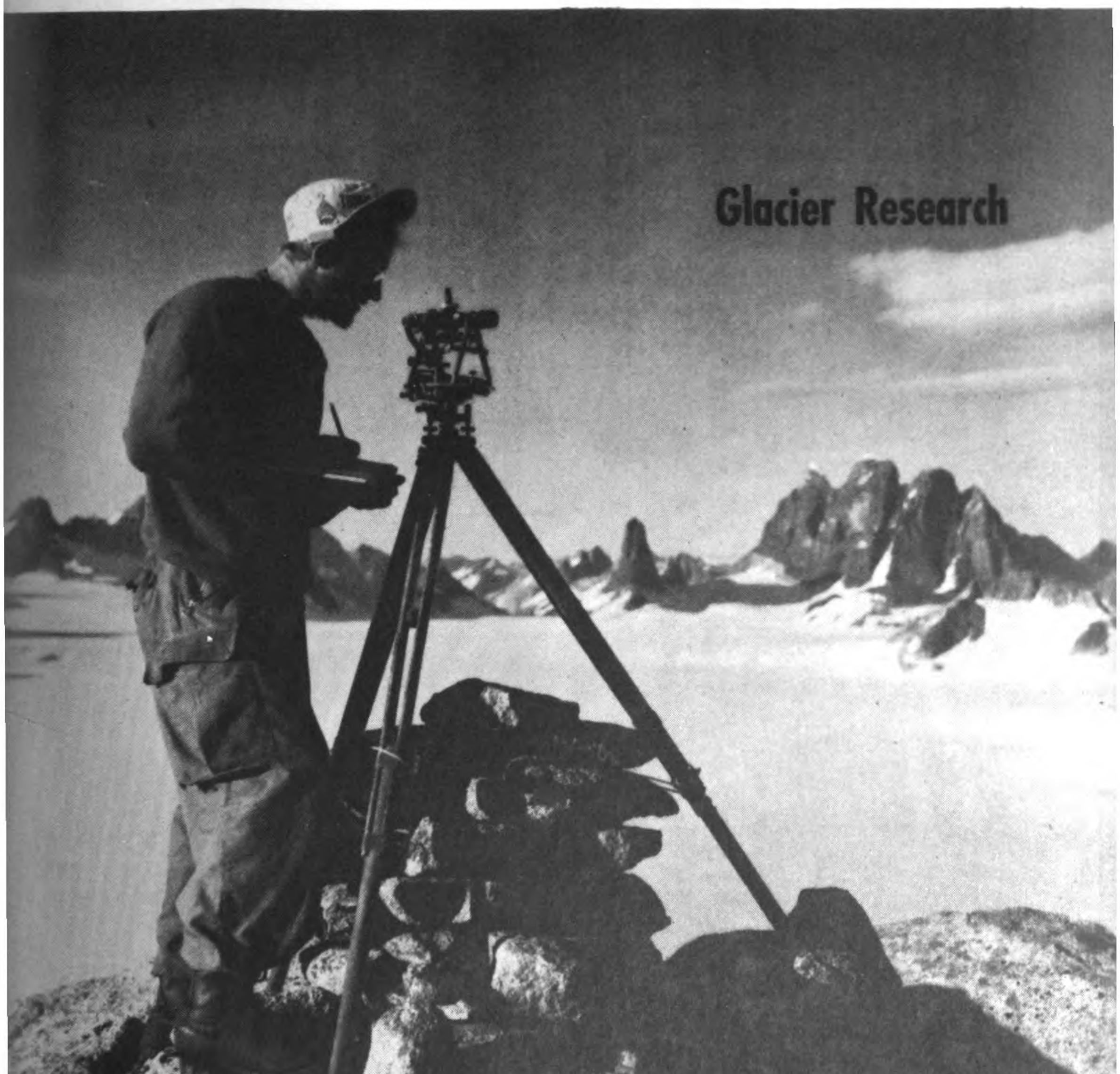
OFFICE OF NAVAL RESEARCH • APRIL 1951

RESEARCH REVIEWS



Glacier Research

NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

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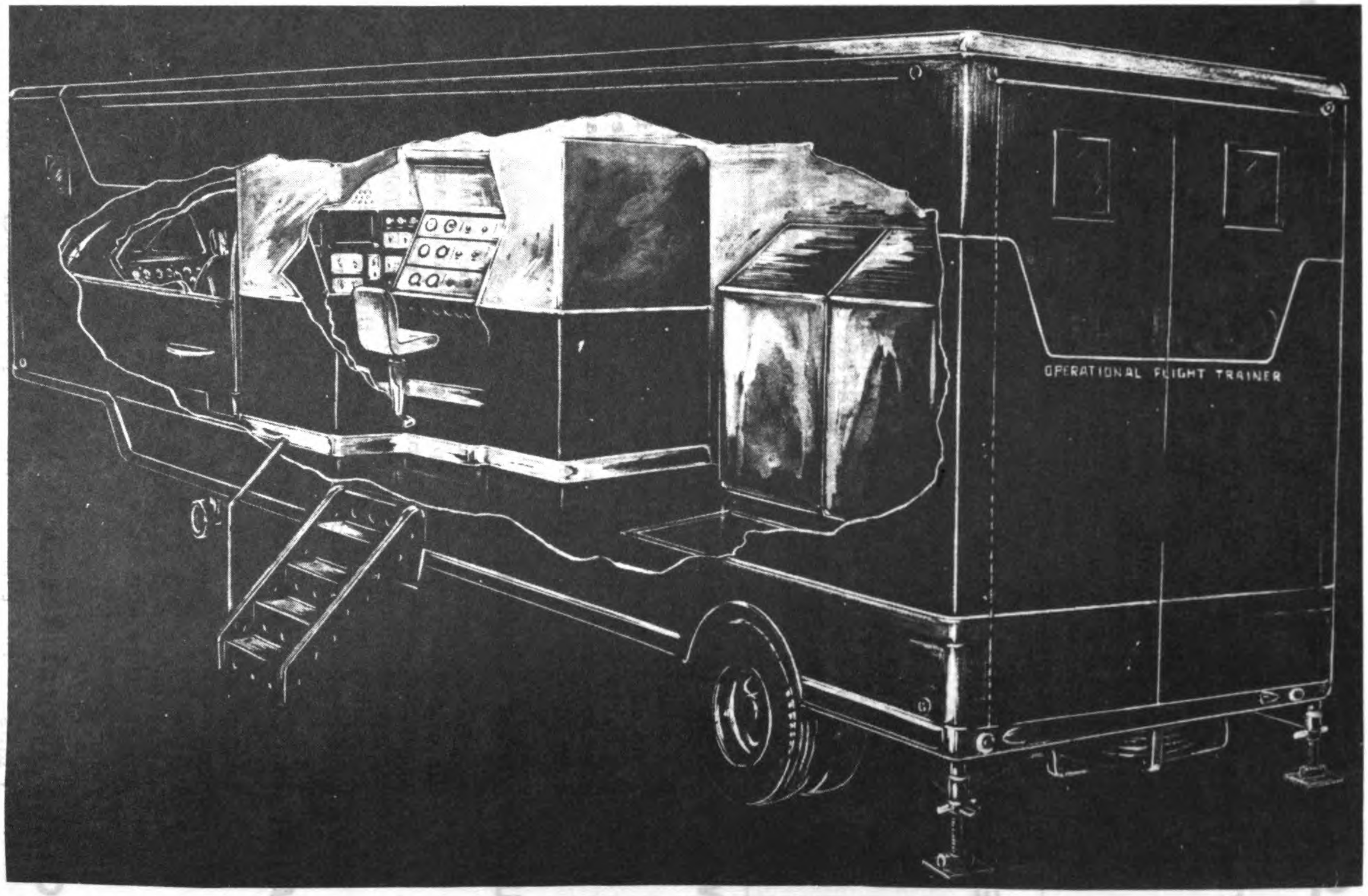
COVER PHOTO: This scientist is carrying out mapping operations from a so-called "triangulation station", one mile up in the Juneau Ice Field. Ten miles away, on the eastern edge of the Ice Field, Devil's Paw, an elevation of 8,584 feet, is visible. This photograph, taken by Zach Stewart, illustrates only one phase of the extensive work being carried out on the glaciers of this region by ONR investigators. The article on pp. 7 to 15 of this month's issue tells more about their work.

Approved by Bureau of the Budget, 13 April 1948.

April 1951

In this issue--



Cut-away drawing of operational flight trainer

The Navy's New Trailerized Flight Trainers

As modern in design and as effective in performance as the actual plane itself is the new trainer F3D OFT (Device 2-F-12) built under contract for ONR's Special Devices Center by Link Aviation. The new OFTs provide remarkably complete simulation of all phases of actual plane operation. Trailer-installed, these self-contained mobile units will provide advanced training for pilots and, with the associated radar simulator (Device 15-V-5) for radar operators in the operation of the F3D night fighter and its airborne equipment. An auxiliary trailer is being equipped with this simulated radar signal-generating equipment which will be used with one of these traveling training stations.

The new trainer has been designed to provide complete on-the-ground flight training under realistically simulated conditions of normal and emergency flight. Its utilization in the jet fighter training program covers every phase of flight instruction and practice--cockpit familiarization (for pilot and operator alike), ground and air engine operation, power settings and attitudes for varying conditions of flight under day and night instrument conditions, navigation by radio, and crew coordination between pilot and radar operator. The F3D mobile Flight Trainer contains all the facilities necessary for the transitional training of new jet pilots in addition to those necessary for increasing the proficiency of the experienced ones.

The setting for realistic flight is in no way left to the imagination of the pilot or operator. As Figure 1 shows, the Link F3D Trainer duplicates in detail the cockpit section of the F3D airplane. The pilot's and operator's station--completely furnished with all of the controls, switches, instrumentation, and associated equipment of the plane itself--provides the proper environment for creating actual flight conditions. Nor does the touch of realism end here. Built-in flight characteristics and over-all performance of the trainer require the pilot to fly the trainer as he would the airplane.

Electronic computing systems develop instrumentally all functions of flight of the aircraft, including engine starting, warm-up, taxiing, take-off, and landing simulation. Aerodynamic effects of dive brakes, landing gear, flaps, external armament, wing tanks, and wing icing upon the aircraft in flight are translated electronically into instrument indications and control reactions. Even the effect of weight change by fuel consumption and armament release is included.

Flight performance varies with altitude and power, and, as in the air, critical airspeeds bear the proper relationship to Mach number. Buffeting is encountered and the nose of the trainer tends to "tuck under" when excessive speeds are reached. In addition, short, sharp "G" effects are actually produced during rough-air simulation by automatically

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The material contained in this article was first printed in the November issue of the Special Devices Center's Monthly Report.

controlled vertical and roll movements of the fuselage. Stalls and spins are realistically manifested through the instruments and control feel.

Flight in the trainer demands all the precautions and all the skills of flight in the aircraft. For example, pilot pre-flight and flight checks are a "must". Even so, simulated failures and emergency situations occur, as well as deviations from specified procedures. The instructor keeps the pilot constantly on the alert by using the 20-odd failure switches on the emergency control panel to provide realistic simulation of unusual conditions ranging from false starts to landing crashes.

Actual operation of the trainer duplicates operation of the plane in every detail. Under the canopied cockpit of the F3D OFT and ready for his training flight, the pilot checks his controls, sets his instruments, and prepares to "fire up" the engines. Battery cart plugged in and switch "on"--throttle aft--master engine switch "on"--fuel switch "on"--throttle over to start-ignition position - and with the whine of accelerating rotors crescendoing into a roar of burners, the engines come to life. The starting sequence of the airplane is paralleled electronically in the trainer even to the actual sounds.

Throughout the flight, the pilot finds the same close parallel between trainer and plane. Engine controls and instruments provide every feature of jet-engine operation. Turbine temperature, oil temperature and pressure, percent rpm, fuel consumption--all vary with throttle setting and altitude, and the pilot learns what to expect when the critical rpm is exceeded or idling is too low. He learns too, how to restart engines in flight and even discovers that the trainer will not fly without fuel, any more than any airplane.

Equal consideration has been given to the instructor (Figure 2) in the design and building of this modern jet training equipment. The instructor's console (Figure 3)--the electronic flight control center of the trainer--is an integral part of the Link F3D. His station within the conveniently arranged U-shaped console provides comfortable operating quarters as well as full facilities for setting up, controlling and evaluating all phases of the simulated flights.

The instructor is kept constantly informed of the progress of the flight problem through an adequate set of duplicated cockpit flight and engine instruments, two automatic aircraft position indicators, and a panel of tell-tale lights. These lights, coded in color, give instant warning of any pilot error, its cause, and resultant condition of the aircraft. For a more complete picture of what goes on inside the cockpit during flight, the instructor has only to look through the observation window which opens directly into the cockpit from the instructor's station.

From the standpoint of instruction and effective pilot training, the center panel of the F3D console provides the instructor with his most powerful set of controls for testing pilot skill, alertness, and reaction to the unexpected. Emergency situations--fire, ice, engine failure, system (hydraulic, electrical) failures, over-speeding (many of which are too dangerous too experiment with in the air)--can be duplicated in the trainer by the push of a button. Other switches provide aural and visual sensations of actual flight--clouds shadowing the canopy, rain, static (crash and precipitation) and lightning.

The instructor too, can add rough air and vary the wind velocity from 0 to 120 knots from any direction to meet the needs of the training flight. He can simulate a shifting carrier base for relative motion navigational problems or he can freeze the problem at any point for immediate instructional purposes. And, most important of all, with a flick of a switch, he can restore the plane after a crash, an engine that has been disabled, or any part that has failed, for immediate resumption of training.

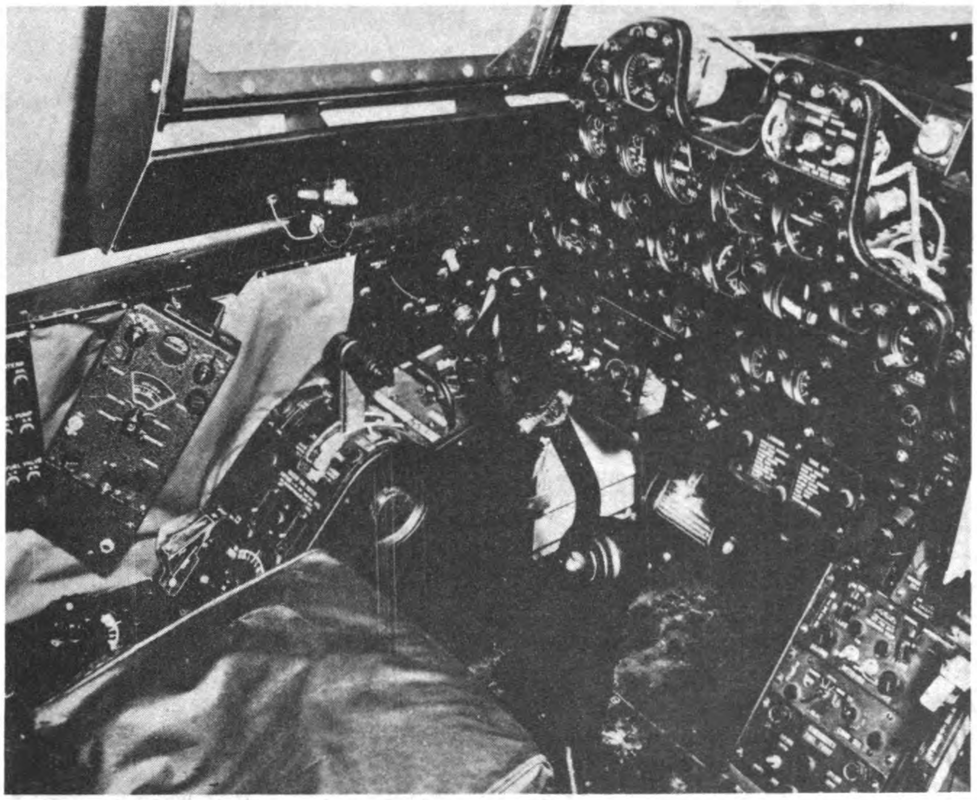

Figure 1. View of pilot's cockpit taken from window of instructor's console.

Selected radio facilities are pre-set before each flight and from then on the systems function automatically, allowing the instructor complete freedom for teaching, evaluating pilot performance, and simulating low- and high-frequency ground-control communications. Low-frequency radio range with flexible multi-station simulation, VHF with all channels functional, H and MH homing stations, YG and GCA simulation are standard facilities of the F3D. Controls and indicators for locating stations, setting up range legs, assigning frequencies and all desired coded identification signals, and selecting the type of stations desired are within easy reach of the instructor on the right wing of the console. Field elevation, magnetic variation and barometric pressure may also be introduced.

The purely automatic feature of the F3D OFT's radio facilities, including signal generation, attentuation and frequency control, provides the pilot with realistic radio aids for all types of radio navigational problems. His cockpit radio equipment, which is identical in appearance

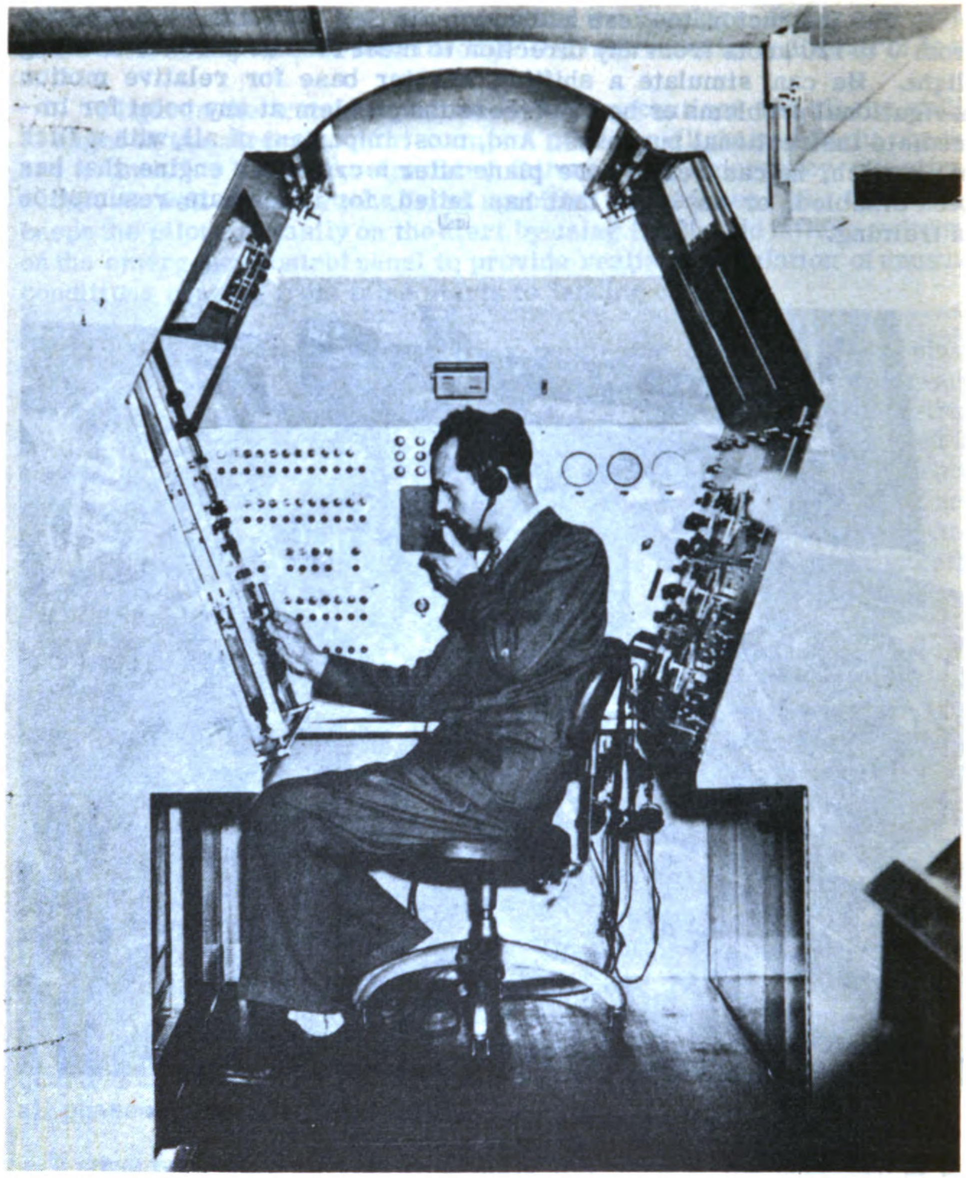

Figure 2. Instructor at his position at the console of the F3D OFT. Small window at his right looks into cockpit.

and function to the airborne equipment, is operated as in actual flight. For LFRR, ADF, loop and aural null problems, there is a functional AN/ARN-6 radio receiver. For VHF reception and transmission there is an ARC-1 trans-receiver. Similarly, for YG and radar problems there is equally functional and realistic equipment--all adding up to more effective pilot training.

The ground position indicator, one of two flight recorders in the console, continuously plots the flight path of the aircraft on a transparency mounted over a standard aeronautical chart. Six recorder scale ratios (0.1 to 70 nautical miles per inch) are available to coincide with the type charts used or problems flown. Small scales (1:2,000,000 RDF

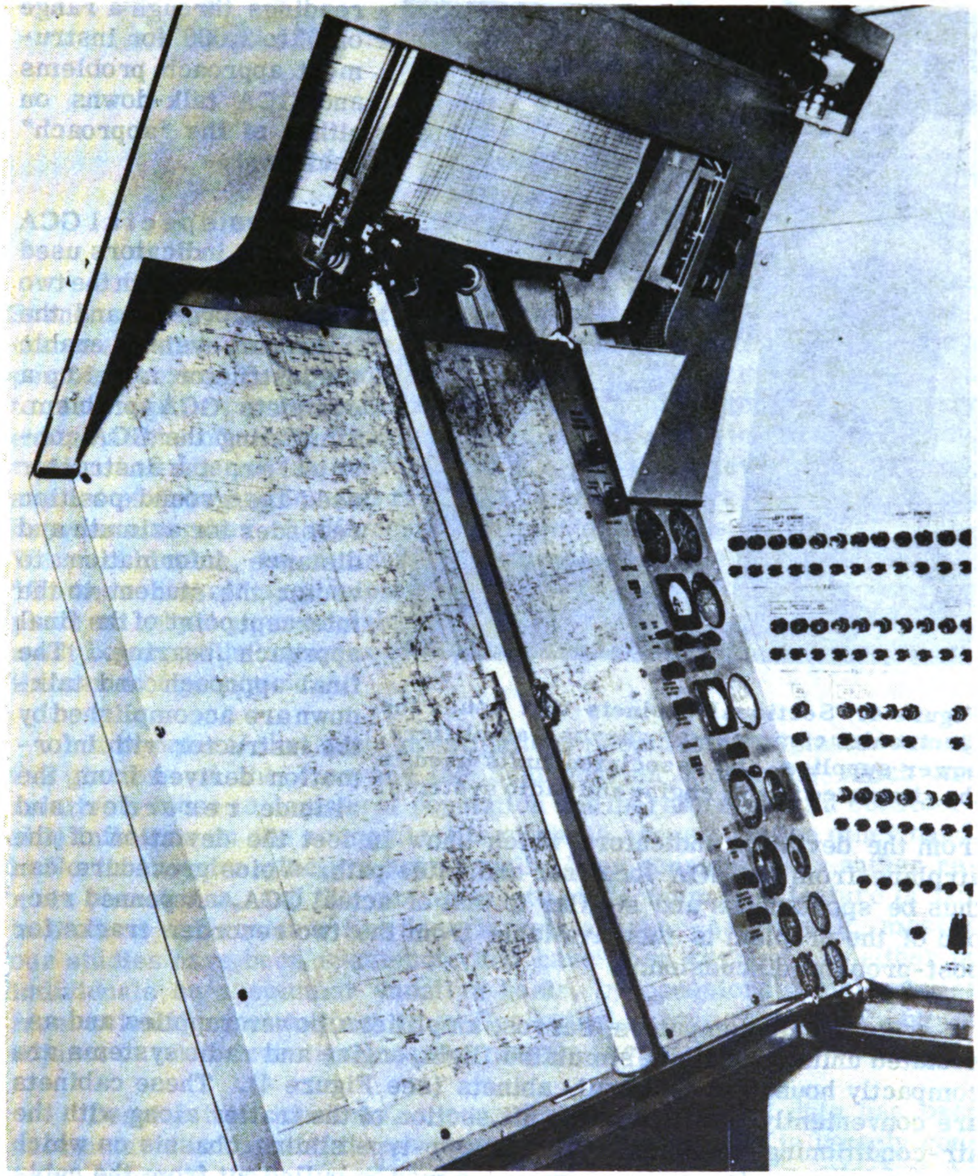

Figure 3. This close-up of the instructor's console shows the ground position recorder and controls, the altitude recorder and controls (above chart) and the instructor's instrument panel (at left of chart).

charts and 1:1,000,000 World Air Charts) are used for long cross-country flights permitting over 1,000 miles straight-line flight. Sectional and Regional Chart Scales are used for other navigational problems. Large scales (1:50,000 and 1:100,000) with charts of appropriate ratio, give accurate tracking for instrument approaches. The recorder scale may be shifted at the instructor's discretion without interrupting the problem being flown.

Synchronized electronically with the ground position indicator is the altitude recorder, which plots and records a vertical profile of glide path performance. The altitude profile recorder provides altitude

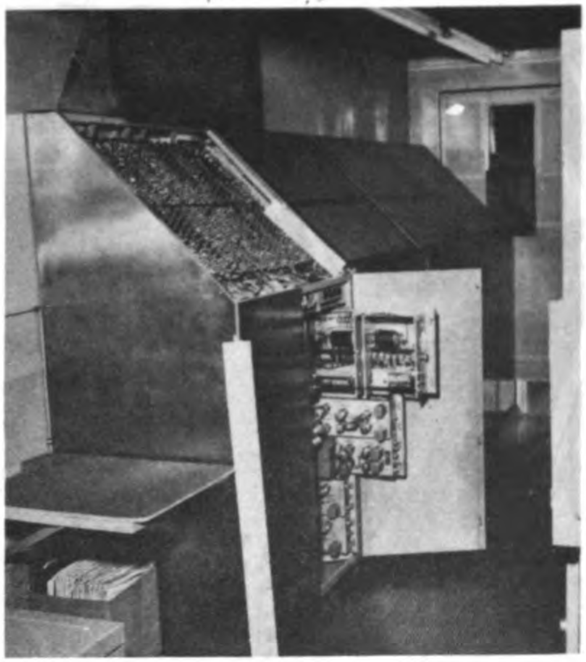

Figure 4. Sectional cabinets that house the electronic computers, servos, amplifiers, power supplies, and associated units used in the simulated flight, engine and radio systems.

readings through a range of 0′ to 2,000′ for instrument approach problems and GCA talk-downs on either of the "approach" scales.

Two special GCA deviation indicators used in conjunction with the two flight recorders and the intercom system enable the instructor to set up a complete GCA problem. Simulating the GCA controller, the instructor uses the ground-position recorder for azimuth and distance information to vector the student to the intercept point of the final approach bearing. The final approach and talk-down are accomplished by the instructor with information derived from the altitude recorder and from the deviation indicators which show in feet the deviation of the airplane from the GCA localizer and glide path. Voice procedure can thus be spontaneous and similar to that of actual GCA. A penned record of the problem is then available from the two recorder tracks for post-problem discussion.

Electronic computers, servos, amplifiers, power supplies and associated units used in the simulated flight, engine and radio systems are compactly housed in sectional cabinets (see Figure 4). These cabinets are conveniently installed in the aft section of the trailer along with the air-conditioning equipment. The drawer-type sliding chassis on which the electronic units are shock-mounted may be pulled out from the cabinet for inspection or servicing. Routine maintenance and adjustments may be accomplished while the trainer is in operation. The electronic nature of the F3D OFT assures a high degree of stability within each integral system, which means added assurance of high dependability of every-day operation.

The F3D OFT's may be used as mobile training installations or they may be removed from the trailers in which they are housed for fixed land- or carrier-based operations. The basic trainer units--pilot's cockpit, instructor's console, and electronic control cabinets--are all mounted on a single plane within the trailer and are sectionalized for easy removal and re-installation at any desired location.

The opportunities the new Trainer provides for on-the-ground training are expected to minimize the hazards of inexperienced flying, and to increase greatly the efficiency of present teaching methods.

Exploring the Juneau Ice Cap

by

Maynard M. Miller, Columbia University
and
William O. Field, American Geographical Society

For the past few decades glaciological research in the Alps and Scandinavia has consisted of intensive studies on certain glaciers where comprehensive observations could be carried out systematically over a period of years. Because of the complexities involved the trend has been to study one or two glaciers exhaustively rather than to conduct cursory examinations of many. Closely related with the shift to greater concentration has been a realization that, in order to achieve useful results, studies of snow and ice and related glaciation require close cooperation between a number of different scientific disciplines. Professor Hans W:son Ahlmann, the eminent Swedish glacier expert, has stated: "To serve its aims, glaciology must in future be founded in the first place on physics, mechanics, crystallography and meteorology, and must belong to the complex of sciences that in certain countries goes by the name of geophysics".

It is natural that such investigations should have originated among the glaciers of the Alps and the Scandinavian Mountains which are relatively close to centers of population and therefore exert a considerable influence on the economic life of these areas. On the other hand, in North America glaciers have usually been considered as rather remote phenomena, and the motivation to study them as a feature of our immediate environment has been largely absent. As a result, most of our studies have been spasmodic and have been carried out either by individuals on a summer vacation basis, by occasional small parties from scientific institutions, or by Geological Survey parties as a minor adjunct to other investigations and mapping activities.

Despite this handicap, a considerable amount of data has been accumulated in the past three-quarters of a century. It is largely confined, however, to descriptive observations of the lower portions of the glaciers, to short-term variations of glacier termini, and to the geomorphological aspects of glacial erosion and deposition. Prior to 1948, few if any, worthwhile observations in North America had been made of regimen (that is, the relationship between water accumulation and dissipation) or of the conditions prevailing in the areas of accumulation in upper parts of any glaciers. This is not for lack of direction or the

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Maynard M. Miller, now a candidate for a doctorate at Columbia University, has been the leader of a number of expeditions into the mountainous and glacial sections of Alaska. He received degrees in the geological sciences from Harvard and Columbia and has published several papers on his research.

William O. Field is Head of the Field Research Section of the American Geographical Society and Chairman of the Committee on Glaciers of the American Geophysical Union. For many years he has made detailed observations on glacier fluctuations in Alaska and other parts of the world.

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realization of need, but rather it has been due to the difficult operational problems posed by such undertakings--the relative inaccessibility of study areas, increased expense, the need for mountain-trained personnel, and the involved logistics.

Yet in recent years several factors have made possible the extension of detailed glaciologic studies in the Western Hemisphere. These are: (1) the stimulation offered by the leadership and experience of British, Swiss, and Scandinavian scientists; (2) the development of, and recent improvements in, aerial photography and techniques of aerial supply; (3) increased interest in the scientific exploration and study of alpine and arctic areas in the Western Hemisphere; and (4) newly available financial support, equipment, and logistic assistance from interested Government agencies.

It is not a coincidence, therefore, that two independent but closely cooperative projects for high-level observations were initiated in Alaska and the Yukon in 1948. The Arctic Institute of North America's project, "Snow Cornice", chose for its area of operation the Seward-Malaspina Glacier System on both sides of the international boundary in the St. Elias Mountains. The American Geographical Society selected the smaller but more accessible glacier system, some 250 miles to the southeast, composed approximately of 700 square miles of central névé and outward-flowing glaciers in the highlands of the Coast Range north and east of the city of Juneau. The area is shown in the map, Figure 1. Most of these outward-flowing glaciers are named, and the big central névé from which each takes its rise has long been known locally, but unofficially, as the Juneau Ice Field or Ice Cap. Thus the name of the Juneau Ice Field Research Project was chosen to describe the program

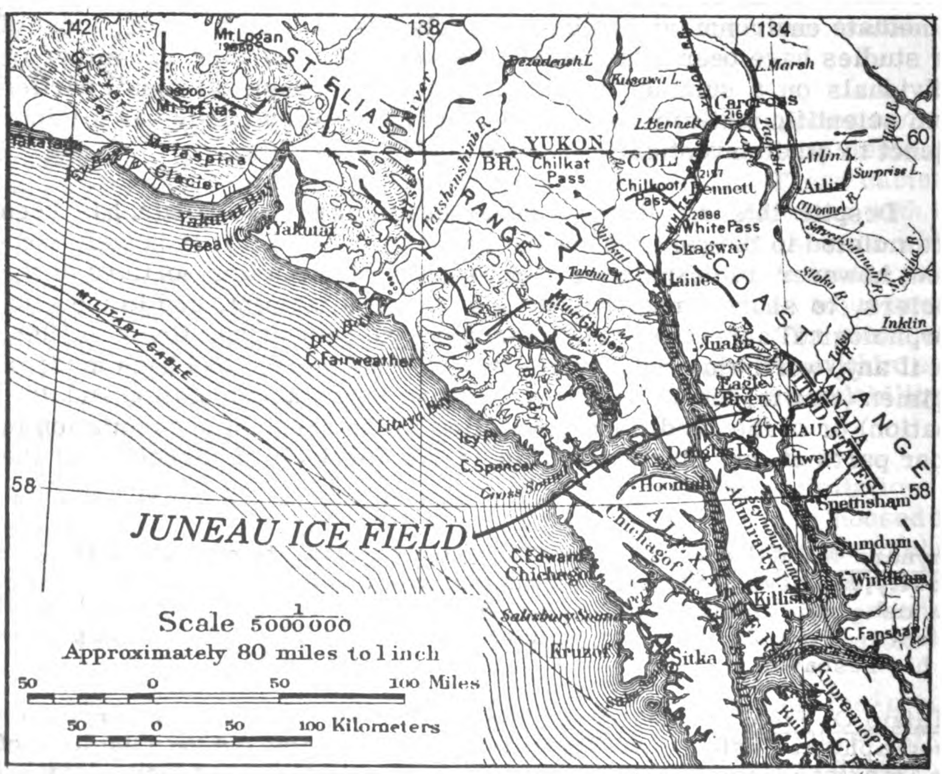

Figure 1. The Juneau Ice Field (scale 1:5,000,000)

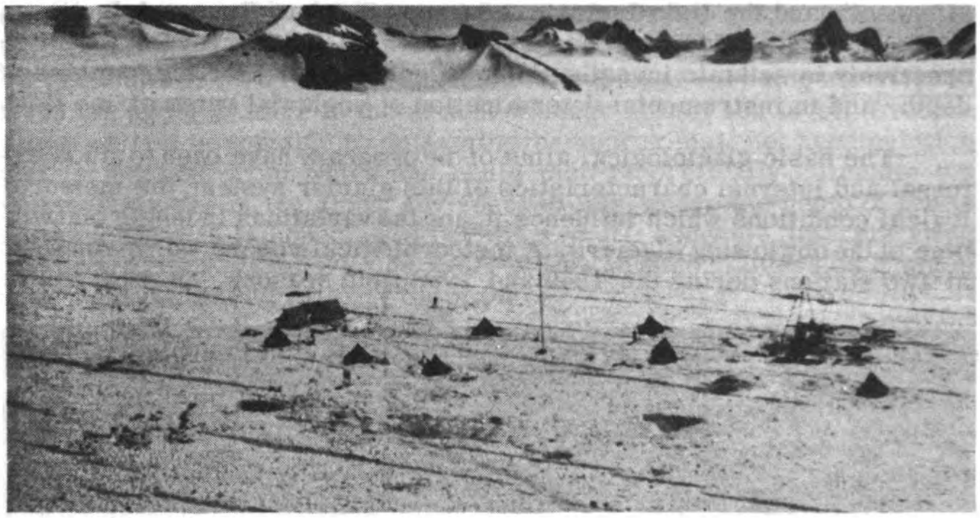

Figure 2. Aerial view of the main ice study camp on Taku Glacier (1950). View west toward a portion of the upper névé.

of study in the névé area and on the individual glaciers radiating from it. To date, the high-level work has been conducted primarily on the Taku and Twin Glaciers, the former being the largest of the outward-flowing ice streams. Studies have also been carried on in and near the terminal areas of many other glaciers in the vicinity.

In 1948 six men conducted a four-week reconnaissance to work out routes of approach, establish camps, determine supply needs, and initiate a few long-term scientific observations. The following year, a full season was spent studying the glaciers at both high and low levels, during which a total of 24 persons took part in the program. A small research station was built at a 400-foot elevation on a rock island 16 miles above the terminus of Taku Glacier, and a network of a dozen camps was established over an area of some 400 square miles. The program of observations begun the year before was continued and greatly expanded. It was further extended in the summer of 1950 by another full field season in which a total of 19 operating personnel and scientific advisors, as well as 12 visitors, took part in the ground program. Figures 2, 3 and 4 show the installations which had been established by this time.

In 1948 substantial airlift was provided by the U.S. Navy Medium Patrol Squadron Four, then engaged in a photographic aerial survey of Southeastern Alaska. The following year, the project was carried out under a Task Order of the Office of Naval Research. Through the Research and Development Board further valuable assistance was provided by other branches of the National Military Establishment. In 1949 and 1950 the U.S. Navy and the Air Force 10th Rescue Squadron provided air support, while supplies and equipment were made available by the Quartermaster Corps, Signal Corps, Corps of Engineers, and Air Materiel Command. Personnel were assigned to the meteorological program by the Arctic Weather Central of the Air Weather Service. Civilian agencies, both government and private, also furnished support and facilities, among them the U.S. Forest Service, the Arctic Institute of North America, the Geological Society of America, the Weather Bureau, the Blue Hill and Mount Washington Observatories, the University of

Minnesota, and the U.S. Geological Survey. Stanford Research Institute, the E.J. Longyear Company, and the Eastman Oil Well Survey Co. aided respectively in seismic investigations, in core drilling for ice samples at depth, and in instrumental determination of englacial rates of ice flow.

The basic glaciological aims of the program have been to study external and internal characteristics of this glacier system, the meteorological conditions which influence it, and the variations in length and volume of the outflowing glaciers. A meteorological record was maintained at two stations during the 1949 and 1950 field seasons, as well as for

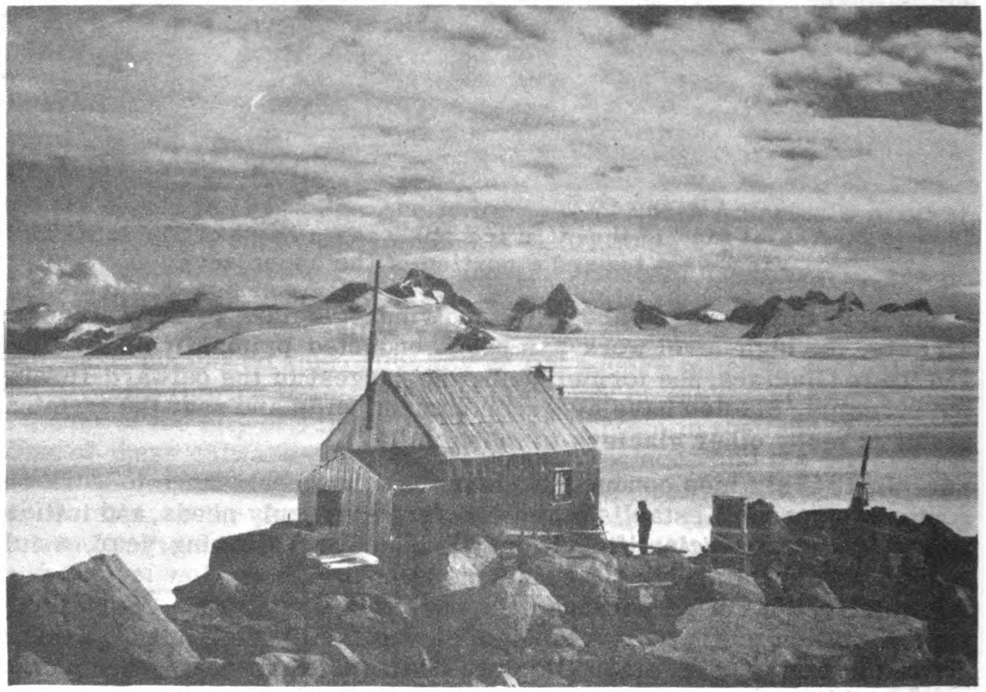

Figure 3. Research station at 4,000-foot elevation on a rock island above the névé of Taku Glacier, 16 miles above its terminus (1950). The lower Taku Glacier is shown at left and the head of the Norris Glacier is visible at right center.

shorter periods at four outlying camps. Glacio-meteorological data was also obtained on the surface of the upper Taku and Twin Glaciers, including observations and instrumental records of solar radiation.

These accumulated data are being analyzed and correlated with the records from the nearby lower-altitude weather stations at such points as Juneau and Annex Creek, immediately adjacent to the ice field on the west and south, and with those obtained in past years at four other nearby stations to the north and east. Closely connected with these meteorological data are periodic observations of short-term changes near the surface of the glacier at selected localities; and determination of surface accumulation and ablation and the position of the late summer névé or firn line during the three years of operation. Instrumental measurements have been made of glacier surface movement at different places both above and below the névé line. Several of these lines of measurement are along profiles where the thickness of the glacier has been determined by geophysical means. Efforts are being made to obtain a vertical velocity profile as well as to provide an answer to the fundamental question of whether ice in such a glacier as the Taku moves faster at depth than at the surface and if so why. This has been a significant unknown in the effort to calculate the volume of ice being transferred from the upper glacier to the area of wastage nearer sea level. Eventually it should be possible to determine the approximate net accumulation and net wastage from which one could then theoretically calculate the volume transfer of ice along any specific line where the depth of ice is known. This, it is hoped, will permit a more accurate interpretation and comparison of the average rates of flow of such glaciers as a whole with their measured rates at the surface.

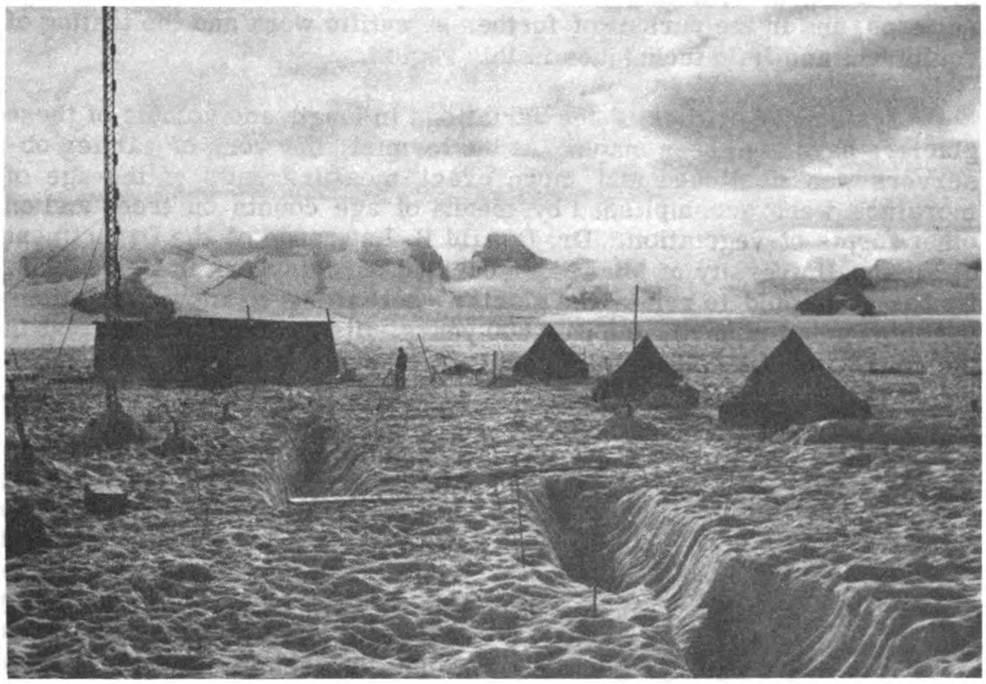

Figure 4. Main camp on upper Taku Glacier (1950). The 40-foot mast at left has metal-sheathed thermistors (radiation reflectors) to record in 1/100°C the micro-meteorological temperature profile immediately above the surface of the névé.

Studies within the Taku glacier were carried out during 1949 and 1950 and are still underway, to determine the structure and physical properties of winter snowfall, of summer névé, and of the underlying crystalline ice at different seasons of the year. Crevasses have been used to penetrate surface layers of névé for detailed observations of ice banding, snow density, melt-water circulation, and crystal structure, at depths down to 60 feet (Figure 5). In 1949 a team from Stanford Research Institute, under the leadership of Dr. Thomas C. Poulter, using a Unitized Portable Seismograph (Figure 6), determined the thickness of Taku glacier along four related profiles, 2, 11, 13, and 16 miles above the terminus. At these, the maximum thicknesses of ice recorded were respectively 1378, 1033, 1534, and 1144 feet.

In 1950 the E. J. Longyear Company provided a rotary Pioneer Straitline Core Drill, shown in Figure 7, to bore holes for the purpose of obtaining ice cores for crystallographic and petrofabric study. In addition, a string of electric thermocouples and several hundred feet of 2″ I.D. aluminum pipe were to be inserted in different drill holes in the glacier for later determinations of temperature at depth and the vertical velocity profile of ice flow. It appears, however, that the depth attained (about 292 feet) is not sufficient to provide more than a partial answer to the problem of subsurface ice motion. Further experimentation with either a modified rotary drill or an electrical "hot point" drilling equipment yet to be devised, will be needed to reach a greater depth and to obtain all of the information desired.

As an adjunct to these studies, control points for detailed mapping have been established in various parts of the study area. This will greatly aid in determining the main topographical features and drainage patterns, and in the pursuit of further scientific work and the testing of equipment and field techniques in this region.

Systematic studies of the variations in length and volume of these glaciers have also been made. At the termini, the work of earlier observers was continued and more exact measurements of the age of moraines were accomplished by means of age counts on trees and on other forms of vegetation. Dr. Donald B. Lawrence of the Department of Botany, University of Minnesota, carried out this work in 1949 - 1950. He has attempted to relate the glacier oscillations to known variations in solar radiation during the past 600 years. His findings indicate that in the middle of the eighteenth century all these glaciers were more advanced than during a number of previous centuries and that considerable net recession has since occurred. Although the general over-all pattern in Alaska is ice shrinkage, two of the glaciers from the Juneau Ice Field have had re-advances which have been observed. The Norris exhibited a minor advance for about a decade which culminated about 1915, and the Taku, since about 1900, has advanced some 3-1/2 miles. It may be that regimen studies can disclose the basic causes for this most interesting and paradoxical phenomenon and thus shed light on other related problems facing glaciologists. At higher elevations botanists have been studying plant life on the nunataks and ridges to help in determining details of the lowering which has recently occurred in the surface level of the ice field. The geologists also have made observations on the manner of rock weathering on recently deglaciated terrain and on geologic factors pointing to the existence of isolated expanses of bedrock during the most recently expanded major stage of Pleistocene glaciation. At the termini, further

Figure 5. This photograph, made last August, shows scientists taking samples of névé in a pit dug at one of the glacier camps. Determinations will be made of density, liquid water content and other properties of samples. Tubes and funnels protruding from wall recesses in the pit represent meltwater collection pans used to determine rates of water percolation downward.

Figure 6. Stanford scientists making depth soundings in upper Taku Glacier. Maximum thickness of 1534 feet was recorded.

mapping and photography have been undertaken to determine changes in their position and the resulting modifications in landform. Such observations have long been made, and established photographic and survey stations exist which have been occupied periodically for comparative data over a number of decades.

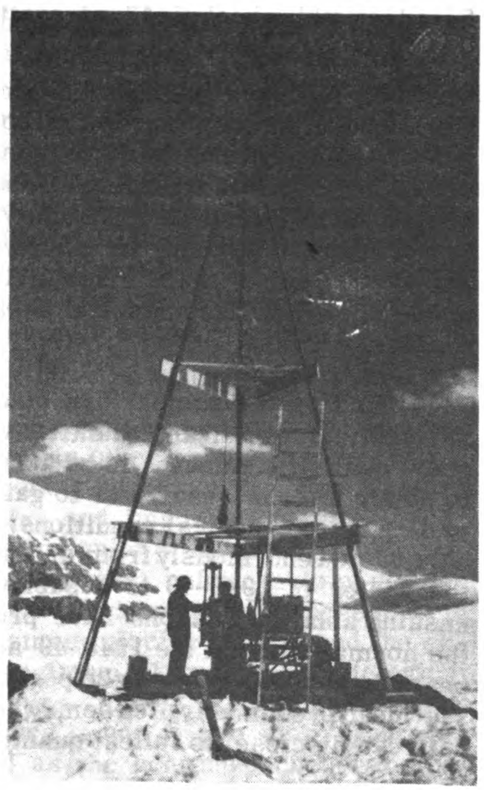

Figure 7. Drill Rig set up at the main camp on upper Taku Glacier, 1950. Cores were obtained to a depth of nearly 300 feet.

In addition to purely glaciological investigations, studies have also been carried out on bedrock geology to determine the origin and nature of the rocks of the area and their relation to the geologic structure of this portion of the Coast Range. The project has also provided an opportunity for studying logistics, testing equipment, and working out field procedures for an operation of this kind. Training personnel to live and work effectively in such an environment has also been accomplished. In three field seasons, 36 different individuals have spent considerable time encamped on the glacier or on the rocks immediately

Figure 8. Supplies being unloaded from the Air Force 10th Rescue Squadron ski-wheel C-47 aircraft at the airstrip camp on the upper Taku Glacier, July 1950.

above it, and have learned the problems of "housekeeping", traveling, and working on such terrain. Experience in carrying out arctic field work has been gained by these men, 20 of whom were at the time graduate or undergraduate students in scientific fields. At the same time the project has afforded an opportunity to both Air Force and Navy air crews to work on air lift and air supply problems of an unusual nature. A ski-wheel C-47 of the Air Force 10th Rescue Squadron (Figure 8) has accomplished 22 landings and jet-assisted take-offs on the upper Taku Glacier.

To date the project has made considerable progress toward the assembly of significant quantitative data for this glacier system, but a great deal still remains to be accomplished. Many years are required to obtain a mean result and to gain a true picture of regimen and prevailing meteorological conditions. During the last two years conditions have varied enormously from an unusually heavy accumulation of snow in the winter of 1948-49 to a subnormal accumulation in 1949-50. The ensuing ablation seasons have probably increased the departure from the normal, so that the 1948-49 accumulation-ablation budget year appears to have been strongly positive and the succeeding one negative. The mean presumably lies somewhere between, but only additional yearly data can disclose its fullest quantitative relationship.

The significance of this project in relation to other glaciological undertakings must be considered. Except for Project "Snow Cornice" it represents the only large-scale systematic study now underway in a névé area in the Western Hemisphere. We must realize that although the general scientific picture will unfold more slowly than we might wish, our main concern must be to amass useful data on a sound and considered basis. Other such projects, we hope, will soon be initiated elsewhere, especially on representative glacier systems in Alaska and British Columbia, and further south in the United States, as well as beyond the equator in the high mountains of South America.

In the meantime, studies of the variations in the terminal portions of the glaciers all along the Western Cordillera, in the interior and coast ranges, from California and Colorado to western and northern Alaska must be evaluated and their relationships established. At this time there is perhaps as much desk work required as there is need for careful and comprehensive field investigations. Particular attention must be paid to systematic classification, collation of all data now existent in published and unpublished reports and photographs, and an analysis and correlation of this data. Nor should we forget that while our immediate concern may be regional, the broader aspects require that the results of studies in one area should be compared with those in other parts of the world. Interchange of information to bridge distance and language barriers is essential if the broader aspects of glaciology, especially those dealing with the relationships of glacier variations to climatic change, are to be adequately understood.

The present glaciological program is thus divided roughly into three parts. First is the concentrated, systematic, and well integrated observations as represented by the Juneau Ice Field Research Project. Second come the still useful though more general and cursory observations of glacier termini on a continental, hemispheric, or even world-wide basis, to determine their over-all characteristics and to record comparative variations and other attendant phenomena. Third is the desk work which must bring together and correlate the results of past and current studies, and provide the means of cooperation and liaison between disciplines and between glaciologists and other scientists whose contributions may also help, not only in our own country but in various other parts of the world. Only by such a well-rounded program can we hope to begin to understand the physical character of glaciers, their meaning, their use to man, and their influence on him, as well as their potential role as registrars of past and future climatic change.

Because we are living at a time when both Antarctica and Greenland are still in an Ice Age and some glaciers in other parts of the world are advancing amid general conditions favoring recession, we have a unique opportunity of studying this interesting and important feature of our planet. The answer to some of the most complex problems of glaciology, such as the mechanics of ice flow and the exact relationship of glacier variation to climatic change may well be found, or at least suggested, in the detailed study of one glacier or a single glacier system and the external factors which influence their regimen. From the glaciological point of view this is the objective of the Juneau Ice Field Research Project. The task cannot be accomplished in one or two seasons but will require a long period of time as well as the continued cooperation of many individuals and organizations. We believe that a significant and useful beginning has been made, however, and that such studies are proving of considerable value in the development of glaciology as well as in the general problem of living and operating in, near, and over areas of perennial snow and ice.

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Who's Who in Naval Research

Last month exciting news came to ONR with the nomination by the President of ONR's Deputy and Chief Scientist, Dr. Alan T. Waterman, for the directorship of the newly established National Science Foundation. It is one more signal recognition of the excellent leadership and guidance which Dr. Waterman has given to the growth and development of the entire Office of Naval Research program in scientific research for the Navy.

ONR staff members can still remember the rather humorous prophecy made during the last office Christmas party when Dr. Waterman was handed a "homemade" telegram drafting him for duty as "apprentice seaman" with the expanding Navy. Well, Dr. Waterman is being drafted for new duties, but he will be far from an apprentice on his new job. The country may look forward to a strong and well-functioning basic research foundation under his able hands.

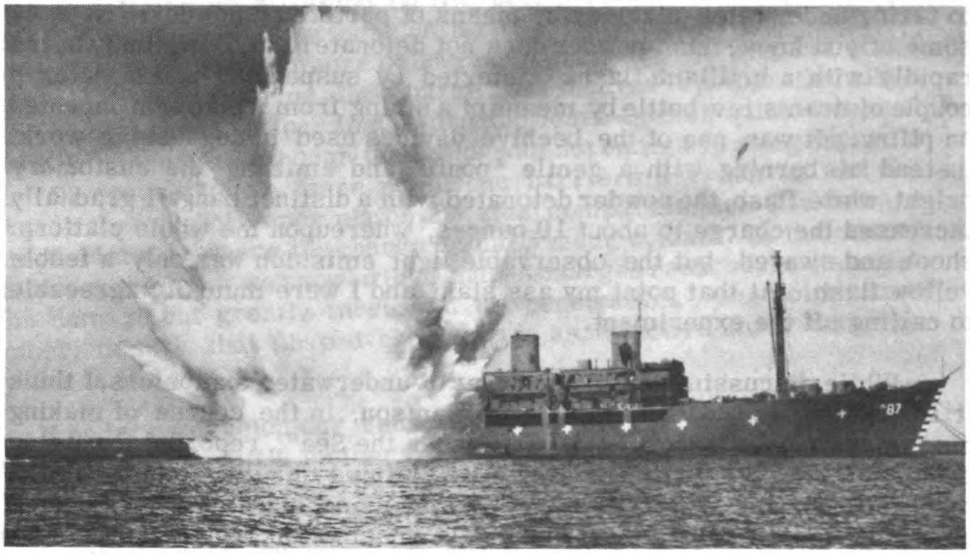
Dr. Waterman has been Deputy and Chief Scientist of the Office of Naval Research since 1947. As such he had had primary responsibility for the research program which the Navy carries on with universities throughout the country. Before that he was head of the Planning Division of the Navy's Office of Research and Inventions, ONR's predecessor. During World War II, he served with the National Defense Research Committee, and in 1945-1946 was Chief of the Office of Field Service of that agency. For his war service, he was awarded the Medal of Merit by the President for civilian meritorious service.

A graduate of Princeton University in 1913, Dr. Waterman received his Ph. D. in 1916. After service with the Army Signal Corps in World War I, he joined the faculty of Yale University and remained there as Associate Professor of Physics until 1949, with a leave of absence during 1927-1928 to King's College, London, and to the Massachusetts Institute of Technology in 1937.

Dr. Waterman's personal research has been in the fields of conduction of electricity through solids; thermionic, photoelectric emission and allied effects; and electrical properties of solids.

But Dr. Waterman is not all "long-hair" science. He's a family man with five grown-up kids, an interest in music (he is capable of playing many musical instruments and is quite adept on the viola), and a love for camping and the outdoors. It is easy to see that Dr. Waterman is a well-rounded man, with many activities and keen interests. It is this kind of alertness that makes for a man who can direct research towards wider and wider horizons. ONR has felt the impact of his scientific direction and has definitely benefited by it.

At this writing, the nomination is still awaiting confirmation by the Senate. ONR extends to Dr. Waterman a hearty "well done" for his work with the Navy and wishes him smooth sailing in his new responsibilities.



Underwater Explosions

by
LCDR E. R. F. Johnson, USNR

My first contact with underwater explosions was very personal. In one of Dr. William Beebe's books, he describes how he fired a dynamite cap in order to kill small fish for collecting purposes. He fired his cap at the end of a ten-foot pole, admitted feeling fear, and claimed that the concussion caused a slight tingling sensation all over his body. Shortly after reading this, I had a piece of tubing and battery holder mounted on the end of an eight-foot pole and loaded with a dynamite cap. My plan was to repel a shark if one should appear in the course of my diving operations.

One bright and sunny afternoon, in about thirty feet of water, I tested this gadget. I was expecting a bright flash, a sharp explosion noise on the order of a two-inch firecracker, and a lot of disturbance in the water. Upon pulling the firing lever a gentle "plop" ensued, of about the calibre created by a baseball dropped in a filled wash basin. Then a couple of bubbles issued from the end of my gun barrel. There was no tingling sensation. This, of course, may have been due to the fact that I was wearing heavy clothing, and that the cap was confined in a gun barrel pointed away from me.

My next experience was during an experiment at the Naval Mine Warfare Test Station in the Patuxent River, which I had hoped would lead

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E. R. F. Johnson, a member of Volunteer Naval Research Reserve Unit 4-2, has for some time directed research in water transparency and underwater photography at his own laboratories. During the war he served with the Mine Countermeasures Research Section, Division of Underwater Ordnance at the Bureau of Ordnance. He has superintended the Experimental Department of the Victor Talking Machine Co. and held several directorships with that organization. He first presented the material contained in this article in a talk before the Research Reserve unit of which he is a member.

to taking underwater pictures by means of photoflash powder. Now, as some of you know, flash powder does not detonate in air. It simply burns rapidly with a brilliant flash. I started by suspending under water a couple of drams in a bottle by means of a string from a platform mounted on piling. It was one of the beehive devices used in degaussing work. Instead of burning with a gentle "pouff" and emitting the customary bright, white flash, the powder detonated with a distinct bang. I gradually increased the charge to about 10 ounces, whereupon the whole platform shook and swayed, but the observable light emission was only a feeble yellow flash. At that point my assistant and I were mutually agreeable to calling off the experiment.

While discussing the lower order of underwater explosions, I think it fitting to mention that Captain Williamson, in the course of making his famous movie, "20,000 Leagues Under the Sea", reported the firing of 45-70 Army rifles under water. He claimed this did no harm to the mechanism of the rifle. He probably was using blanks. I have seen a motion picture of the firing of a .22 rifle underwater, which showed that the bullet travelled only about three feet.

Thus, we can come to our first conclusion in respect to underwater explosions--namely that underwater guns using powder as a propellent are of no use, and one need not fear shrapnel from an explosion. The underwater shock wave will probably harm you at a much greater range than will underwater shrapnel. This is just the reverse of an explosion in the air.

Now is the time to stop and consider a little more carefully the nature of an explosion under water. Then we will try to acquire a little better conception of how much explosive it takes to hurt you or damage a vessel, and at what distance. If you have a mind to explore the thing mathematically, you can start out by remembering that you are dealing with a much denser medium than air, and that the explosion starts from what may be regarded as a point source; and that in the course of its outward travel it is globular in form and, therefore, diminishes rather rapidly, more or less in accordance with the inverse square law. But after that, you will immediately run into trouble in your calculations because of reflections from the bottom, from the surface, and because of other variable factors.

Let us now step up the scale of our example explosions and note their effects. Just by way of a parting salute to some friends one night, I fused up a half pound of TNT and tossed it overboard while underway, half a mile from several yachts. The charge was suspended from a float so that it would go off about one fathom under water. My yachting friends didn't even hear it. On another occasion I tossed a half-pound charge into 12 feet of water, at a distance of less than 100 feet from several yachts. This explosion produced a little lump or dome on the surface of the water. There was very little noise audible above decks, but my friends accused me of swimming under water and using a hammer on the hulls of their boats. Of course there was no damage.

So, let us step up our charge a little bit to slightly over 1000 lb of Torpex. At one time I had duty aboard an explosion test barge, and my station was about 70 feet away from these charges, which were about 10 feet under water, and in contact with the hull of the barge. When we first began firing we all stood on life preservers or took station in a house mounted on steel springs. After two or three charges had been fired, however, nobody bothered about such precautions. The end of the barge which was bearing the charge was heaved up into the air a little -- about three or four feet -- but the heave-up was quite slow, and the shock transmitted through the decks was not enough to sting anyone's feet. Of course, there were numerous barriers between us and the charge in the form of armor plates and steel compartments. The damage was considerable where the charge actually made contact. In the course of these experiments we showed that shaped charges reduced the diameter of the damage but greatly increased its penetration. One point to remember, then, is that shaped charges are as effective under water as they are in the air.

Now let us develop our sense of proportion in respect to underwater explosions a little further by shifting to a wooden barge which by range finder was anchored at a distance of 312 yards from these same explosions. This craft was sheltered from the direct path of the shock wave by the body of the explosion barge. On several occasions when I went aboard this wooden barge the effect of the shock could be distinctly heard striking it with a gentle "thud" sound, and a slight tremor could be noted. That was all.

Before we leave this level of explosions, that is, those ranging from 600 to 1000 pounds, let us consider what happens to human beings in the water under such conditions. There is little doubt in my mind that a human being will be killed at a much greater distance from the center of an explosion than that at which a small craft or a submarine will sustain damage. For example, you have practically got to hit submarines with a depth charge before they suffer enough damage to sink. Probably in all cases where submarines are actually sunk by depth charges, the charge has been dropped and sunk below the level of the submarine and exploded almost or directly underneath it. Hedgehog charges and similar devices of smaller power than the depth charge must actually hit the submarine.

To return to the more interesting subject of what will happen to humans who may be in the water when an explosion occurs, we can say that their air-containing cavities will take the worst punishment. In a diving suit you can go to a great depth and sustain pressures in the order of 200 or 300 pounds per square inch without harm, but this is because the pressures are equal inside and outside when applied and when relieved. But when you are near an explosion you will experience unequal compression. Eardrums rupture; brains suffer concussion; intestines and lungs receive bruises, and sometimes ruptures and bleeding; spinal cords suffer concussion which leads to paralysis. Facing away from the expected center of the blast, and keeping your head out of water, will afford some protection by reason of the heavy muscles in the back. Water can enter the anus, however, so it is advisable not to be swimming directly away if any judgment can be exercised as to the position and time of the expected explosion. Probably the best position in which to receive an underwater shock wave would be with back toward its center and slightly bent by drawing up the knees, and, of course, with head held out of water. This position can be maintained with a little paddling of the hands and feet. Distance is the best protection, and one should swim away if there is a reasonable chance that the explosion will not come for some minutes.

Very little is known about how far away a man can be from a given amount of underwater explosive charge and survive. But the experience of Baron Roberto Frassetto an Italian naval officer fighting against the British at Malta, should encourage hope that a man can survive in the water during bombing and depth charging at much less than 1000 yards. Frassetto was piloting a one-man surface torpedo boat in a flotilla with several other similar craft when the British discovered their approach. The boats were put under full speed and attempted to run into the harbor under a hail of fire, depending on their speed to skitter over the top of the torpedo nets. All boats were hit and all personnel were killed with the exception of Frassetto, who was thrown clear. He was in the water some 14 to 17 metres away when his burning gasoline supply detonated his 600-pound charge. His injuries included a concussion, cracked lower ribs, collapsed lung, a compound fracture of one leg, and intestinal damage. He spent three and a half years in hospitals and now, ten years after the explosion, is sufficiently recovered to engage in shallow water diving.

This recalls to me a story in a lighter vein, which is illustrative of how a light craft can sometimes survive where heavier ones are destroyed. While reading reports in the Bureau of Ordnance during the war, I came across one which mentioned that a native canoe with two persons in it was seen over an influence mine when the noise of a motorboat propeller set it off. The natives and their canoe were blown into the air, but upon landing they righted their canoe and bailed out the water. When last seen they were paddling northward at a high rate of speed!

Not comical at all was the experience of a civilian tug off of Cape May. A German submarine had laid a circle of influence mines with period delay mechanism, but reports were that the area had been swept clear. We were carrying out some underwater tests connected with Mine Countermeasures. One of my group later went fishing along the shore and observed a large civilian Navy contract tug; this craft was steaming through the area where we had recently conducted our tests. The observer had turned away, but suddenly heard a terrific blast. Looking back again, he saw the plume of the explosion subsiding. There was no sign whatsoever of the tug. All hands were lost except two who had been seated on the fantail, and they sustained serious back injuries.

In general, water should be regarded as a tamping agent for explosives. Sound and blast travel a little faster than in air. If a charge is dropped into water, and it is desired that it do damage below the surface, there should be a little delay in the firing mechanism so that the pipe of bubbly water above, created by the plunge of the missile, has time to pass away. Otherwise a good portion of the blast will expend itself upward through this pipe.

Shock waves in water are clearly visible when photographed with high-speed cameras. If the charge is set deep, a dome will rise which will be related in size to the size and depth of the charge. If the charge is set shallow there will be the same sequence of events: first, a shock wave, then a dome arising, and eventually the appearance of a plume, rising upward from the center of the dome (see NRL photograph at beginning of article). Finally, there will be a series of surface waves moving out concentrically from the explosion center. In large-scale explosions, these waves in themselves can do a great deal of damage. In the case of the atom bomb they were 90 feet high in the center, and even at a distance of two miles they were ten feet high. For an explosion taking place in shallow water the waves at the same distance might be twice as high.

It is probable that maximum lethal damage radius is achieved by a charge in deep water. Therefore, the figure of about 1/2-mile, estimated as maximum radius for serious damage, may be taken to represent an upper limit for the more complicated cases of shallow shots in either deep or shallow water. The shock wave is the source of the largest amount of available energy in the waters surrounding the charge, even though the secondary bubble pulses which follow are of greater duration. Although the latter have impulses comparable to that of the shock wave they have much lower peak pressures and their importance for damage is strongly dependent on the position and state of motion of the gas sphere in reference to the surface, the bottom, and the target.

It generally may be concluded that a bubble pulse is of significance only if the arrangement of the charge and target and other surfaces is favorable. The lethal or sinking range of all types of surface vessels is very much the same--in the neighborhood of 1200 to 1800 feet from surface zero. Serious loss of efficiency is to be anticipated within a radius of 3600 feet from surface zero. Submerged submarines will probably be lost at 2700 feet from the explosion, while vessels underway may be expected to suffer somewhat more severe machinery damage than vessels at anchor.

Although the major portion of a shock due to a shallow underwater atomic explosion is propagated through the water, a not inconsiderable amount is transmitted as a shock wave in the air. It is admitted in the literature however, that damage to shore installations would be a little more than half of those of an air burst. As a consequence of a deep underwater atomic bomb explosion, apart from damage caused by waves, it is believed that little harm would result to harbor and shore installations with the possible exception of damaged piers and breakwaters.

In the case of the atom bomb, there is, in addition to the normal effects of an underwater explosion, a distribution of radioactive materials. The radioactive content of the gas bubble is vented through a hollow plume and forms a mushroom-shaped cloud at the top. It contains some of the fission products and other bomb constituents as well as water droplets. In addition, there is evidence that material sucked up from the bottom fell on the decks of ships some distance from the Bikini Baker burst. In that test it was observed that the column of water and spray, constituting the plume, fell back into the lagoon, but there developed on the surface, at the base of the column, a gigantic cloud of mist approximately 1000 feet in height which completely surrounded the neck of the plume. This was a dense cloud of liquid droplets which has the property of flowing almost as if it were a homogeneous fluid. As it traveled outward at high speed it gradually lifted from the surface of the lagoon and, after about five minutes, assumed the appearance of a mass of cumulo-stratus cloud which eventually reached a thickness of some thousands of feet.

A moderately heavy rainfall, moving with the wind, and lasting for nearly an hour after the atomic bomb explosion, developed from this cloud mass. In its early stages the rain was augmented by small water droplets, equivalent in a sense to the fall-out of an air burst, still descending from the cloud. This was highly radioactive. It may have represented a serious hazard for a distance of several miles, especially in a downwind direction; but most of the activity was retained in the sea water. The deposition of highly active foam on a nearby shore might, however, represent a hazard. Should an atomic burst occur in bottom sand or mud, the debris would, of course, be very radioactive.

I attended a lecutre on the atomic bomb at the Navy Yard two or three years ago and asked the question of whether it would be best for an enemy to explode one in the river or in the air over the Navy Yard. The answer was that there was so little water and mud in the river that the radioactive cloud and debris would not be a great factor. There would be, of course, a diminution of the explosive force and a reduction in the fireball due to dropping the bomb in the water, and, therefore, should an attack be planned on the Navy Yard it would be better to fire the bomb up in the air above the Yard. However, it may be easier to deposit a bomb off the Navy Yard from a passing ship, so in spite of the reduced efficiency the attack on the Yard may be by means of an underwater explosion.

These thoughts are, of course, in the realm of conjecture; yet such speculation can serve a useful purpose by training us to think in terms of possible emergency situations and of ways to cope with them.

ONR Launches Program to Study Burn and Blast Injury

Research into burn injuries resulting from blast and thermal radiation has been launched by ONR's Physiology Branch. This program aims to fill important gaps in the knowledge and understanding of this medical problem, the solution of which is so vital to both the civilian and military in time of disaster.

Problems of a fundamental nature in the field of thermal burn require solution. We need to know what changes are produced in the organism by burn injuries and how these changes can best be simulated in experimental animals. The hormone changes produced by thermal burns, the cause of the anemia which follows thermal injury, and the problem of pain in thermal injury are typical areas needing investigation. Basic studies which will provide the information necessary to the development of protective, diagnostic, and therapeutic measures for personnel exposed to, or suffering from these injuries will also be initiated.

Dr. J. L. Lilienthal, Jr., Professor of Environmental Medicine, Johns Hopkins University, is handling the administration of the program. His project steering committee is headed by Dr. Isaac Starr, Professor of Therapeutic Research, University of Pennsylvania.

Auditory Communication

by
Hallowell Davis
Central Institute for the Deaf

The generalized idea of communication has just recently made its appearance in full scientific regalia, with a special vocabulary and mathematical formulae. Only within the past few years have such terms as "cybernetics" and "communication theory" become familiar to us. Because few are interested in or capable of understanding the mathematics involved in the work of experts in the field (Wiener, Shannon, McCulloch) there has been little understanding of the unifying ideas in the academic areas of speech and of audiology. Nevertheless, with the expression of the concept of information in precise mathematical form, a great step forward has been taken in this important branch of scientific knowledge. I venture the prediction that we will someday look back on the postwar era of 1945-1950 as marking the beginning of a development in the non-material sciences as important for psychology and biology as relativity and the quantum theory have been for the material sciences of physics and chemistry.

Let me explain and illustrate some of these generalities. Transmission of information cuts across the disciplines of physics, anatomy, physiology and psychology. To understand the process of auditory communication we must know something of each of these disciplines. Each of us must be more expert in one than in another, but we must be able to use the language and the principles of all three in our thinking.

An idea starts in the mind of the talker, in the realm of psychology. An idea is hard to define, but we all have ideas or we wouldn't be here. It may be something as simple as "it is too hot in here" or "I don't like the speaker's necktie". If you decide to communicate this idea to your neighbor you somehow formulate this idea into language, still at the psychological level, although presumably the process involves operations of physiology in your brain. The message emerges clearly into physiology and anatomy as nerve impulses stream over certain nerves and cause a complicated series of muscular contractions. We can describe the action more clearly at the next stage--in the movements of tongue, jaws, and larynx, and in the final output, the series of sound waves that issues from the mouth. The message has emerged in this physical form and has entered the channel of audio communication, the air between you and your neighbor. Here we can study and describe the message in some detail as a pattern of physical events occurring in time, in a single channel. A certain wide but finite band of frequencies is involved, the

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Hallowell Davis, Director of Research for the Central Institute for the Deaf, was author of the article "How Noise Affects Our Behavior", which appeared in last month's issue. His contribution this month is a slightly abridged version of a paper he recently presented at the meeting of the American Speech and Hearing Association in Columbus, Ohio. Dr. Davis received his M. D. from Harvard University, became a faculty member there and was eventually made Head of the Physiology Department. He took his present position with the Central Institute for the Deaf in 1946. He has been active in the field of scientific writing for some time.

familiar speech band from about 100 to about 5000 cycles per second. The intensity of the energy involved varies continuously over a range of many decibels. But in this phenomenon of sound (described here in physical terms), the message (i.e., the information) is carried. The sound may be transformed into a corresponding pattern of electrical events, as in a telephone or a hearing aid, and back again into sound waves if we wish. In such transformations, however, the basic code remains the same. We still have a single channel, and the frequencies and the relative intensities remain the same as in air.

We have learned a great deal from studies of how much the range of frequencies and the range of intensities can be reduced in the electrical channel without losing the message. Very interesting also has been the successful attempt to translate the audio signals automatically to visible signals and thus convey the information to our neighbor through another sensory channel, namely vision. I refer, of course, to the "Visible Speech" of the Bell Telephone Laboratories. I believe that the greatest contribution of Visible Speech will not lie in any practical application, either in speech correction or in teaching speech to the deaf, but rather in the analysis of the structure of speech and of those aspects of speech which are essential for the successful transmission of information.

But let us return to normal auditory communication. The sound waves enter the ear, mixed with the ambient sound always present in the common channel that connects the talker and the listener. The ambient sound may be informative in its own right or, on the other hand, it may interfere with the message by masking the speech; in extreme cases it may even be injurious to the ear. In any case the ear analyzes the speech sounds and recodes the information in the form of nerve impulses in the fibers of the auditory nerve. The processes now are physiological, and the channels (i.e. nerve fibers) are described in anatomical terms. The nerve fibers converge in the nerve centers and the nerve impulses interact in various places in the gray matter of the brain. Our knowledge of both the physiology and the anatomy of the process is still elementary but some important principles are already clear. The greatest gaps in our knowledge lie at the highest level where the information finally emerges in the mind of the listener as an idea more or less closely corresponding to the idea that originated in the mind of the talker. The point is that the information gets through, and we know therefore that it was present, coded in one way or another, at each point along this elaborate pathway. This fact is of the utmost importance as a unifying principle and as a guide to identifying and understanding the essential features of the various steps along the way.

Let me call attention at this point to what we call "speech control". This refers to what happens as the talker hears the sound of his own voice. This "monitoring", as you all know, is essential to good normal speech. The deaf, deprived of this monitor, have great difficulty in learning to speak intelligibly. Other sensory channels, tactile or kinaesthetic, must be substituted, but since the substitution is very imperfect and incomplete, communication by speech is a real task for them. It requires much conscious effort to mobilize and use these substitute mechanisms of control. Here, in the principle of "feed-back" and control, i.e. the continual automatic directing of action toward a goal, is one of the central ideas of the "cybernetics" to which I referred in my opening sentences. The goal toward which the action of speech is directed is the production of signals that can be understood through the ear of a listener. We speak much better if we are continually informed as to the success or failure of the nervous messages to our muscles of speech in producing sounds that are actually intelligible to ourselves. A demonstration presented by the University of Illinois, in which the "side tone" returning to the talker is artificially delayed, shows dramatically how seriously speech can be disrupted by tampering with this automatic control.

Now let us look more closely for a moment at the inner ear and consider what it does in transforming the patterns of speech sounds into corresponding patterns of nerve impulses. How do we study this process? The tools include the wave analyzers and sound level meters of the physicist that enable us to describe quantitatively the sounds that we use as stimuli. We take advantage of the art of the electro-acoustic engineer to produce known and relatively simple patterns of sound waves such as pure tones, "white" noise, and clicks, of definite frequencies, intensities and time relations. We also need the dissecting tools and the microscope of the anatomist to learn something of the structures that are moved by the energy of sound. Physical studies of the mechanics of the ear and of properties such as the mass and the stiffness of the moving parts help us to predict their probable behavior. Some skillful investigators such as von Bekesy have made direct physical observations of many of these movements. We are now quite sure that motion of the delicate basilar membrane and the organ of Corti that rests on it is an essential step in the process of audition. We also know that, by virtue of the special anatomical structure and the physical properties of the moving parts, the inner ear acts as an acoustic analyzer. This means that one part of the structure moves more in response to sound waves of one frequency and other parts of the structure in response to other frequencies.

The neurophysiologist takes up the task at this point. His most powerful tool is the electrical amplifier and oscilloscope. Fortunately for him each nerve impulse generates an electrical disturbance, the so-called "action potential". These signals are weak and lie just at the limit of our ability to detect them. Our recent successes in studying their relationships to the sound waves that initiate them depend on several technical procedures. First, we employ animals, under anaesthesia of course, and we place very fine wires within the inner ear or in the auditory nerve or in the nerve centers of the brain, as close as possible to the places where the electric signals are generated. This method alone has told us much about the exact location within the brain of the pathways that conduct the auditory impulses to the higher levels. Second, we use auditory signals such as clicks or very brief bursts of pure tone that set up impulses in many nerve fibers at the same instant. The action potentials re-enforce one another and the combined signal is easier to detect and study. In some fortunate situations, however, using electrodes of microscopic dimensions, we have been able to study the activity of one single nerve cell and to learn how it behaves.

Electrical studies such as this (not all confined to the auditory system) have shown that the basic code of signalling of the nerve fibers is very simple. All nerve impulses are alike. Either a nerve impulse is present or it is absent. For a given fiber there is no significant gradation in the size of its impulses. They are, we say, "all or none".

And the frequency at which impulses can follow one another in a nerve fiber is not over 1000 per second -- usually somewhat less. The only degrees of freedom are, first, in differences in frequency below 1000 per second; second, in the exact time-relations between impulses in different fibers; and third, in which nerve fibers or how many nerve fibers are active. Nevertheless the auditory system carries all the information that makes up the spoken message, in spite of the severe limitation of the all-or-none law. This it can do because of the large number of nerve fibers, i.e., the large number of independent channels, that it contains. This property is in sharp contrast to the single channel for sound waves in the air. In the air, however, higher frequencies can be carried and all gradations of intensity are possible.

These, then, are some of our problems and our methods of attack upon them. There are many other phases of the subject which require study. One involves obtaining a complete description of the relations between the pattern of sound waves and the pattern of nerve impulses. Another concerns the nature of the process of excitation that initiates the nerve impulse. This problem is of interest to the physiologist in its own right. The solution will have large implications, for it may give us a lead to the next major problem: how the nerve impulses interact with one another in the gray matter of the brain.

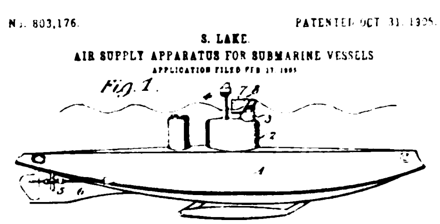
In the gray matter, the many channels of the auditory nerve converge and the impulses interact with one another. The generalization that the information carried in the message is still preserved tells us that, as the number of channels is reduced in this convergence, there must be some compensatory gain in another dimension. Some escape from the straight-jacket of the all-or-none law must be possible in the form of gradation of intensity. We have not found this gradation yet with certainty although there are clear indications of it. We know what kind of process we are seeking, and with this sign-post to guide us we can look forward with confidence to ultimate success. The same kind of assistance can surely be found in examining other steps in the process of auditory communication from the point of view of transmission of information. Such other steps are the generation of speech sounds, the control of the organs of speech, and possibly, in due time, the very difficult problems of aphasia and of the rate at which we can assimilate and react to the information that reaches our brains.

Let me now return to my very first point, which is at the philosophical level.

The importance of a unifying principle that connects physiology and psychology cannot be overestimated. In the exact concepts of information and communication we shall find, I believe, the key to understanding the relationship between mind and body. More precisely I should say that they will show the essential unity of mind and body. Ideas are patterns of information, some of it just arriving, some of it stored from previous experience. The old and the new interact, and various bits of the old interact with one another. But the information and the interaction do not exist apart from matter and energy. Information and ideas are patterns of interrelated physical events occurring in time and in definite places. The key words here are patterns and physical. I believe that our minds are the successions of our ideas, including our motor ideas. By motor ideas I mean the initiation of an action like clenching my fist or communicating an idea to my neighbor. The identification of information as negative entropy specifies the nature of the relation between mind and body. The nature of this relationship is difficult to grasp and I will not attempt to explain it here. The concept is as difficult as the concept of transformation of matter to energy--and its implications are fully as profound.

At a more practical level let me emphasize that an all-out, all-around attack on the problem of auditory communication is now going on. It involves the diverse disciplines and techniques of physics, of physiology and anatomy, and of psychology. Each has its own methodology and concepts. Each speaks its own language. But they can be coordinated and unified by attention to something that is common to all of them, the concept of information itself.

Snorkel--1905 Version



This sketch from the patent of the first workable snorkel bears a date that will surprise many--October 31, 1905. For although by this time the device is familiar to everyone, comparatively few people are aware that it dates back to the pioneer American submariner Simon Lake. This canny inventor equipped his first submersible with snorkel--though his term for it, as described in the patent, was "an air-supply apparatus for submarine vessels."

Today the first cruise of Lake's submarine using this device sounds like a hilarious affair, for the craft was equipped with wheels enabling it to run along the bottom while the crew stood over the opened diver's hatch gathering oysters, sea-shells and other souvenirs. The internal pressure of the diving compartment equalized the water pressure and prevented flooding.

Essentially Lake's invention is similar to today's snorkel. He terms it "a device projecting from the vessel but slightly above the surface even when the sea is otherwise than entirely calm, the temporary submergence of the receiving device being insufficient to permanently cut off the air supply or permit water to enter the boat."

The rest of the story of snorkel--its development by the Dutch and Germans during World War II--is more familiar to us, but it is interesting to recall that the American Navy was the first to make the device workable.

On the Naval Research Reserve

Fourth Annual Research Reserve Seminar Scheduled for June 10-23 by ONR

For the fourth successive year, 100 specially qualified Naval Reserve officers will have the opportunity to observe and study Naval research programs at first hand. The occasion will be the annual scientific seminar to be held June 10 to 23 in Washington, D. C.

The Seminar, sponsored by the Office of Naval Research, will feature lectures by outstanding scientists and engineers closely identified with research and development activities of the Naval Establishment. In addition to hearing these first-hand reports, visiting reservists will have the opportunity to see for themselves the activities proceeding at various Government laboratories in the Capital area. These will include the Naval Research Laboratory in Washington D.C., and several Maryland laboratories: the Naval Ordnance Laboratory (White Oak), the Applied Physics Laboratory (Silver Spring), the Naval Medical Research Institute (Bethesda), the Engineering Experiment Station (Annapolis) and the United States Naval Academy (Annapolis).

A number of the Naval Reserve officers attending the seminar are presently working as civilians on Navy research projects in university and college laboratories throughout the country. These meetings give them a unique opportunity to make the acquaintance of their fellow-researchers and to gain a thorough knowledge of the Navy's long-range scientific interests.

The Chief of Naval Research will welcome the Reserve officers at the opening seminar session at 2:00 p.m. Monday, June 11 in the Navy Department.

Effects of Atomic Weapons Being Studied By VNRRU 4-2, Philadelphia, Pa.

The effects of atomic weapons are the timely subject of an intensive program of study by VNRRU 4-2.

The Philadelphia unit has organized its investigation in a thorough manner which other units, contemplating similar programs, may wish to emulate. The problems involved are being studied under three broad categories of interest. The first period of study, now completed, dealt with the fundamental aspects of atomic phenomena. Lectures were given on nuclear physics, explosion phenomena, explosions of atomic bombs, and the effects of radiation. The article "Underwater Explosions" by LCDR E. R. F. Johnson, USNR, which appears on pp. 17-22 of this month's issue, was first presented in this series of lectures. The second series will include studies of atomic detection and instrumentation, while the final group will deal with after-effects of atomic explosions and methods of survival.

Officially Activated
Volunteer Research Reserve Units

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
1-1	1930, 1st & 3rd Mon. Rm. 4-370, M.I.T. 77 Mass. Ave. Cambridge, Mass.	CAPT L. M. SMITH, USNR 34 Parkland Ave. Lynn, Mass.
1-2	1930, 2nd & 4th Tues. USNROTC Bldg. Brown University Providence, R.I.	CDR Charles J. FISH, USNR CDR Carl PFAFFMAN, USNR (O in C) 16 Cabot St. Providence, R.I.
1-2 Sub-Unit	1600, 1st & 3rd Tues. Rm. 305, Ranger Hall, Rhode Island State College Kingston, R.I.	CDR Charles J. FISH, USNR (O in C) Narragansett Marine Lab. Kingston, R.I.
1-2 Sub-Unit	2000, 1st & 3rd Tues. Oceanographic Institute Woods Hole, Mass.	LCDR Mary SEARS, USNR Glendon Rd. Woods Hole, Mass.
1-3	1900, 1st & 3rd Tues. University of Mass. Amherst, Mass.	LCDR E. D. EMERSON, USNR Dept. of Mech. Eng. University of Mass. Amherst, Mass.
1-4	2000, 1st & 3rd Tues. Coburn Hall University of Maine Orono, Me.	LT Francis J. SULLIVAN, USNR Dept. of Mech. Eng. University of Maine Orono, Me.
1-5	2000, 1st & 3rd Mon. Stratton Hall Worcester Poly. Institute Worcester, Mass.	CDR Emerson A. WIGGIN, USNR 25 Bay State Rd. Worcester 6, Mass.
1-7	2000, 1st & 3rd Tues. Wentworth Hall Dartmouth College Hanover, N. H.	CDR George Z. DIMITROFF, USNR Dartmouth College 21 Lyme Rd. Hanover 30, N. H.
3-1	1915, Alt. Thurs. Auditorium, Med. College Cornell University New York 21, N. Y.	CAPT Robert H. GRIFFIN, USNR 105 Pennsylvania Ave. Tuckahoe 7, N. Y.
3-2	1930, 2nd & 4th Mon. Special Devices Center Eng. Bldg. Port Washington Long Island, N.Y.	LCDR A. A. CHESTER, UNSR Navigation Training Section Special Devices Center Port Washington Long Island, N.Y.
3-3	2000, 1st & 3rd Mon. USNRTC & MCRTC 3 Porter Ave. Buffalo, N.Y.	CDR Morris BEERMAN, USNR 479 Eggert Rd. Buffalo, N.Y.
3-4	1930, 1st & 3rd Tues. Harkness Hall University of Rochester Rochester, N.Y.	CDR Henry C. SHEVE, USNR USNRTC & MCRTC 900 East Main St. Rochester 7, N.Y.

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
3-5	1930, 2nd & 4th Thurs. USNRTC Fort Nathan Hale Park New Haven, Conn.	CDR D. S. ROWELL, USNR USNRTC Fort Nathan Hale Park New Haven, Conn.
3-6	2000, 2nd & 4th Mon. USNRTC Syracuse (Liverpool), N.Y.	LCDR Leslie R. PARKINSON, USNR 117 Harrington Rd. Syracuse, N.Y.
3-7	2000, 2nd & 4th Thurs. USNRTC Scotia, N.Y.	LCDR Edward E. VEZEY, JR., USNR USNRTC Scotia, N.Y.
3-8	1930, 2nd & 4th Tues. Conf. Rm. General Foods Personnel Offices New York, N.Y.	CDR Alfred WEEKS, USNR Rm. 1205, 247 Park Ave. New York, N.Y.
3-9	2000, 1st & 3rd Wed. Brookhaven National Lab. Upton, Long Island, N.Y.	CDR John S. MEDD, USNR Brookhaven National Lab. Upton, Long Island, N.Y.
4-1	2000, 1st & 3rd Wed. Nassau Tavern Princeton, N.J.	CDR Herbert G. DYKE, USNR c/o CDR Harry C. HART, USNR 21 Lilac Lane Princeton, N.J.
4-2	1930, Alt. Thurs. Franklin Institute 20th St. & Parkway Philadelphia, Pa.	CDR John H. NEHER, USNR Philadelphia Electric Co. 1000 Chestnut St. Philadelphia, Pa.
4-3	2000, 2nd & 4th Thurs. Rm. 232, Cathedral of Learning University of Pittsburgh Pittsburgh, Pa.	CDR Neil D. COLE, USNR University of Pittsburgh Rm. 303, Thaw Hall Pittsburgh, Pa.
4-4	1900, 1st & 3rd Wed. Rm. 200, Engineering "E" Pennsylvania State College College Station, Pa.	LT Robert F. MARBOE, USNR 215 West Foster Ave. P.O. Box 274 State College, Pa.
4-5	2000, Alt. Mon. USNRTC Foot of Madison St. Wilmington, Del.	LCDR Donald MacCREARY, USNR USNRTC Foot of Madison St. Wilmington, Del.
4-6	1930, 2nd and 4th Wed. USNRTC Bethlehem, Pa.	LCDR John O. CHELLEVOLD, USNR USNRTC Bethlehem, Pa.
4-7	1930, 2nd & 4th Tues. Rm. 107, Old Armory Ohio State University Columbus, Ohio	LCDR Karl E. KRILL, USNR Engineering Exp. Station Ohio State University Columbus, Ohio
4-8	2000, 1st & 3rd Mon. USNRTC 1089 E. Ninth St. Cleveland, Ohio	LCDR Viktor SCHRECKENGOST, USNR 2366 Noble Rd. Cleveland 21, Ohio
4-9	1930, 2nd & 4th Mon. USNRTC Dayton, Ohio	LT Nathan L. WENER, USNR 1007 Amherst Pl. Dayton 6, Ohio

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
W. Battalion	2000, 3rd Thurs. Auditorium, Interior Dept. Washington, D.C.	CDR Fred C. WIESNER, USNR ONR, LI 5-6700, X-65755 Rm. 2714, Bldg. T-3, Navy Department Washington, D.C.
W-1	2000, 1st Thurs. Lecture Room Material Testing Laboratory National Bureau of Standards Washington, D.C.	CDR W. M. RICHARDSON, USNR ONR, LI 5-6700, X-61235 Rm. 2602, Bldg. T-3, Navy Department Washington, D.C.
W-2	1900, 1st Thurs. Auditorium, Bldg. 8, NRL Washington, D.C.	LCDR H. A. TANNER, USNR NRL, JO 3-6600, X-561 Rm. 152, Bldg. 8, Naval Res. Lab. Washington, D.C.
W-4	2000, 2nd & 4th Tues. Rm. 6618, Interior Dept. Washington, D.C.	Herbert B. CHANDLER, ET 1/c, USNR RR #2, Silver Spring, Md. National Institute of Health Bethesda, Md.
W-5	2000, 2nd & 4th Thurs. Conference Room, NMRI Bethesda, Md.	CDR Barry G. KING, USNR 5617 Wood Way Circle Summer, Washington 16, Md.
5-1	1930, 1st & 3rd Wed. Rouse Physics Lab. University of Virginia Charlottesville, Va.	LTJG Harold S. MORTON, USNR P.O. Box 1716 Univ. Station Charlottesville, Va.
5-2	1915, 1st & 3rd Fri. Bldg. 364, Virginia Poly. Inst. Blacksburg, Va.	LT Burt C. HORNE, USNR University Club Blacksburg, Va.
5-3	2000, each Tues. Camp Detrick Frederick, Md.	CAPT LeRoy D. FOTHERGILL, USNR Camp Detrick Frederick, Md.
5-4	2000, 1st & 3rd Thurs. Rm. 202, Maryland Hall Johns Hopkins University Baltimore, Md.	LT Joseph T. MORAN, USNR 1801 Tower Rd. Harundale, Glen Burnie, Md.
5-5	1700-1900, 2nd & 4th Mon. Medical College of Virginia Richmond, Va.	CAPT Roscoe D. HUGHES, USNR Medical College of Virginia Richmond, Va.
6-1	2000, Alt. Thurs. Rm. 103, Physics Bldg. Ga. Inst. of Tech. Atlanta, Ga.	CDR J. E. BOYD, USNR Physics Bldg. Ga. Inst. of Tech. Atlanta, Ga.
6-2	1915, 1st & 3rd Mon. Rm. 204, Ross Lab. Ala. Poly. Inst. Auburn, Ala.	LTJG J. E. LAND, USNR Dept. of Chemistry Ala. Poly. Inst. Auburn, Ala.
6-3	2nd & 4th Wed. AEC Townsite Oak Ridge, National Lab. Oak Ridge, Tenn.	LCDR Edward I. WYATT, USNR 138 Tabor Rd. Oak Ridge, Tenn.
6-4	1930, 1st & 3rd Tues. Engineering Bldg. University of Florida Gainesville, Fla.	LCDR Chester L. EGGERT, USNR College of Education University of Florida Gainesville, Fla.

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
6-5	2000, 1st & 3rd Thurs. USNRTC Gulfport, Miss.	LT V. O. SMALLWOOD, USNR 2412 East Ave. Gulfport, Miss.
6-6	1945, 2nd & 3rd Wed. USNROTC Armory University of North Carolina Chapel Hill, N. C.	LT Robert F. SCHENKKAN, USNR 103 Stephen St. Chapel Hill, N. C.
6-7	2000, 2nd & 4th Thurs. Biology Bldg. Duke University Durham, N. C.	LCDR John H. ROBERTS, USNR 2813 Legion Ave. Durham, N. C.
6-8	2000, 1st & 3rd Mon. Underwater Sound Reference Lab. Orlando, Fla.	LCDR D. T. HAWLEY, USNR 1027 Guernsey Ave. Orlando, Fla.
6-9	1930, 2nd and 4th Tues. Rm. 101, Baldwin Hall University of Georgia Athens, Ga.	LCDR A. R. ROBERTSON, USNR Baldwin Hall University of Georgia Athens, Ga.
6-10	2000, 1st & 3rd Wed. Rm. S-110, Memorial Classroom Bldg. University of Miami Coral Gables, Fla.	LT R. D. KRESKE, USNR Dept. of Geography University of Miami Coral Cables, Fla.
6-10 Sub-Unit	2000, 1st & 3rd Wed. 151 South County Rd. West Palm Beach, Fla.	LTJG John H. COLEMAN, USNR 121 Worth Ave. West Palm Beach, Fla.
8-1	1930, 1st & 3rd Tues. USNROTC Bldg. Tulane University New Orleans, La.	LCDR John M. SCOTT, USNR Dept. of Chemistry Tulane University New Orleans, La.
8-2	2000, 1st & 3rd Wed. Rm. 221, Coates Lab. Louisiana State University Baton Rouge, La.	LT John A. ALFORD, USNR Dept. of Bacteriology Louisiana State University Baton Rouge, La.
8-3	1930, 2nd & 4th Mon. PMA Bldg. or Bolton Hall Texas A & M College College Station, Tex.	LCDR Norman F. RODE, USNR Dept. of Elec. Eng. Texas A & M College College Station, Tex.
8-4	1930, Alt. Wed. USNROTC Bldg. The Rice Inst. Houston, Tex.	LCDR L. J. CASTELLANOS, USNR 6513 Rutgers St. Houston, Tex.
8-5	2000, Alt. Tues. & Wed. Rm. 15, Chemistry Bldg. University of Texas Austin, Tex.	LCDR G. H. AYRES, USNR Dept. of Chemistry University of Texas Austin, Tex.
8-6	1930, Last Mon. USNRTC Galveston, Tex.	LTJG C. N. SECHRIST, USNR 1235 3rd Ave., North Texas City, Tex.
8-7	2000, 1st & 3rd Wed. USNRTC 1805 S. Yale Ave. Albuquerque, N. M.	LCDR Sherman A. WENGERD, USNR 1044 N. Stanford St. Albuquerque, N. M.

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
8-8	2nd & 4th Wed. Senior High School Bartlesville, Okla.	LCDR Alvin R. GREGORY, USNR 915 Dewey Ave., Box 1102 Bartlesville, Okla.
8-8 Sub-Unit	1930, 2nd, 3rd, & 4th Thurs. USNRTC Stillwater, Okla.	LT Dariel E. HOWELL, USNR 1408 Lewis St. Stillwater, Okla.
8-9	1705 1st & 3rd Tues. Rm. B-117 Los Alamos Scientific Lab. Los Alamos, N. M.	CDR Henry HEYMAN, USNR (Acting) 1072-48th St. Los Alamos, N. M.
8-10	1930, 1st & 3rd Thurs. Physical Science Lab. N. M. College of Agr. & Mech. Arts Las Cruces, N. M.	LT Calvin I. RICKETTS, USNR Box 548 State College, N. M.
8-11	1930, 2nd & 4th Thurs. USNRTC Orange, Tex.	LT Joseph L. SCHWEPPE, USNR 2229 Cross Lane Orange, Tex.
8-12	2000, 2nd & 4th Tues. Rm. 127, Fondren Science Bldg. Southern Methodist University Dallas, Tex.	LTJG Homer B. HIX, USNR 2516 So. Llewellyn Ave. Dallas, Tex.
9-1	1900, 2nd & 4th Tues. Navy Pier Campus University of Illinois Chicago, Ill.	LCDR Walter E. PETERSON, USNR 411 South 15th Ave. Maywood, Ill.
9-2	1930, 1st & 3rd Mon. Rm. 319, Gregory Hall University of Illinois Urbana, Ill.	CAPT Chauncy M. LOUTTIT, USNR Dept. of Psychology University of Illinois Urbana, Ill.
9-2 Sub-Unit	Peoria, Ill.	LT Thomas J. PRIDHAM, USNR 1004 N. Underhill St. Peoria, Ill.
9-3	1930, Alt. Mon. Rm. 18, Angell Hall University of Michigan Ann Arbor, Mich.	LTJG Wm. C. TRUCKENMILLER, USNR 419 Second St. Ann Arbor, Mich.
9-3 Sub-Unit	Houghton, Mich.	LCDR Roy W. DRIER, USNR 715 Pine St. Calumet, Mich.
9-5	1930, 1st & 3rd Wed. USNROTC Bldg. Iowa State College Ames, Iowa	LCDR O. C. KREIDER, USNR Dept. of Mathematics Iowa State College Ames, Iowa
9-6	1930, 1st & 3rd Mon. Rm. 4, Mech. Eng. Bldg. University of Minnesota Minneapolis, Minn.	LCDR J. A. WISE, USNR Rm. 222, Aeronautical Eng. Bldg. University of Minnesota Minneapolis, Minn.
9-6 Sub-Unit	2000, 2nd & 4th Wed. ROTC Armory Smith College Brookings, S. Dak.	LT Gerald B. SPAWN, USNR South Dakota State College Entomology - Zoology Dept. Brookings, S. Dak.
9-7	1930, 2nd & 4th Thurs. Rm. 111, Stanley Coulter Hall Purdue University Lafayette, Ind.	LT L. M. BAKER, USNR Dept. of Psychology Purdue University Lafayette, Ind.
9-8	2000, 1st & 3rd Thurs. Rm. 101, Crew Hall Washington University St. Louis, Mo.	CDR R. N. VARNEY, USNR Dept. of Physics Washington University St. Louis, Mo.

Designation	Time and Place of Meeting	Commanding Officer and Mail Address
9-8 Sub-Unit	Louisiana, Mo.	LT Tracey P. MOORE, USNR Bureau of Mines Louisiana, Mo.
9-9	1930, 1st & 3rd Thurs. Rm. 204, Mechanics Hall Missouri School of Mines and Metallurgy Rolla, Mo.	CDR R. A. COOLEY, USNR Missouri School of Mines and Metallurgy Rolla, Mo.
9-12	1930, 2nd & 4th Tues. Rm. 2, Botany Bldg. Annex Colorado A & M College Fort Collins, Colo.	LTJG W. D. THOMAS, USNR Dept. of Botany & Plant Pathology Colorado A & M College Fort Collins, Colo.
9-12	1900, 1st & 3rd Fri. Boulder, Colo.	LTJG George J. MALER, USNR Dept. of Elec. Eng. University of Colorado Boulder, Colo.
9-13	1930, 1st & 3rd Thurs. USNRTC Des Moines Still College Des Moines, Iowa	LCDR J. R. MALONEY, USNR 2920 48th St. Des Moines, Iowa
9-14	1930, Wed. or Thurs. (2/mo) USNRTC University of Wisconsin Madison, Wis.	LT Richard M. SHACKELFORD, USNR Dept. of Genetics University of Wisconsin Madison, Wis.
9-14 Sub-Unit	1930, 1st & 3rd Tues. Inst. of Paper Chemistry Appleton, Wis.	LTJG Edward G. SNYDER, USNR Inst. of Paper Chemistry Appleton, Wis.
9-15	1900, 2nd & 4th Thurs. Conf. Rm. Pers. Bldg., Dow Chem. Co. Midland, Mich.	LTJG D. D. McCOLLISTER, USNR 1220 Michigan St. Midland, Mich.
9-16	1900, 1st & 3rd Mon. USNRTC 1620 E. Saginaw St. Michigan State College East Lansing, Mich.	LCDR Ira B. BACCUS, USNR 407 Marshall St. East Lansing, Mich.
9-17	1930, 1st & 3rd Mon. Rm. 103, Eng. Bldg. University of Wyoming Laramie, Wyo.	LTJG Robert S. BRADFORD, USNR Dept. of Physics University of Wyoming Laramie, Wyo.
9-19	1945, 3rd Thurs. Senate Chamber, Old Capital State University of Iowa Iowa City, Iowa	LT John L. DAVIES, USNR East Hall Iowa City, Iowa
9-20	2000, 1st & 3rd Mon. Naval Science Bldg. University of Kansas Lawrence, Kans.	LTJG Russell C. MILLS, USNR Dept. of Biochemistry University of Kansas Lawrence, Kans.
9-21	1700, 2nd & 4th Wed. General Motors Research Lab. 485 W. Milwaukee St. Detroit, Mich.	LCDR Ralph A. RICHARDSON, USNR General Motors Corp. 485 W. Milwaukee St. Detroit, Mich.
9-22	1930, 1st & 3rd Wed. Military & Naval Sci. Bldg. University of Nebraska Lincoln, Neb.	LCDR Lloyd W. HURLBUT, USNR 2640 Colonial Dr. Lincoln 2, Neb.
9-23	1800, 2nd Thurs. Argonne Nat. Lab. Du Page County Site, Ill.	LCDR Howard C. BALDWIN, USNR c/o AEC, Box 6140A Chicago, Ill.
11-1	2000, 1st & 3rd Tues. 1030 E. Green St. Pasadena 1, Calif.	LCDR Frederick P. DILLON, USNR 1030 E. Green St. Pasadena 1, Calif.

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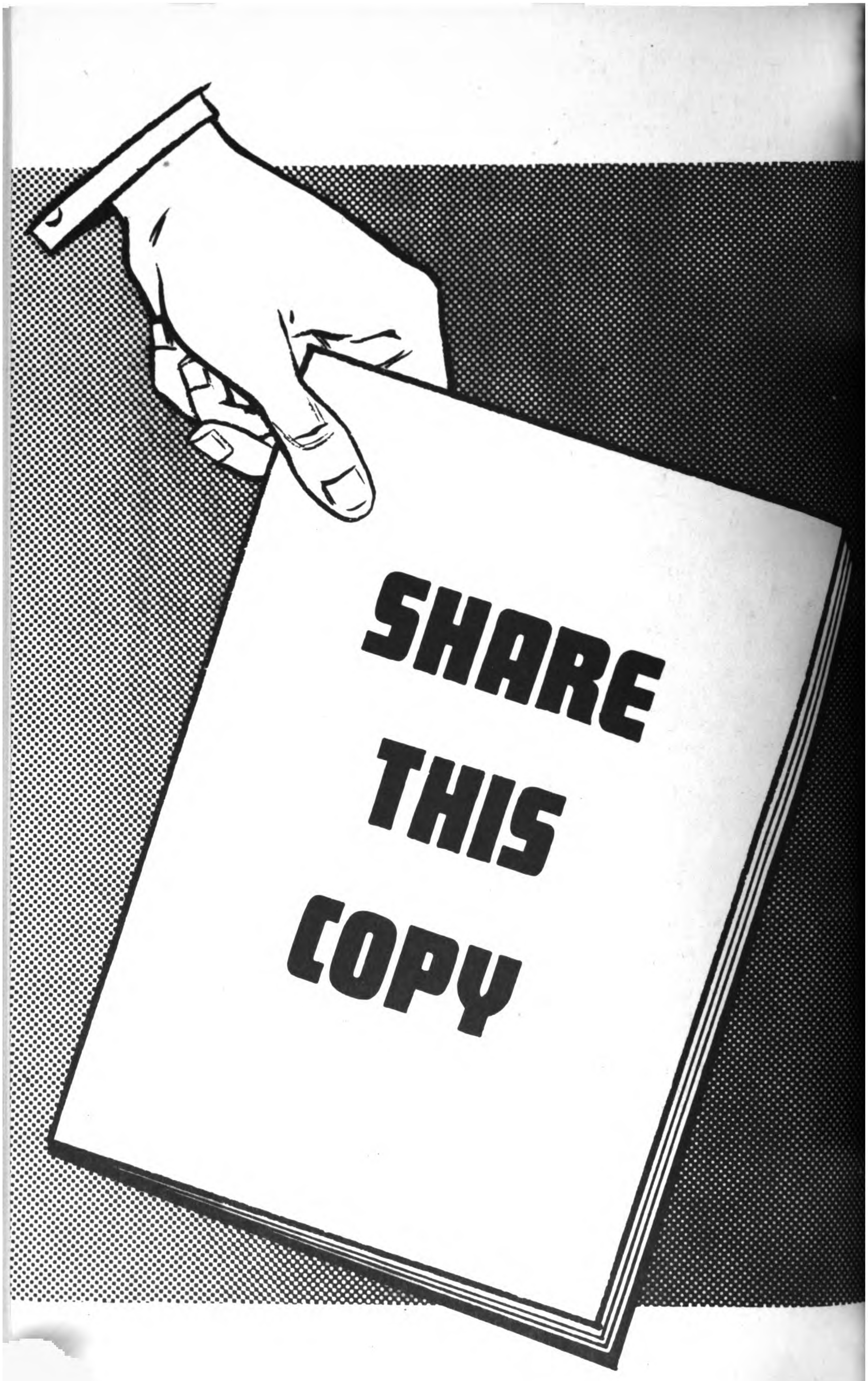
Designation	Time and Place of Meeting	Commanding Officer and Mail Address
11-2	2000, Alt. Thurs. USNRTC Pasadena, Calif.	LT Herbert D. STRONG, USNR 2208 Montrose Ave. Montrose, Calif.
11-3	2000, 2nd & 4th Mon. USNRTC & MCRTC 851 Chavez Ravine Rd. Los Angeles, Calif.	CDR Frederick W. HINRICHS, USNR 9425½ W. Olympic Blvd. Beverly Hills, Calif.
11-4	2000, 1st & 3rd Wed. USNRTC San Pedro, Calif.	LCDR Philip B. WILSON, USNR 2633 E. 7th St. Long Beach 4, Calif.
11-5	1930, 2nd, 3rd, & Last Tues. USNRTC San Diego, Calif.	CDR Gifford C. EWING, USNR 1205 Muirlands Dr. LaJolla, Calif.
11-6	2000, 1st & 3rd Wed. USNRTC Phoenix, Ariz.	LCDR Milton B. MORSE, USNR 522 West Virginia Ave. Phoenix, Ariz.
12-1	2000, 2nd & 4th Mon. 1000 Geary St. San Francisco, Calif.	CDR J. E. LAURANCE, USNR 1000 Geary St. San Francisco, Calif.
12-2	1945, 2nd & 4th Mon. Rm. 201, Donner Lab. University of California Berkeley, Calif.	LCDR Nello PACE, USNR Rm. 2519, Life Science Bldg. University of California Berkeley, Calif.
12-3	2000, 2nd & 4th Wed. Rm. 208, Engineering Corner Stanford University Stanford, Calif.	CDR L. S. JACOBSEN, USNR Dept. of Mech. Eng. Stanford University Stanford, Calif.
12-4	2000, 2nd & 4th Thurs. Rm. M-103, McLane Hall Fresno, Calif.	CDR R. A. JACK, USNR Dept. of Physics Fresno State College Fresno 2, Calif.
12-5	1930, 2nd & 4th Wed. Rm. 208, LeConte Hall University of California Berkeley Calif.	CDR C. F. GARLAND, USNR Div. of Eng. Design University of California Berkeley, Calif.
12-6	2000, 1st Tues. 1200 & 1630 3rd Tues. Tower Rm., Animal Science Bldg. University of California Davis, Calif.	LCDR T. R. HEDGES, USNR Rm. 7, T. B. 2 University of California Davis, Calif.
12-7	2000, 2nd & 4th Fri. USNRTC, Fort Douglas Salt Lake City, Utah	LCDR H. L. FOOT, JR., USNR 136 East South Temple St. Salt Lake City, Utah
13-1	1930, 2nd & 4th Mon. Rm. A-223, Health Science Bldg. University of Washington Seattle, Wash.	CDR H. S. BENNETT, USNR Dept. of Anatomy School of Medicine University of Washington Seattle, Wash.
13-2	1900, 2nd & 4th Mon. American Legion Hall Richland, Wash.	LCDR Donald R. GUSTAVSON, USNR 1510 Cottonwood Dr. Richland, Wash.
13-3	1930, 2nd & 4th Mon. Rm. 39, Holland Lib. Pullman, Wash.	LCDR W. G. GNAEDINGER, USNR 601 High St. Pullman, Wash.
13-4	2000, Tues. USNRTC & MCRTC, Swan Island Portland, Ore.	LCDR Richard F. STEVENS, USNR 830 N.E. Holladay St. Portland, Ore.
13-5	1930, 2nd & 4th Mon. Rm. 114, Chemistry Bldg. Oregon State College Corvallis, Ore.	LCDR Albert V. LOGAN, USNR Dept. of Chemistry Oregon State College Corvallis, Ore.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