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RESEARCH REVIEWS

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DEPARTMENT OF THE NAVY

WASHINGTON, D. C.

COVER PHOTO: RADM Rawson Bennett, II relieved RADM Frederick R. Furth as Chief of Naval Research on 31 December. The new Chief, still a Captain when the picture was taken, was most recently Assistant Chief of the Bureau of Ships for Electronics. More about him on Page 23.

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

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Approved by Bureau of the Budget, 28 February 1955

In This Issue

Guided missile in container requires heavy truck and trailer for transit.

Keeping Ahead of Military Operations

RADM F. R. Furth
Former Chief of Naval Research
Office of Naval Research

One of the results of research and development is the necessity to perform more research. It is axiomatic in science that whenever you make an important breakthrough, you usually open up a whole new host of problems to be solved. This is certainly true of military research and development. The application of scientific research to military weaponry has brought advances during the past 15 years that dwarf all the progress made up to that time.

As a research organization, it is the job of the Office of Naval Research to lay the foundations for new techniques which will insure the best possible movement of supplies and equipment to the operating forces. It is not enough to set out to solve problems as they arise in the Fleet; it is not even enough to anticipate problems. If we intend to keep ahead of operational needs, we must systematically examine the fundamental working principles of our operations, to find out if the assumptions we have always taken for granted are really true.

The whole field of logistics is being formally studied to find out more about the principles which govern the production and distribution of goods in modern military operations. One principal aim of this work is the introduction of objective planning factors to replace guesswork in computing initial requirements and resupply shipping requirements for any operation. Logistics research includes research and development on new and improved mathematical methods and computing equipment for carrying out the statistical and administrative activities involved in military logistics planning. A special-purpose electronic digital computer, designed specifically for use in logistics computations, is now in operation as a part of this research.

This work is supporting research. It helps to develop the techniques which can be used to solve specific operating problems, and to design equipments for the best possible performance of a certain job. It is concerned with finding out what the true problems are, then analyzing them for solution.

In the Navy, some of our most pressing requirements are dictated by the demands of mobile logistic support. A principal emphasis here must always be on speed—especially upon improving the rate of transfer from ship to ship and upon speed in striking cargo below decks. During replenishment operations ships are naturally more vulnerable to attack. While striking cargo, the water-tight integrity of the combat ship is broken, because hatches on deck and between water-tight compartments below decks must remain open.

Navy development programs have been working toward improved ship-to-ship rigging and cargo nets for handling the transfer of materials, and new types of conveyors for getting it out of the hold of the issuing ship. New types of overhead cranes and deck equipment, such as wheeled trucks, are under development. The concept of unitized loads, in which individual packages are glued or otherwise fastened together to form large modules, is being employed and appears to offer many advantages. We are also experimenting with other devices to speed up transfer.

The Navy is extremely interested in improving shiploading methods, especially cargo-handling gear for combat ships, to speed up the rate of striking the material below once it has been transferred. The problem is principally a matter of working out techniques for the large aircraft carriers such as FORRESTAL. One fruitful line of attack seems to be conveyors for moving cargo over the deck and into the hold, to gain the advantages of keeping material and equipment moving in a continuous flow, rather than in a series of reciprocating motions.

The Navy is likewise interested in improving methods of materials handling ashore, and has carried out extensive testing of methods of blocking and bracing in freight cars, more efficient methods of warehousing and the use of well cushioned containers—especially for critical electronic parts. Some cushioning of bonded hair and a typical steel drum are shown in Figure 1.

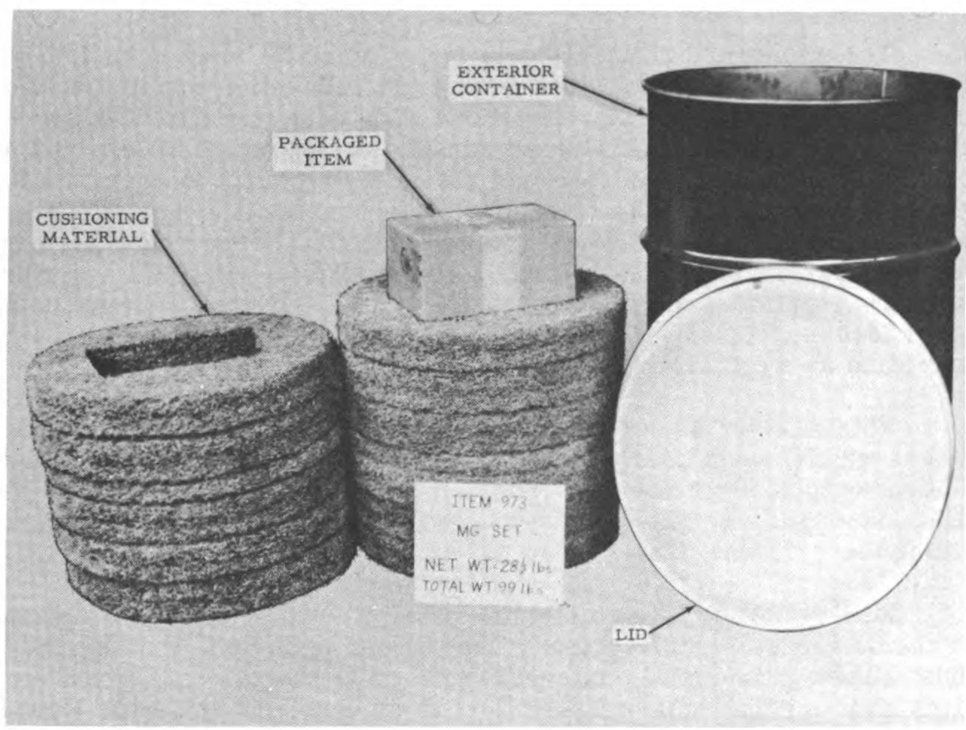

Figure 1 - Cushioning material and steel drum for packaging electronic items.

In packaging the many items which must be transported in this system, a major factor is to select the optimum sizes for the containers. The logistics research program now includes investigating the role of the size of modules flowing in transportation networks. The Bureau of

Supplies and Accounts has been conducting studies in such aspects of the problem as the nesting of round containers, to improve efficiency of handling and storing. A main factor from the Navy's standpoint is that no container is useful unless it can be stored on deck or be easily moved through a hatch. Any container which does not meet these fundamental requirements could quickly create a bottleneck in the system.

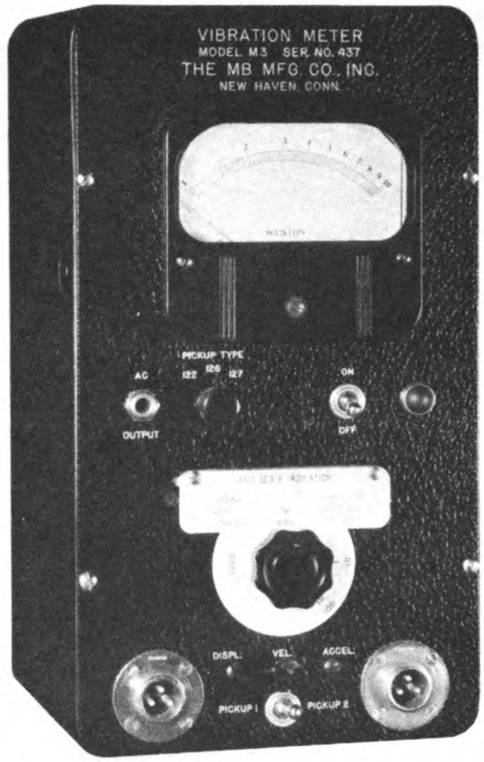

Figure 2 - Tests on packaging make use of vibration meter.

The greatest problems in packaging have been created by requirements imposed by new developments in warfare. In amphibious operations we are faced with the necessity for hitting the enemy with greater surprise and speed than ever before, to nullify the possible use of atomic weapons against our attacking forces. One answer to this is to develop techniques for bringing troops in by air, which means dropping weapons and supplies by air. The military services are extremely interested in aerial resupply operations in other areas than the beachhead, of course, but I mention amphibious operations because of the Navy's responsibilities in this area. Packaging to withstand the shock of an air drop has created problems for all the services.

One interesting development in this field is the Roto-chute (Research Reviews, March 1955), developed to meet Marine Corps needs for supplying beachheads and other confined areas. It consists of two rotor blades attached to a hub, which is fastened to a standard military M2 supply container. The M2 container is currently used for supply drop by parachute. The rotor blade attachment permits drops from lower altitudes and at higher speeds, with greater accuracy than is possible with a parachute. It is much less susceptible to wind drift than a parachute, and will permit pin-point airdrops within small areas.

Another great problem area in packaging has been created by the development of guided missiles, which are now reaching the operating forces in the Army, Navy and Air Force. The central problem here is packaging extremely complex and precise machinery in such a way that it will not be injured by any shock or vibration in spite of all the handling it must undergo from the manufacturer's plant to the storage areas aboard ship, at an Air Force base, or Army installation. Elaborate preliminary tests employ such an instrument (Figure 2) as the MB Vibration Meter.

The ticklishness of the problem can be illustrated by a resume of the high degree of reliability that must be obtained if a missile is to function well enough to reach its target. The designer and builder is faced with minimizing every possibility of technical failure in a series of different systems which must all operate together. A typical guided missile contains a fuel system, an engine, a generator, regulated power supplies, antennas, receivers, amplifiers, gyros, computing elements, hydraulic servos, and measuring potentiometers—and this is to mention only a few of its parts. Each of these depends upon dozens of sub-components, such as resistors, condensors, transformers and diodes. If we assume that there are only 100 links in this chain, although actually there are many more, the engineer must design and the builder must build so that each one of these parts has less than one chance in a thousand of failure, in order to give us a 90-percent probability that the missile will complete its mission. When we must demand this degree of reliability from delicate electronic and mechanical systems, we must be absolutely certain that we can package them and move them around without damage.

Engineering for the packaging of large, complex items began about ten years ago, with the design of containers for large aircraft engines. The knowledge and experience which was gained in this work has been a good foundation for solving the problems of packaging guided missiles. Illustrations of

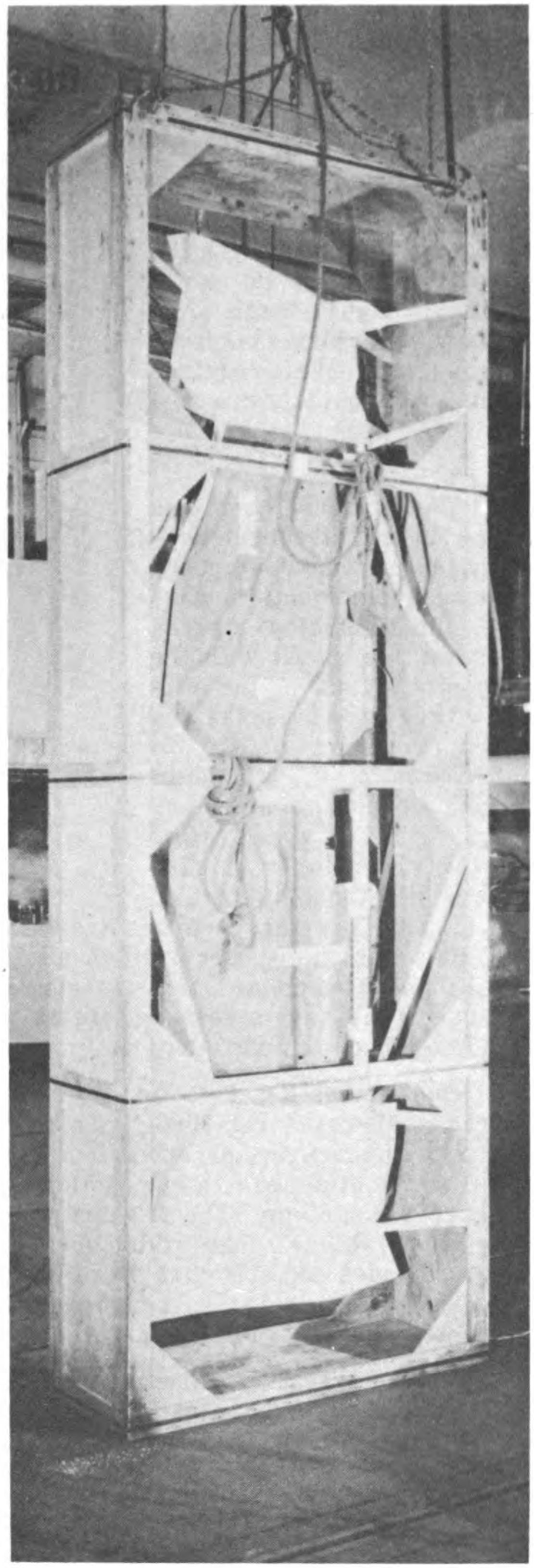

Figure 3 - For drop tests, special mounts were built to contain items tested.

progress in package design are afforded by Figures 3, 4, and Frontispiece.

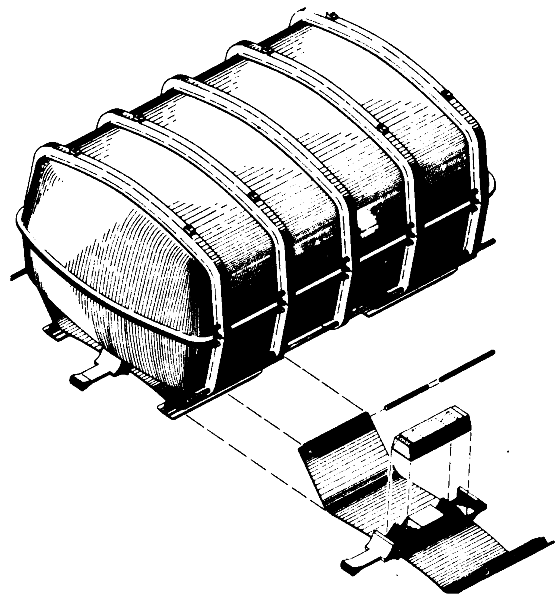

Figure 4 - Light-weight container designed by Fairchild Guided Missiles Division.

To design and construct containers for guided missiles entails a knowledge of the environmental conditions to which the package and its contents will be subjected, plus information about the fragility or ruggedness of the missile itself. Many of the difficulties arise from the fact that all of this essential information is not at present available to the design engineer. One step to correct this is the compilation of a book covering all the important aspects of packaging guided missiles, which has been prepared for the Department of Defense under the sponsorship of the Assistant Secretary of Defense for Research and Development. This book is coming out in sections; the first is already in print. It is an interim publication which was designed to meet urgent needs.

This first comprehensive publication on guided missiles packaging is truly a team effort, which has been written and compiled with the cooperation of industry. All the military services, the laboratories of other Government agencies and more than twenty industrial concerns are among the contributors to this volume.

It has been pointed out that, ". . .there are no fundamental engineering differences between the design of guided missile containers and the design of containers for other types of equipment. The sole difference is the degree of difficulty in arriving at the correct solution. This difference of degree, however, may be of about the same order of magnitude as the difference between designing a model aircraft and designing a guided missile. Over the years, standard rules of thumb have been developed for designing containers for the vast majority of military equipment. For a relatively small number of highly complex devices, reliance on rules of thumb is not sound, and a detailed engineering approach is required. Containers for guided missiles are definitely in this category." This is clearly an area in which a new operational need is placing urgent demands upon our development program.

The age-old problem of packaging materials so they will withstand the ravages of time and the elements has assumed major importance today, when our military forces must be prepared to operate in any part of the world, and when we maintain permanent bases with large supply depots in some of the most varied and rugged climates known to man.

One of the chief problem areas has been the inability to package materials for storage for long periods, such as three to five years. Regardless of conditions inside the package, deterioration sets in from the outside with the passage of time, particularly in tropic environments.

An area in which we feel much work should be done is that of exploring the use of the new materials which are now being developed on almost a monthly basis, with an eye to alleviating potential wartime shortages of more conventional materials, such as aluminum foil. We know that the demand for aluminum and other basic raw materials would rise sharply in case of mobilization, yet at present we depend heavily upon them for packaging. The present highly vigorous activity in applied chemistry and metallurgy would appear to open many new doors for packaging experts.

Major breakthroughs have been made in developing new methods of staving off corrosion of packaged materials. One of these breakthroughs, the development of volatile rust inhibitors, provides a good example of how basic research can lead to unexpected gains in addition to solving the problems which originally prompted the research.

During World War II, the Naval Research Laboratory was performing basic chemical research in an area which held promise for aiding the development of synthetic oils for very high and very low temperature operation. One of the problems was to find rust inhibitors to use with these oils, since they would not contain the inherent rust-inhibiting qualities of natural oils. The basic research on rust inhibition led to the development of inhibitors which were volatile—they vaporized readily and impregnated the surrounding air. Obviously, if we have a substance which will render the air around it "rust-proof," so to speak, we have something with great value for packaging. These volatile inhibitors have been developed and they work. Furthermore, the method of using them is extremely simple and provides an enormous advantage to the man who ultimately uses the equipment. One method is to impregnate paper with the rust inhibitor and place a piece of the treated paper in the container.

For field weapons, such as rifles, machine guns and pistols, this provides a very great military advantage, as well as a gain in convenience. Weapons which are to be issued directly in the field need not be packed in cosmolene or other grease. They can be packaged dry, in an air-tight container, with a piece of treated paper in the package and a small tube of the paper inserted in the bore of each weapon. A Marine on the beachhead could receive via air-drop a rifle that had been packaged long in advance. When he ripped open the container he would be ready to insert the ammunition and fire.

This technique could be extremely important in affecting the outcome of an engagement fought in very low temperatures, as in Korea, where the thermometer sometimes drops to 40 degrees below zero. At this temperature a greasy protective coating cannot be cleaned off the weapons well enough to permit them to fire, so resupply directly in the field was virtually impossible. Research has now changed this picture, and the new volatile rust inhibitors should help our ground forces keep ahead of the need for greater speed and greater flexibility imposed by modern warfare.

In logistics research there are opportunities to use abstract techniques such as mathematical analysis, in dealing with fundamental aspects of certain problems. Some of this work is essentially the creation of a laboratory model of a real situation, in order to study it under controlled circumstances. At the other end of the scale we have research in which laboratory work is obviously not enough, and much of the work on corrosion aspects of packaging is in this category.

The Navy maintains a corrosion laboratory and tropical exposure sites in Panama (Research Reviews, December 1955), where research and development results can be submitted to the impartial judgment of nature herself. This is a facility for combining the hard facts of nature with laboratory precision. Our scientists can put actual materials and equipments out in the jungle, then watch the termites, or the fungi, or the humidity rot them away, and make careful measurements of the process. There are facilities for immersing materials in sea water and in fresh water, for leaving them in salt-free air in the interior, or subjecting them to other environmental conditions. It is possible to simulate actual operational use, imitating the best possible handling practices and the poorest practices, and see what actually happens to the equipment when it is treated this way in the environments in which it may be used.

This not only helps our research workers to spot a good material; it helps prevent wasting time and money on a poor one. A good example is the work with a material developed to prevent fungal growth on electronic equipment. Preliminary laboratory tests indicated the material would work, but by actual field testing in the jungle our people were able to tell, two years in advance of any concrete laboratory proof, that it was no good. This was one of many experiences which confirm our belief that nature is so complex that we cannot predict just how well a material will last without actually putting it in the field. Field testint new materials under operational conditions is another way of trying to keep a step ahead of operational needs. It enables our research and development programs to put pre-tested materials in the hands of the operating forces. As a result, there is less likelihood that the packaging job will have to be done over again because of poor materials.

Packaging and material handling is a field in which many of the problems are common to all the services, and many of our projects are supported jointly by the Army, Navy and Air Force. The post-war decade has seen a virtual explosion of technology, and the military forces of the world have been the first to feel its effects. Speed and complexity are the hallmarks of this new era, and flexibility and mobility become its rewards. More materials must be handled faster; a bottleneck exacts greater penalities than ever before. New materials and new kinds of equipments need to be packaged, while costs are kept at a minimum. The rewards for ingenuity are greater than ever before.

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The Squid - A Little Squirt With A Big Nerve

Philip B. Armstrong
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Woods Hole, Massachusetts

Although the squid and its relatives, such as the octopus and cuttlefish, are of special interest to the scientist, these animals also have general interest and importance. An aquarium exhibit of any of these forms is sure to attract the attention of the general public. Their bizarre anatomy, rapid color changes and the sinister reputation of the octopus combine to give them special interest. Also they are particularly modern in their locomotion as they are principally jet propelled. In Germany, they are known as "Tintenfisch" (ink fish) because of their ability to emit a cloud of ink as an aid in escaping from some predator.

The squid (Figure 1) and its close relatives are the cephalopods (head-footed) although the five paired appendages grouped around the mouth with their sucking discs are usually referred to as arms. With these arms the squid can capture live food—a small crab or minnow—and draw it to his mouth which is armed with a pair of powerful horny jaws. Water, trapped in the mantle, can be ejected through the siphon with

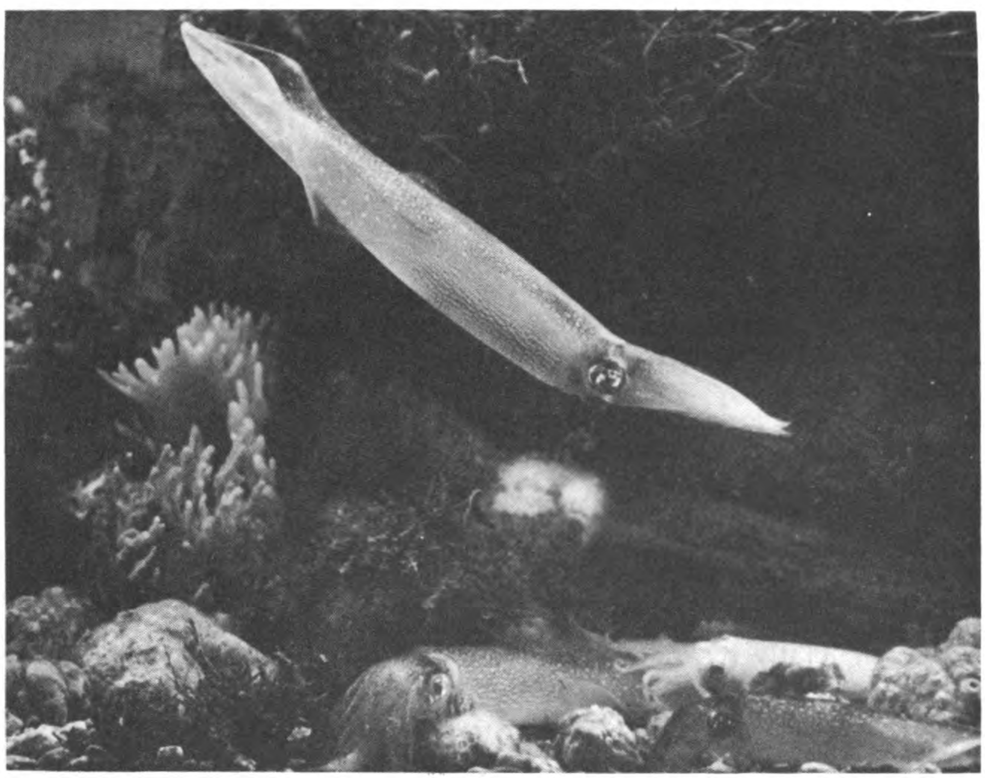

Figure 1 - Squid used for laboratory study are usually a few inches long; giant varieties are considerably larger (Photo courtesy Woods Hole M.B.L.)

considerable force, thus propelling the animal rapidly through the water. By changing the direction of its siphon the squid can dart toward its prey or in the opposite direction if required for escape. The sudden color changes, characteristic of the squid, result from the very rapid expansion and contraction of unique pigment cells. They are really small organs, an elastic sac containing pigment and a large number of radial muscle cells which when they contract, expand the sac and disperse the pigment.

The squid is of considerable economic importance particularly in the Near and Far East where large quantities are consumed as food. In Japan alone the annual catch of squid and related forms has at times exceeded 750,000 tons. In the western countries it is used as bait particularly in cod fishing. Sportsfishermen use the whole squid as bait for striped bass, tuna, swordfish, etc. Some of the fishes of economic importance to man feed extensively on squid. Sepia, a rich brown water-soluble pigment used in water colors, is prepared from squid ink.

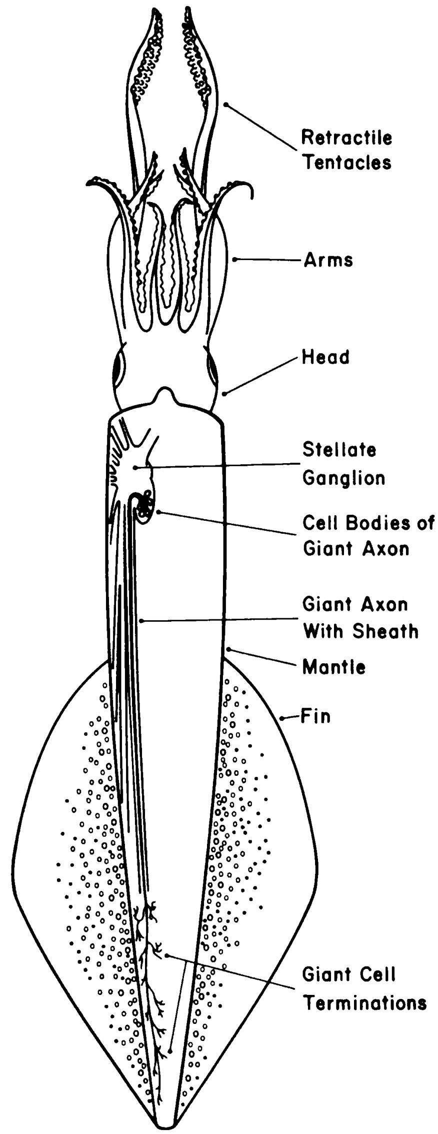

Figure 2 - Diagram of Squid showing Stellate Ganglion and Giant Nerve Fiber.

We know how and where squid migrate, but the "why" is not so well understood. They come into the southern shore waters of Cape Cod in late spring and early summer, their normal spawning time, and are taken in large numbers in fish traps. They are much less abundant on the south shore of the Cape in late July and August but are taken in numbers on the north shore at this time. This may be associated with the water temperatures, the water of Cape Cod Bay being about 10° lower than Martha's Vineyard Sound in mid-summer. At any rate, it is a fortunate circumstance for the Marine Biological Laboratory, since it assures a continuous supply of squid for research purposes throughout the summer.

The transportation of live squid to the Marine Biological Laboratory from the nearby fish traps is very easy. The squid are removed directly from the fish traps into tanks in the Laboratory's boat. Water is pumped through this tank continuously during the trip back to the Laboratory. The squid commonly release large quantities of ink when handled, fouling the water in the tank. This water must be replaced as the squid's own ink, or one of its components, makes him sick. From the north side of the Cape the squid are transported by truck. Under an ONR contract the Laboratory has developed effective equipment for this purpose, involving a tank with a cooled, aerated, circulating system. Losses of squid in transport are negligible. The squid will survive in the Laboratory tanks from 4 to 5 days if properly fed. This period could probably be extended considerably with proper temperature control of the tanks.

An extraordinary characteristic of the squid, the thing that is attracting scientific study of the unusual animal, is the size of his mantle nerve. Imagine a nerve cell with an axon or nerve fiber one millimeter (.04 in.) in diameter. Compare this with the largest nerve fibers seen in man, which are only 20 microns in diameter or one-fiftieth that of the giant squid axon. With suitable microtechniques, certain experiments can be carried out on giant squid axon (Figure 2) which are impossible with smaller vertebrate nerve fibers.

The giant axons commonly used in physiological research are found in the mantle. They are concerned with the contraction of the mantle muscle and with chromatophoric activity. The mantle is translucent, and the giant nerve fibers can be made visible by transillumination. It is possible with microinjection equipment to inject materials directly into the interior of the axon. Colloidal dyes thus injected spread rapidly through a giant axon into the ganglion of origin. Most interestingly a giant axon has a large number of cell bodies of origin, the individual processes from these cell bodies uniting to form the single large axon. The rapid spread of the dye reveals the highly fluid character of the axon contents. The injected dye however does not spread beyond the cell bodies to the next nerve cell in the chain of conduction. Apparently there is a real physical barrier at the junctional points or synapses between the adjacent cells in the chain of conduction. However by increasing the injection pressure these barriers can be ruptured and the dye flows into the next cell.

The giant axon of the squid has been particularly useful in studying the conditions associated with the conduction of the nerve impulse and the characteristics of the associated electrical potential changes. Evidence obtained from experiments on vertebrate nerves suggested that ionic differences across the surface membranes of nerves played an important role in the electrical changes propagated along the nerve fiber. The evidence was indirect and involved complicated assumptions and mathematical computations with some question as to their validity. However, much progress has been made on the above questions using the squid nerve in conjunction with appropriate techniques which have been developed specifically for this material.

The squid axon is usually removed from the mantle for most of these experiments. This dissection can be rather laborious, particularly if the surrounding connective tissue sheath has to be cleaned off the fiber. Since the axon contents are so fluid, the cut ends must be tied off to prevent their escape. A few centimeters of axon frequently are adequate for many of these experiments. In the earliest experiments done on the isolated axon at the Marine Biological Laboratory, a capillary electrode containing sea water was inserted through the end of the cut axon. A second electrode was placed in the sea water surrounding the axon. There was found to be a constant resting potential of about 50 millivolts. On stimulation of the nerve fiber there was a reversal of the sign of the potential with an action potential of slightly more than 100 millivolts.

It is a fortunate circumstance that the contents of the squid axon are so fluid. This fluid may be expressed from the axon in quantities sufficient for reasonably accurate determinations of the ionic concentrations of various components, particularly potassium, sodium, and chloride. Determinations have also been made on the water and the amino acids. The protoplasm of the squid axon is similar to many other cells in its relatively high potassium content and low sodium and chloride content. Studies have also been made of shifts in these ionic concentrations on changing the corresponding ions in the surrounding bath. The use of radioactive sodium and potassium has aided materially in tracing the movements of these ions across the membrane of the axon. Some ingenious experiments have been carried out in which the metabolic activity has been studied in combination with the radioactive ions to follow the concurrent ionic shifts. In other experiments the internal composition has been changed by direct injections of various ions into the axon, the microinjection pipette serving at the same time as an electrode. The most recent work strongly suggests that the action potential of the nerve is associated initially with a transient change in permeability to potassium.

Conditioning of the feeding reactions of the squid is readily achieved using appropriate experimental techniques. Although information on the mechanism of the transmission of the nerve impulse cannot explain behavioral responses, nevertheless, our interpretations of behavior would be greatly limited without valid information on the activity of individual nerve fibers.

The Radio Electrocardiograph

In reporting on the radio ECG developed at the Naval Medical Research Institute ("Wire-tap on the Heart," July 1955), Research Reviews committed the not unusual journalistic error of overlooking concurrent work done elsewhere and published earlier. The Holter Research Foundation of Helena, Montana had successfully demonstrated a radio ECG in 1952. At any rate, congratulations are in order to both institutions, for having independently developed systems which permit analysis of heart action while a patient is exercising or at work, not merely while he is at rest.

Technical Aids for Weather Forecasting

Project AROWA

Weather information is collected around the clock 24 hours a day, at thousands of points throughout the world. There is a standard system of reporting, and basic facts on the weather are communicated from scattered collection points to centers where forecasts are made. At giant centers like that of the National Weather Analysis Center, Suitland, Md., the stream of information comes in almost deluge proportions. High-speed computers are in use to process some of the vast intake, but other less standard information is still handled by conventional analysis, piece by piece.

The entire business of collecting and processing of weather information has come to a recognized state of affairs where the intake of data far exceeds any ability to process in a space of time that is meaningful for weather forecasting. This situation has been of as much concern to the Navy as it has been to the Weather Bureau. As far back as 1950, action was started in the Navy to initiate a program to meet the weather-data-processing problem. In a joint action, the Bureau of Aeronautics, the Chief of Naval Operations, and the Commander-in-Chief, U. S. Atlantic Fleet, established Project AROWA—Applied Research; Operational Weather Analysis.

Since late in 1950, the Project has been operating with offices and laboratory space in Building R-48 of the Naval Air Station, Norfolk, Va. Originally there were five officers and ten enlisted men detailed to the activity. Now there are seven Naval Aerologists, two civilian meteorologists, five scientific consultants, 40 enlisted men with ratings from Chief Petty Officer to AGAN, and a clerical staff of four to meet the challenge of finding technical aids to expedite weather-data processing.

Primary missions set up for the project are in the fields of meteorology, climatology, and oceanography. The approach has been to prepare operational analyses which fall into three general categories:

- The prosecution and/or coordination of specific research tasks assigned by the Bureau of Aeronautics,
- The solution of specific meteorological and related problems confronting the Navy and submitted by field aerological units,
- Services in the capacity of the "middle man" between basic research and the forecaster aboard ship or in the field.

The Project was given authority to seek solutions to its problems through the employment of competent individuals or organizations. An obvious choice for the first contract was the Meteorological Division of Pennsylvania State University. Key people in this Division had been working on Navy meteorological problems for some time, and were well qualified to undertake the task at hand. On 14 March 1951 the contract became effective, and work was started to find the best method of data presentation for interpretation, forecasting, and briefing purposes.

An early report from the University pointed out that it required countless daily manual operations to plot observations on the many kinds of charts common to weather forecasting. Manual methods of transcription were held to be much too slow to meet demanding deadlines on weather forecasts. Thus it became apparent from as early as the first formal report to Project AROWA, that the advantages of automation would be exploited in bringing about quicker, more satisfactory processes for interpreting weather data.

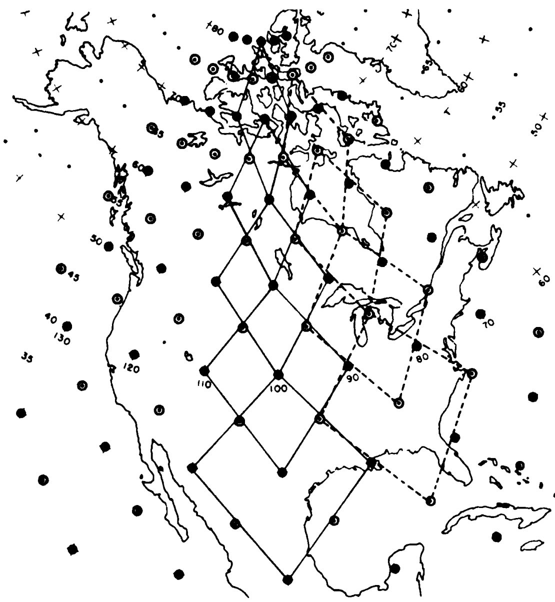

Figure 1 - Use of the Diamond Grid presenting weather data.

The investigators at Pennsylvania State University were also concerned with weather briefing for Navy personnel. They pursued this task on the premise that the extent and content of weather briefing is directly related to the functional use of meteorological information. The practices of the Naval Aerological Service on briefing were found to be highly variable. This was attributed to (1) the wide diversity in naval fleet and shore operations and (2) a wide range of levels of familiarization. Also cited were unfavorable factors with respect to time, personnel, and space available, as well as non-uniformity in the training and experience of forecasters within the Navy organization.

The studies of these experienced people working on the Project AROWA contract reinforced opinion as to the value of centralized analysis and forecast centers for the Navy. Data presentation by means of block patterns was considered practicable for operational purposes. It was felt that the amount of weather information sent out from sources was sometimes excessive, and that improved selection procedures would result in more rapid and extended coverage of meteorological data. The diamond grid system (Figure 1) came out of these studies.

PRESENT PROGRAM

Because of the extent and complexity of meteorological and related requirements, the Research Program of Project AROWA is as diverse as it is interesting (Figure 2). This program consists of the following research tasks:

- Pressure height prediction,
- Selection, collection and dissemination procedures,
- Forecasting rules for specified areas,
- Sonar forecasting,
- Hurricane and typhoon forecasting,

- Secondary cyclones,
- Operational research into the detailed structure of the Jet Stream,
- Arctic forecasting,
- Trajectory and wind field forecasting,
- Jet Stream investigation for specified areas,
- Ballistic wind computations,
- Absolute altitude computations,
- Weather display and presentation techniques,

and several others of subordinate importance.

The significance of weather and related forecasts in areas of meager observations and data cannot be over-emphasized inasmuch as during periods of world peace, and more importantly, during wartime conditions, the magnitude of the forecast problem confronting the naval aerologist at sea is great indeed. In many oceanic areas, the naval aerologist has available to him only the surface and upper-air observations made aboard his own "floating weather station."

Because of this severe restriction of available meteorological data, it is mandatory that the forecaster aboard ship be highly proficient in the extraction of detailed information therefrom for the purposes of synoptic chart construction and the preparation of prognostic weather charts and subsequent weather and related forecasts. This fact was clearly demonstrated during World War II and was re-emphasized in the waters off Korea.

Of paramount interest to the Department of the Navy, quite naturally, are oceanographic conditions and the preparation of accurate predictions pertaining thereto. This interest runs the gamut from amphibious aspects to fueling at sea.

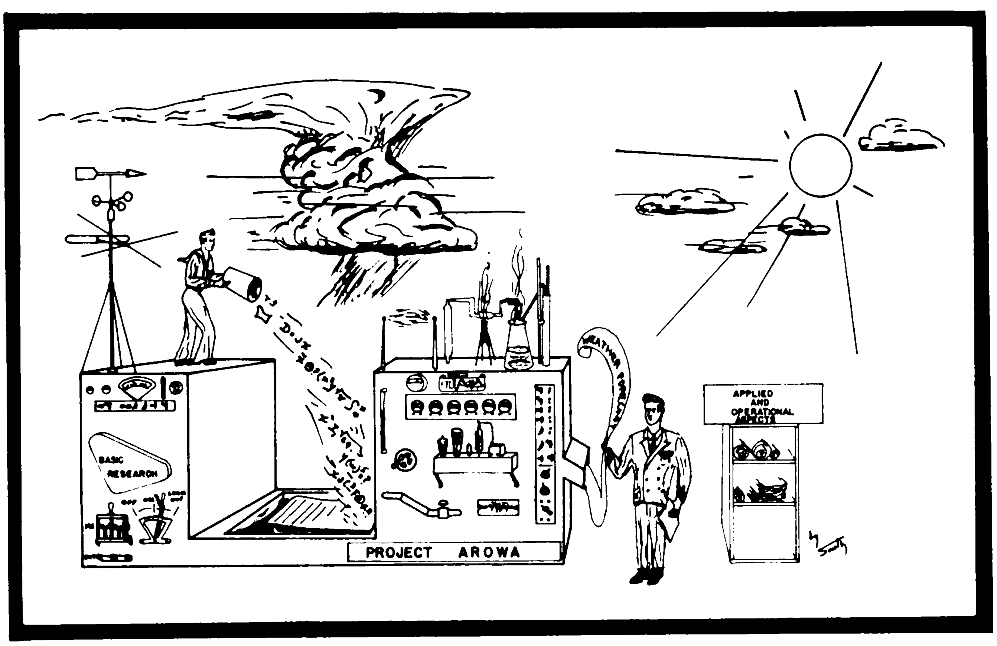

Figure 2 - Functions of Project AROWA as seen by Navy cartoonist.

Unfortunately, there are presently in existence numerous technical papers, many of them obsolete or subsequently proved erroneous in theory, relating to the subjects of sea, surf, and swell observations and forecasting techniques. The lack of individual and organizational liaison and faulty coordination of research effort has resulted in considerable difference between theoretical and empirical relationships, and the publication of numerous texts and pamphlets which either support, duplicate or contradict each other.

To improve this situation and simultaneously to support the policies of progressive Fleet efficiency, a "Handbook of Oceanography" has been undertaken by key Project personnel. This text is all-inclusive, encompassing the theoretical and practical considerations of the science, as well as the numerous and diversified naval operational aspects and requirements. The handbook is being printed by the Hydrographic Office and should be available by mid-1956.

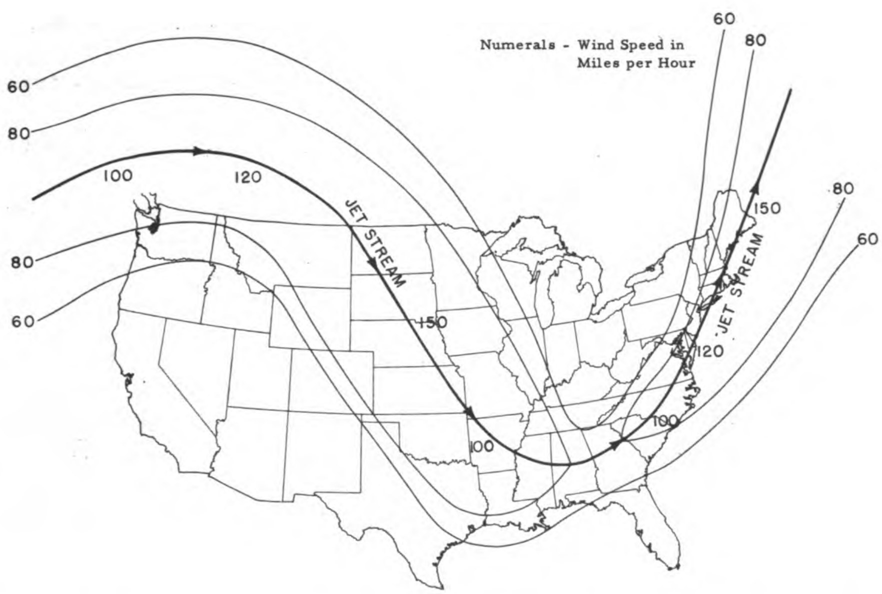

Figure 3 - Lines of equal wind speed over the United States at about 30,000 feet, showing horizontal wind distribution at 1500 G.C.T. on 25 Jan. 1951. The Jet Stream shown by the heavy line is a zone of maximum horizontal wind speeds in miles per hour. Direction is shown by arrows, and changing wind speed by numerals on Jet Stream.

Also of tremendous interest and import is the "Jet Stream," a narrow zone of extremely strong winds in the upper troposphere (Figure 3). Wind speeds in the Jet Stream, on occasion, reach values in excess of 300 miles per hour. As a result, definitive knowledge and data relating to this phenomenon are a "must" in naval operational circles.

The Jet Stream normally has a strong westerly component; however, with a reversal of temperature gradience, a Jet can appear in the atmosphere with a predominantly easterly component.

Although fundamental concepts of the Jet Stream have been developed, and a considerable amount of literature has appeared in the various meteorological journals, this material is somewhat disconnected. Often highly theoretical, it does not provide the proper applied and operational perspective in a form presenting ready availability to the naval aerologist afloat for planning and operational purposes. As a result, this work is being diligently prosecuted by obtaining detailed data, utilizing F3D aircraft (Skyknight), specially instrumented, on Jet Stream probing flights. These aircraft are twin-jet night-fighters. Data are being reduced at the University of Chicago.

The task encompassing the presentation of meteorological data, contrary to most opinions, is not a simple one. The approach has been to survey current techniques and methods in order to determine whether the meteorological data presently available are most advantageously utilized.

In an attempt at least partially to fulfill data and prediction requirements, research into the hurricane and typhoon forecasting phenomena are also being diligently prosecuted. Techniques are presently being developed which, it is hoped,will eventually do the following:

- Predict the proper danger areas where a hurricane or typhoon may be generated.
- Position the center of a hurricane, after its generation, 24 hours in advance.
- Predict the probable intensities that will be encountered and the extent of dangerous areas to either surface or sub-service vessels, or aircraft, as the typhoon or hurricane progresses along its path.

In addition to the comprehensive research program, Project AROWA personnel also conduct refresher courses in the AROWA laboratories for Naval Reserve Aerological Officers. The reserve officers are on board at AROWA for two weeks. They receive theory courses, engage in seminars, and perform analysis work (under instruction) in the laboratories. These courses encompass primarily the latest techniques and developments associated with long-range and upper atmospheric analyses and forecasting.

CONCLUSION

As previously indicated, the research tasks mentioned in this article represent only a small portion of the total program of Project AROWA. While this program is an ambitious one, the accomplishment of tasks currently assigned, already has been and will continue to be of great benefit to the Navy and to the science of meteorology as well.

Arts and sciences are not cast in a mould, but are formed and perfected by degrees, by often handling and polishing, as bears leisurely lick their cubs into form.

--Michel de Montaigne

When Is Noise Too Loud? *

Dr. H. E. Page
Director, Psychological Sciences Division
Office of Naval Research

The recent and rapid increase in the amount of noise produced by jet aircraft has created medical, operational, legal, and community-relations problems of the most serious nature. These problems all result from the simple fact that the noise-level intensities produced by jet engines are quickly approaching the utmost limit of human endurance. When this point is reached—and engines capable of such levels are now being tested—there will be imminent the complete disruption of all human activity in the immediate vicinity of aircraft using such engines.

Noise has been loosely defined as "unwanted sound" and as such is constantly present—mostly as a by-product of civilization. In nature, noise of a sufficient intensity to be annoying or bothersome to mankind is rare. By and large it is limited to thunder, wind, and rapidly moving water. As he has become more and more civilized, however, man has been able to create more and more noise which, at the same time, is less and less desirable.

What the ear perceives as noise or sound are rapid changes in air pressure. Sound energy, or intensity, varies as the square of these pressures change. The range in relative energy, or relative physical intensity, between the faintest and loudest sounds is enormous. To cope with this range, scientists have adopted a logarithmic unit, the decibel. Noise of an intensity of 40 decibels is not double that of a 20 decibel sound, but rather, is one hundred times as "loud."

Among the noises created by man, the output of the jet airplane is certainly among the greatest. Most of the planes now in use create sound levels on the order of 130 decibels, and others, now in the production stage, will have engines producing up to 160 or 170 decibels. On the drawing board are more powerful engines which will be even louder. Noise levels in excess of 120 decibels produce pain to the human ear; the average person finds noise above 140 decibels intolerable; and noise levels of 160-170 decibels are greater than human beings can stand. Moreover, severe physiological and psychological effects result from continued exposure to noise levels above 120 decibels.

Early in 1952, in anticipation of more powerful jet engines the Navy sponsored some shipboard studies of sound fields to which flight-deck personnel were exposed. Data collected on the USS CORAL SEA indicated the Navy would soon have to face the problem that noise aboard carriers was reaching acute intensities. Also simultaneously psychologists working under contract with ONR became concerned with the performance of deck crews aboard carriers (Figure 1). The high noise

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*Adapted from a speech delivered at a meeting of the Pittsburgh Psychological Association, Carnegie Institute of Technology, December 2, 1955.

Relative Intensities of Various Common Sounds Expressed in Terms of Decibels	
DECIBELS	**SOURCE OR TYPE OF NOISE***
160-170	J-57-Type Engine w/Afterburner
140	F3D at Take-Off (J34 Engine)
120	DC4 Take-Off (150 feet from Tail)
110	Thunder
100	Boiler Factory
90	Large Truck - Unmuffled
80	Street Corner Traffic, Large City
70	Conversational Speech (3 feet)
50	Private Business Office
40	Quiet Home - Average Living Room
10	Quiet Breathing in Anechoic Chamber
0	Average Threshold of Hearing

*All examples are computed at a distance of twenty-five feet unless otherwise indicated.

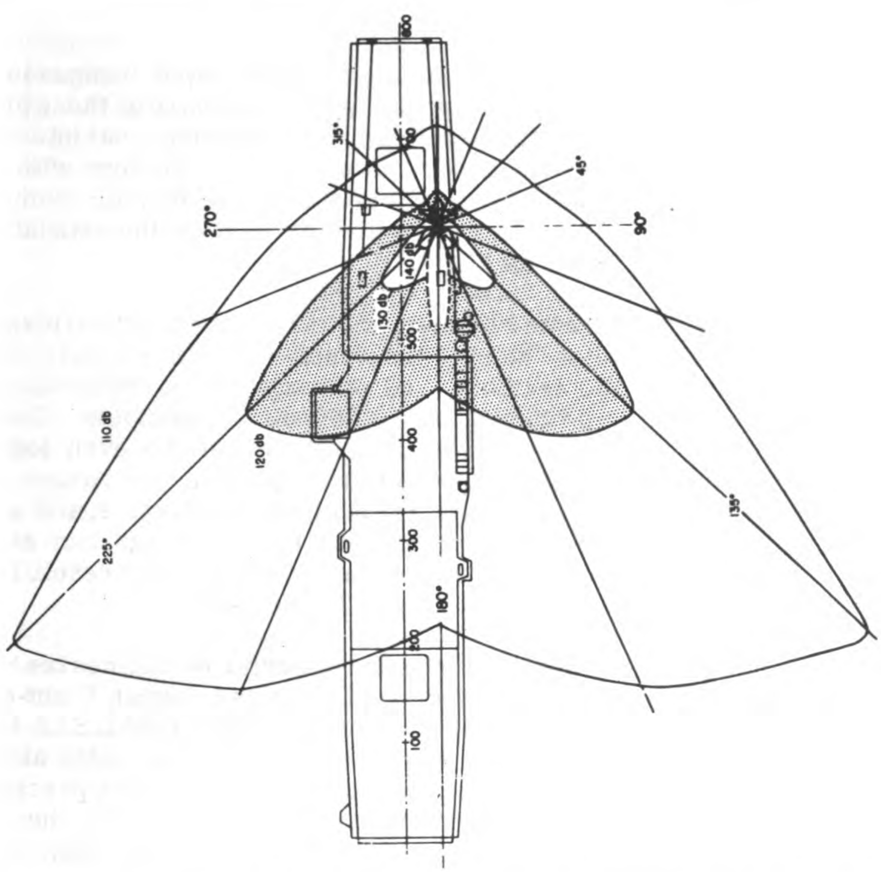

Figure 1 - When a Carrier 800-feet long launches a jet plane from its catapult, the intensity of noise has a pattern as shown above. Many crewmen work in the area where the noise level is between 120 and 130 decibels (shaded); noise as high as 140 decibels (near catapult) is intolerable.

level under which groups such as the catapult crew were working made verbal communications impossible. This was equally true for the personnel involved on the bridge of the ship, a vital communications center when planes are taking off and landing. In May of 1952 the National Research Council Committee on Hearing sponsored a survey of the available research groups who might turn their attention to the problem.

The Armed Forces-NRC Committee on Hearing and Bio Acoustics, hereafter referred to as CHABA, and jointly supported by the three Services, was organized early in 1953 to provide consultation and advice to the Armed Forces in the general areas of: (1) effects and control of noise; (2) auditory discrimination; (3) speech communication; (4) the fundamental mechanism of hearing; and (5) auditory standards.

In the summer of 1953 a Working Group of the Committee undertook, through an ONR contract with the University of Chicago, a short-term "quickie" program investigating the Biological Effects of Noise. This was undertaken with joint support from the Air Force and the publication of the now famous BENOX (Biological Effects of Noise-Exploratory) report was the result.

It has long been known that machine-generated noise damages man's ear. Studies in World War II revealed hearing losses in pilots much like those found in boilermakers and other occupational groups exposed to industrial noise. Helmets and enclosed cockpits developed to provide protection for pilots from wind did aid in protecting man's hearing, but intensities were already so great as to prevent complete elimination of the noise problem by such means.

More recently headgear, ear muffs and ear plugs have been developed and evaluated for their attenuation characteristics (Figure 2). This work has been going on at Pensacola and at U.S. Navy Electronics

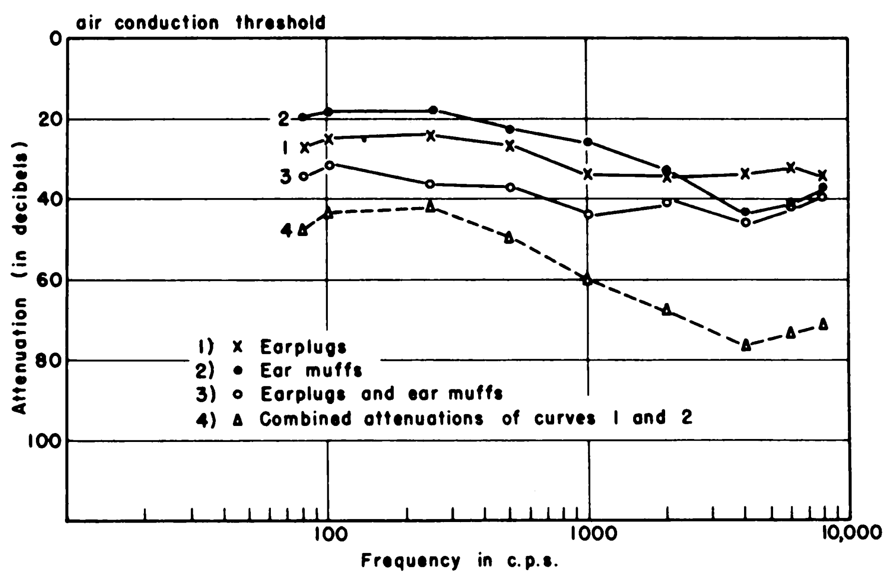

Figure 2 - Test results on devices used to protect the auditory system of human beings from high-intensity noise.

Laboratory. In addition, work is being supported at Harvard to develop such muffs and ear plugs. The latter have been standard equipment for some time but surveys aboard carriers have shown that the men simply do not use the item due to pressure upon the ear canal. The plug developed in the Psychoacoustic Laboratory at Harvard is soft and conforms to the ear canal without the usual pressure and discomfort, in addition to providing better attenuation. These plugs were developed, incidentally, to meet a basic research need rather than through a deliberate attempt to build a protective device.

It is not too well known that man actually has a fine defense mechanism for helping him adjust to the noises of nature. While such a system has been postulated by theory for a long time, it has been difficult to demonstrate because of inability to experiment on man's auditory system. Working with the cat, Dr. Glenn Wever at Princeton University has now established the presence of a reflex which operates in the ear to provide protection when noise levels approach that of the cochlear potential. In some instances this reflex is set into operation at a level slightly below this point while at other times it operates shortly after this level has been reached.

There is little certainty today on the extent of the non-auditory effects of noise. But as in the case of high speed escape and other problem areas, emergencies do arise and evidence gradually filters in.

People who have worked within close range of jets have reported complete shaking, inability to clamp the jaw tightly, flapping of loose skin about the face, pains and pressures of unpleasant intensity and nausea. Work in the laboratory with certain strains of mice and with rabbits has shown that high-intensity noise can produce convulsive seizures. We know that outputs in decibels not much in excess of our present levels reach the point where man will experience a physical trauma rather than an auditory stimulus. ONR has a research program to ascertain some of these influences, e.g. vestibular, through utilization of totally deaf individuals. Subjected to sounds of different intensities and frequencies, they are asked to perform tasks of varying complexity. One practical possibility would be the employment of these individuals in situations where the impairment of hearing would not decrease function.

Studies of other influences of damage to the auditory pathways are being conducted by Neff at Chicago, Gross at Lehigh, and Ades at Southwestern Medical. In these instances behavioral patterns are studied in man and animals before and after destruction of these pathways and certain cortical areas associated with hearing and auditory discrimination. Ades is also concerned with the vestibular system and high-intensity noise.

The need for communication is often pressing, even vital, when temporary conditions may make it difficult or impossible to receive or send a message. Should there be a strict blackout, for instance, communications visually would be blocked off; the presence of loud noises hampers or prevents auditory communication. Attention has been directed accordingly to communication possibilities that do not employ either sight or hearing. The work of Dr. Geldard at the University of Virginia is aimed at determining the discrimination and differential sensitivity of various areas of the human body (Research Reviews, October 1955) to determine if man's skin might be used as a communication channel.

Using areas of man's chest Dr. Geldard has been able, through the use of vibrators, to vary the intensity and duration of vibrations against the skin (Figure 3). With five such contact points he has developed an "alphabet" or "Vibratese." Experiments have shown that an individual can be trained to discriminate between these variables and make the proper associations within 30 trials. An individual has received messages by means of this vibration system and repeated them accurately.

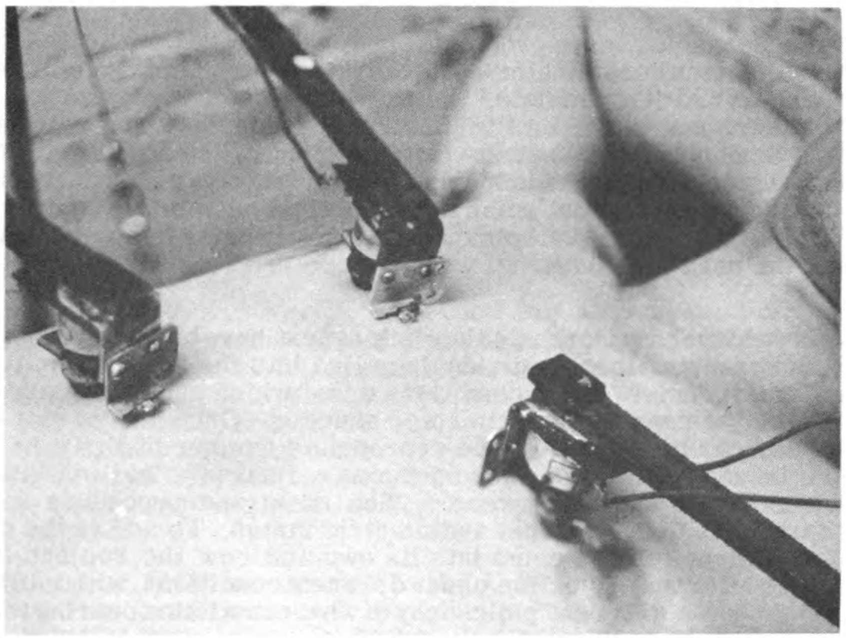

Figure 3 - Vibrators, mounted on long flat springs, in place on the chest in the Virginia experiments. Each vibrator is capable of delivering amplitudes up to 0.5 mm at low frequencies. (Photo courtesy of Dr. F. A. Geldard, University of Virginia).

While it is unlikely that wide operational use will be found for such a complex system it is easy to visualize its use, as a simple signalling device, as a warning that wheels are not down in aircraft, omitted procedures in missile firing and a number of other tasks where it is desirable to leave vision and audition free for other signals.

It is inevitable that increased noise from heavier and faster aircraft would constitute a public nuisance as well. Unfortunately, airports were originally placed beyond city limits with little appreciation of the manner in which both city limits and runways would be extended to effect a merger. For some reason, areas around airports were settled early and densely.

The Office of Naval Research has sponsored a major symposium devoted entirely to this problem of community reaction. Certain members have played a role in the establishment of a Navy committee designed to deal with all phases of this problem, from the designing of a base for maximum comfort of the worker who must be there, to the location and relocation of housing for the families who play so vital a part in determining whether the jet pilot becomes a career officer in the Navy.

That the Services have not heard the last of this problem is perhaps indicated by data available in a study conducted by the National Opinion Research Center of the University of Chicago for the National Advisory Committee for Aeronautics. In Report #54 entitled, "Community Aspects of Aircraft Annoyance" it is stated that while about two-thirds of the residents living within two miles of each of eight airports studied were greatly annoyed with the airplane situation (propellor-type aircraft only), only six percent of this group have even taken any action to express their hostile feelings to any person in authority.

Adequate solutions to problems such as those I have indicated depend upon one common denominator—an accurate measure of the individual's ability to hear and discriminate. This introduces audiometry as an essentially basic aspect of the entire picture. In this area, there are still pressing demands for research. Measurement of the auditory threshold has been accomplished in a number of different ways through the years, and one might assume that some standards had been established. On the contrary the divergence of opinion among the experts has only served to sharpen the need for additional work.

The whisper test or the coin clicking test have been commonly employed in screening those individuals called into the Services in time of war or "emergencies." The conditions under which such tests are given would make the average experimenter shudder. Once the person being bested has heard and repeated the appropriate number of digits, he is in. When he leaves the Service, he undergoes a final physical examination. Conditions have changed, however. The room and procedure allow a more careful evaluation of his audiometric status. To add to the confusion, the audiometer has come into its own and now the subject leaves the Service after an evaluation under different conditions, with a different test based upon a different philosophy of what constitutes hearing threshold. The sad part of this little oversight in experimental design is the fact that such a person can charge the government for any differences which reflect an impairment, whether actually incurred in war or incurred through change of procedure.

The fact that high-intensity noise associated with jets, rockets and new artillery will actually produce more claims of a legitimate nature established ONR's interest in getting audiometry upon a firm foundation where experts will agree and the Services will standardize testing procedures and philosophy.

Members of CHABA are devoting much of their effort in settling many of these perplexing problems which have plagued the field of audiometry for years. More data must be accumulated upon normal losses of hearing associated with aging to separate that part from any decrement incurred during military service. There must be more knowledge on normal recovery after exposure to high-intensity noise environments. Maybe a man should be rotated in and out of such duties with some specific basis for so doing. Maybe types of audiometers can be developed which will assure validity and reliability beyond that now realized.

Man has created this noisy environment. Science must find ways for him to live in it.

New Chief of Naval Research

RADM Rawson Bennett II, who relieved RADM Frederick R. Furth as Chief of Naval Research 31 December, is a career naval officer who is outstandingly qualified by inclination, training, and experience for top-level administration of a major scientific program. He has been closely involved in naval research and development since 1938.

ONR's new Chief graduated from the Naval Academy in 1927. After a series of deck and communications assignments in the Fleet and on the Asiatic Station, he was ordered to the Postgraduate School, Annapolis, for instruction in radio engineering in 1934. Following graduation, he went on to the University of California and earned a Master of Science Degree in Electrical Engineering.

His first R & D tour came when he was ordered to the staff of Commander Destroyer Division NINETEEN (later redesignated DesDiv FIFTY), a group of old four-pipers given the special assignment of test and development of destroyer weapons and improvement of sea tactics. Bennett was Radio and Sound Officer of the unit until June 1941. The Division operated out of San Diego and he established, there, the technical program for the first Fleet Sound School.

Throughout World War II, he served in the Bureau of Ships, first as Head of the Underwater Sound Design Section, and subsequently as Head of the Electronics Design Division. He was also liaison officer with Division 6 of NDRC. This assignment brought him in close contact with the OSRD-NDRC underseas warfare program, and with the sonar work going on at NRL. The senior scientists of the naval research community therefore know him as an old friend. For underwater sound gear which he personally designed during this period, he was awarded the Legion of Merit.

In August 1946, he reported to the U.S. Navy Electronics Laboratory, San Diego, as Director. It was then a small and rather minor research facility. When Captain Bennett left there, four years later, it had become the huge, diversified Laboratory it is today.

Since 1950 he has been successively Director of the Electronics Production Resources Agency of the Department of the Army, Navy, and Air Force, Head of the Mine Warfare Branch of the Bureau of Ships, and Naval Inspector of Machinery and Naval Inspector of Ordnance at the General Electric Company's plant in Schenectady, and, most recently, Assistant Chief of the Bureau of Ships for Electronics. He became Rear Admiral when he assumed command at ONR.

RADM Bennett is married to the former Agnes Louise Holmes and has four children, Rawson Bennett III, Sally Ann Bennett, Holmes T. Bennett, and Gregory C. Bennett. They are presently living in Arlington, Va. The Admiral is a Fellow of the Institute of Radio Engineers, a Fellow of the Acoustical Society, and a Fellow of the American Association for the Advancement of Science.

Admiral Furth Goes Ashore

When Admiral Furth was "piped ashore," at the close of two years as Chief of Research, he also requested retirement from the Navy after 30 years of distinguished service. In his latest assignment there were not only heavy duties in connection with the administration of ONR's far-flung program—including the new "Vanguard" satellite project—but in addition he was given the responsibility for evolving a system of closer coordination of the developmental phases of the navy-wide scientific effort. The Secretary of the Navy, in announcing RADM Furth's retirement, praised him "for his vigorous prosecution of the Navy research and development program."

In the near future the ex-Chief will assume his new duties as a civilian with the International Telephone and Telegraph Corp. He will be greatly missed by the naval research community, for he has been a leader in naval development, especially in electronics, for more years than most of the ONR family can remember.

A New Director of Research at NRL

Dr. E. O. Hulburt, Superintendent of the Naval Research Laboratory's Optics Division from 1924 to 1951, and since then Director of Research, retired on December 31. Like RADM Furth, he is going on to a challenging new position: Senior Scientist of the U.S. National Committee for the International Geophysical Year.

Dr. Oscar T. Marzke, until recently Associate Director of Research for Materials, is NRL's new Director of Research. He has been at the Laboratory just short of ten years, for he joined the scientific staff early in 1946 as Superintendent of the Metallurgy Division. During a part of that time, from 1951 to 1953, he was also Head of the Metallurgy Branch at ONR. And last year, from January to August, he served ONR as Development Coordinator.

A native of Lansing, Michigan, Dr. Marzke received his undergraduate education at Michigan State College, and did his graduate work at M.I.T., getting a Sc.D. in Metallurgy in 1932. From 1933 to 1946, he was a metallurgist with the American Steel and Wire Company, doing both research and plant metallurgical work, his last position with the company being that of works metallurgist at the Waukegan, Illinois plant, beginning in 1942.

He is a member of the American Society for Metals, the American Institute of Mining and Metallurgical Engineers, the American Welding Society, Tau Beta Pi, the Research Society of America, the British Institute of Metals, the British Iron and Steel Institute, and the Washington Academy of Sciences.

Computer Symposium at SDC

The Special Devices Center of the Office of Naval Research recently sponsored a two-day computer symposium to discuss the design, development and performances of computers currently used or contemplated for use in simulators to provide training in the operation of aircraft. SDC has pioneered in the development of simulators, or operational flight trainers, as they are more commonly called, and is currently providing them for the Navy's newest aircraft.

The typical Operational Flight Trainer consists of three main sections or components: the cockpit section, the instructor's station and the computer section, where the mathematical information necessary for flight simulation is computed. The discussions and papers read at the Center's symposium were directed toward problems of computer design, development and performance. Leading civilian and military engineers, scientists and aircraft manufacturers were in attendance.

On The Naval Research Reserve

L. V. Berkner Appointed Rear Admiral

Early in November, The Secretary of the Navy announced the selection of Lloyd V. Berkner, USNR, to the rank of Rear Admiral. Dr. Berkner is the second Research Reservist to be so honored.

RADM Berkner has so many distinctions, it is hard to choose the greater kudoes from the lesser. He is President of Associated Universities, Inc., a sort of advanced-research "Ivy League" that operates—among other major installations—the Brookhaven National Laboratory for AEC; he is President of the International Council of Scientific Unions; Vice President of the International Scientific Radio Union; Chairman of the Section of Geophysics of the National Academy of Sciences; and Vice President of the (international) Special Committee on the International Geophysical Year. As a matter of fact it was Berkner—in a quiet coffee session with other geophysicists—who first proposed that "IGY" be held in 1957-58 rather than 25 years later.

As a naval reservist, RADM Berkner began as a Seaman 2nd Class while an undergraduate at the University of Minnesota. He received flight training at Great Lakes and Norfolk and was commissioned Ensign in 1927. In that rank he served as an aviator and radio operator with the first Byrd Antarctic Expedition in 1928-30. Shortly before World War II, he was commanding USN Squadron VS6-R at NAS Anacostia when the Squadron won the Noel Davis trophy and a commendation, for the Commanding Officer, by the Secretary of the Navy.

On active duty throughout World War II, he organized the Radar Section of BuAer and later the Electronic Materiel Branch; he was instrumental in the introduction of VHF communications into the Navy. Toward the last, he got into the fighting aboard the Carrier ENTERPRISE and took part in the Okinawa operation.

Since the War he has served in various high-level capacities with the Dept. of Defense Research and Development Board, with NATO, and as a scientific consultant for the Dept. of State. As a geophysicist he has found time for research with the National Bureau of Standards and with the Carnegie Institution. He is co-discoverer of the F_1 region of the Ionosphere, and was intimately involved in the discovery and development of VHF scatter propagation that underlies the success of present-day arctic defense communications.

Seventh Annual Nuclear Sciences Seminar

The Seventh Annual Nuclear Sciences Seminar was conducted at Oak Ridge, Tennessee, 27 November to 10 December 1955, under the sponsorship of the Naval Research Reserve, the Atomic Energy Commission and the Oak Ridge National Laboratory. The seminar emphasized Nuclear Reactors. The program was established and conducted by members of Naval Reserve Research Company 6-3 at Oak Ridge, LCDR R. R. Rickard, USNR, Commanding. The Seminar Chairman was CDR Richard B. Martin, USNR.

The seminar was attended by approximately sixty-five reserve officers ordered to two weeks active duty for the training. Both the Army and the Air Force were represented, twenty-one Army and nine Air Force officers being present.

Most of the daily sessions were given over to talks by scientists and engineers attached to ORNL on various phases of atomic energy. The following are representative titles of the talks, cited to give an impression of the scope of the seminar: "Operations at Oak Ridge," "Nuclear Energy in 1955," "Reactor Theory," "Development and Use of Radioisotopes for Industrial Purposes," "The Army Package Power Program," and "The Geneva Conference." Dr. T. J. Killian, of ONR, spoke on "Nuclear Physics and Future Naval Power," and Dr. W. G. Pollard gave the closing address, "Origin of the Universe."

Naval officers who gave outstanding addresses were: RADM C. F. Behrens, MC, USN ("A Few Medical Highlights"), CAPT L. D. Coates, USN, Deputy and Assistant Chief of Naval Research, ("Research and Development Changes the Navy"), and CAPT N. R. Richardson of BuAer ("The Navy's Interest in Nuclear Power for the Propulsion of Aircraft").

During the course of the seminar several field trips were made to activities in the area. These included a Lecture Tour of the American Museum of Atomic Energy, a tour of the Oak Ridge National Laboratory, a tour of ORNL Facilities, A TVA Tour of Loudon Dam and the Kingsport Steam Plant, and a tour of the Abbott Laboratories. Officers attending the seminar were entertained at a Smoker on the evening of 28 November, at a Dinner Dance on 1 December, and at another Smoker after the conclusion of the program on Friday, 9 December.

Group Training Duty

Thirty-eight members of Eighth Naval District Naval Reserve Research Companies participated in Group Training Duty at the U. S. Naval Advanced Undersea Weapons School, Key West, Florida from 4 to 6 November 1955.

All details of the event were coordinated by the staff of the Commandant (Assistant C/S Naval Reserve and Training) and Commander, U. S. Naval Base, Key West, Florida. Naval Air transportation was provided by the Chief of Naval Air Reserve Training and Commanding Officer, NAS, Dallas, Texas.

Participants in the event, representing four of the eleven Reserve Research Companies in the Eighth Naval District, were from NRR Co. 8-3 College Station, Tex., NRR Co. 8-3 Houston, NRR Co. 8-5 Austin and NRR Co. 8-12 Dallas.

In addition to the training received at the Advanced Undersea Weapons School, the Naval Reservists were given an orientation tour aboard the USS ODAX (SS484).

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Sixty-five officers from the three military services attended the Seventh Annual Nuclear Sciences Seminar at Oak Ridge, Tenn. (see page 26).

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