of Technology.

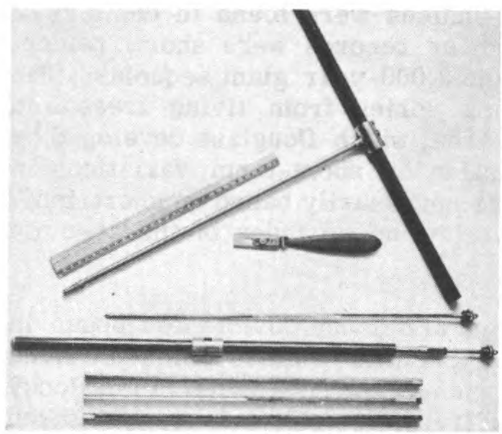
The centuries-long records of drought and flood locked up in the growth rings of old trees have in recent years begun to provide new insight into some of the long-term variations in rainfall and river flow of western North America. The dust-bowl year 1934, the heavy snows of recent years in the northern Rocky Mountains, the dangerous drop in river flow throughout the Southwest and elsewhere in the last decades—these and other climatic anomalies have called attention to the need for maximum information about past climatic changes. Apart from its statistical use such information might also contribute to a better theoretical approach to the problem of long-range climatic forecasting.

That the thickness of tree rings can be related in part to rainfall has been recognized by botanists at least since the mid-1800's. The pioneering efforts, begun soon after the turn of the century, by Ellsworth Huntington and especially by A. E. Douglass, to set up long climatic histories in the giant sequoias and in other western trees, yielded highly promising first approximations to such histories. But it was soon recognized that reliable rainfall indices could be derived only after careful attention to the many sources of error and only from specially selected trees. The clearest indices were found in conifers of the arid Southwest; unfortunately, these records were short, seldom exceeding about a tenth of that in the 3,000-year giant sequoias. The 1900-year overlapping chain of ring series from living trees and archaeological beams in the Pueblo area, which Douglass developed by 1934, indeed contains much information on short-term variations in climate. But, because this study was necessarily based on short individual sequences, it is seriously limited as an index of the absolute values of past annual rainfall.

In an attempt to overcome this deficiency, the writer began in 1939 a search throughout the West for suitable conifers which had lived beyond the 500 years regarded as normal for such trees in the Rocky Mountain area. From these overage trees, sample borings were taken and, through measurement of rings and statistical processes, chronologies were developed for past rainfalls. Under the sponsorship of ONR and with the full cooperation of the University of Arizona, this program has been greatly accelerated during the past three years. The resultant indices, based on measurement of about one-third of a million annual rings, are believed to provide fair approximations to the climatic histories of all source regions of western streams for 500 years to (in some cases) 800 or more years.

The basic steps in this work are completed with relatively simple instruments (see picture, bottom of page 2). Rapid sampling of many trees is possible with the Pressler borer (or Swedish increment borer),

The author samples a ponderosa pine with the increment borer. Only a moderate starting pressure is normally needed to get the borer to "bite." A bit of luck is usually necessary to hit the pith or center of even the most symmetrical mature tree on the first attempt.



When the borer is as deep in the tree as desired (or as possible), the thin wedge is inserted in the shaft, slipped past the core, and firmly pressed home; backing out the borer slightly then serves to break off the core, which is tightly held by the shark teeth at the wedge tip. Wedge and bit lock in the handle for easy carrying. Cores may, if desired, be readily and adequately surfaced and examined in the field with a razor blade (in holder) and later permanently mounted in grooved half-rounds.

a tool used by foresters for decades. A 15-inch core may be obtained from conifers in only a few minutes. It can then be permanently glued to a prepared mount. The core extractor, of trough design to slip easily past the core within the shaft, is tipped with shark teeth. Bit and extractor telescope into the handle (see picture).

The most critical process in this analysis is dating and marking the ring series on the core, for which a good working surface is desirable—in the case of very crowded ring series, it is essential. Microtome sectioning of the core is not very suitable. With a fresh razor blade, however, a surface of cleanly cut cell walls and maximum ring visibility can be obtained from coniferous wood by a slicing cut with the grain and at a low angle to it. Such surfaces facilitate comparison of

Near the top of this slope in Bryce Canyon National Park, Utah, stands the oldest known ponderosa pine, about 860 years old.

Close-up of pine at left. Though much of the tree is dead, it still has a life expectancy of scores of years.

many cores, so that any identity problems presented by false rings, locally absent rings, or other anomalous structures may be solved and absolute precision in ring dating attained.

The sequence of ring-widths on any specimen may be readily measured with a micrometer device (see frontispiece). Even with a conveniently low magnification of about 30X, a reproducibility to within .02 millimeter is possible.

Not infrequently a research program receives a great boost by a favoring circumstance which seems not only good fortune but almost miraculous. Such an aid came in the discovery, early in this program, that occasional western conifers on the most arid sites in their ranges had not only greatly outlived their more favorably situated brethren but had recorded the annual rainfall with high fidelity throughout their long lifetime. The principal resinous drought conifers of the Rocky Mountains—Douglas fir, ponderosa pine, pinyon pine, and limber pine—had long been thought to have a maximum age near 500 years. For the first three species, however, trees have now been found which are in, or which approach, the 1000-year age class and, for limber pine, the 1500-year age class.

As one might expect, overage drought conifers are extremely slow-growing. Usually found on steep, rocky slopes, stunted in height growth, often gnarled and spirally twisted of stem, with sparse foliage, thin bark, and weathered barkless areas, and possessing one or more leaders that have turned to branchless dead spikes, these inconspicuous trees are unattractive to the timberman or even the firewood cutter and have often been left untouched in cut-over areas and thus saved for the dendrochronologist. One of these conifers is pictured on page 3.

However, not all of these provide ring chronologies which can be interpreted in terms of climatic history. For example, the oldest western juniper trees have records not yet solved, though younger trees of this species on less difficult sites have provided significant indices.

Deserving special mention among the species whose ring-growth is so erratic or complex as to be, in general, quite useless as an index of climate are the coast redwood (in contrast to the giant sequoia of the Sierra Nevada), Arizona cypress, the Southwestern junipers other than J. scopulorum, lodgepole pine, and, at present, all the semidesert hardwoods of the Southwest.

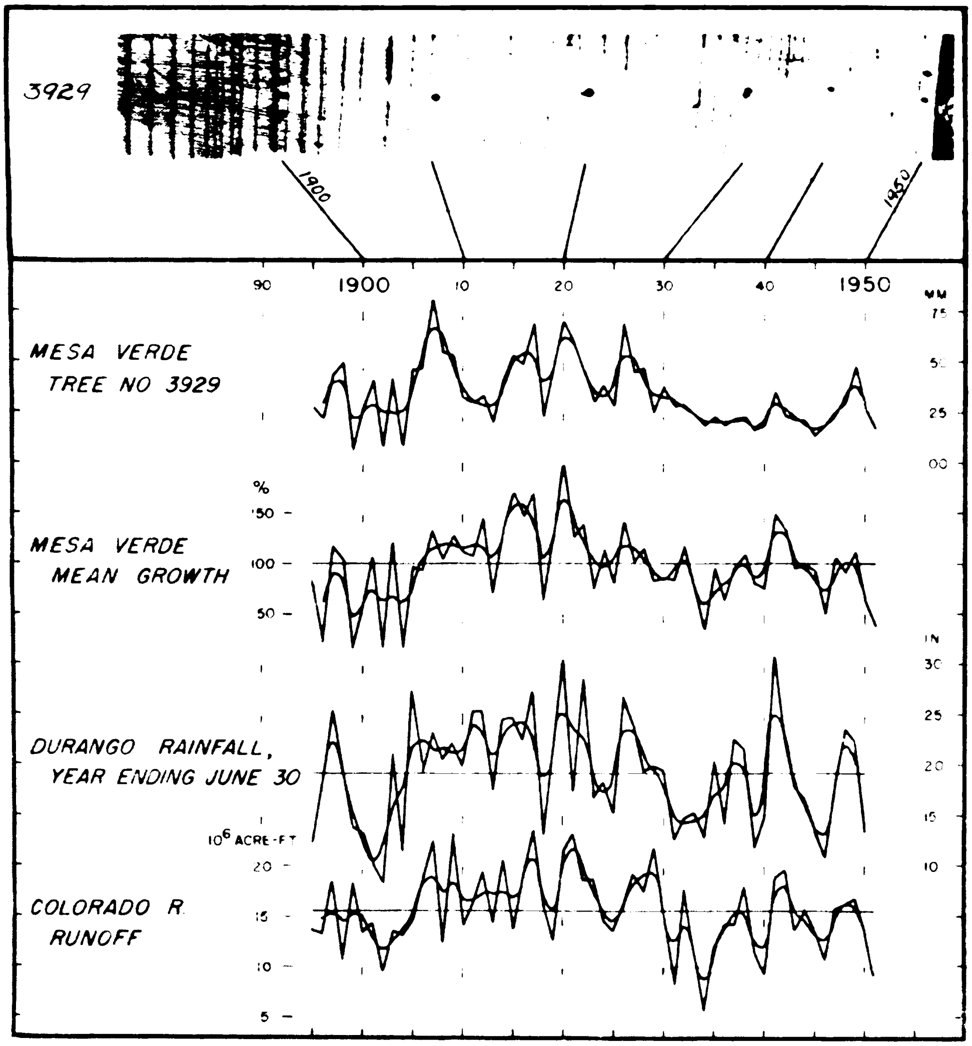
One of the areas possessing an unusual number of highly sensitive conifers is the Mesa Verde National Park in southwestern Colorado. The ring record in the outer decades on a core from a typical Douglas-fir tree from this area is shown on page 5. The total radial stem-growth for each year since 1895 (light-colored "springwood" plus dark-colored "summerwood") is plotted just below the photograph. It is evident from this figure that the single core provides a fair approximation to the mean growth derived from many trees. In turn, it is evident that the mean growth is in close parallel with the rainfall of a nearby station and the run-off of the Colorado River.

The run-off series shown in the same figure represents the total flow for the water year ending September 30, in the entire Colorado River Basin above Lee Ferry, Arizona, a region comprising western Colorado, eastern Utah, and parts of Wyoming, New Mexico, and Arizona. The relation of general run-off to single-station growth and rainfall is a clear illustration of the essential similarity in the yearly climatic chronology over large areas of the West. This phenomenon, of course, increases the effectiveness of averaging ring series from many localities to reduce local errors and arrive at a more reliable regional index.

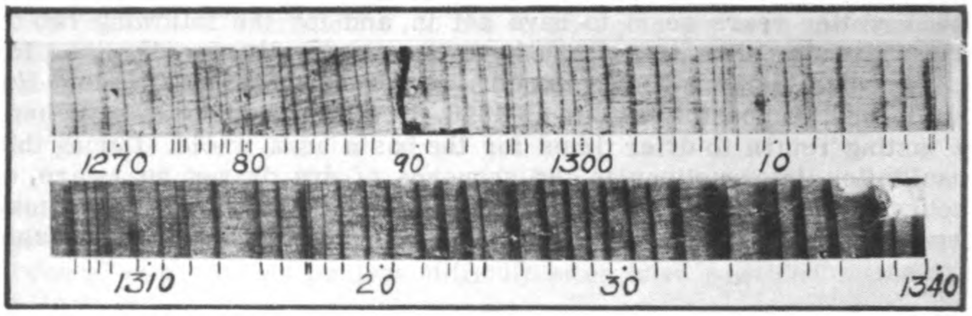
In this brief statement we may only touch upon the results of analysis of the overage drought conifers. Among these results, perhaps the most interesting are those which highlight the extreme possible departures from "normal" climate.

What appears to be the most pronounced climatic fluctuation of the past thousand years and quite likely for the preceding millenium also, was the approximately 200-year oscillation in the amount of tree growth and in the inferred rainfall in the Colorado River Basin during the thirteenth and fourteenth centuries. From A.D. 1215 to 1299 seriously deficient rainfall seems to have been the rule, the last 24 years of this interval representing a specially marked phase. About A.D.

1300, wetter years seem to have set in, and for the following two or three decades storminess may have been generally greater than for any comparable period in the modern gage records for this region. Not until 1389, or possibly as late as 1396, does there appear to have been a lasting return to drier times for the basin as a whole. During this oscillation, interruptions in the sequence of dry or wet years are, of course, not lacking. On the whole, however, this entire period may have required great adjustments in the economy of the Colorado Basin tribes.



The annual ring on the photograph of a radial pencil of Douglas-fir wood from Mesa Verde National Park, Colorado, appears as a double band of light "springwood" and dark "summerwood." The largest ring in the photo, for 1907, is almost exactly one-thirtieth inch in thickness. It is evident that the measured and plotted ring-widths for this tree are similar to those for the area in general and also correspond closely in size to the amount of annual rainfall and river flow. In order to emphasize the longer fluctuations, there is superposed on each broken-line curve a smoothed curve of the same data.



The change from the drought of the 1200's to the wet period of the 1300's is shown in the annual rings along a pencil-like core from the stem of a living 800-year-old Douglas fir at Mesa Verde National Park.

The statistical chance that the generally deficient rainfall and run-off of recent decades in the Colorado Basin is to continue for many decades more, as in the 1200's, is small; indeed, one might more justifiably look for an early swing to excessive rainfall. Yet, until a succession of wet years has occurred or some comforting physical theory developed to explain these fluctuations, a little uneasiness is perhaps warranted!

Evidence for the change from dry to wet climate near 1300 may be observed directly in the photograph above. In this series, the transition is somewhat more gradual than is indicated by most analyzed trees living through this interval. Another dry period, about twenty years long but very intense and blanketing a great area from southern California at least as far north as southwestern Montana, is indicated in the late 1500's.

Some of the indices suggest the possibility of a peculiar change in the characteristic march of western rainfall some three centuries ago. In southern California the tendency for long-term swings to one side of the growth-mean or the other, which had been typical for some centuries preceding the mid-1600's, gave way to cycles of much shorter average duration. This tendency is pronounced in the Colorado River Basin. On the other hand, a reverse tendency seems to be indicated in the Missouri River Basin indices, in which shorter variations are more characteristic preceding 1650. It is perhaps no more than a coincidence that about 1640 to 1716 occurred the well-known great dearth in sunspots, for representative growth indices from regions other than those noted apparently do not record such a change.

Pairs of regional indices from widely separated latitudes, such as Banff and southern California, show that decades-long intervals of strong negative correlation may be succeeded by long intervals of strongly positive or of no correlation. The reasons for the inferred long-term changes in certain details of the general circulation of the atmosphere may perhaps be clarified with the aid of more dendrochronologic data.

The Navy Experiments With Hydrofoils

LCDR Robert J. Johnston, USN

. . .Engineering Duty Officer of BuShips and Hydrofoil Project Officer attached to the Mechanics Branch of ONR, graduated from M.I.T. in naval architecture.

On Saturday, 30 May 1953, a press release was issued by the U.S. Navy that a program was under way in testing hydrofoils. This rather inauspicious news item didn't make any headlines in the Sunday papers but was crowded out by news of the Coronation, the Indianapolis Speedway Classic, and the Navy's own June Week at Annapolis. However, to a small group of scientists, engineers, industrialists, and naval officers this announcement represented a big step forward in the effort to build an operating hydrofoil ship.

The word "hydrofoil" sends most of us to the dictionary. Webster defines it as a plane surface, flat or curved, designed to obtain reaction from the water through which it moves. It is similar to an airfoil or wing that supports an airplane in flight. The major difference is that an airfoil uses air as the supporting medium and a hydrofoil uses water. In other words hydrofoils are really "water wings." Since water is approximately 800 times more dense than air one expects to achieve 800 times the lift from the same size foil in water as in air. But unfortunately there is also 800 times the drag.

A search in the patent office reveals the surprising fact that the initial ideas behind the hydrofoil are as old as the airplane. Back in 1905, patents were recorded on the principle of deriving lift from boat hulls and foil shapes using some other principle than Archimedes' Law. Before that time, man's travels on water had been dependent on Archimedes' Law which says that a body displaces a volume of water equal to its own weight.

One of the first revealed hydrofoil experiments was undertaken by Capt. H. C. Richardson, USN (retired), who installed them on a canoe in 1908. In 1911, in collaboration with Mr. N. White, he fitted controllable foils to a dinghy. When towed by a motor boat, the craft rose clear of the water at about six knots. In the same year, Mr. A. Guidoni in Italy applied foils to seaplanes which assisted in take-offs and landings. This application was practical for a number of years and was used in aircraft which weighed as much as 55,000 pounds. However, as the speed of the aircraft began to increase, added difficulties were encountered and the usefulness of the hydrofoil began to decline.

Dr. Alexander Graham Bell, an early hydrofoil enthusiast, did experimental work on a ladder-type hydrofoil. In this system a series of hydrofoils are supported one over the other giving the appearance of a stepladder. From these experiments several craft were built, and in 1919 one of these, the HD-4, using two airplane engines, reached a speed of 79 miles per hour. The HD-4 had four ladder systems, one

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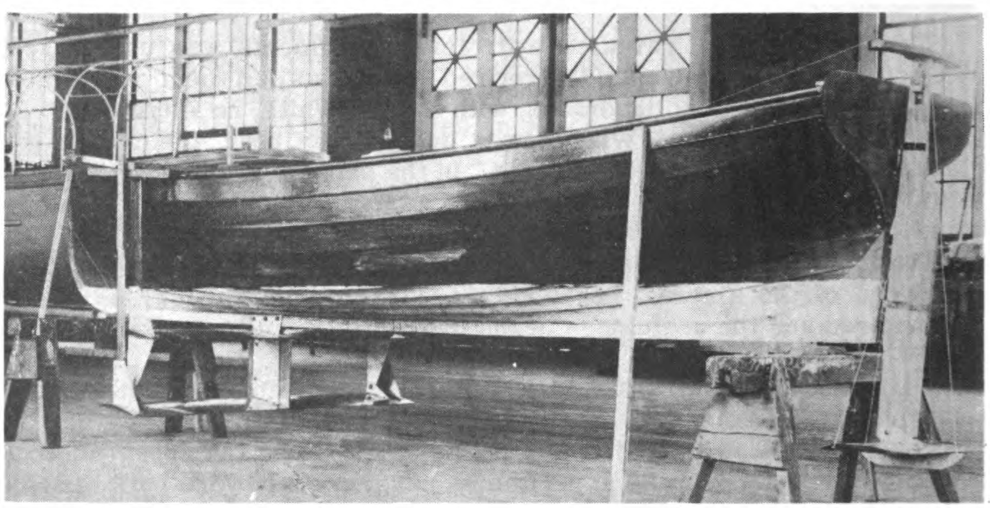
stabilizing system forward, one port and one starboard main lifting surface, and a tail foil system aft. As is often the case, this development appeared ahead of its time. Great interest was created by the craft, but there was no outlet for practical application. Dr. Bell continued his efforts and several craft were built using the ladder system. The Canadian Navy during World War II built some small smoke layers utilizing the ladder system.

Another interesting name in the history of hydrofoils is Dr. O. Tietjiens of Germany who began extensive research on ship applications in the early 1930's. Tietjiens used a 20-foot sport craft which had a large foil forward and a small tail foil aft much like the arrangement of conventional airplane lifting surfaces. This craft used a fixed, V-shaped foil which pierced the surface of the water. As the ship went through waves and changed speed, the submerged area changed and it was this feature that stabilized the craft.

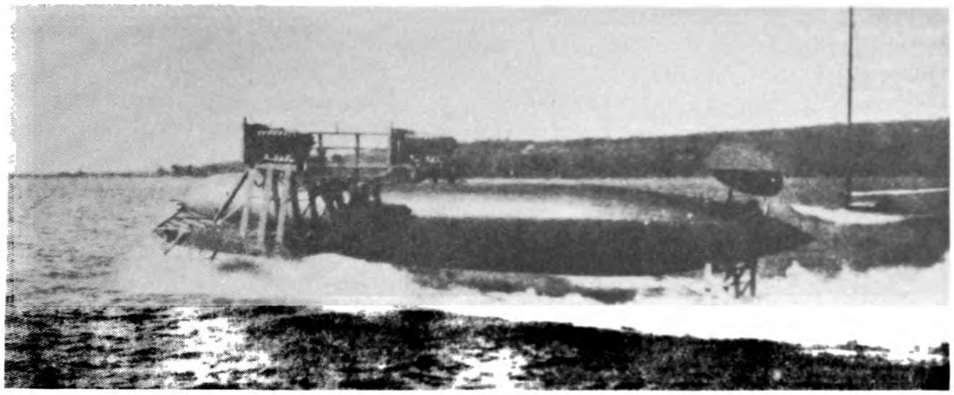
During this period, Dr. Tietjiens was employed in this country. Some of his early experiments were conducted in Philadelphia. After his return to Germany, he continued his effort and built other experimental surface-piercing hydrofoil craft.

Mr. von Schertel was another early devotee to hydrofoils. In 1937, he became associated with the Sachsenberg shipbuilding firm in Germany, where extensive design studies and experimental work on hydrofoil craft were conducted. The work of von Schertel, which goes back to 1927, was concerned primarily with hydrofoil systems that were stabilized by surface-piercing foils.

This German effort expanded in World War II and several craft were built, which took the shape of high-speed assault craft and tank carriers. One interesting sidelight is that the Tietjiens interests and the Sachsenberg interests were in actual competition to build a satisfactory hydrofoil vessel. It is not clear which firm was the more successful. Crafts displacing 80 tons with 5000 installed horsepower were built. Speeds over 50 knots were reported. The hydrofoil effort was



This hydrofoil-fitted dinghy was constructed by Captain H. C. Richardson, USN, and Mr. W. White in 1911.



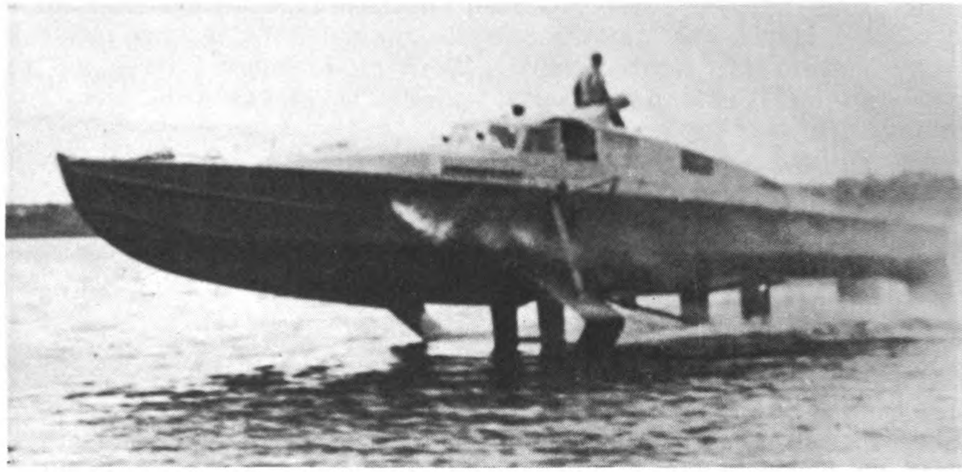
An A. J. Bell model of a hydrofoil boat called the HD-4 passes at full speed on Baddeck Bay. This craft made a speed of 70 mph in 1919.

cut short by the approaching end of the war, and much difference of opinion existed as to the success achieved. In general, the craft performed well. However, in several instances they were found to be underpowered when operating in a following sea.

The efforts of Bell and the German groups were of different concept in detail but they both used systems of hydrofoils whose lifting surfaces pierced the surface of the water. Like the HD-4's ladder system, the V-foils of the German effort were also named after their shape. Some of them were not strictly V-shaped but were semi-elliptical and semicircular. All of these systems obtain their stability from the area of the foil that is underneath the water surface. This area varies as waves are met and as the speed changes. The more area submerged, the more lifting force developed so that the foils rise with the craft, reducing the area submerged until the weight of the craft balances the lifting force of the foils.

A second type is the totally submerged hydrofoil, which cannot change its lifting force by submerging more or less area. However, if the angle at which the foil moves through the water is increased more lift is developed; if the angle is decreased less lift is developed. Now if this angle can be adjusted as the waves are met, the hull of the boat will ride out of the water and over the waves. One way of doing this is to give the pilot a control stick by which he can adjust this foil angle. However, it has been found experimentally to be quite a task to keep this action up for any practical length of time. So now the ingenuity of the designer must be exercised to find a device to control the foils so that the hull will not spank the wave crests. Unfortunately, even the longest conceivable stilts for boats leave little room for error, and the control device must be extremely accurate and must direct the foils in a minimum amount of time.

Let us take a look at some of the early attempts to control the angle of attack of the foils. Mention has already been made of Capt. Richardson's craft which used a pilot control stick. In 1938, a patent was issued to Mr. W. Grunberg of France who used surface skids on the forward end of his craft and a large submerged hydrofoil aft, which supported most of the weight of the boat. As the skids went over the surface of the waves, the boat pitched up and down. The pitching motion



A test is made of a German World War II hydrofoil boat built under a Tietjiens design.

changed the angle at which the after foils went through the water. By this method the "angle of attack" was varied and the craft was stabilized.

Mr. Christopher Hook, a British inventor, has developed the "Hydrofin" which is stabilized by angle-of-attack control. In the words of the inventor, "the 'Hydrofin' is defined as a hydrofoil boat with incidence control by surface contact and predictor effect comprising a hydroped of great simplicity which can be folded up, thus enabling the craft to be designed as an amphibian for beach and land propulsion." The surface contact is maintained by feelers ahead of the craft which control the hydrofoil or "hydropeds."

From this sketchy history of the development of hydrofoils, we see that a period of fifty years has failed to produce any large quantity of operating hydrofoil craft. With such a background, why should the U.S. Navy in 1953 announce a program of testing hydrofoils? To answer this question briefly, fundamental research and experimental evidence have proved that the hydrofoil can be made to operate successfully. However, considerable development work is still required before this principle can be applied to naval operating craft.

The present Navy program of fundamental research and experimentation dates back to 1947. Mr. W. P. Carl, Jr., after wartime service with the National Advisory Committee on Aeronautics, had started his own program of hydrofoil investigation with the assistance of Dr. K. S. M. Davidson using the Stevens Towing Tank at the Stevens Institute of Technology. Here initial work was undertaken on a surface-piercing foil configuration. In March 1947, a contract was let by the Office of Naval Research to John H. Carl and Sons for basic research and experimental work on surface-piercing foils. This was the beginning of the present Navy program in hydrofoil-supported craft.

Dr. Vannevar Bush had become a strong advocate of the development of the hydrofoil principle. Through his personal effort (with the Department of Defense) and that of his executive officer in the Carnegie

The Hook "Hydrofin" powered by an outboard motor makes a speed of about 25 mph.

Institute, Mr. Paul Scherer, added emphasis was given to the program. Additional contracts were awarded to make design studies, to conduct fundamental research, and to build test craft. The Office of Naval Research was requested to administer this program with Bureau of Ships and Bureau of Aeronautics support. The National Advisory Committee for Aeronautics has cooperated, and other branches and offices of the Department of Defense have maintained an active interest in the program and have made many timely and useful suggestions.

The real working group has been the organizations who, through their ability and willingness to tackle something new, have made it possible for the Navy to say "a hydrofoil can be made to operate successfully." Those who deserve this credit are: John H. Carl and Sons, Rockville Center, New York; The Joshua Hendy Corporation, Los Angeles, California; Hydrofoil Corporation, Annapolis, Maryland; Bath Iron Works, Bath, Maine; Gibbs and Cox, Inc., New York, New York; Baker Manufacturing Company, Evansville, Wisconsin; Stevens Institute of Technology, Hoboken, New Jersey; Miami Shipbuilding Corporation, Miami, Florida; Bethlehem Steel Shipyard, Staten Island, New York; and the University of Minnesota, Minneapolis, Minnesota. In addition to this group, the Consolidated Vultee Aircraft Corporation, San Diego, California and EDO Corporation, College Point, New York, have been doing experimental work for the Bureau of Aeronautics, on hydrofoils applied to sea-based aircraft.

As an indication of the progress made to date, in early June 1953, news representatives were invited to witness hydrofoil boat tests at the U.S. Naval Air Station, Patuxent River, Maryland. A 24-foot test craft built by the Baker Manufacturing Company under contract with the Office of Naval Research was demonstrated. This craft has made speeds up to forty knots and has operated in waves four feet high.

To date the test program has consisted essentially of operations with craft varying in size from relatively small boats provided with outboard motors to a fifty-foot test craft. Investigations have been carried out with foils made of aluminum, various grades of steel, glass-reinforced plastic, and wood.

The interest of the Navy in hydrofoil craft can best be explained by checking performance comparisons. The data given below were taken from an article published in the June 1953 Bureau of Ships Journal by CDR J. J. Stilwell, USN, titled "Wings for Ships."

Performance Comparison

Conventional Boat	Hydrofoil Boat
Length - 50'	Length - 50'
Weight - 45,000 lbs.	Weight - 49,000 lbs.
Power - 1500 hp.	Power - 1500 hp.
Top Speed - 40 knots	Top Speed - 60 knots *

*Power required at 40 knots - 800 hp.

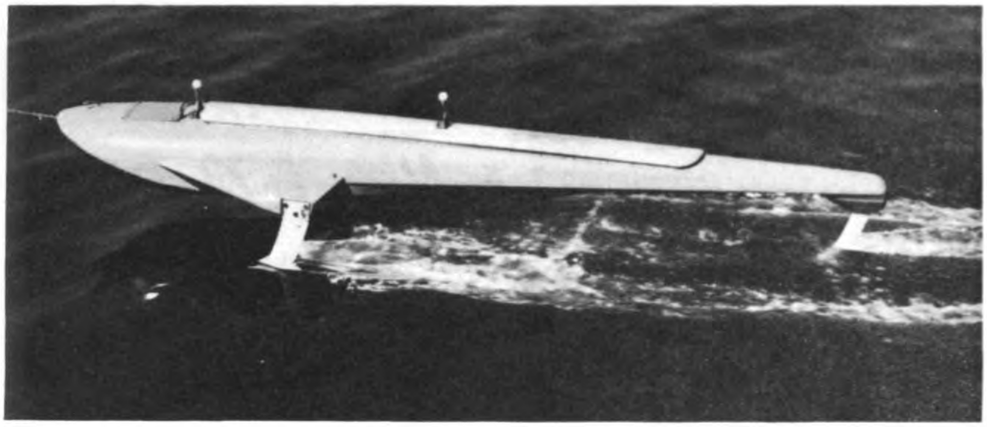
The advantages of the hydrofoil boat now become apparent. Here is a way of increasing the speed of ships without increasing the power. As a displacement type boat increases its speed, large increases in engine horsepower are required. To the speedboat enthusiast who has experienced the pounding of the boat hull as the waves are met, the advantage of getting the hull out of the water is obvious. If a hydrofoil boat can be built which will combine high-speed characteristics with relatively small power requirements and maintain this speed to give a smooth ride in rough water, then any group concerned with marine transportation will be interested.

But it would not be fair to mention the advantages of the hydrofoil without taking a look at some of the inherent disadvantages. If there were not inherent disadvantages, it could only be concluded that during the past fifty years the proverbial boat had been missed.

Like its cousin, the airplane, the hydrofoil boat must take off and land. Therefore, a conventional boat hull is required for slow-speed operation and for the "all engines stopped" condition. Being a marine craft, it must operate in harbors, alongside docks, and in many instances in shallow water. With its wings below it and sticking out at the side, it presents added problems in maneuvering. One obvious solution is to make the foils retractable like the landing gear of an airplane. However, this is complicated and increases the weight and cost of the craft. The foils and associated gear are expensive to build and one must ask "What price speed?"

The lifting ability of the "water wings" depends on the speed and their area. The amount to be lifted, of course, is the weight of the hull and its contents. But as the size and weight of the hull increase, the physical dimensions of the foils required increase disproportionately fast. At the present state of development, this places limitations on the maximum size of hydrofoil craft. So the Navy does not plan to build a supercarrier supported by hydrofoils.

Just what does the Navy plan to do with hydrofoils? As can be seen from the photographs accompanying this article, the hydrofoil craft take many different forms. And there are probably just as many ideas of what might be done with operating ships supported on hydro- foils. The Navy does have many ideas of application of the "water



An experimental towed hydrofoil craft, built for the Navy by John H. Carl and Sons, Rockville Center, Long Island, N. Y.

wings" to their craft. But at the present time, most of these applications are in the experimental stage and must be protected by security classifications. However, of most importance, the Navy can say that the hydrofoil principle can be made to work. It is now a question of checking the requirements of the operating personnel, and then for the naval architects, marine engineers, and hydrodynamicists to determine if craft can be built which will meet these specifications. A great deal of effort and further research will be required before the hydrofoil principle can be widely applied with confidence of success. However, under the direction of the Office of Naval Research, the experimental program has been carried to the point where many answers are available to assist the engineers and naval architects in solving the application problem.

Head of Dental Branch Receives Legion of Merit

CDR William E. Ludwick, USN, Head of the Dental Branch at ONR, has been awarded the Legion of Merit with the Combat "V" for his service in Korea. The presentation was made for the Secretary of the Navy by RADM C. M. Bolster, Chief of Naval Research, at a ceremony in his office on August 4. The citation reads in part: "For exceptionally meritorious conduct in the performance of outstanding services to the Government of the United States while serving as Senior Dental Officer of the First Marine Aircraft Wing in connection with operations against enemy aggressor forces in Korea from 8 November 1951 to 22 August 1952."

Who's Who in Naval Research

A warm personality and a contagious enthusiasm for getting things done are some of the qualities which inspire loyalty in the coworkers of Captain Charles B. Hart. Recently arrived from duty in San Francisco, the new Assistant Chief for Research already "sits easy" in his new position. A first impression one gets of the Captain is that, in spite of his long military career, he has never learned the knack of talking up or down—he has the happy faculty of talking straight across the table.

Captain Hart, who began life in southern Idaho and went through high school in Twin Falls, was graduated from the Naval Academy in 1926. After two years at sea, a required "apprenticeship," he went to the Submarine School in New London for six months. From then on, his service has been almost a regular alternation between submarine engineering and production work in Navy Yards. In these two fields he has gone progressively up the chain of command. He was first assigned to the USS S-45, where he remained under instruction for four months. Then came three years on the S-44 as Engineering Officer, followed by a two-year course in marine engineering (operating) at the Naval Academy Postgraduate School. His next duties were: Engineering Officer on the USS BASS, Ship Superintendent at Mare Island Naval Shipyard, and, for a few months, Second Officer on the SWORDFISH, which was just being completed at Mare Island.

In November 1939 Captain Hart became Division Engineer for Submarine Division 16 (later changed to 22) made up of newly constructed submarines including the SWORDFISH. (In December 1941 he received notice of designation as Engineering Duty Officer (General)). When the war broke out, Captain Hart was right in the middle of it. He had been transferred along with Squadron 6 to Submarines, Asiatic, and was in Manila when the Japanese attacked that area on December 8 (the 7th in Hawaii). In March of 1942 the Squadron went to western Australia and continued operations from there. Then in July the Captain was transferred to the USS HOLLAND for one month's duty as Repair Officer. His next posts were with BuShips; at the Portsmouth, N. H., Naval Shipyard as Machinery Superintendent; at the N. Y. Naval Shipyard, Brooklyn, as Repair Superintendent (where, strangely enough, he worked on everything but submarines!); at MSTS, North Pacific, in Seattle as Director of the Maintenance and Repair Division; and finally, before coming to ONR, as Production Officer at the San Francisco Naval Shipyard.

With a career like that behind him it is not surprising that Captain Hart "just relaxes" in his spare time. His wife and 7-year-old son no doubt account for a big share of it. (SGF)

Tagging The Elusive Micelle

Karol J. Mysels

. . . is Associate Professor of Chemistry at the University of Southern California. In 1943-45 he was associated with Stanford University and Edgewood Arsenal doing research on napalm and flame-throwers.

When a substance is dissolved in a liquid the particles which it forms in solution may differ widely depending on circumstances. For example, acetic acid (the acid contained in vinegar), in concentrated water solution, forms chiefly acetic acid molecules, while in dilute solution it splits into two electrically charged particles called ions. When it is dissolved in benzene, the molecules join together in pairs. A large group of chemists is always concerned with the dual problems: What are the particles in a given solution? Why are these and not some others formed? Of course, it is only as the first problem is solved that the second can be investigated.

The number and variety of methods used to study particles in solution is great; in fact, almost every measurable property of the solution has been interpreted in terms of the nature or size of the dissolved particles. One of the most valuable methods is based on the freezing point lowering or other properties which depend entirely on the number of particles in a solution and not on their nature. The presence of dissolved particles in a liquid decreases the tendency of the solvent molecules to escape from the solution—and this decrease is roughly in proportion to the number of dissolved particles. Thus during freezing, water molecules have less tendency to escape from a salt solution than from pure water to form crystals of pure ice. Hence in order to freeze, the salt solution must be at a lower temperature than the pure water and this difference—the freezing point lowering—is a measure of the number of particles in the solution.

Another method of studying dissolved particles makes use of diffusion—the spontaneous process by which all particles are urged equally toward uniform distribution as a result of their incessant random thermal motion, and are slowed down by viscous forces of the liquid. Hence the rate of diffusion will depend on their size and shape and, from the measured rate of diffusion, an estimate of their size may be made. A third means of investigation is electrophoresis by which the charge of the particle may be measured. In this process the particle is driven by an electric force which depends on the known applied potential and on the charge of the particle. The motion is hindered by essentially the same viscous forces as in diffusion. Hence by measuring diffusion (to get the viscous resistance) and then electrophoresis, the charge of the particle may be computed. This can be compared to what happens when a tug tows a ship. From the speed we can estimate the size of the ship if we know the power of the tug, or we can compute the power of the tug if we know the size of the ship.

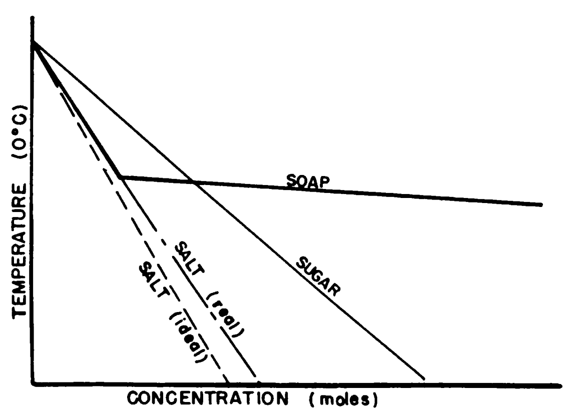
While these methods may sound simple, the perfection of experimental procedures often took years. Interpretation of results is frequently difficult and uncertain because of the complications resulting from interaction of the particles with each other and with the solvent. Despite these difficulties, we have learned a great deal about the particles of most common aqueous solutions, including many large colloidal particles such as the proteins.

There is, however, a large class of colloidal solutions, exemplified by ordinary soaps and detergents, which resisted successfully many attempts at determining the nature of their particles. We shall consider briefly why their study presented special problems and how these are being overcome.

By examining the freezing points of solutions of a pure soap, we discover a marked decrease in freezing point lowering as the concentration goes up (drawing below). In the very dilute range the freezing point lowering is relatively large, about the same for the soap solution as for a solution of ordinary salt of similar concentration, showing that many (and therefore small) particles, single ions, are formed. Instead of continuing smoothly, however, the line changes direction suddenly, and in more concentrated solutions the freezing point lowering is relatively small, showing that few, and therefore large, particles are formed by any added soap.

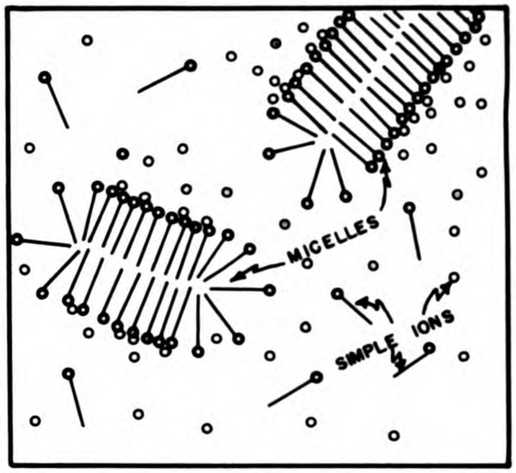
These large particles present in concentrated soap solutions were named "micelles" a long time ago, but little is known about them except that they are large as shown by the decreased freezing point lowering, that they are charged as shown by the fact that their solutions conduct electric current, and that they must be formed by ions tightly packed together (as illustrated at the top of the next page). The formation of large colloidal micelles by association of small particles is the basis for calling soaps, detergents, and similar substances "association colloids."

The association and tight packing of many soap ions gives rise to a minute region of oil within each micelle. This is perhaps best proven by the ability of aqueous soap solutions to dissolve water-insoluble materials such as many dyes, benzene, and oily dirt. This "solubilization" must be sharply differentiated from emulsification in which droplets (and not molecules) of the insoluble material are dispersed giving a turbid, milky liquid. Solubilization has probably been of great importance in our lives ever since soaps have been used, but its intensive study began when it was realized, during World War II, that the polymerization reaction by which synthetic rubber is made always begins with the styrene or butadiene solubilized in a soap micelle.



The freezing point of some solutions. The lower the freezing point, the more numerous the particles present and for the same concentration the smaller they are. In concentrated soap solutions large particles, the micelles, must be present.

The particles of a soap solution may look like this. A few ions retain their individuality, but most of the organic ions have associated into large micelles. Both kinds contribute to all properties of the solution.



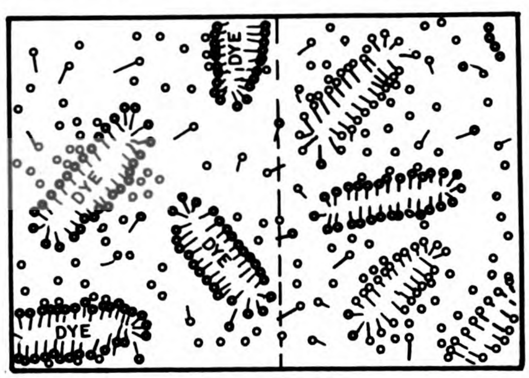
The size and charge of micelles are still obscure. They are difficult to determine because a soap solution contains not only micelles but also the simple metallic and soap ions. In other words, instead of having a "pure" solution of micelles we always deal with one which is "contaminated" by the small ions. Hence any ordinary measurement gives only an average for all the particles, and it is difficult to apportion the results between the small ones and the large ones.

For example, the freezing point lowering is affected by each little ion just as much as by each big micelle. In diffusion or electrophoresis not only can the soap travel in one form or the other but it may even use infiltration tactics: The micelle may break up totally (or partially) into the single ions which can travel individually and then reform a micelle at another place to the despair of the scientist who tries to see how fast the micelle has moved as a unit.

Thus, the distinction between micelles and simple ions is not an easy one to determine experimentally. It requires finding a tag which can be applied to the micelle because only by looking at the motion of a tag can we see how the micelle is moving. Such a tag must be easily observed, must stick well to the micelle, and must affect the properties of the micelle as little as possible.

This kind of tagging is now being accomplished by using dyes which are water-insoluble but are solubilized by micelles. In a soap solution

The micelles in the solution on the right have been tagged by a few solubilized dye molecules. Hence their movement through the solution may be observed and separated from the movement of the small ions and of the untagged micelles.



the molecules of such a dye, since they are insoluble in water, are found exclusively within the micelles (as shown at the bottom of the preceding page); in other words the tag sticks to the micelle. The dyes are so strongly colored that as little as a few parts per million is easily visible and measured; hence the tag is easily observed. The amounts of dye are such that there is never more than one dye molecule per micelle and it is tucked well inside the micelle so that its influence upon the properties of the micelle is presumably small. Furthermore, different dyes seem to give concordant results which indicates that none of them affects the micelle markedly. Hence the tag is also satisfactory from this point of view.

In applying this tagging method to the study of micelles the procedure generally involves placing next to each other, as shown in drawing, two solutions of the same concentration. If the solutions are allowed to stay thus in the absence of any disturbance, thermal motion of the particles, in time, will cause the micelles carrying the dye to distribute themselves uniformly throughout. This is diffusion, and hence by watching the rate of diffusion of the dye we can measure the rate of diffusion of micelles because the dye moves only by "riding" in a micelle. From this rate of diffusion we may then estimate the size of the micelles.

If, instead of allowing the two solutions illustrated to stay undisturbed, we apply an electric potential, all the micelles will move in one direction at the same rate. This is electrophoresis, and this movement is easily followed by the displacement of the boundary between colored and colorless solutions since again the dye moves with the velocity of the micelle in which it is riding.

While simple in principle, these measurements required the painstaking development of an entirely new type of apparatus both for diffusion and for electrophoresis. These are now brought to the point where values good to about one percent can be obtained. The application of these techniques to selected colloids is already giving us definite information about how the micelle behaves. It should soon give us the long sought answer to the question "What are micelles?" and bring us closer to solving the problem "Why are micelles what they are?"

Keel Laid for Second Nuclear Submarine

The keel of the SEA WOLF (SSN 575), the second nuclear powered submarine, was laid on September 15. The submarine will be built by the Electric Boat Division of the General Dynamics Corporation at their Groton, Connecticut, yard. The nuclear-powered propulsion machinery for the SEA WOLF is being built by the General Electric Company. A land-based prototype of this machinery has been under construction at West Milton, N. Y., since last summer.

SEA WOLF will be the third vessel of the United States Navy to bear that name. The first was authorized in March 1909. Her name was changed to H-1 in November 1911, and she was lost at sea in March 1920. The second SEA WOLF (SSN 197) was commissioned in December 1939. She is credited with one of the best records for fleet submarines during World War II.

Communication by Meteor Reflection

Oswald G. Villard, Jr.

. . .has his Ph.D. in radio engineering from Stanford Univ., where he is Chief Investigator on an ONR contract on meteor ionization.

As every user of the high-frequency radio spectrum knows, the number of channels available for communication at distances over 100 miles is strictly limited. Long-distance transmission is made possible by the ability of certain layers of the earth's upper atmosphere to reflect radio waves which would otherwise escape along straight lines into outer space. Great distances can be traversed by signals which make many successive bounces back and forth between the earth and the reflecting layers, being thus constrained to follow the earth's curvature.

The gas layers reflect because they are ionized by radiant energy from the sun. The average intensity of this ionization rises and falls, from day to day and from winter to summer, just as does the average temperature outdoors on clear days. Now a given intensity of ionization is capable of reflecting signals in the high-frequency portion of the radio spectrum only up to a certain frequency; transmissions at higher frequencies penetrate the layers like light waves and go on through. This is why FM and TV signals—which are on very high frequencies—have a reliable transmission range only out to the optical horizon.

At any given time, therefore, the layers will support long-distance transmission up to the frequency at which penetration occurs. Propagation engineers call this the "maximum usable frequency" for a particular transmission path and abbreviate it M.U.F. This M.U.F. varies tremendously. On a winter's day, it may be as high as 32 megacycles. That is, any frequency in the spectrum from 2 to 32 megacycles could be used for long-distance communication. (Two megacycles is usually taken as the lower limit. Below that lies the standard broadcast band.) This is a span of four octaves. If one allowed 5 kilocycles of the spectrum as the amount required for each radio service (assuming transmission to be radiotelephony or radioteletype) the total number which could be accommodated is 6000.

On the other hand, on a winter's night, the M.U.F. may drop to 8 megacycles and stay in that vicinity for most of the hours of darkness. The usable spectrum is then cut to two octaves, and the total number of channels available has dropped to 1200—a reduction of four-fifths.

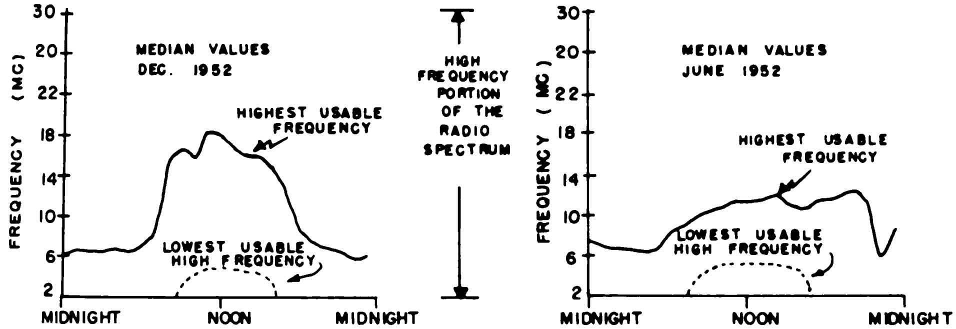
If twelve hundred channels seem like a great many, consider the number of ways in which this number must be divided. Since the channels are good for long distances, they must be regarded as international. There is, first of all, a nominal division among the various nations of the world. Second comes a division between the various classes of radio service within any one country—and here the list is long. Users include police, aircraft, marine and military services, shortwave broadcasting, radio aids to navigation, and commercial telephone and telegraph. There is even provision for radio amateurs! In some cases channel sharing is practicable (two of the three channels available to fishing boats, for example, are the world's busiest "party lines"); in others, only limited sharing is possible.

If we assume that one-third the total number of channels available on a winter's night may be used by the United States, and that this number is divided equally among the eight classes of service enumerated above, the number of channels per service is a mere 50. To pursue this further, if it were agreed that each city of over 20,000 population in the United States should be allowed one long-distance police radio, and that this radio should have a clear channel to avoid interference, we would find over 660 stations competing for the 50 available channels!

These considerations apply, of course, to a winter's night, when the number of channels available is at a minimum. It might be expected that the situation would be much improved the rest of the time, and this is to some extent true. However, although more channels become available during the day, uncertainty as to the reflecting power of the ionosphere greatly cuts down the efficiency with which they can be used. Unfortunately, the daily variation of the layers is by no means as smooth and predictable as that of the tides. Ionospheric storms not infrequently cause upsets, sometimes blacking out communication altogether. There may be weeks at a time when radio transmission is subnormal.

Most radio services require the highest feasible degree of reliability. To provide this in the face of changes in the layers both regular and irregular, it is customary for each station to have available a number of alternative channels, so that if transmission on one frequency fails, operation can be shifted to another. For the very utmost in reliability, some services (such as shortwave and shore-to-ship marine broadcasting) transmit simultaneously on several different frequencies, so that the receiving operator can select the strongest at any given time merely by tuning his receiver. These practices, of course, represent inefficient use of the radio spectrum, since the five-fold increase in number of channels when night gives way to day is offset by the requirement that a good share of the new channels be set aside for alternative use by the same service.

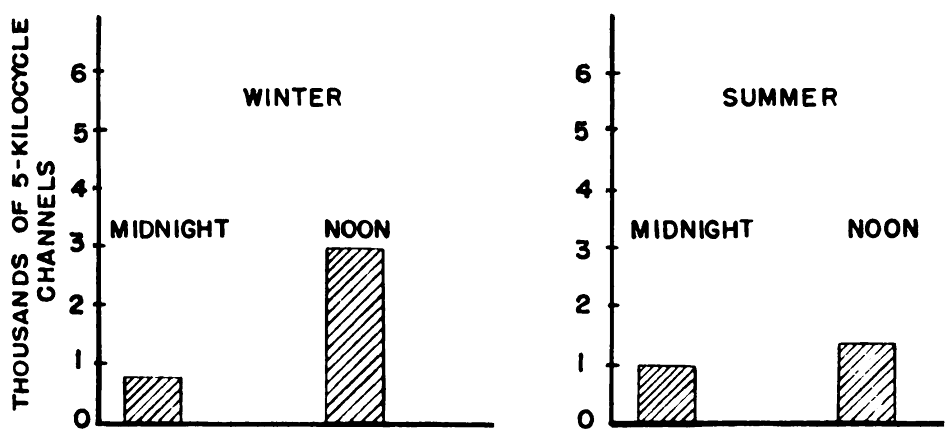
An example of this inefficiency is provided by the shortwave stations of the British Broadcasting Company. These stations regularly transmit several programs at once, often beamed to different parts of the world. They must occasionally contend with actual or unintentional jamming by other stations. Nevertheless, in order to carry on their work, they have assigned to them no fewer than 69 channels in the 6-, 7-, 9-, 11-, 15-, 17-, 21- and 26-megacycle shortwave bands. In the most-used of these bands, which are the first five, the maximum number of channels per band is 15, and the minimum 10. It is not unreasonable to conclude from this that the maximum number of separate programs which will be originated at any given time is probably in the neighborhood of 12. Thus the total number of channels reserved for BBC use is of the order of five times their minimum needs if ionosphere were not a factor.



Hourly variation of the highest and the lowest usable transmission frequencies for a 900-mile path with midpoint over Stanford, California. Median values for months of June and December, 1952, are based on Central Radio Propagation Laboratory records. The lowest usable high frequency is estimated on assumption of radiotelephony and one kilowatt of radiated power.

In another respect, too, the daytime advantage is not as great as it seems. While radiant energy from the sun enhances the reflecting power of the layers, it also increases transmission loss at the lower frequencies, so that frequencies below 4 or 5 megacycles are restricted to more or less local communication during the daytime. (This increased loss is why distant stations are only heard during the nighttime hours in the standard broadcast band.) Thus the useful daytime frequency range is more like three octaves, and the total number of channels more like 5600 than 6000.

Thus far, communication over very long distances has been considered. Curiously, the number of available channels is actually reduced when the object is to transmit over relatively shorter distances. A quantitative picture of a typical situation may be obtained from the curves above. These illustrate the way in which the median value of the highest usable frequency varies according to the hour of the day for a 900-mile path whose midpoint lies over Stanford University, California. It will be noted that the M.U.F. did not exceed 18 megacycles during the month of December, 1952.



Actual channel capacity of the ionosphere for a 900-mile path from data shown in the graph above, assuming each channel to be exactly 5 kilocycles wide.

The dotted curves represent the lowest usable frequency. At still lower frequencies, daytime absorption may be expected to be so great that transmission will be unsatisfactorily weak. (The exact frequency at which the dotted line is drawn depends, of course, on the type of transmission and the power available; in this instance the assumption has been made that radiotelephony with a transmitter power of the order of one kilowatt is being employed.)

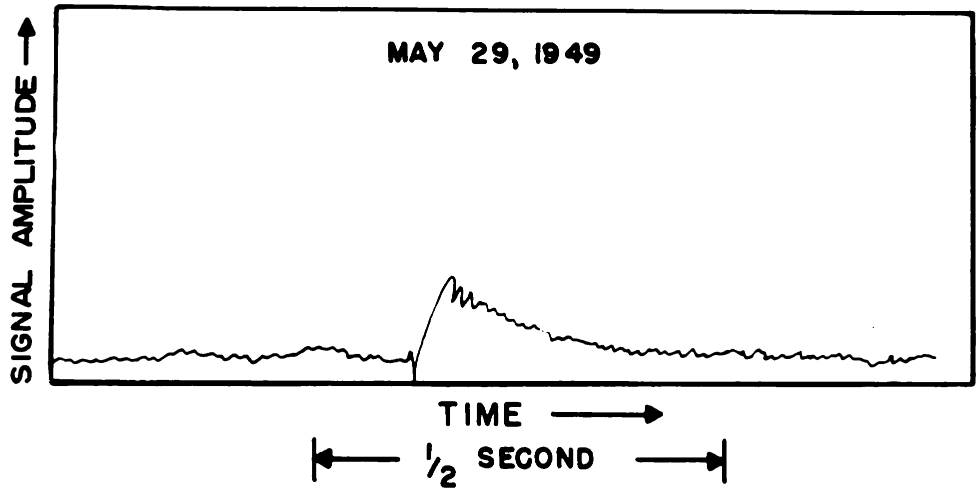
The graph at the bottom of page 21, based on the first graph, shows the actual number of 5-kilocycle channels which can be accommodated over the path at the extreme hours of the day (i.e., noon and midnight), both for winter and summer conditions.

Note that the daytime increase in channel capacity is much less in summer than in winter. In view of the greater solar radiation in summer, this seems unexpected. In summer, however, the average temperature of the atmosphere is higher, and the gas as a whole swells up as a consequence of this heat. The reflecting power of an ionized region turns out to be proportional to the density of its component gases, and swelling reduces density. Thus, the summer increase in ionizing radiation is to a considerable extent offset by thermal expansion of the layers.

These limitations on the channel capacity of the radio-reflecting layers make it desirable to find a way to extend the utility of the high-frequency radio spectrum. As the world's population grows, the volume of long-distance communication steadily increases. By now, the reflecting properties of the ionosphere have been quite thoroughly explored and exploited. It is interesting that the search for more channels has brought to light within the past few years a new concept in propagation engineering: the possibility of utilizing small irregularities in the radio-reflecting layers.

A radio wave, in passing through an ionized region, will have some portion of its energy deviated from the direction of its travel by any small discontinuities which it may encounter. Now it happens that in the lowest reflecting layer, situated in what is known as region "E" of the ionosphere, an almost continual source of ionic irregularities is provided by the passage of meteors. These meteors produce very intense columns of ionization easily capable of reflecting—and hence deviating—radio waves. At times of day when regular E-layer ionization is too weak to reflect, so that the main body of a given transmission passes on through, considerable radio energy is nevertheless deviated downward by the individual meteor ionization columns. Each meteor produces bursts of signal which are readily detectable at a distant point. The number of individual meteor occurrences is so large that if the power and wavelength are properly chosen, the bursts actually overlap, giving rise to a signal which is substantially continuous and hence useful for communication.

It is in an altitude region centered at roughly seventy miles above the earth that most meteoric particles give up their energy. The visible flash which we call a meteor is caused by the collision between the earth's atmosphere and bits of dust and matter which are found in interplanetary space. The relative speed of the earth and of most of these particles is so great that the medium-sized ones (about the size

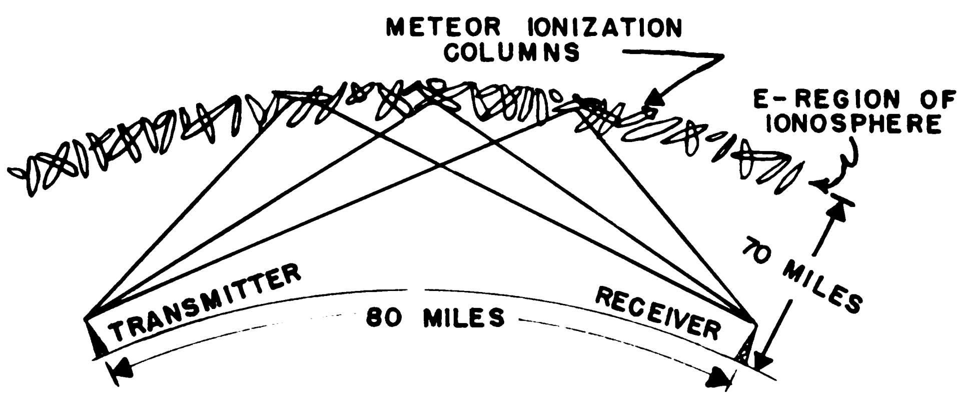


Recording of a typical meteor echo of 23 megacycles. The transmitter and receiver are at the same location as in radar practice.

of a shotgun pellet) do not survive their initial contact with the earth's atmosphere and are evaporated by frictional heating while still at great altitudes. Very large chunks—meteorites—and very small fragments—invisible micrometeorites—do survive and fall to the earth, although for different reasons. In between these extremes are literally myriads of particles which incandesce upon collision and create radio-reflecting columns of ionization along their track.

These columns may be detected by means of the echo they produce on a suitable radar apparatus. The sensitivity of a typical equipment of this sort is vastly greater than that of the human eye. Whereas an observer can see eight to ten meteors per hour on a nonshower night, the radar "sees" several thousand.

Owing to the availability of surplus wartime radar gear, and the convenience of being able to have transmitter and receiver at the same place, most of the postwar research on meteor echoes has been conducted on the radar principle—that is, the reflected signal travels back over substantially the same path as the transmitted signal. Because of



This diagram shows how overlapping meteor echoes can support long-distance transmission.

this circumstance, and the fact that most radars use relatively high frequencies, the communication possibilities of meteor reflections had not been appreciated because the observed echoes were of short duration and well separated in time.

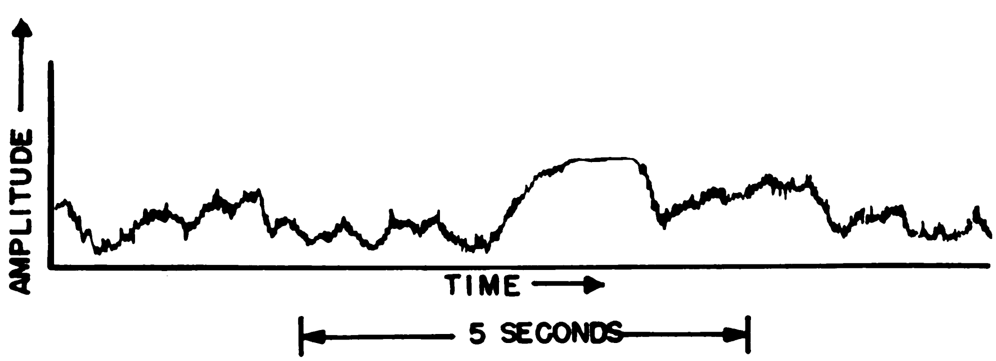
A typical meteor echo, as seen on a radar screen, begins as a sudden burst of signal rising rapidly out of the background noise level to some maximum amplitude, and then decaying evenly (exponentially, in fact) back down into the noise. It is possible to define a duration for the echoes as the time interval between maximum amplitude and 37 percent of this value. At a radio frequency of 50 megacycles, using radar technique and typical radar parameters, the majority of echoes have durations of the order of fractions of a second, and the rate of occurrence of detectable echoes is relatively low. A typical echo recording, made with a radar system at 23 megacycles, is shown at the top of the preceding page. Random wiggles of the trace are caused by the receiver's noise output.

In the course of research on meteor ionization conducted at Stanford University, with joint Service support under the supervision of the Office of Naval Research, it has been found that when transmitter and receiver are separated, the duration (as defined above) of a reflection from a given meteor column is greatly increased. This increase can be as large as 25 times for an 800-mile transmission path.

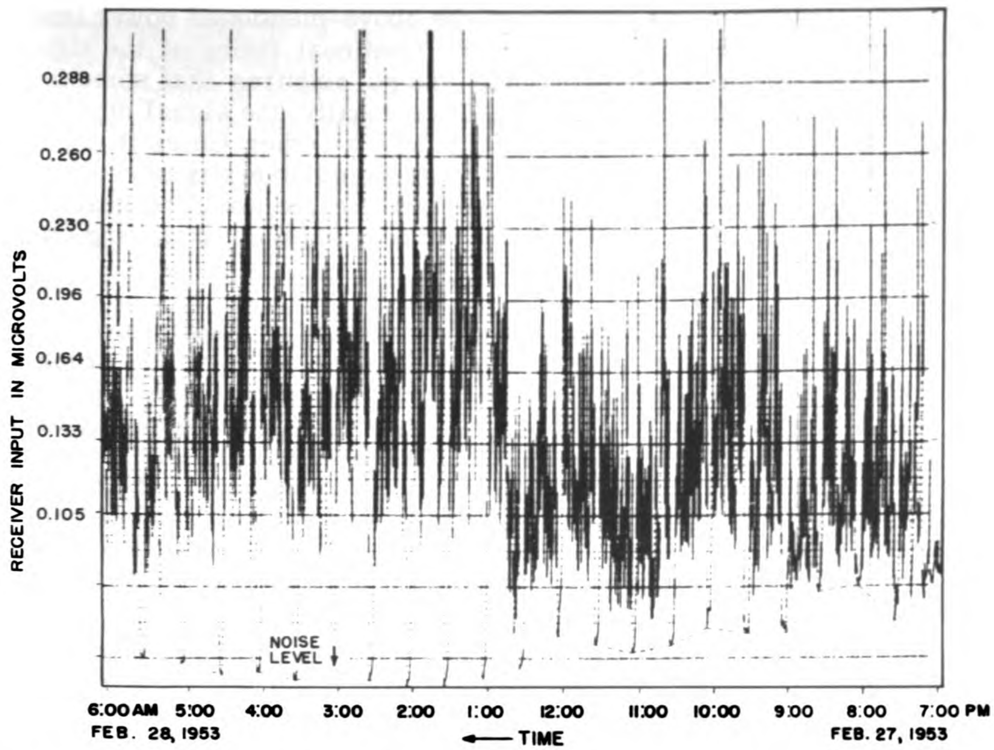
It can furthermore be shown that the peak amplitude of these echoes varies inversely as frequency to the three-halves power, and duration, as defined above, varies inversely as frequency squared.

Still another factor—essentially a system parameter—also acts to increase the signal strength of a given meteor reflection as frequency is lowered. This is the increased size of the receiving antenna, and its correspondingly greater ability to extract energy from a passing wave.

All these circumstances conspire, at radio frequencies of the order of 15 megacycles, and for transmission distances of the order of 1000 miles (roughly one-half the maximum distance of transmission by one reflection from the E-layer), to produce a surprisingly strong and continuous signal by multiple reflection from meteoric ionization. This is true even when moderately low powers are used (order of one



High-speed recording of a 300-watt 14-megacycle signal transmitter over a path of 750 miles by overlapping reflections from meteor trails.



Slow-speed recording of a signal transmitted from U.S. Naval Radio Station, Seattle, Washington to Stanford, California on 24.8 megacycles on the night of February 27-28, 1953. No layer propagation of any kind could be shown to be present. Transmitted power: approximately 2.5 kilowatts.

kilowatt), along with normal communication receiver bandwidths (approximately 3 kilocycles).

The geometry of the reflection process involved is shown at the bottom of page 23. The next two figures (at bottom of opposite page and above) illustrate the characteristics of a continuous-wave signal transmitted in this manner. A high-speed recording of a 300-watt, 14-megacycle signal transmitted over a 750-mile path appears in the first of the two recordings. Contrast the multiple reflections of this figure with the single echo on page 23. Note the difficulty of distinguishing individual echoes when overlapping occurs. Above is a slow-speed recording of a 1.5-kilowatt, 25-megacycle signal transmitted over a 750-mile path from the U.S. Naval Radio Station at Seattle, Washington, to Stanford, California, on the night of February 27-28, 1953. The effective time constant of the recording pen is several seconds. No form of layer transmission could be shown to be present at any time during the night. Note the enhancement of the signal during the early morning hours when meteors are most frequent in occurrence.

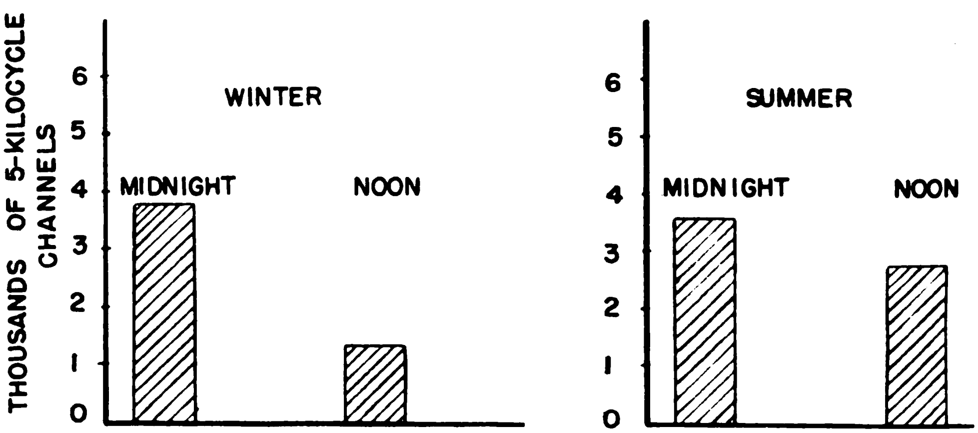
The sole requirements for successful transmission of this sort are (1) relatively noise-free locations without serious restriction as to vertical angle of transmission in the desired direction, and (2) antenna systems of moderate gain and sufficient height to ensure radiation of a reasonable proportion of their power at the lower angles.

The signal strength obtained at the above-mentioned power levels is adequate for hand-keyed telegraphy. Continual fading of the signal, as individual meteor reflections come and go, requires that some form of receiver output limiting be used. Occasionally, the signal dips down into the noise level and is momentarily lost; at other times it is many decibels above the noise. With higher power and diversity reception, it seems clear that high-speed telegraphy and teletype would be practical. Frequency-modulated voice telephony would avoid the distracting effect of sudden changes in signal amplitude.

The advantages of this type of transmission are the following. In effect, it makes available, for 24-hour use over paths of the order of 1000 miles, any of the frequencies in the high-frequency band. Between 15 and 30 megacycles, of course, the average signal strength for a given transmitted power will steadily decrease, but this can be overcome by increased power and antenna gain. A frequency of 24.8 megacycles has been successfully used, for example, in tests between Stanford, California, and Seattle, Washington, with a transmitted power level of approximately 2.5 kilowatts and a transmitting antenna consisting of a rhombic of standard dimensions. (See the record on page 25.)

Meteor-reflected transmission over a given circuit will of course be supplemented during many hours of the day by direct layer transmission, or by layer transmission via scattering from the ground. Transmitter power can be reduced during periods when these other forms of transmission are present.

The ability to use one frequency for a given circuit twenty-four hours a day will considerably simplify operating and maintenance problems. In the first place, an antenna designed for single-frequency operation can be used. In many situations, the space required for nonresonant antennas (such as rhombics) is not available, and a multiplicity of resonant directive antennas is awkward. Second, a skilled technician is no longer needed at the transmitter to perform frequency changes. Third, circuit interruptions while frequency changes are taking place are avoided. On many communications circuits, particularly



Additional capacity made available by use of meteor-reflected transmission in the situation illustrated at the bottom of page 15, assuming 25 megacycles to be the highest frequency employed.

multichannel ones, it is necessary to reserve one channel as an order wire over which maintenance personnel can compare notes on circuit quality, impending frequency changes, etc. The reliability of meteor-reflected circuits may make such supervisory traffic unnecessary.

One of the most remarkable features of meteor-reflected transmission is its freedom from the effects of ionospheric storms. Sunspot-caused magnetic storms can affect only to a minor extent, if at all, the ability of meteoric particles to produce columns of ionization. Thus meteor-reflected circuits can be expected to be much more reliable than those employing the regular layers. There is only one type of ionospheric disturbance—the Dellinger fadeout, known to be associated with solar flares—which may be able to affect meteor transmission by causing strong absorption in the region where the ion columns are formed. It is not known yet whether these fadeouts, which occur only on the sunlit side of the earth and usually last from five minutes to half an hour, will affect oblique meteor reflections at 15 megacycles.

On the graph opposite is shown the additional channel capacity made available by use of meteor-reflected transmission in the situation depicted in the graph at the bottom of page 21. The total capacity, therefore, becomes the sum of the two graphs. Employment of meteor reflections more than doubles the number of channels available. It is assumed here that the highest frequency for meteor transmission is 25 megacycles. Still higher frequencies could be employed, with proportionate increases in channel capacity, but power requirements would become greater. Furthermore, most presently available communication transmitters are not designed to operate above 25 megacycles.

Thus it appears that the many thousands of tiny meteors which bombard the earth's atmosphere at all times are about to be put to a practical use—that of providing a weak but reliable method of communication over distances of the order of 1000 miles. By taking advantage of the dispersive properties of ionized layers, in addition to their well-known reflecting properties, the capacity of the now-overloaded high-frequency spectrum can be greatly extended. Many of the channels now silent for so many hours of the day and year will at last be made to work around the clock.

Naval Research Committee Elects New Officers

Dr. Augustus B. Kinzel and Dr. John A. Hutcheson have been elected Chairman and Vice-Chairman, respectively, of the Naval Research Advisory Committee. Formerly Vice-Chairman of the Committee, Dr. Kinzel succeeds Dr. A. H. Compton, Chancellor of Washington University. He has been President of the Union Carbide and Carbon Laboratories, Inc. since 1948. Dr. Hutcheson, a member of the Committee since 1947, is Vice-President of the Research Laboratories of the Westinghouse Electric Corporation.

Established by Public Law in 1946, the Committee is the senior research advisory group of the Navy. Its members, eminent in the fields of research and development, are appointed by the Secretary of the Navy.

On The Naval Research Reserve

LT Thomas and Company 9-12 Receive Commendation

LT Walter D. Thomas, Jr., Commanding Officer of Naval Reserve Research Company 9-12 (Fort Collins, Colorado) received the letter quoted below for noteworthy leadership and outstanding performance of duty by his Company. Presentation was made by LCDR William Robison, Research Reserve Program Officer, Chicago.

From: Chief of Naval Personnel
To: LT Walter D. THOMAS, Jr., USNR, 402216/2305
Commanding Officer, Naval Reserve Research Company 9-12
Fort Collins, Colorado
Via: (1) Office of Naval Research
(2) Commandant, NINTH Naval District

Subj: Commendation

1. I note with pleasure that Volunteer Naval Reserve Research Company 9-12, under your command, was evaluated OUTSTANDING by the Commandant, NINTH Naval District for fiscal year 1952.

2. This creditable showing could result only from noteworthy leadership on your part and excellent cooperation and performance of duty by the personnel under your command. I commend your entire Company for its excellence, and I send it a hearty "well done."

/s/ J. L. HOLLOWAY, JR

Billets Announced by Company 13-2

Naval Reserve Research Company 13-2 (Richland, Washington) has announced the following organization billets and duties: Commanding Officer, LCDR D. R. Gustavson; Executive Officer, CDR Lloyd D. Weir; Training Officer, LCDR Gustavson (dual responsibility); Asst. Training Officer, CDR Weir (dual responsibility); Training Aids Officer, CHELE Roy F. Smith; Administrative Officer, LCDR C. I. Anderson; Security Officer, LCDR Myron Russ; Public Information Officer, LTJG R. C. Langton; Special Events Officer, LT Ross Lovington; Supply and Fiscal Officer, LTJG C. A. Junghans.

Information Officers: Promotion, LCDR M. E. Forsman; Retirement, LT L. P. Bupp; Correspondence Courses, LT R. M. Wagner; Training Duty, LT L. W. Lang; Physical Examinations, LT E. T. Merrill; Personnel Officer, LT D. M. Knott; Recruiting, LT G. L. Swezea; Uniforms, LT L. H. Clark. Policy Board: CDR L. D. Weir, CDR P. Thompson, CDR G. Bunker, LCDR F. H. Ames, LCDR R. L. Oldbright, LCDR G. C. Oberg, LCDR C. B. Wagner.

I Live in the Wrong Age

Robert C. Ruark

We obtained permission from Robert C. Ruark, Syndicated Columnist, to quote his views on the sea which appeared in one of his columns. We believe they are more than one man's feelings, and that many Research Reservists will find themselves kindred spirits with Mr. Ruark.

At sea, Dec. 11—I use the airplane nearly as much as any man, and I admire the iron bird for its speed and its functionality in a rapid age, but once in a while a man who has been to sea before needs to go to sea again, to let the wind and the salt spray blow his spirit clean. This is not accomplished on one of the speed demons that bucks across the north Atlantic at 30 knots, with the bone in its teeth and its eye on a record.

I am a slow ship man myself. I like a ship that takes time. Such a ship is the wonderful old Vulcania, where the doctor, the food and the crew is a thousand percent Italian. We have sacrificed so much to streamlining and extreme function in recent years that it is wonderful to get back aboard an old-fashioned craft, with cherubs and chandeliers in the dining saloon and gold paint and frescoes and thick carpets on the floors.

And it is wonderful to sail in a sea-going version of the Hotel Splendide, where the stewards are polite and the wine waiter obsequious, where the band plays corny concerts and the food comes in endless courses and we do not deal in blackstrap, yoghurt, or spinach juice. On this ship we tend more to a dozen fattening hors d'oeuvres, pasta that lays the pounds on you with a trowel, and desserts that would certainly flounder you ashore.

We indulge in high tea in the afternoon and a light lunch at midnight. We get fat and we do not care and I have finally reached the full conclusion that I live in the wrong age. I should have been a Victorian. I love schmaltz. I can hear one fiddle and wallow in Weltschmerz. Being at sea drives me to drool. I'd rather see a porpoise leap than watch all the television in the world. I admire the old world of steamer trunks and deck chairs and stewards tucking you in.

There is a little veranda outside my room and I spend all day and half the night just looking at the water. I have spent a good portion of my life on ships, in the Merchant Marine as a kid, and in the Navy in the last war, and they still fascinate me. I can tell what a ship is thinking by the way she creaks in a heavy sea, and I love all the sounds you hear in the night on a ship at sea.

We busted a propeller blade off her yesterday and I could feel immediately that something had hurt the old girl. There was just an imperceptible change in her gait before the skipper slowed her down. We are running this floating castle a great deal slower now, because of the lost propeller blade and that's fine with me. Ten years ago I would have been scared stiff, because it would have had to drop out of convoy and now I don't care how slow she goes, or if we ever touch land and I like it out here in the fresh air, with nothing much to do but sit and let people be nice to you in an old-fashioned way.

Combat Paintings Available for Exhibit

"Operation Palette," a group of 100 paintings and drawings by official Navy combat artists, may be the answer to your problems about what to offer at that next exhibit. These paintings, done by some of the most outstanding artists in the United States, are eye-witness records of the Navy's role in the war on the seas, on the beaches, and in the air. Research Reserve Companies may borrow this group of paintings without charge for exhibit. They are transported in a 3-1/2-ton truck which also carries portable wall space for hanging. Requests for exhibit of "Operation Palette" in your community should be addressed to: Combat Art Branch (OI-350), Room 1538, Main Navy Building, Washington 25, D. C.

In addition to Operation Palette, the Combat Art Section has 3,000 other paintings which may be requested for exhibit in any number desired. The theme of your exhibit should be stated, and a suitable group of paintings will be selected for you. Sponsorship and purpose of the exhibit, its location and details for display, security, etc. should accompany the request.

Psychological Warfare Seminar Held by Research Reserve Company 6-6

Last month Research Reserve Company 6-6 (Chapel Hill, N. C.) held its Second Annual Psychological Warfare Seminar, with LCDR Robert Shenkkan (Commanding Officer) as Officer-in-Charge. The opening address on 3 August was made by RADM C. M. Bolster, USN, Chief of Naval Research. LCDR E. S. Churchill, USNR, Training Officer, was on hand for the opening days of the Seminar. Program Chairman was CDR Wallace Carroll, USNR, and LCDR Marvin Woodward, USNR, was Security Officer. Seminar members and some of the "top brass" who attended are shown on the opposite page.

RADM Bernard Austin, USN, Director, Division of International Affairs, Navy Department, participated in the ONR-sponsored seminar. The two-week program, which consisted of lectures and discussions on modern psychological warfare, was the second to be held at the University of North Carolina by VNRRU 6-6.

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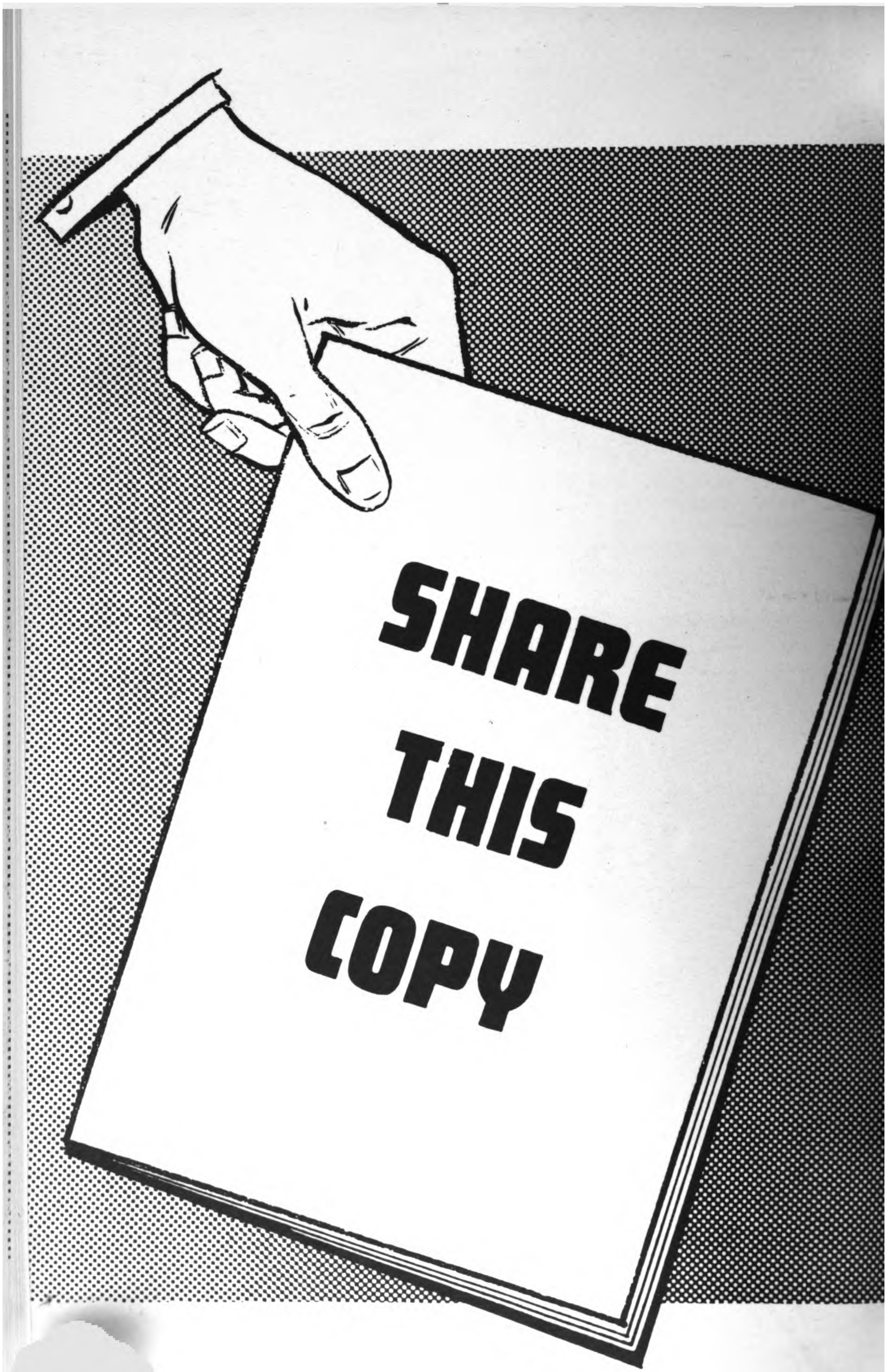
Members of Psychological Warfare Seminar,
Chapel Hill, North Carolina, 2-15 August 1953

Discussing events at the Seminar are (left to right) CAPT W. E. Guitar, USN, Reserve Coordinator, ComSIX; LCDR Robert Shenkkan, USNR, Commanding Officer, Research Reserve Co. 6-6 and Officer-in-Charge of Seminar; CDR Wallace Carroll, USNR, Seminar Program Chairman; Chancellor Robert B. House, University of North Carolina; LCDR Marvin Woodward, USNR, Seminar Security Officer; RADM Bernard Austin, USN, Director, Division of International Affairs, Navy Department; and RADM C. M. Bolster, USN, Chief of Naval Research.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