• JUNE 1950

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OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

NAVEXOS P-510

COVER PHOTO: Eugenie Clark, equipped with face mask and spear, is shown searching the waters of the Western Carolines for some of the dangerous fish she describes in the story on page 1. Dr. Clark was engaged in a study of reef fish, a project undertaken as part of the Scientific Investigation of Micronesia. (See Editorial Notes on SIM, p. ii.)

Approved by Bureau of the Budget, 13 April 1948.

RESEARCH REVIEWS

Informs the Fleet of ONR-sponsored Research

Contents

June 1950

Editorial Notes

Halfway across the world, ONR-sponsored research has helped the Navy accomplish one of the many complex tasks it inherited from the recent war. This task was the administration of the U. S. Trust Territory of the Pacific--the Islands of Micronesia, which were taken over from the defeated Japanese.

Some conception of the difficulties involved may be glimpsed when it is recalled that Micronesia, covering an area two-thirds of the size of the United States, comprises more than 1,000 atolls and islands (the Marshalls, the Marianas, and the Carolines) inhabited by more than 50,000 natives, differing widely in language, social customs and economic status. The Navy's job was to rehabilitate these people after the impact of the war had shattered their economy and traditional way of life.

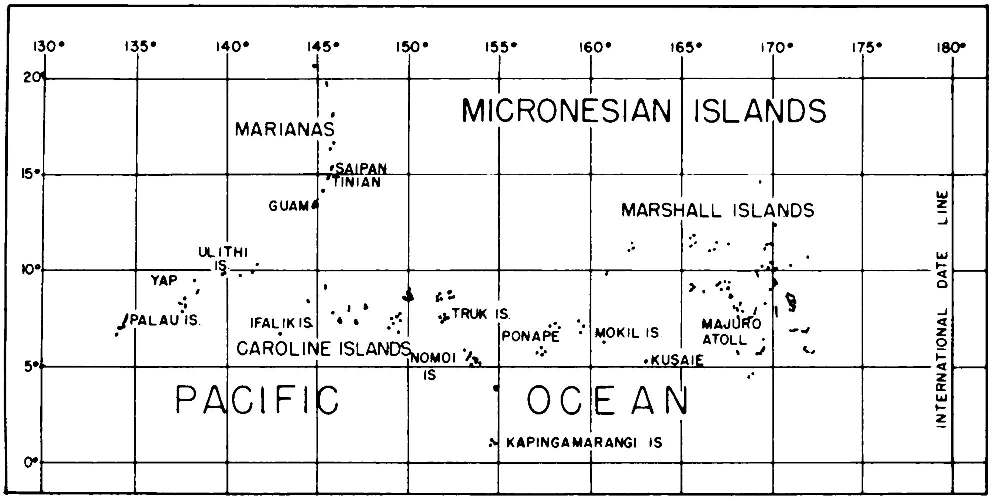
The question may be asked: What part can scientific research play in solving a problem that is (apparently) purely administrative? The answer lies in the fact that knowledge of any kind about the peoples of the islands was painfully scarce. The Japanese had written little about their native charges and the previous German regime had left meagre and outdated information. The Navy, then, had to start almost "from scratch" in gathering any and all data that would further an understanding of these native peoples. Only in this way could it hope to improve their living conditions, and their economic status without arousing their antagonism or destroying completely their previous pattern of living.

The problem was attacked through the formation of a project known as the CIMA project and now called SIM (Scientific Investigation of Micronesia). The Pacific Science Board, under ONR contract, sent dozens of scientists from universities all over the United States to study Micronesia. Small teams of investigators delved into the islanders' language, anthropology, social customs, and countless other facets of native existence.

The fruits of this program have been many. A typical example of the practical results of such research was the accomplishment of the linguists who went to Micronesia. They found that the natives had a spoken tongue--which varied from island to island--but among many groups means for communication were sharply limited by the lack of a written language. This gap was bridged by investigators, who prepared alphabets, dictionaries, and grammars in the native languages. These, in turn, have been utilized by native teachers as tools to instruct the islanders on improvements suggested by other scientific investigators. Such progress is only the beginning of the opportunities for self-improvement which will be available to Micronesians through SIM.

Thus, research adds another page to the record of tasks it has helped the Navy to accomplish. It is now clear that the technology of war is not the only area in which research can aid the Navy; peacetime problems are also amenable to the skill and knowledge gleaned from scientific investigations.

The two articles which follow, and others which will appear in later issues of Research Reviews, will document some of the findings and accomplishments of SIM.



Fisherman Beware!

Fishing for Poisonous Plectognaths in the Western Carolines.

by

Eugenie Clark
American Museum of Natural History

There are probably no waters in the world where a greater variety of poisonous fish can be found than among the coralline reefs around the islands in the South Pacific. During a brief underwater exploration, it is not unusual to spot a dozen different kinds, ranging from common looking, drab-colored creatures to the most bizarre and beautiful members of the tropical marine fauna.

The subject of poisonous fish has long been one of popular interest both to the specialist and to the general public. Numerous articles have appeared, but the problem of understanding fish poisons is a complex one and much of our data is still fragmentary and confusing.

A number of fish are considered dangerous to man but when we speak of poisonous fish, we refer specifically to those which possess a definite toxin. Poisonous fish, then, can be grouped into two types: the venomous variety, which inject their toxins into man through skin lesions; and those which produce noxious effects when eaten by man.

Eugenie Clark received her B.A. degree from Hunter College and her Ph.D. degree from New York University. She now holds an AEC fellowship for research at The American Museum of Natural History, New York. The studies reported here were made under the joint sponsorship of ONR, the Pacific Science Board of the National Research Council and The American Museum of Natural History, as part of SIM.

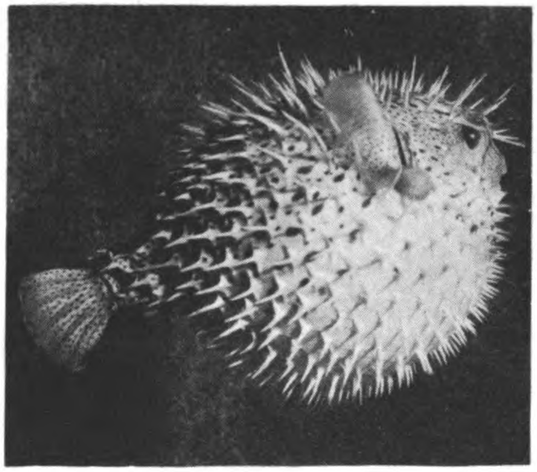


Figure 1. Diodon hystrix, a circumtropical blowfish. The mature ovaries of this fish are reported to be strongly toxic. (Photo courtesy of New York Zoological Society

The venomous types include certain rays, sharks, chimaeras, the filamentous and slow-swimming zebra fish, and the ugly, sedentary scorpion fish. All of these inject their poison from hollow spines which project from their fins or body and act like hypodermic needles or snakes' fangs. No fish are known to possess teeth with such a mechanism, although there is a report that poison stored in the palate of certain moray eels may be released and enter the wound made by the bite of their sharp teeth. Venomous fish are dangerous to swimmers, or to anyone incautious enough to touch them. On Kwajalein last June, the writer interviewed a seaman who had been hospitalized because of fish poisoning. He had attempted to catch with his hand a sluggish creature resting among some shallow-water rocks. A single prick between the thumb and first finger of his right hand had caused his whole arm and shoulder to swell greatly and become numb. He identified the fish from some pictures as one of the scorpion type, with a dorsally located mouth.

Fish are the chief food of the island peoples; hence, those species which are "inedible" really represent a serious hazard. Unfortunately there are no simple rules for identifying these dangers. Some poisonous species closely resemble excellent food fish. The fact is that similar species may be "edible" in one locality, yet poisonous in another environment. Such factors as seasons, and age of the species are important in the determination of a fish toxicity. A number of species have their poison localized in particular organs, such as the gonads--for example the blowfish shown in Figure 1, of which the mature ovaries are reported to be highly toxic.

The Palau Islands in the Western Carolines are popularly rumored to be free of inedible fish.[1] Certain species of moray eels, barracudas, carangids, snappers, sea bass and surgeon fish, that are believed to be poisonous in other areas of the Pacific--especially around the Marshalls and the Marianas--are considered to be wholesome food.

[1] Cf. Survey of the Fisheries of the Former Japanese Mandated Islands, by R. O. Smith; Vol. 10 of the United States Commercial Co. Economic Survey, Honolulu, 1946.

All over the Palaus the flesh of two species of siganid fish (Siganus fuscescens and S. lineatus, called "meas" and "klesebuul" by the natives) is considered delicious eating. However, these fish are reported to cause effects similar to alcoholic intoxication when eaten in large quantities during the months of October through January. These siganid fish gather in large numbers in the bay just south of Geklau during this period. Outside of this bay, however, their inebriating powers have never been reported in any season! Is this bay their breeding place? Do biochemical changes related to reproduction cause the peculiar effect? Are there some seasonal elements in the bay's environment which produce an effect on the flesh of these siganids? These are problems for future investigation. Actually, these fish are not considered very dangerous or poisonous. In fact the natives near the Geklau bay refrain from eating them only if they have work to do which requires sober concentration.

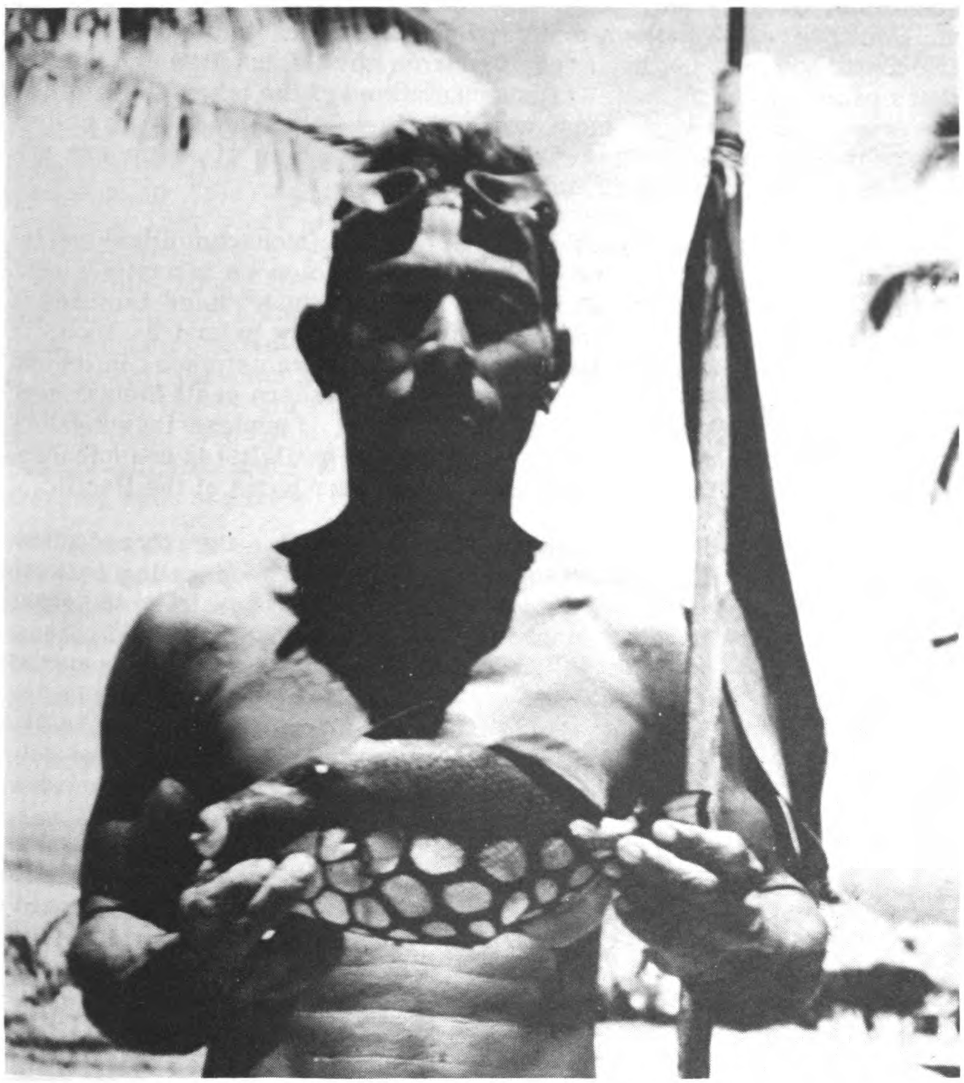


Figure 2. A spear fisherman of Sonsorol holds a specimen of the trigger fish, Balistes conspiculum, reported to be highly poisonous in parts of the Pacific other than the Palaus.

Interviews with the native fishermen and other people living in the Palaus revealed that only one group of fish is eaten with caution, and several of the species are completely avoided by some persons. These fish are the plectognaths--notorious, in many parts of the world where they occur, for their highly noxious properties.

Scientific investigators are not only interested in the toxicity of fish of the Order Plectognathi, but also in certain unique anatomical features, such as the mechanisms employed for defense. Among these mechanisms are the expansible stomach of the puffer fish, the erectile spines of the porcupine fish, the trigger-like mechanism of the balistid, and the carapace or shell of the trunk fish.

These fish form a large fraction of the piscine population in coral reef waters and usually constitute a part of the catch brought in by the trap and spear fishermen in the South Pacific. There are nine families of plectognath fish: Triacanthidae, Balistidae, Monacanthidae, Triodontidae, Ostraciidae, Tetraodontidae, Canthigasteridae, Diodontidae, and Molidae. The pelagic molids, deep sea triacanthids, and the rare triodontid have not yet been reported from the Palaus although some of these probably occur there. Representatives of the other six families, however, are among the most common reef fishes and a large collection of these was made comprising 25 species, nine of which are new records for the Western Carolines.

The trigger fish (Balistidae), the file fish (Monacanthidae) and the trunk fish (Ostraciidae) are reported to be poisonous in various parts of the Pacific, but in the Palaus the flesh of these three families is eaten without ill effect. The trunk fish is highly prized as food; it popularly is prepared by baking with the viscera in place, in its own "shell." The natives claim that the flesh and viscera of all their trigger and file fish are harmless, raw or cooked. Japanese investigators have found that some of the Palau species (e.g. Balistes conspiculum, shown in Figure 2) are highly poisonous in other parts of the Pacific.

The flesh of the three families of puffer fish, the tetraodontids, canthigasterids, and diodontids, are considered good eating but the viscera, especially the eggs, are known to be poisonous. Fatalities have been reported from a number of regions in the Pacific, including the Palaus. A serious case of poisoning occurred on Koror when one of our native assistants, depressed by some family troubles, ate one of the mature ovaries of a large Tetraodon mappa. He suffered severe cramps and a condition of shock developed a few hours after eating the roe. Some natives prefer to avoid the puffer fish, but many eat the flesh after having cleaned out the viscera, particularly the ovaries.

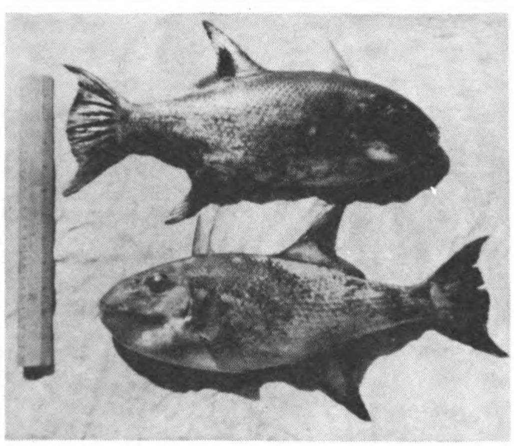


Figure 3. Male (upper) and female specimens of Canthidermis viola Herre, a rare trigger fish reported from the Palaus for the first time.

The Navy, the SCAP representatives on Angaur, the Pacific War Memorial Station on Koror, many civilians and friendly natives provided help. We had various methods for obtaining plectognath fish for study purposes. The more common and larger varieties of fish were, in some cases, bought from local fishermen who obtained their catch in large cagelike bamboo traps set inside the "fringing" reef, in water up to about 12 feet deep. Hook-and-line fishermen on Angaur provided fine specimens of the rarely collected trigger fish Canthidermis viola (see Figure 3), obtained from deeper water outside the reefs. Various types of nets and explosives yielded many fish but comparatively few plectognaths. Occasionally, young trigger fish of the genus Balistapus, including those belonging to the same and related species of the famed humahumanukanukaapuaas of the Hawaiian Islands, were captured by merely picking up chunks of coral from shallow water and shaking them over a net. This was possible because these miniatures, like the slightly more elongated adults, have the habit of darting into crevices when startled.

Figure 4. A Palauan spear fisherman prepares to make the first throw at a large fish he has sighted.

Some of the smaller plectognaths--particularly the smooth blowfishes, and some file and trigger fishes--were obtained by poisoning tide pools. A new preparation of rotenone was used for this purpose; for most of the smaller pools, a few cubic centimeters were sufficient. The number of plectognaths obtained in this way was limited, however, for many of the Western Carolines have few and poor tide pools. Moreover, collecting from them by poisoning was usually possible only during a brief time at low tide.

Spear fishing, however, had many advantages over the poisoning method; moreover, it is the most pleasant method for the collector who enjoys swimming and observing fish in their natural habitat. And too, it is the most direct way of securing specific or rare types of plectognaths. The writer, equipped with a face mask, accompanied the highly skilled native divers and pointed out the desired specimens. In the clear reef waters many of the species could be identified at distances of 30 feet or more. Fortunately the plectognaths are not fast swimmers. They seem to depend more on their protective armature than on speed for protection; hence they are easy targets for a long-handled spear or spear gun. Spears with several prongs proved useful in catching smaller specimens in open reef waters. In this manner some choice examples of various species were secured.

Larger species of file fish are usually slow-moving and are easily speared while swimming. When chased for a short distance, they frequently retreat under a coral ledge or hollow and remain almost motionless except for the movement of their transparent fins. Spearing these stationary, deep-bodied subjects was, for our native experts, like hitting the broadside of a barn (see Figure 4). Trunk fish likewise were easy to hit because they hovered about one spot long enough for us to get a close aim. Their tough shells were penetrated by every spear that reached them from the strong, sure hands of the native divers. The writer, however, tantalized by these easy targets, succeeded only in nudging most of them along with the spear tip!

The larger species of trigger fish presented more sport. We spotted most of these fish about 18 feet or more below the surface of the water. Usually they swam quickly away without seeking shelter, yet spearing them in the open was extremely difficult. Most specimens were caught by heading them off into shallower water until they were forced into a retreat. Like their smaller trigger fish relatives they sometimes "lock" themselves in holes and crevices in the coral where they usually can be speared and chopped out.

The writer made two sea trips to collect specimens on some of the outpost islands in the Western Carolines. From the base on Koror one voyage was made to the southern islands of Sonsorol, Pulo Anna, Merir, and Tobi, on the LCM 448 under the command of LT Shannon. Another voyage on an A.G. was made to the north central islands of Ngulu, Fais and Ulithi, with LT Parnell in charge of the ship. Many of the collections had to be made in a short half-day visit to an island. In spite of delays, fish were collected, whatever the tide. In many instances, spear fishing was the only practical method for obtaining specimens. The "number one" spear fisherman of the island, sought out by our interpreter, had little trouble catching the exact fish requested. But he could never quite see the point of going after the odd assortment described to him, most of which were undesirable as food. Samples of the flesh and viscera were prepared for laboratory analysis at the Hooper Medical Foundation of the University of California. Smaller specimens were preserved in formalin. Larger ones and those which required description (note: formalin destroys color) were put in the ship's freezer.

Now, after the fishing expeditions are over (at least for the present) and many desired specimens obtained, much difficult and careful work still remains to be done. The expeditions have, of course, provided material for many weeks--even months--of intensive laboratory study. When this is completed and the data has been sifted, classified, and documented, important additions will have been made to the rich store of knowledge which the Navy is accumulating on the Islands of Micronesia.

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Native Navigators

by

M. W. de Laubenfels
University of Hawaii

When Magellan was sailing across the vast Pacific, his crew almost died from hunger, thirst, and scurvy. Yet he passed through a region in the western Pacific Ocean which is abundantly dotted with islands and atolls, so that--as one now traces his course on the map--it is well said that he accidentally performed a "miracle of missing." Again and again he must have passed, barely out of sight, an island where he could have obtained water, food and rest. Though such a mischance would be highly unlikely today, emergencies still occur when instruments are lacking or defective and the location of the nearest land is an urgent need.

The natives of the Pacific Islands often skilfully avoided the danger Magellan encountered. They set out to islands that they had never seen or to find "new" islands, and they succeeded. Their very presence on such islands proves this. They claim--and can demonstrate--that if, by design or accident, they come within 20 or 30 miles of an island, they can locate it. They usually accomplish this by observation of wave patterns, although they may also use clouds and other indications.

During the summer of 1949, the author made an intensive zoological study in the Marshalls, Marianas, Carolines and the Palaus, through the courtesy of the Pacific Science Board of the National Research Council and the Geography Branch of the Office of Naval Research. Again and again, when sailing in native outrigger sailboats, or in boats with more occidental rig, the native navigators gave practical proof that they could locate and steer to the nearest land. Though all this was very interesting, study of it threatened to be time-consuming, and other duties prevented the author from making more than a preliminary study of these "native navigators" and their methods.

The location of distant land may be estimated from cloud formations, sea birds, sea weeds, and many other indications. An excellent, brief, practical description of these methods is found in Harold Gatty's "The Raft Book" (Grady Press, 1943). In it he devotes a few pages and one plate (No. 10) to a method which relies upon observa-

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M. W. de Laubenfels, Professor of Zoology at the University of Hawaii, received an A. B. degree from Oberlin College, where he was later a member of the faculty. He was awarded an M. A. from Stanford University, and as a Fellow of the Carnegie Institution of Washington, received his doctorate in zoology in 1929. Dr. de Laubenfels is a consultant of the Bureau of Fisheries and Secretary-Editor of Biological Abstracts.

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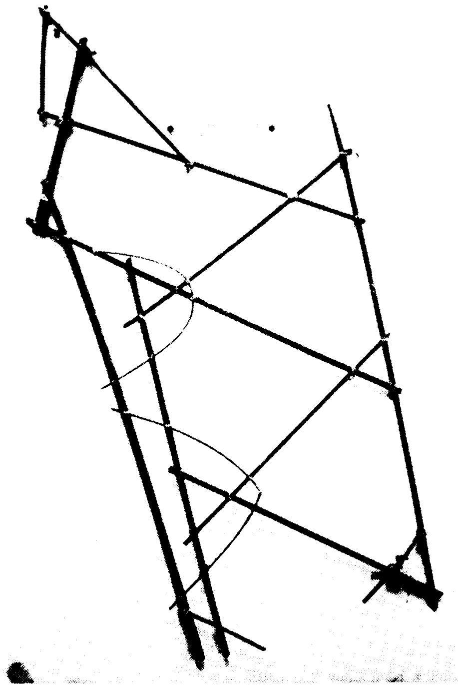

Figure 1. A stick chart of the map type or rebillib. (Photograph courtesy of the Bernice P. Bishop Museum, Honolulu.)

tion of wave patterns. He mentions that the Micronesian natives were especially skilled in such lore. These were precisely the natives who inspired the present article.

About 50 years ago anthropologists and other investigators began to realize that some special knowledge of such matters existed, and made efforts to get it on paper. Some success was attained, but all the investigators encountered great resistance from the natives. The lore was held as a precious trade secret by a very small group, who possessed a great advantage over the others because they alone could take charge of expeditions. These natives passed the knowledge on to their sons, or to favored neophytes, but refused to make it public. Even when highly paid by European investigators, they released only evasive and partial answers.

By 1949 a very different attitude had arisen. The surviving old navigators have gradually awakened to a situation which shocks them. The younger natives, instead of seeking to learn the secrets of the trade, have become contemptuous of them. Several of the most successful old navigators volunteered to give their knowledge to the writer, explaining that they were alarmed lest it be forever forgotten.

It may be suggested that everything is already known about wave patterns. Certainly those along continental shores have been exhaustively and successfully studied by the Scripps Institute of Oceanography at La Jolla. Some of this information differs from that obtained by Gatty, who offers very practical advice regarding the use of the wave pattern. It is possible that Gatty's findings are correct, although they differ from the teachings of the ancient navigators.

Captain Winkler of the German Navy[1] seems to have had the greatest success in finding out the pattern and the native names for its component parts. He does not, however, seem to have understood what the pattern really meant in terms of practical use. Probably the natives held back a great deal. Erdland,[2] Kraemer[3] and Neverman[3] report less than Winkler.

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[1] Smithsonian Annual Report, 1899
[2] Collection Internationale de Monographies Ethnologiques, 1914
[3] Ergebnisse der Süedsee Expedition 1908-1910

The native navigators use "stick charts" as an aid to land location. A few of them conform to the casual notion as to what a map should be - that is, some are webs of criss-crossed strands that represent possible boat-courses, with island locations indicated by bits of coral tied to the reticulation. One may readily compare such a chart (or rebillib), to a modern map, and admire the accuracy shown in locating the relative positions of the scattered islands. Figure 1 shows such a chart, which, in this case is called a meddo, because it is part of a larger series of charts. The courses in "tacking" into the wind may be indicated by the angles of the sticks, which certainly show the direction which the navigator should take.

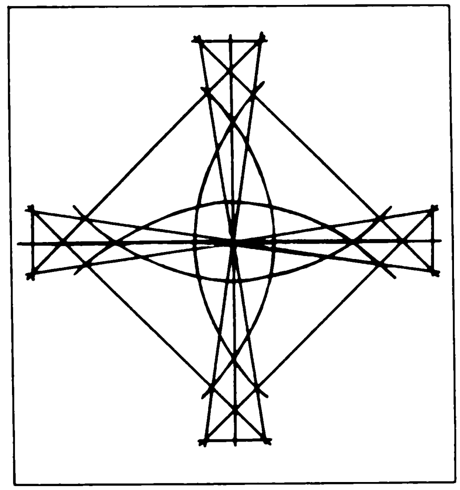

Figure 2. A common pattern for a stick chart of the mattang type. (Photograph courtesy of the Bernice P. Bishop Museum, Honolulu.)

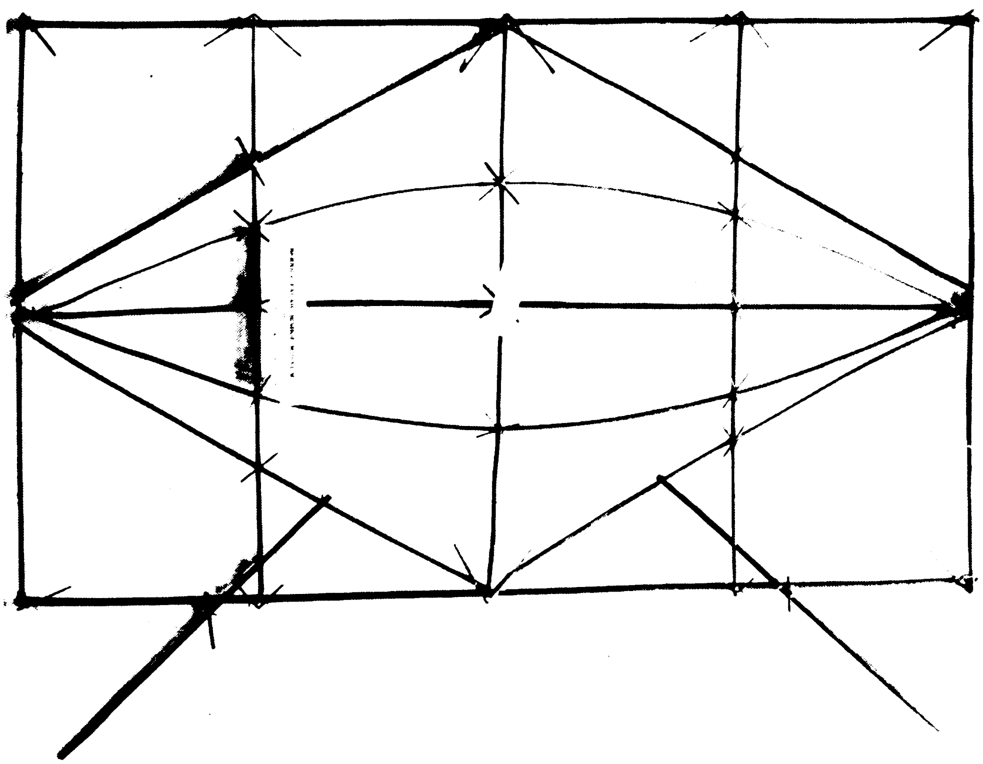

Figure 3. A stick chart of the mattang type. This chart can be turned so that any side is up, and almost any important wave pattern can be pointed out somewhere on it. (Photograph courtesy of the Bernice P. Bishop Museum, Honolulu.)

The usual native stick-chart, however, is a rather symmetrical pattern of straight and curved lines, called a mattang (see Figures 2 and 3). Its maker gave some puzzling answers to inquiries about it. First, for example, he would say that such-and-such a point represented Jaluit, and later he might say it was Namorik. Why should this be? The natives were quick to explain that it didn't matter - the chart was not to show where Jaluit in particular lay, but where land was. They stoutly maintained that it could be some island in another part of the world, one that they had never seen. The first reaction was utter skepticism, but practical demonstration seems to confirm this explanation. We are dealing with a set of wave patterns due to reflections, and the importance of reflection is an old story to a physicist or oceanographer.

To use the wave pattern method of navigation, one must first determine a direction of prevailing winds, for a year if possible, or at least for the preceding weeks - that is, one must start by observing the wind-direction which is responsible for the main or primary wave-series.

In most of the ocean the trade wind or the westerlies determine this primary wave pattern. Needless to say, the method now under discussion is of no use in a flat calm, nor after a long period of fitful winds which often change direction.

To demonstrate the way the natives are able to locate land, let us first assume that the navigator gazes out over the waves and decides that they show the pattern which in Marshallese is called rilib. This must be compared most carefully to the undisturbed pattern. The more distant the land, the less is the difference, of course, but in the trade wind regions, the land effect can be seen for more than 20 miles. A rilib pattern means that the land is off in the general direction toward which the waves are traveling. The reflected waves are coming back against the main series, and interfering with them, but the secondaries are parallel to the primaries. The rilib area is a quadrant, and the navigator does not know whether he is in the middle of it, or to the left or right of center, but he has a first general direction, which he takes.

Now he watches for a line which he calls (in Marshallese) Jurrinokamie; there are two such, at about 90° apart, with the island at the apex, and the rilib in between. At the Jurrinokamie the reflected waves are no longer parallel to the primary swells, but at such an angle that they form a choppy interference pattern. When he sees it, the wise old native turns parallel to the Jurrinokamie and follows it neatly to land.

As another example let us assume that the navigator decides that the swells show the pattern which the Marshallese call kailib. This tells him that the land lies off in the direction from which the waves are coming. The main stream has passed on each side of an obstruction and the two fractions have reunited with effects on each other, something like the situation in the wake of a ship. Yet one must compare a ship of zero draught; in the wake of a real ship, most of the pattern is due to the turbulence of water currents. In the kailib, however, currents play no part - in fact, the current is often directly counter to the direction of wave travel (the famous equatorial counter current).

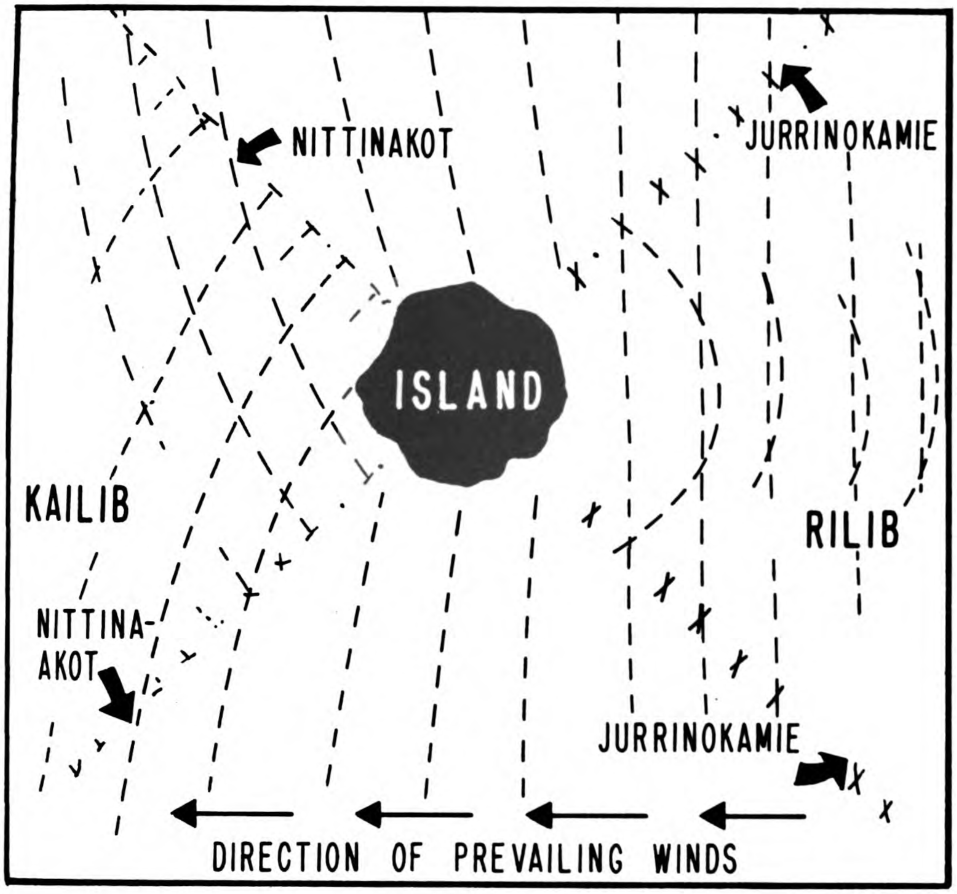

Figure 4. Diagram of the wave pattern about an island, according to Marshallese navigators.

The kailib, like the rilib, is a quadrant, and the navigator at first knows only that he now can set his course in the general direction of land. Again he watches for a line, which he calls the Nittinakot. This is where the waves which have passed on the right side of the island no longer are affected at all by those which have passed to the left of the island, or vice versa. When the navigator sees this line, he turns parallel to it, and thus is again able to find land.

Finally, let us assume that the navigator decides he is in a region neither rilib nor kailib, but in one which we may call Bungdok, although this is really a term of wind direction. These quadrants are very difficult to recognize. The best one can say is that the wave pattern just isn't what it ought to be if it were affected by the wind alone. The angles made by the swells are slightly at variance with the perpendicular to the direction of prevailing winds, as though they were being held back a little at one edge. This indicates that there must be land in that direction.

Again the general course is set, and lookout kept for either Nittinakot or Jurrinokamie, and when either is sighted, the helmsman turns parallel to it, and follows it to land.

The stick chart of the mattang type, as illustrated in Figure 3, does not show the pattern in the way we would expect. It can be turned, for example, so that any side is up. How then was it used? Obviously it was only for purposes of instruction; the real data were entirely oral. Yet the teacher could point to the mattang and say that in such-and-such a location the waves made a certain pattern, while in a different situation they made another pattern. Presumably nearly any important wave pattern could be pointed out somewhere on the stick chart, and visualized. The mattang illustrated in Figure 3 must be held in different positions to show the wave patterns of a single island.

As Gatty points out, study of the swells might be the best way for men in a small boat under a heavy overcast to locate land. Yet even if the vital need never again arises in the modern world of radar and loran, it would be interesting merely for historical values to secure a permanent record of the relation of wave pattern to distant islands.

* * *

Prevention of Deterioration Center

by

Glenn A. Greathouse
Director

Deterioration implies lowering of value or decrease in the ability of an object to fulfill the function for which it was intended. By extending this line of reasoning, we can define deterioration as the process of going from a higher to a lower energy level. For example, steel is produced by raising the energy state of iron from that existing in the chemically bound state of an oxide ore to that found in the free elemental state of an iron or steel beam. This energy must be supplied to the iron from an outside source, as by the burning of coal. In any situation, for the conversion of raw materials to finished products, energy must be deposited in the "bank" represented by the finished product. The useful life of the product depends upon its ability, or the ability of some outside influence or maintenance agent, to keep that energy safe in the bank.

It is not necessary to go far to see a rotted textile awning or wooden fence; a chipped, cracked, or otherwise weathered paint; to feel the roughened surface of a once-smooth piece of furniture; to smell the musty odor of mildewed books or shoes; or to taste the bitter acids of spoiled butter. Natural or man-made forces are constantly at work trying to open the "bank" doors to withdraw some of the stored energy and, in effect, to lower the value or usefulness of good materials.

It is interesting to note the cost of deterioration. Termite damage, only a fraction of the total insect damage to wood, estimated, in "Our Enemy The Termite" by Dr. Thomas E. Snyder of the United States Department of Agriculture, to cost $40,000,000 per year. A paper by W. F. Clapp and A. Rhoads of the Clapp Laboratories reports that losses resulting from marine borer attack on wooden structures in waters surrounding the United States (see Figure 1) amount to $50,000,000, annually. Bacterial damage to raw cotton has been estimated at $70,000,000 per year. Many other forms of degradation add to the total. The annual national bill covering all forms of deterioration, excluding foodstuffs, is probably in the neighborhood of twelve billion dollars.

Glenn A. Greathouse, Director of the Prevention of Deterioration Center, National Research Council, Washington, D. C., received the B. S. and M. S. degrees from the University of Illinois and a Ph. D. from Duke University. From 1931 to 1936 Dr. Greathouse was an assistant professor of biophysics at the University of Maryland; from 1936-43, he was Project Leader, U.S. Dept. of Agriculture; from 1943 to 1945 he served as director of deterioration of material project, Office of Scientific Research and Development. Dr. Greathouse received the National Defense Research Committee award in 1945; in the same year he also received the Naval Ordnance Development award; and in 1948 His Majesty's Medal for service in the cause of freedom, from the British Government.

Although a complete prevention of deterioration cannot be attained in practice, the magnitude of the losses makes even fractional savings worthwhile. For example, a railroad using one million ties could save $150,000 by increasing the life of ties by only one year.

Probably the most inclusive term one could use in assigning responsibility for deterioration is "climate", or more universally "environment". Climate or environment determine which agents of destruction can exist in a given spot to shorten the useful life of materials. The intensity of the physical agents--heat, light, dust and grit--is governed by geographical location and the prevailing climate of the region. The chemical agents--moisture, salts, acids, alkalies and gases--likewise are dependent on climate or industrial effluents for intensity of their action. The biological agents--fungi (molds), bacteria, insects, and marine organisms--all depend upon the existence of optimum humidity, temperature, and nutrients to thrive in an active, destructive condition.

The actual components of climate, that is, heat, sunlight, moisture, wind, and dust, might be called the prime factors of deterioration. The biological agents are of the nature of corollaries since the intensity of their effects is governed by the prime factors.

Temperature affects many properties of materials. High temperatures may cause breakdown of organic substances, as in paints or insulating coatings, and impairment of operation of electrical or electronic equipment. Low temperatures result in mechanical difficulties such as those produced by differences in the coefficients of expansion of dissimilar materials or increased viscosity of lubricants. Some plastics, rubber, textiles, leather, and metals become stiff, brittle, or fragile at low temperatures. At -40°F and lower, many components of electronic equipment cease to function as a result of physical changes. Elec-

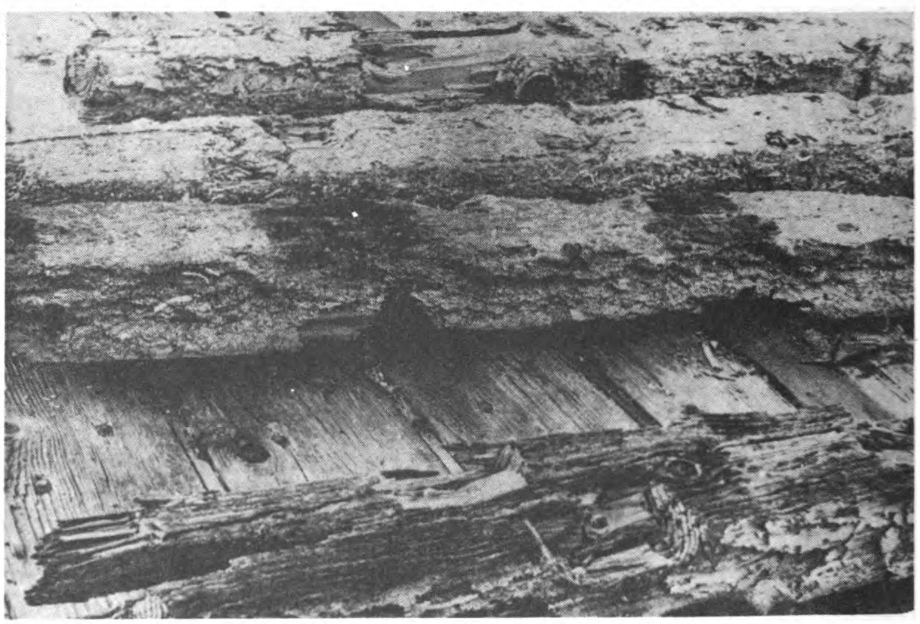

Figure 1. Timbers of a seaplane ramp in Guantanamo Bay, Cuba, showing damage by marine borers.

trolytic capacitors become unsuitable, quartz crystals frequently fail to oscillate, storage batteries lose most of their capacity, and dry cells become useless.

Fluctuation, however, is even more serious than either extreme of temperature. Differences in expansion of coatings and substrates cause paint films to crack, or instrument seals to open, allowing ingress of moisture and microorganisms.

Sunlight activates certain chemical changes in the organic systems represented by textiles, paints, plastics, and rubber. All of these are known to be degraded by actinic energy. Textiles lose strength and fade; paints crack, craze, peel, and fade; and plastics and rubber harden, become brittle and crack.

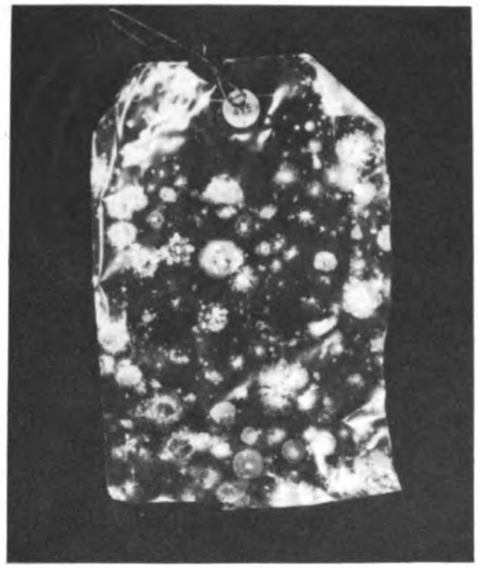

Figure 2. This growth of mold accumulated on a cellophane sample which had been exposed for six months in the jungle at Ft. Sherman Reservation, Panama Canal Zone.

Dust and grit, in combination with high winds, act as serious abrasives, which may remove protective coatings or, having gained admittance to moving parts of equipment, may be carried by lubricants to highly machined or polished surfaces, where they rapidly cause damage. Under the dry operating conditions encountered in the desert, dust and grit cause even greater harm. In the Pacific, many islands are of coral composition and during dry seasons coral dust creates a serious hazard around airfield runways, taxi strips, and maintenance areas. Some dusts, furthermore, may be alkaline in reaction, adding the problem of chemical attack to that of abrasion.

Water, as vapor in the air, as a liquid film on surfaces, or as fog, rain, sleet or snow, is associated with most forms of deterioration--a fact explained by the great ability of water to dissolve chemical agents, its electrical conductivity, and its role in supporting the life of all biological agents. As a solvent, water carries destructive chemical agents to the surfaces of materials and acts as a medium through which the chemical and substrate react, as, for example, in the formation of sludges in lubricants. The part water plays in deterioration caused by such biological agents as fungi and bacteria is clear. As an essential factor for these agents, it governs their general growth, spread, and reproduction.

Salts, acids, alkalies, and gases are important in sea-coast areas, desert regions, and man-made industrial areas, and manifest their destructive power in abrasion, and other specialized degradation.

Biological agents are distributed widely throughout the world. Microorganisms such as fungi and bacteria thrive in

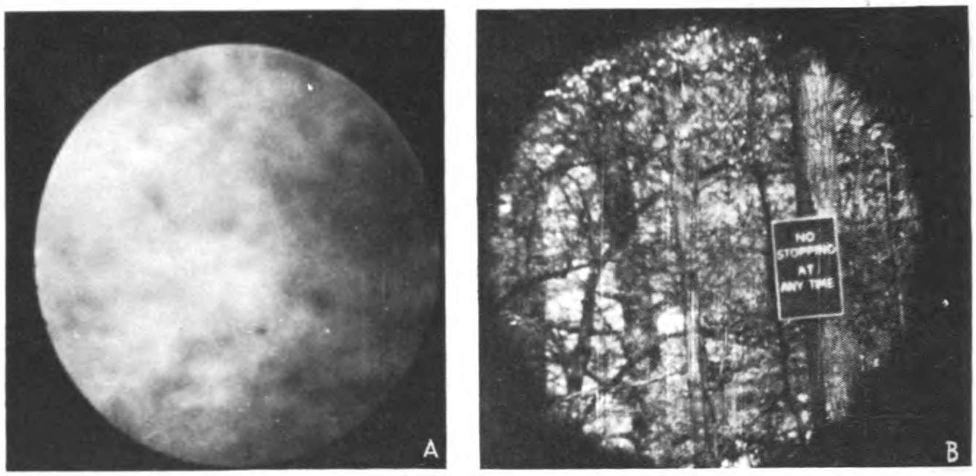

Figure 3. Photographs taken through telescopes which had been exposed for two months in tropical testing chamber. Telescope (A) was untreated; (B) was treated with radium foil.

warm, humid regions and attack most organic substances which they use for food or as substrates for colonies. Fungi, exemplified by bread mold, are perhaps the more destructive of the two forms and cause great damage to textiles, paper, and leather. Although the fungi are not able to extract nutrients, as such, from surfaces of metals, glass, or some plastics, they can send out watery filaments from an actively growing colony onto biologically inert surfaces, such as in optical, photographic or electronic equipment, and cause etching of the glass, corrosion of the metal, or short circuiting of hookups.

Many insects cause serious damage to organic materials. The commonest of these are the termites, silver fish, clothes moths, carpet beetles, wood-boring beetles, and roaches. Termites, sometimes called white ants, comprise more than 1800 species distributed throughout most of the world. Only the Arctic and Antarctic are free of these pests. Their destructive effects are noted mostly on wood, paper, textiles, leather products, and food.

Clothes moths, silver fish, and carpet beetles are known to almost everyone as destroyers of textiles, paper, leather, feathers, and fur. They are represented by many species with wide distribution. Wood-boring beetles are of five types--pinhole borers, longhorn beetles, powder post beetles, death watch beetles, and furniture beetles. Among these types the powder post and furniture beetles probably produce the greatest economic losses. Roaches are widely distributed and known to everyone. Mainly active at night or in dark basements, they feed on bindings and leaves of books and magazines, labels, and various food products.

Marine organisms, mainly the molluscan shipworms and boring clams (Teredo, Bankia, and Martesia), the crustacean gribble and pill bugs (Limnoria and Chelura), and the fouling organisms (barnacles, clams, oysters, and others), cause great damage to harbor installations and shipbottoms in certain salt or brackish waters.

Men have not been entirely idle in the war against deterioration. The efforts to overcome degradation can probably best be grouped under four headings: (1) the utilization of known deterioration-resistant materials or development of new ones; (2) the control of immediate environments; (3) the use of preservatives; and (4) chemical modification of old, well known materials to render them resistant.

In selecting a resistant material for a particular purpose one recalls that the use of resistant nylon, acetate fibers, glass fibers, and similar, recently developed materials have decreased fungus damage. Resistant plastics used as substitutes for textiles, paper, and leather are considered practical improvements.

The control of immediate environments may be accomplished by air-conditioned storage, proper packaging, and application of protective coatings. Resistant pipeline coatings have made practical the long-distance piping of fuels. Application of protective paints, varnishes, lacquers, and enamels have added years to the life of wooden and metal structures found in buildings, bridges, ships, and aircraft.

The use of preservatives has been widespread and encompasses such items as preservatives for metals, wood, leather (Figure 4), paper, plastics, rubber, and lubricants. Preservatives include fungicides, bactericides, insecticides, rodenticides, as well as agents which protect against sunlight, water, shrinkage, and fire.

Measures taken to modify old, well-known materials include chlorination or modification of disulfide linkages of wool to provide shrink resistance, and acetylation of cotton to give mildew resistance.

These are but a few examples of the many lines of attack that have already been tried in an attempt to overcome the numerous and complex problems of deterioration.

Figure 4. Leather binocular cases were exposed for five months in the jungle at Ft. Sherman Reservation. The effects on untreated leather are shown in (A). The case shown in (B) was mold-proofed with ANX-1416 compound (a mixture of salicylanilide and parrafin).

During World War II deterioration problems became a matter of grave importance to the Armed Forces. In 1943 the Army-Navy Project AN-14, the Tropical Deterioration Information Center, was established under the Office of Scientific Research and Development of the National Defense Research Committee. This functioned until the close of the war when, in December 1945, it was transferred by request of the Army and Navy to the National Academy of Sciences, National Research Council, and became known as the Prevention of Deterioration Center.

Briefly, the principal functions of the Center are to:

1) Collect information from Government, industrial, and academic institutions on problems relating to the prevention of deterioration of materials and to make such information available in readily usable form;

2) Maintain contact with work on the prevention of deterioration of materials which is being carried out by the Government, particularly the Department of Defense;

3) Serve in a consulting and advisory capacity on deterioration prevention problems;

4) Conduct studies and surveys in fields of deterioration prevention.

Collateral interests developed by the Center include:

1) Stimulating research in the field of deterioration prevention of materials, with the object of increasing knowledge, strengthening the national defense, and of contributing in other ways to the public welfare;

2) Promoting cooperation among research workers engaged in the field of deterioration in order to concentrate effort and minimize duplication;

3) Directing the attention of scientific and technical investigators to the current research problems of the Department of Defense, and on request, aiding in the solution of these problems.

To accomplish the Center's program, its full-time members are organized as three staffs: consulting, publications, and library. The consulting staff is composed of persons with training in diverse branches of the sciences so that problems may be attacked broadly. In addition to this consulting staff at the Center, a Scientific Advisory Committee, consisting of individuals pre-eminent in various fields of science and research, aid with general guidance on major problems. The Center has access, therefore, to the reservoir of scientific and technical knowledge of the members of the National Academy of Sciences and the National Research Council, as well as that of many other outstanding scientists not actively associated with these organizations.

The consulting staff acts in an advisory capacity to the National Defense agencies and other authorized groups on any problem of deterioration which comes within the scope of the project, and also keeps the various agencies informed on the latest developments in the field of deterioration. In cooperation with the Advisory Committee and other scientists and on request of the Armed Forces, this group carefully scrutinizes proposed contracts with nongovernmental organizations. Advice is offered as to the need for the proposed work, the qualifications of contractors to carry out the work, and the stipulations which should appear in the contract. This staff often follows the progress of the contracted work. Visits are made to defense laboratories doing research and development work and close cooperation is also maintained with industrial and educational research organizations. Through representation on committees, the Center maintains liaison with research and development activities of the Armed Forces, scientific societies, and other research groups.

Among its other activities the consulting staff of the Center initiated and is operating a program for evaluating compounds as fungicides for the protection of National Defense materials. This work involves procuring samples for testing, searching literature for data, preparing and indexing file cards, distributing samples, and coordinating an over-all project involving several defense agency laboratories. Further activities in this program include standardizing test methods, evaluating results, correlating structure with fungicidal activity, and indicating lines for further investigations. A small laboratory, located at the University of Maryland and made available through the courtesy of the Office of Naval Research, is maintained to assist in testing fungicides and bactericides.

As an outcome of this program, Fungicide Screening Reports 1 and 2 have been issued. In these reports data are presented on several hundred potential fungicides tested for possible use on materials susceptible to microbiological decomposition. The Center's file on fungicides and bactericides, containing detailed information on some 6500 compounds, is maintained for the use of the National Defense agencies.

To aid with the consulting and advisory work, the Center has been compiling a Handbook of technical knowledge relating to the prevention of deterioration. This facilitates the extension of service to Defense agencies situated long distances from Washington, D. C.

The Center, in cooperation with personnel of the Armed Forces and others, also has in preparation a primer, Introduction to the Prevention of Deterioration of Materials, which aims to summarize current phases of deterioration prevention.

The publications staff of the Center has, as its main task, the preparation and production of the Prevention of Deterioration Abstracts. Here the varied and voluminous data relating to the prevention of degradation of material is systematized and classified. The literature in the deterioration field cuts across the boundaries of such fundamental sciences as biology, chemistry, and physics and of such applied fields as metals, plastics, and textiles. From the majority of the literature sources throughout the world the Center gathers approximately 250 reports per month pertaining to the field of deterioration.

Approximately 2000 pages of abstracts are published per year, of which about one-fourth represent unpublished reports. Many of the abstracted reports originate in foreign countries. The Defense Agencies receive 250 copies of the Abstracts for their technical personnel and fifty copies are supplied to the Canadian, British Australian, New Zealand, and South African governments in exchange for information and data from their laboratories. The Abstracts are also made available to industry, libraries, and others desiring to purchase them.

An unusual feature of the Abstracts is offered in the carefully documented comments of the technical personnel of the Center. These comments attempt to correlate relevant information from different sources to point out important factors, to evaluate reports, or to make suggestions for further research.

Because of personnel limitations at the Center and in view of the nature of some of the reports, it is neither practical nor necessary to abstract all literature received. Since not all reports are abstracted, and since there is necessarily a short time lag between reception of reports and preparation of abstracts, an Advance List is issued. This list notes the title, author, and sources of all reports on deterioration which have been received at the Center during a period of about a month.

The library staff obtains and catalogues pertinent reports suggested by the technical staff and maintains an index of the information they contain. In addition to procuring reports for the publication staff, this division, upon request, will loan technical reports to the Department of National Defense. Many such loans are made each month. Unpublished summary and progress reports are particularly in demand, as well as those received from the British Commonwealth Scientific Office and other similar sources.

The PDC library is unique in that it is probably the only one in the United States containing the majority of specialized reports concerned with the prevention of deterioration of materials. This comprises some thirteen to fourteen thousand reports and includes reference works and bibliographies covering world literature.

The store of information available through the Center, is at the disposal of the National Defense Agencies. The Center desires that the facilities be utilized to their fullest capacity and that the results of its efforts be put into practice. All persons interested in its activities in deterioration prevention are invited to write or to call in person. The Center's address is National Academy of Sciences Building, 2101 Constitution Avenue, Washington 25, D.C.; the telephone is EXecutive 8100 or Code 148, extension 174 or 175.

The author desires to acknowledge the valuable suggestions and comments given by Dr. Carl J. Wessel and Miss Dorothy Valent, in the preparation of this manuscript.

* * *

Computation of Economic Programs

by

Oskar Morgenstern
Princeton University

Let us assume that the following problem must be solved: the three military forces have separately established their needs for arms, men and services. It is necessary to determine, first, whether the American economy is able to supply all these goods; second, whether it is able to provide the manpower to be enlisted in the Armed Forces; and finally, how much the civilian sector of the economy has to be curtailed as a result of these demands. It is also necessary to find out

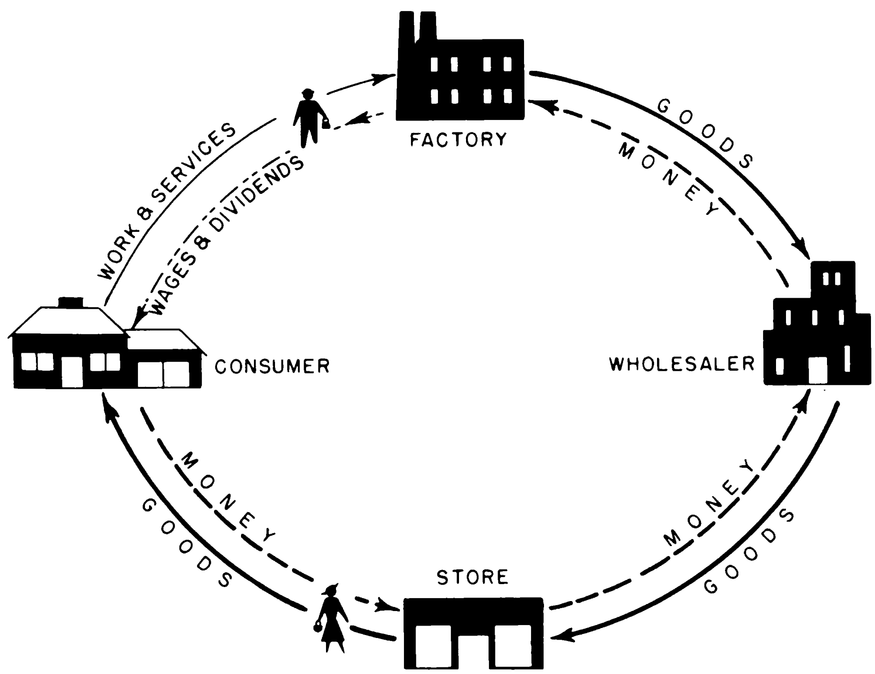

Figure 1. Basic Economic Flows

whether the individual requirements of the three military services are compatible with each other. For example, it might be impossible to build as many ships and tanks as the Navy and the Army together require, since, to accomplish this objective, too much steel would have to be diverted from the needs of the railroads. The ensuing reduction in the activity of the railroads would be intolerable because of the heavy movements of goods and men that must be expected. Still another problem must be solved--it has to be specified how much steel, copper,

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wiring, and machinery go into shipbuilding and how much into the making of tanks and airplanes. This has to be spelled out in detail and involves a surprisingly large number of computations, which would take months to perform. By the time the computations are made, the original programs are probably no longer appropriate because the military-strategic situation has changed and very different demands are being made. This is somewhat akin to the difficulty meteorologists have--they would like to predict the weather on the basis of good information, but the computations take more time than it takes the weather to arrive. By the time their calculations are completed, entirely different weather conditions already prevail.

Let us assume that the task is to provide answers to all the problems connected with the wartime situation stated in the shortest possible time and with a very high degree of accuracy. Obviously this is a formidable problem--if it can be solved at all. Moreover, the only acceptable solution would be a quantitative one, which would show us the actual magnitudes of the expected shifts in activity of the various industries.

More generally we would like to know what constitutes the "best" program that could be imposed upon the economy. That is, we wish to find one which, while giving the military services as nearly as possible what they want, least disturbs the ordinary functioning of the economy as a whole. It might also be that the initial program is too ambitious--perhaps not feasible at all. Clearly, the American economy cannot produce within, say, a year, 1,000,000 combat airplanes, perhaps not even 10,000. It may never be able to produce the larger number. But precisely how many can we make without at the same time having to curtail shipbuilding and tank production? We may be able to give up for some time all manufacture of automobiles, but we cannot stop the railroads too. What balance is the right one?

This example was a military one and if a method could be found to facilitate decisions in this field, it should certainly be applied. But it is clear that the scope of the applications is much wider. In peacetime, for example, one might wish to discover whether the simultaneous introduction of, for example, a health plan, an old age security scheme and a public building program is possible. Would they defeat each other? Could one be safely expanded while another might have to be curtailed? These are questions that can be answered intelligently only after all these interrelations are fully understood.

This is the type of problem that confronts the economist and which he would like to solve numerically. Difficulties arise, first, from the need for great masses of statistical information (which usually do not exist) describing the activities of hundreds of industries and, second, from the interdependence of all economic activities. The first is a very practical, the second chiefly a theoretical difficulty. It is hard to say which one is the more formidable.

Consider first the theoretical problem. The interdependence of economic activities was recognized early by the French economist Quesnay in 1758. He set up the famous "Tableau Economique", designed to give an idea of the flows of goods and money in 18th century France. After long neglect these ideas have again become of interest to contemporary economists. Figure 1 demonstrates the fact that in an economy there are flows of commodities and services and flows of money-payments which, necessarily, move in opposite directions. If one is broken or changed in magnitude, the other is affected thereby. For example, if the productivity of labor increases the commodity stream, while at the same time the money flow remains constant, this means a price fall, viz., the ability of money to buy more commodities. On the other hand, the money stream can be swelled by injections of money from the banks without a concomitant increase of production; this leads, as a rule, to an increase of prices. Thus, the individual's economic fate depends on things largely outside his control, such as variations in the total quantity of money, in the spending habits of other people, and on whether new technological advances are made and introduced in industry. In a much more subtle way he depends on what others do and what they think he might do. This kind of interdependence in social organization cannot be described by mechanical analogies. Instead it requires the application of the theory of games of strategy, where similar phenomena are studied.

There is a second kind of interdependency, largely of a technological nature. In order to produce a certain commodity, for example an automobile, many different raw materials must be combined in production. Some freedom of choice exists between combinations, but not everything can be replaced by something else. We may use less steel, but then we need more wood, aluminum or copper; likewise, we may use nylon or rayon in tires instead of cotton, but some textile is necessary. Besides this technical interconnectedness there is a form of interference, since the same machines, electric power, and transportation go into the making of virtually everything. Thus, railroad cars used in transporting raw materials for automobile production cannot at the same time be used for the shipment of agricultural products. This links these two industries which otherwise have no intimate connection with each other.

It is clear, then, that the economy as a whole is a maze of interconnected processes which are kept going because a demand is exercised for the finished goods. This demand is made effective by money offers to the producers who, in turn, must pay money to demand the services of labor and capital.

Since it would be impossible to give a complete description of a large, interconnected economy, a simplification into a manageable form has to be attempted. This is achieved by the formulation of a mathematical "model" or representation of the economy. The model has to be mathematical in order to express properly the precise nature and degree of the interdependence of the economic processes. Without a mathematical construct, it would be impossible to make quantitative estimates or predictions of the consequences of a change in the demand for the products of one industry upon the activity of all others. Because of the intricacies and the often unexpected character of these interrelations, no intuitive approach based on mere "experience" is satisfactory. No matter how high a man may be placed in business or government or how wide a field his activities cover, he does not have equipment sufficient for these tasks.

The innumerable different transactions that occur in an economy could not, of course, be computed individually, even if we had a perfect theory and data so numerous that a complete description could be given. Our information relates, at best, to whole industries, or to entire groups of industries and even then it is of bewildering complexity. Our theory is still very rudimentary, although some simple formulations are possible. It is, therefore, necessary to compress drastically the information about individual economic transactions. Otherwise, it would be impossible, even for the fastest electronic computing machines, to analyze the data and to interpret them according to the theory. Even such vast operations have to be carried out on the basis of greatly reduced information.

This compression of the information into more comprehensive groups produces the so-called "aggregation" problem. For example, instead of having data about each steel mill in the industry separately, we only have a global figure for all, to which may be added the transactions of the shipyards, the processing plants, and railroad building. The total figure for this "industry" is obviously simpler than all the figures from which it arises. It gives us less detailed information but makes computations easier.

Economic programs are subject to <u>restraints</u>. To take an obviously absurd case, it is impossible, in one year, to double the Nation's steel capacity. Common sense tells us that much, but it is easy to give technical engineering data. Since large quantities of steel are needed to increase steel capacity by one ton, we could perhaps, with enormous effort, double the capacity within ten years, and certainly within twenty-five years, but obviously not in one year. Such limits are one form of "restraint". Another is the fact that any of these programs would cause enormous changes in the economic life of the nation, which may be entirely unwelcome.

Other restraints are less easily seen. Take, for example, labor. If we wish to expand production, we must attract more labor into industry and agriculture. If there is unemployment, that may be easy, unless we need exceptional skills. If we start with full employment, we have real difficulties: we must work harder, require longer hours, pull women into industry, recall the old from retirement, and perhaps stop some production altogether, so that the workers engaged there can be induced--or if need be even shifted by law--to those industries where the expansion is needed. Such adjustments were made during the war in varying degree by trial and error, at great cost and with much loss of time--which in war is often more precious than money or material.

Therefore, it is desirable to discover methods which allow us to determine quickly and accurately whether given programs are <u>feasible</u>, that is, whether they are possible within the given objective restraints of each situation. This requires that all the information about the initial situation has to be taken into consideration when the program starts. But such description, besides being expensive and time-consuming, will always be incomplete. Furthermore, the most important restraints to consider are not the technological-physiological ones, but those that arise by virtue of the <u>relations</u> among the economic quantities and processes. Otherwise it would be merely an engineering matter to determine how much of the various things required by the military can be produced. The economist will soon discover, however, that there are conflicts and he will have to decide if and how these can be resolved.

A further step, far more formidable, is to decide whether the proposed plan is an optimum plan, that is to say, whether further improvements upon it cannot be made. If a program can be shown, by computations, to be feasible, this merely means that one solution--not necessarily the best solution--has been found. Similarly in business many business men believe they have solved their problems if they are making money; but they may be far from the point where they could make the greatest amount of money. That is, few can be certain that they have found the policy that assures them their maximum profit. And the businessman's problems are very minor compared with those of the economy as a whole. These questions are again intimately related to the theory of games.

The notion of "feasibility" also occurs in logistics.[1] This is no coincidence. A logistics program offers problems very similar to some of those confronting the economist. Although logistics programs ought to be computed in much greater detail than the economic programs ever can be, the economic problems are far more difficult, since there is no central control over the nation's economic activities. Instead, they are carried out on the basis of individual decisions made by millions of people. These are influenced by prices, prospective profits, costs, and in war (we hope) to some extent by patriotism. The study of the economy is of profound significance for logistics: first, because all logistic plans involve economic activities such as production and transportation, and second, because economics is a field where many methods have been tried out and much experience has been gained. Although economics is far from being as well developed a science as physics, for example, the services which the newer quantitative-mathematical techniques may be able to render may ultimately turn out to be highly significant.

However, the point is that we do not have, at present, powerful methods that allow the rapid and accurate computation of economic programs. For one thing, the basis of our information is too narrow. Currently, a great effort is being made by the Bureau of Labor Statistics to gather so-called input-output data for 1947 covering the entire American economy (as originally formulated in terms of inter-industry relationships by W. W. Leontief). This work will eventually result in a table for 150 industries, i.e., 22,500 mutual transactions. This information will be of a kind we have never had before, but it will not be available before 1951, four years after the time measured. Its interpretation will consume additional time and meanwhile the economy may have changed significantly.

Consider a much reduced table: in Table I all activities of the American economy are represented by eight groups. The horizontal rows indicate how much each industry sold to all others. The vertical columns indicate how much each industry bought from all others. This is obviously true because every sale is somebody else's purchase and

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[1]See "Mathematical Research in Logistics" by C. B. Tompkins; Research Reviews, January 1950.

Table I

Input-Output Data, Showing (in millions of dollars) Transfers Among Industries in 1939

Industry* Producing	1	2	3	4	5	6	7	8	Final Demand** 9	Net Total 10
1	1,188	-	24	1,340	43	661	64	370	197	2,699
2	-	20	57	217	-	57	31	390	398	1,150
3	-	-	8,113	-	-	167	931	732	21,320	23,150
4	41	16	999	2,981	33	2,589	277	3,656	5,662	13,273
5	138	5	179	466	1,615	1,617	59	731	881	4,076
6	654	335	7,737	3,139	1,015	10,253	4,766	7,075	14,833	39,554
7	1	63	462	211	55	1,203	5,410	3,324	10,195	15,514
8	597	226	4,326	2,950	932	7,909	3,596	9,136	19,512	40,048
Gross Outlay	2,619	665	21,897	11,304	3,693	24,456	15,134	25,414	72,998	139,464

**The industries of the economy have been classified into the following groups:*

1. Ferrous metals; 2. Rubber; 3. Agriculture, fishing, food, tobacco, and kindred products; 4. Motor vehicles, industrial and heating equipment, and metal fabricating; 5. Nonferrous metals and products, nonmetallic minerals and products; 6. Fuel and power, construction, transportation and trade; 7. Lumber, paper and products, printing, publishing, textiles and leather; 8. Chemicals, munitions, all other manufacturing, business and personal services, and undistributed.

***Final demand includes foreign trade, households, government, and stocks.*

every income someone else's expenditure. Also, the same industry always sells to and buys from itself. Naturally no individual firm will do such a thing. But the U.S. Steel Corp. will sell steel to other steel processing firms and both will be grouped together into the "steel industry". This is one case in which information is often lost, a fact we have to accept to penetrate through the maze of interconnections.

By using a more detailed table of 18 industries we can demonstrate the complexity of relations that exists (Table II). The first column shows the industries; the second gives the last net output for each in millions of dollars, thus describing a certain level of activity for the whole country. We now assume that the government orders from the chemical and munitions industry $435.3 million more than for the current year. Since this is only a 25 percent increase in demand, we may take it for granted that this order can be filled. But what must happen to each industry's output in order to satisfy this new order? The third column shows the increases needed in all industries; the last column is merely the sum of the second and third. It is perhaps rather startling

Table II

An Illustration of the Effect (in million of dollars) on Outputs of a 25% Change in the Final Demand of One Industry in 1939*

Industry	Old Net Output	Change in Output	New Net Output
1	11,525	23.8	11,548.8
2	17,266	9.1	17,275.1
3	2,699	9.0	2,708.0
4	6,027	16.0	6,043.0
5	7,862	27.2	7,889.2
6	1,632	14.2	1,646.2
7	2,454	17.9	2,471.9
8	10,943	50.4	10,993.4
9	4,173	444.1	4,617.1
10	6,741	25.3	6,766.3
11	8,913	5.6	8,918.6
12	1,150	4.3	1,154.3
13	2,180	4.4	2,184.4
14	10,089	14.5	10,103.5
15	7,477	45.7	7,522.7
16	18,610	137.8	18,747.8
17	20,163	44.1	20,207.1
18	21,049	160.0	21,209.0

**The final demand for the products of industry 9 (Chemicals and Munitions) is assumed to be increased by 25 percent from $1,741 million to $2,176 million.*

that the total of these side effects is $618 million, considerably larger than the original order! It would have been impossible to foresee these changes intuitively. They could only be computed from a mathematical theory of the interconnection of these industries achieved by solving 18 linear equations simultaneously (a task involving approximately 40,000 multiplications). Normally in expanding economies, new orders for several industries are considered.

The theoretical difficulties involved in such calculations are formidable, especially when the conditions are placed simultaneously, producing even more complex patterns. In this manner, however, economic programs can be computed and their desirability be judged. Great efforts are required to push ahead in this field, but it offers very promising prospects with wide applications.

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On the Naval Research Reserve

Field Trips for VRR Units

In view of the success enjoyed by some of the VRR unit field trips, all units able to participate in this type of activity are urged to contact their reserve Program Officer to make arrangements for visiting some Naval activity.

In planning a field trip, the unit members must consider several factors. First, of course, the hours of operation of the selected activity must be ascertained, so that the visit may be planned for an appropriate time. Second, availability of government transportation must be checked; if government air is to be used the area in which the activity is located must have a convenient airport, either military or commercial, where the plane may land. All this information may be obtained by contacting the Program Officer in the area in which the activity is located.

The following is a list of Naval Air Reserve Training Activities that may be called upon for airlifts:

NAS Akron, Ohio
NARTU Wash., D.C.
NAS Atlanta, Ga.
NAS Birmingham, Ala.
NAS Los Alamitos, Calif.
NARTU Memphis, Tenn.
NAS Miami, Fla.
NAS Minneapolis, Minn.
NAS New Orleans, La.
NAS Columbus, Ohio
NAS Dallas, Texas
NAS Denver, Colo.
NAS Glenview, Ill.
NAS Grosse Ile, Mich.
NAS Lincoln, Neb.
NAS New York, N.Y.
NARTU Norfolk, Va.
NAS Oakland, Calif.
NAS Olathe, Kan.
NARTU Seattle, Wash.
NAS Spokane, Wash.
NAS St. Louis, Mo.
NAS Squantum, Mass.
NAS Willow Grove, Pa.
NAS Niagara Falls, N.Y.
NARTU Jacksonville, Fla.
NARTU (LTA) Lakehurst, N.J.

Orders without pay covering such trips should be requested from the Commandant. The Service Dress uniform of the day should be worn. The Reserve Program Officer in your area will assist you in every way possible in arranging these trips.

Promotions

The annual promotions boards begin meetings early in June. Promotion zones have been set up for these Boards as follows:

<u>ENS</u>: Three years in grade (all ensigns with the dates of rank in 1947). Actually no board exists for ensigns; they are promoted automatically if service has been creditable.
<u>LTJG to LT:</u> Last man has date of rank of 1 January 1946 and register number 202136.
<u>LT to LCDR</u>: 1 July 1944 and register number 67882.
<u>LCDR to CDR</u>: 17 October 1944 and register number 13510.
<u>CDR to CAPT:</u> 1 November 1942 and register number 1215.

All Promotion Boards are authorized to go down and "pick up outstanding men who have special qualifications."

Training Duty at Research and Development Board

The Research and Development Board has announced that it will accept three or four Research Reserve officers for two weeks of training duty every third Monday beginning 5 June. Members of Volunteer Research Reserve units who are interested in this training duty should submit requests to Commandant of Naval District via VRR Program Officer (Branch Office of Naval Research), via ONR Washington (Code 230), via Research and Development Board, Washington. Qualifications of the applicant should accompany requests, which must be submitted at least 60 days prior to the date duty is to commence.

Correspondence Courses

The following information, in the form of questions and answers, should be of interest to many Reserves:

Q. What is the relationship between Reserve retirement credit and Reserve promotion credit?

A. There is none. They are entirely different things. Under certain conditions you may get both kinds of credit for the same piece of work; under other conditions you may get only one, either promotion or retirement. For instance, Officer A, taking a 12-point (retirement), one-unit (promotion) correspondence course appropriate to his classification will earn both types of credit. Officer B, taking the same course, which is not, however, appropriate to his classification, will earn only retirement credit. If Officer A took the course while on active duty he would earn only promotion credit.

To earn retirement credit, a course must be taken while on inactive duty and after 1 July 1949.

To earn promotion credit, a course must be taken in grade, on either active or inactive duty, and at any date while in grade. So calculate your promotion credit and retirement credit separately.

Q. From what date are Reserve promotion units calculated?

A. From the date of rank in your present grade. Correspondence courses you completed in previous grades do not add promotion units for your next promotion.

Q. From what date are Reserve nondisability retirement points calculated?

A. From 1 July 1949.

Q. May a Reserve officer receive credit for courses that are not listed as appropriate to his classification?

A. Retirement credit, yes. Promotion credit, no. However, if classified S, see the following Question.

Q. What correspondence courses can a Reserve officer classified S take for promotion credit?

A. Any course approved for promotion credit. The S classification is so broad that it is impractical to attempt to limit the areas of study. The S officer should select courses that would aid him in his likely mobilization billet. He is the best judge of what those courses are.

Q. What correspondence courses can a Reserve officer classified A, AL, SA, WA, SA1, SA2, SA3, SA4, SA5, or SA6 take for promotion credit?

A. General Course for Aviation Specialists (2 units) and any other courses that grant another two units. An officer of any of these classifications should select courses that would aid him in his likely mobilization billet.

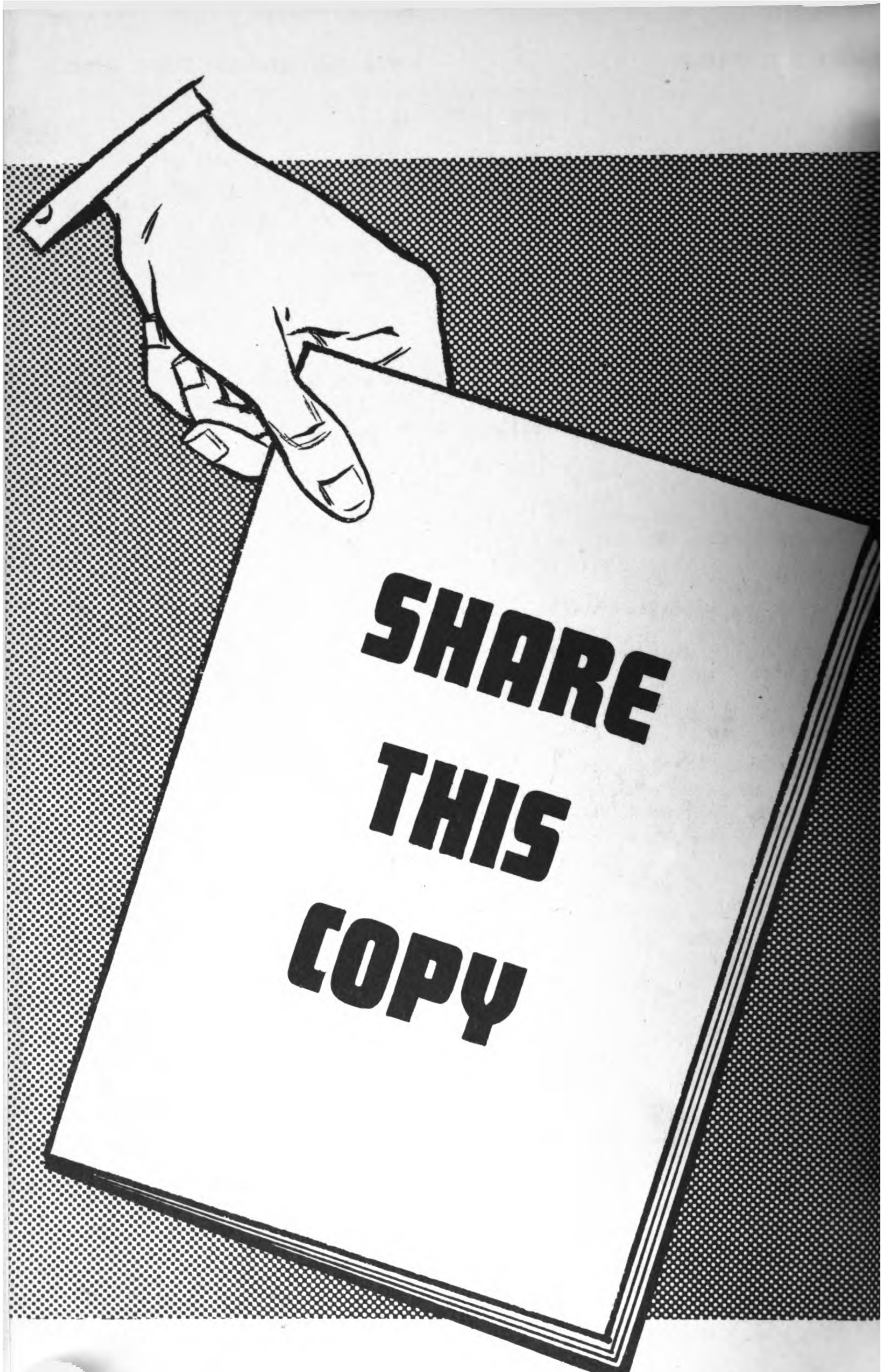
Q. I was promoted from Lieutenant to Lieutenant Commander in the Naval Reserve while enrolled in Navy Regulations, 1948, NavPers 10740-A. I completed three assignments prior to my new date of rank, and nine subsequent to it. In which grade are the two promotion units credited?

A. If you did not use the two units to qualify for promotion to Lieutenant Commander, they are credited to you in that grade, as you completed the course as a Lieutenant Commander. However, if you used the two units to qualify for your promotion, you will receive no promotion credit for the course in your new grade of Lieutenant Commander.

Q. If part of a correspondence course is done in one "anniversary year," part in another, for which year are the Reserve retirement points granted?

A. Each assignment is credited to the year in which it was completed. Date of completion is the date the enrollee places the assignment in the mails. No credit is granted, however, until the entire course is completed. (LCDR J. A. Umhoefer, USNR, Training Division, Bureau of Naval Personnel, in U.S. Naval Training Bulletin, March 1950.)

U. S. GOVERNMENT PRINTING OFFICE : O—1950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