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RESEARCH REVIEWS

Table-top Warfare

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DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: These two young ladies are studying their next move in the air war game described by Dr. Thrall on pages 9 to 14. Since John von Neumann and Oskar Morgenstern promulgated their "Theory of Games" in 1927, games of strategy have become valuable tools of research, with practical applications as well. They're still fun, though. The set in the picture is easy to make. The boards are photographic blow-ups of the chart on page 11, a baffle (not shown) was cut from cardboard, and the pieces are ordinary washers painted red and blue.

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

Approved by Bureau of the Budget, 14 February 1952

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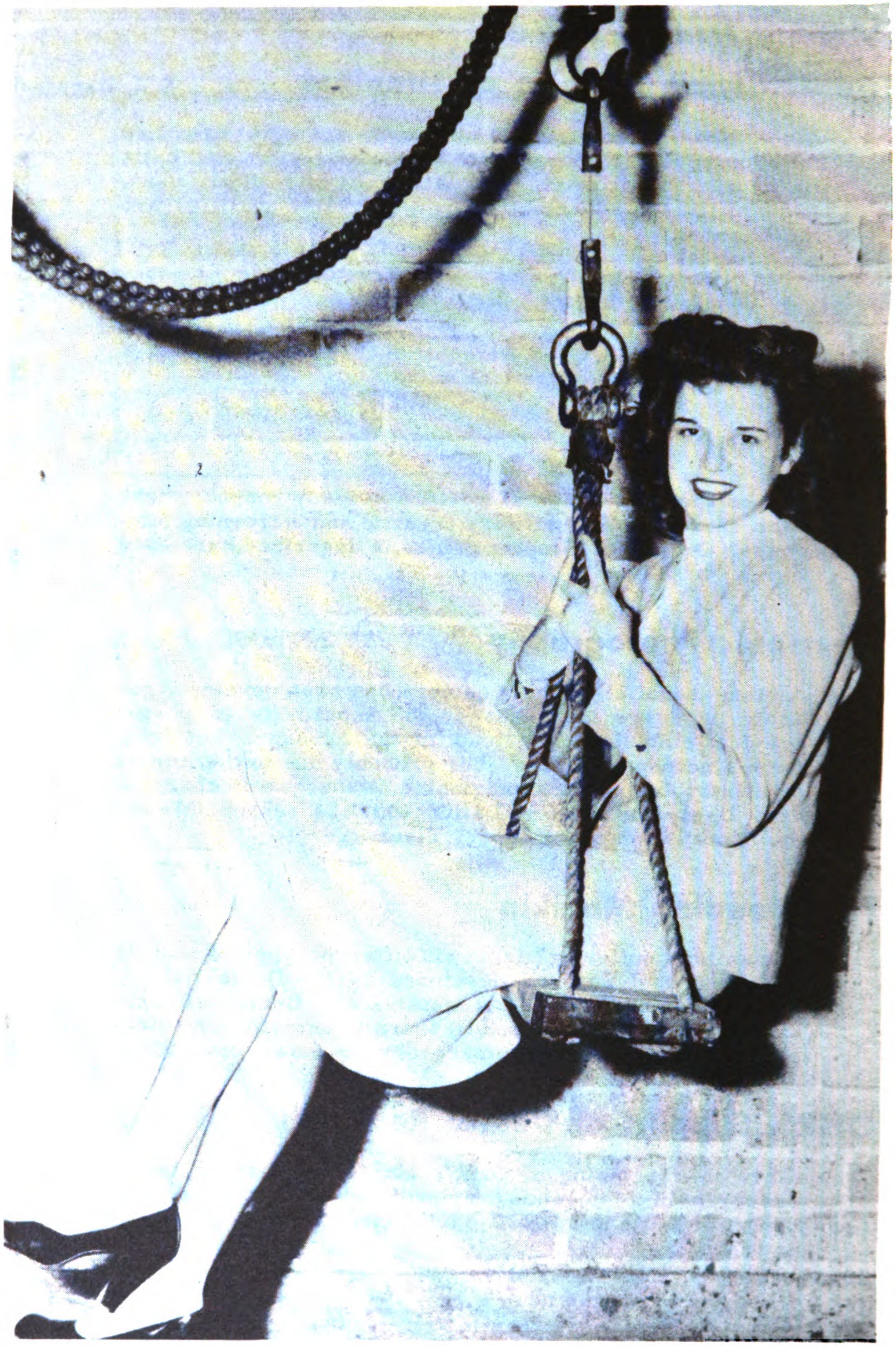

A thin wire of titanium supports the young lady above. Because of the high strength-to-weight ratio, as well as other valuable properties, the military need for this metal and its alloys is great. Production at the present time lags far behind demand, but is catching up.

The Growing Promise of Titanium

Julius J. Harwood

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Material Sciences Division, ONR

The most widely publicized metallurgical development of the past decade has been the production of ductile titanium. The "wonder metal," the "Titan of metals," and other equally glamorous terms applied to titanium are evidence of the excitement it has stirred. Although continued study has sobered early over-enthusiastic claims for the metal system, there is no doubt that the future position of titanium in our metal industry is firmly established. Undeniably there are attendant uncertainties and difficulties, but these result largely from the attempt to develop an entirely new industry in a fraction of the time normally required.

What are the characteristics of this metal that have inspired the widespread interest in its engineering development and exploitation? One of the most significant is the high strength-to-weight ratio of titanium and its alloys. Even in the unalloyed state it compares favorably with most of the well known structural metals and alloys. But intensive development has produced alloys with strengths twice that of unalloyed annealed titanium, and continued study may result in useful alloys with much greater strengths up to 200,000 psi. These alloys exhibit strength-to-weight ratios significantly higher than that of the high-strength aluminum alloys and closely approaching or equal to the values for very high-strength quenched and tempered alloy steels. Comparing equal volumes of material, commercially pure titanium has twice the strength of pure iron and six times that of pure aluminum.

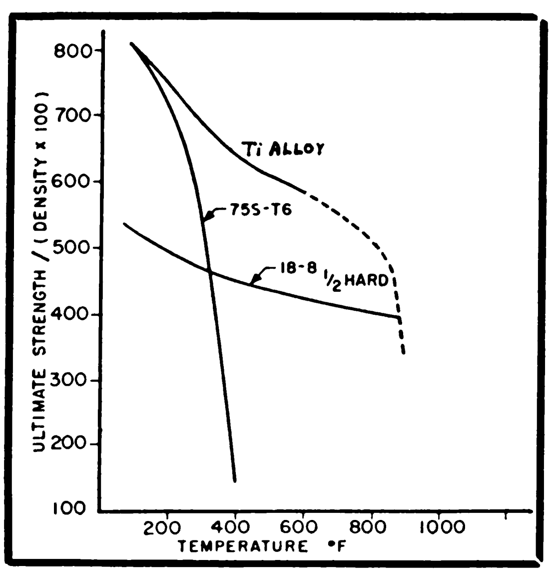
Another important characteristic of the metal and its alloys is fatigue behavior. It has now been established that titanium exhibits one of the highest fatigue strength : tensile strength ratios of all known structural metals. As compared to ratios for steel of 0.45 to 0.55, flexural fatigue tests of unnotched titanium bars show ratios as high as 0.8 at room temperature. In addition, the fatigue strengths themselves are comparable to those of steel. This characteristic is of obvious importance in aircraft applications. The fatigue properties of titanium alloys are considerably superior to high-strength aluminum and magnesium alloys and to many commercial alloy steels. The notch-fatigue performance of titanium also shows up favorably. Even at temperatures as high as 1000°F, titanium alloys exhibit fatigue strengths equal to at least one-half of their tensile strengths.

Like steels at low temperatures, titanium and titanium alloys exhibit a transition from ductile to brittle behavior, but the change-over temperature for titanium is considerably higher than for most steels. However, unlike steels, within the so-called brittle fracture range, even at temperatures as low as -100°F, titanium alloys exhibit an appreciable impact resistance or toughness characteristic. Alloys which exhibit remarkable impact properties, even at subzero temperatures, have led to serious consideration for ballistic and armor plate applications. In general it can be stated that titanium exhibits useful engineering toughness characteristics from -100° to 600°F and higher.

From a naval point of view, one of the most remarkable assets of titanium and its alloys is their complete inertness to marine environments. After much testing, it has been concluded the marine corrosion resistance of titanium is unsurpassed by any of the common structural materials and is equalled only by the precious metals and Hastelloy C. Titanium is highly resistant to quiescent sea water as well as to water moving up to 27 feet per second. Rotating spindle tests in sea water at speeds of 1,140 rpm (peripheral speeds of 26 feet per second) for more than 60 days indicated negligible corrosion attack. Although the metal fouls in sea water, no pitting has been observed. Other strenuous corrosion tests produced the same results. In cavitation-erosion tests, titanium was almost equal to the best of a series of alloys which were considered good marine propeller materials because of their outstanding resistance to cavitation attack.

With respect to other corrosive environments, resistance is also good. Titanium has excellent resistance to nitric acid of all concentrations, including fuming nitric acid at all temperatures up to the boiling point. It is resistant to dilute solutions of sulfuric and hydrochloric acids up to 100°F, and, with iron or copper salts as inhibitors, it can be used in more concentrated solutions of sulfuric acid and hydrochloric acid up to the boiling point. Titanium is very resistant to aqua regia, to ferric and copper chlorides, and to strong bleaching agents containing hypochlorites. It has exhibited outstanding resistance to contact and crevice corrosion and intergranular corrosion. Only red fuming nitric acid has been found to produce stress-corrosion cracking in titanium! These and many other chemical and corrosion characteristics indicate that the metal will be useful in numerous applications now requiring highly alloyed and expensive materials or frequent maintenance.

The high-temperature properties of titanium are intermediate between those of aluminum and steel, and the strength : density ratio offers opportunities for appreciable weight savings. Consequently we may anticipate substitution of titanium alloys for aluminum alloys, steels, and stainless steels in appropriate applications where weight-saving and temperature resistance are of major importance. So far, investigation of titanium alloys indicates that 800°F is the upper temperature limit at which useful engineering properties still exist. However, alloys now in the development stage may raise this limit to 1000°F. Some of the temperature-limiting features are poor oxidation resistance above 1200°F and the embrittling effects of oxygen and nitrogen at these temperatures.



Comparative strength-weight-temperature relationships

Just as important as these outstanding characteristics is the question of availability and production of titanium. Although difficulties are encountered when it comes to extracting the metal from its ores, in actual quantity titanium is the ninth most abundant element and comprises about 0.65 percent of the earth's crust. The two most important sources are rutile (titanium dioxide) and ilmenite, a ferrotitanate. Ample deposits of ilmenite are found in New York, Florida, the Carolinas, Idaho, and in Canada. Rutile, though not as plentiful, is present in substantial deposits in Virginia.

These specimens were exposed to brackish salt water to determine the resistance to pitting attack from common packing materials. Titanium shows no deleterious effects

Although titanium was discovered about 1800, not until 1946 was a workable process developed by Dr. William Kroll of the Bureau of Mines for the preparation of ductile titanium. The first commercial plant was completed in 1948, and this process is still the only one used for the commercial production of titanium. Basically, the Kroll process involves the exothermic reaction of titanium tetrachloride with magnesium to form metallic titanium and magnesium chloride. To prevent contamination of the metal, the reduction is carried out under an inert gas atmosphere. The reaction takes place at about 800°C (1475°F) in a steel pot. When the reaction is completed, the bulk of the magnesium chloride is drained out of the reaction chamber as a liquid, and the remainder, with any unreacted magnesium, is subsequently removed by a high-temperature vacuum treatment. The metal titanium remains as a spongy mass which serves as a starting material for subsequent solidification treatments.

Up to five tons per day are being produced commercially by this process in a "batch" type of operation. The present price of titanium is $5. per pound for sponge and from $15. to $30. per pound for mill products depending upon the shape, size, and thickness. Obviously, the major obstacles limiting the full-scale military applications, and conversely the full-fledged growth of this infant industry, are these high prices and the limited availability of the metal. To help remedy this situation, the Defense Minerals Production Authority has provided financial assistance to several companies (the DuPont Company, the Titanium Metals Corporation, and the Crane Corporation) for the construction and operation of production plants. It is hoped in this way to provide enough titanium to meet military needs which are estimated as 25,000 tons for 1954.

The need for lower cost production has stimulated an enormous amount of industrial development. Several new processes are in the pilot plant stage, and it is expected that within the next two years lower cost processes will be entering the production picture. One of the paradoxes facing the titanium industry is the reluctance of producers to expand their production capacity despite the immediate market which far exceeds present availability. They are afraid that a simpler and lower cost process will be developed.

Sponge titanium produced by the Kroll process serves as the raw material for further consolidation and fabrication into useful shapes and products. Because of the extreme reactivity of titanium in the molten state with all known crucible and mold materials and because of the necessity for using inert atmospheres to prevent gas contamination and embrittlement, conventional processes and techniques could not be used. In the early stages of development titanium and its alloys were fabricated from powder by powder metallurgy (pressing and sintering) techniques. But the development of arc-melting and induction-melting techniques has practically eliminated, with one or two exceptions, research and development work on powder metallurgy processing of titanium. Practically all ingot titanium is now made by arc-melting, which is used for both the metal and its alloys.

Continuous casting arc-furnaces have been developed, and titanium ingots weighing as much as one-half ton have been produced. Since it appears that the ingots will be processed chiefly in steel mills, we can anticipate the development of larger ingots for more economic fabrication. One disadvantage of the process is the insufficient homogeneity of arc-cast titanium alloys. This factor must be improved before we can expect wider acceptance and application of the alloys.

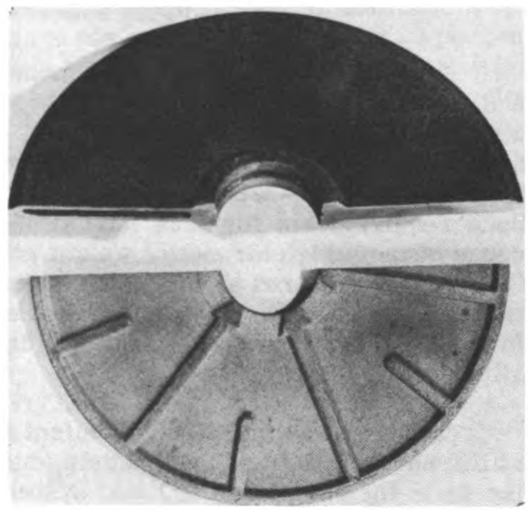
The machining characteristics of titanium most closely resemble those of the stainless steels. Especially in the early stages of development, much difficulty was experienced in ma hining. However, by using methods especially adapted for titanium, and by the development of suitable lubricants, many of the problems are being overcome. Because of the high rate of wheel wear, titanium and its alloys are difficult to grind. Galling and seizing have been particularly bothersome problems. The ease with which titanium sticks to metal surfaces is also causing concern for some proposed applications. Intensive research is now under way for the development of lubricants and surface treatments to eliminate some of these difficulties.

Welding still remains as another major problem. Pure titanium can be successfully welded by resistance or inert gas-shielded arc methods. Obviously, because of its reactivity, care must be exercised to prevent hydrogen, oxygen, and nitrogen from coming in contact with hot titanium, or else brittle welds will result. However, in the case of titanium alloys, ductile weldments are the exception rather than the rule. The problem of the welding of titanium alloys is intimately associated with the state of understanding of heat-treatment of these alloys. Much research is going on to learn how to heat-treat alloys so as to avoid embrittlement.

It would be highly desirable if casting techniques, similar to those used with other engineering metals, could be applied to titanium. The areas of potential application would increase manifold if shapes of titanium could be cast directly, not to mention the reduction in price if costly machining and fabricating processes could be eliminated. As the case with melting titanium ingots, contamination is a terrific problem. Molten titanium reacts with all known crucible and mold materials, and vacuum or inert atmospheres must be used.

The most promising method which has been developed to circumvent these problems is the "skull-melting" process in which titanium actually is melted within itself. Water-cooled copper or non-metallic (graphite or ceramic) crucibles are lined with a shell or skull of solid titanium. This skull holds the molten pool and reduces pick-up of embrittling impurities. Arc-melting techniques are employed with skull melting and the molten pool within the skull is then poured into a mold. The pouring operation is often done within the arc-furnace so that the entire melting and casting procedure is carried out under vacuum or inert atmospheres. Because of the rapid heat transfer of the water-cooled copper container, only a limited amount of metal is molten at any time and only small castings can be made.

Castings ranging from 10 to 100 pounds have been produced by skull-melting techniques with interesting properties. Mechanical properties have compared favorably with wrought alloys of similar compositions. Carbon pick-up has been held down to non-detrimental amounts. Skull-melting techniques are being applied also to the production of ingots, and it appears that the process will be developed into a useful commercial process.

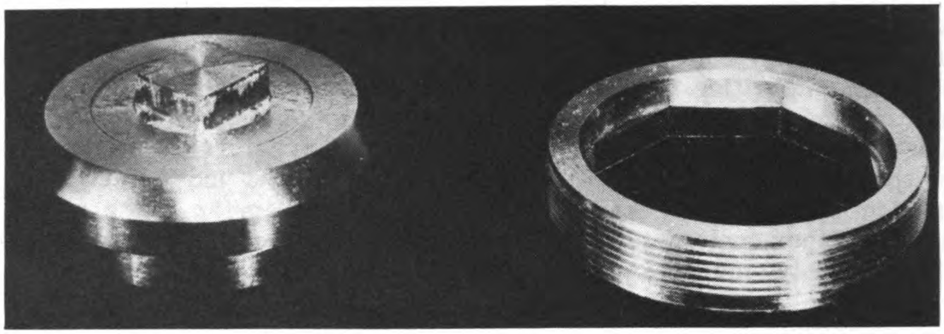


Titanium filter for fuming nitric acid

Despite the minor attention being given to the processing of titanium by powder metallurgy, methods have been developed by at least one industrial concern for pressing titanium compacts to theoretical density. Recent tests have indicated that such compacts exhibited properties equivalent to those of arc-melted material. This pressing operation is now being expanded for the production of titanium ingots, and sizeable ingots have already been produced on an experimental scale.

It seems reasonable to expect that applications exist for titanium alloys for which appropriate use of powder metallurgy processes may solve fabricating problems. By resorting to direct pressing methods and thereby omitting the cast-ingot and subsequent processing stages, it seems conceivable that the present high cost of some titanium products could be reduced substantially.

An excellent example of the use of powder metallurgy methods in appropriate applications is the titanium filter above. This filter is being employed for applications involving fuming nitric acid. Whereas such filters perform satisfactorily after 700 hours operation in fuming red and white nitric acid at 160°F, stainless steel filters under similar tests were disintegrated in four to seven days. The filters are pressed in two separate halves and then the two plates are joined together at the edges by a self-sintering process. Valve bonnets and seats have also been fabricated by powder metallurgy processing.



Valve bonnet and seat

In spite of the difficulties encountered in processing titanium, the end product makes the effort definitely worthwhile. Titanium is a "natural" for many military uses. In fact, it is anticipated that for the next several years practically all the titanium production will be used in military applications—for prototype evaluation and for production items. Such requirements for 1954 have been announced as 25,000 tons. Because of their high strength : weight ratio and their mechanical properties at temperatures as high as 800°F, the primary large-scale use of titanium and its alloys will probably be found in the aircraft industry. In many cases, the weight saving and high temperature properties of the alloys offset the present high cost.

Titanium has proven an excellent material for aircraft engine firewalls, shrouds, baffles, diaphragms, ductwork, brackets, and fittings adjacent to the engine and exhaust system. In the standard firewall test, both titanium and stainless steels satisfactorily withstand a 6-inch-diameter flame impingement for at least 15 minutes, with the temperature approaching 2000°F at the impingement point. Headway is also being made in applying the alloys as structural airframe components: in airframe skins, wing edges, ducting, aft sections, shrouds, door and panel assemblies, and many other places. The new Douglas DC-7 uses some 600 pounds of titanium, the major use being for engine nacelle coverings.

The aerodynamic heating and high surface temperatures which occur with missiles and supersonic planes almost necessitate the use of titanium alloys. The skin temperature of a jet plane flying at 1400 miles an hour may rise as high as 450°F; at higher speeds surface temperatures of missiles can rise to 900°F. Since aluminum and magnesium alloys lose their structural usage above 300°F, plans are under way to use titanium for skins, leading edges of wings and fins for supersonic aircraft and missiles.

One of the more important applications developments is the use of alloys for gas turbine compressor components—discs, blades, and stator vanes. A 300-pound weight saving (representing up to 40 percent of the total weight) could be achieved by substituting titanium alloys for stainless steel in these applications. Research is also under way on titanium propeller blades and landing gear components made of titanium alloy forgings.

The outstanding resistance of titanium to sea water and marine environments, together with its light weight and fatigue resistance, immediately points to extensive shipboard uses. Although present prices are a discouraging factor here, considerable prototype testing and evaluation is under way. Some of the uses being studied are: titanium seats and disc trims in salt-water valves, tubing for condenser systems and heat exchangers, wet exhaust mufflers for submarine diesel engines, and turbine blades for low-temperature steam turbines. Because of its high corrosion fatigue resistance and freedom from pitting, titanium has been considered for salt-water pump shafts, small outboard propeller shafts, and snorkel tubes, and as hull material for small craft such as PT boats.

As for ordnance applications, use of the metal in 81-millimeter mortar base plate has been widely publicized. The substitution of titanium for steel has cut the weight from 47 to 24 pounds, making it possible for one man to carry the base plate and increasing by 50 percent the fire power per man. The important weight saving advantages have attracted further military interest for airborne and man-carried equipment. The Bureau of Ordnance is considering its usage in gun, guided missile, and armor plate programs. There is no question that, as production increases and prices become lower, the military applications of titanium will increase tremendously.

New Chairman of ONR Advisory Panel for Microbiology

Dr. J. R. Porter, Chairman of the Department of Bacteriology, School of Medicine, University of Iowa, has been appointed Chairman of the Office of Naval Research Advisory Panel for Microbiology. In addition to Dr. Porter, members of the Panel are: Dr. W. J. Cromartis, University of North Carolina; Dr. N. F. Conant, Duke University; Dr. Emil Mrak, University of California; Dr. H. R. Morgan, University of Rochester; Dr. W. J. McElroy, The Johns Hopkins University; and Dr. H. P. Treffers, Yale University.

Dr. Porter is the author of an authoritative text and reference book on the physiology of bacteria and is Editor of the Journal of Bacteriology. He is a member of the Council of the Society of American Bacteriologists.

The fall meeting of the Panel was held in Washington, D. C. on 7 and 8 December. Applications for the support of research in the field of microbiology were reviewed at this time. The Microbiology Branch of ONR, which is headed by Dr. Roger D. Reid, includes in its program projects in bacteriology, virology, parasitology, mycology, and immunology. At present this branch has under supervision 80 contracts with 55 universities in 27 states.

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CAPT A. B. Cook

Who's Who in Naval Research

The head of ONR's Military Services Division—Captain Albert B. Cook—is a jovial man with many a good story on tap to temper the serious task of naval administration. He came to his present position in August 1951 after almost two years as Director of the Research Reserves. Besides this Program, which is still under his cognizance, he is responsible for mobilization and war plans, security for all of ONR, and military personnel.

CAPT Cook was born and raised in Kentucky. He was appointed to the U.S. Naval Academy from his home state and was graduated in the class of 1921. After five years of sea duty on the TEXAS battlewagon and the submarine tender SAVANNAH, he decided in favor of "dry land" for a time. So in 1926 he changed his field and became associated, as plant engineer, with Foster and Kleiser, an outdoor advertising firm in Los Angeles. Then in 1933 he accepted a position as engineer and assistant to the president of a carbon dioxide and dry ice concern, the Witt Ice and Gas Company in Los Angeles.

The year 1941 found him, as LT Cook, back in the Navy at the Bureau of Ships where his duty lasted two years. Then came three years sea duty on the USS WASP (CV) in the 3rd and 5th Fleets, as First Lieutenant and Damage Control Officer. For six months after that, now CDR COOK, he was stationed at the U.S. Naval Shipyard, Long Beach, in small craft planning. From 1947 to 1949, while in the inactive organized reserve, he owned and operated a chain of Ship Service Stores at Naval Reserve Armories in the Los Angeles area. In March 1949 he was ordered back to active duty. After short-term service as Volunteer Reserve Program Officer in ONR Pasadena and ONR San Francisco, CAPT Cook came to ONR Washington in January 1950.

He and Mrs. Cook live in Arlington, Va. They have an 18-year-old daughter who attends Mary Washington College. Their only son was killed at the age of 19 in the Battle of the Bulge. CAPT Cook became so fond of California during his working years there that he bought a farm in the San Gabriel Valley, where he plans to retire. He is an avid Navy football fan and rarely misses a game. (SGF)

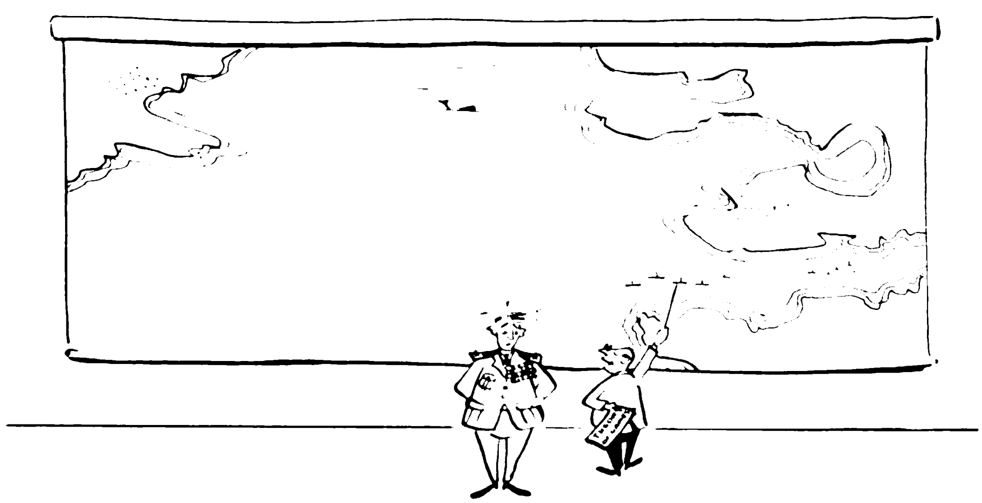
An Air War Game

R. M. Thrall

Associate Professor of Mathematics at the University of Michigan, is Director of an ONR contract on applications of mathematics to the social sciences. His chief interest is abstract algebra.

It is likely that many a primitive man, who continually had to take a chance in a life full of hazards, found some pleasure from time to time in taking chances that were a test of skill, strength, or cunning. Thus the activity became a game rather than a task involving risk related to more mundane aspects of primitive life. Gradually more sophisticated games of cunning or intelligence developed with certain kinds affording pastime in the home, the village square, or other places where people got together. These were forerunners of our present "parlor games."

Games giving unusual opportunities for intellectual exercise or strategy also date back centuries. Chess in some of its early forms was played by the Chinese and Indians long before it was so popular with the Persians in the seventh century. Gypsies are said to have brought playing cards out of the East to the Saracens and Arabs before



the thirteenth century. On the other hand, the well known game of poker is alleged to be an American invention and is only something over a hundred years old. Bridge is even newer.

New implications were brought to games involving chance and strategy in 1927 when John von Neumann came out with his "Theory of Games." He published a comprehensive paper on the subject the following year, and since then there have been hundreds of technical articles and popular discourses on the Theory of Games. More recent interest in the manner in which the theory fits into probabilities, statistics, and applied mathematics has been confined largely to games that involve strategy and do not rely upon pure chance for the outcome. Thus attention has been directed to a whole series of games extending some of the ideas of chess; other completely different and novel kinds of games also have been advanced for the purpose of adding to the theory and widening its applications.

Because the theory is so interwoven with ideas of strategy, the procedure has been to select "not strictly determined games"—that is, games in which it would be disastrous if a player's strategy were discovered by his opponent. To carry the reasoning further, if a player finds during the course of the game that detection of his course of action would be disastrous, he then can take steps to protect himself by avoiding the use of a pure strategy. Von Neumann has demonstrated in the development of his theory that there is a "stable" or rational course of action that represents the best strategy. Such a strategy would involve mixing pure strategies according to certain probabilities.

Theory holds that the substitution of statistical strategy makes the discovery of the action by an opponent impossible. It is contended that if a player is to conceal his chief aim from his opponent and prevent any leakage of information, then it is best for the player not to have the information himself. Thus the player does not choose a precise course of action; he resorts to the use of various possible alternatives which in turn are influenced by different probabilities.

Because probability is such a vital factor in determining final action, the player himself does not know the final outcome until he makes the decisive move—likewise the opponent will not know. This type of indecision is a well-known empirical fact. When the advantage lies in not having one's intentions detected, people resort to evasion, try to create uncertainty in the minds of others, produce doubts, and at the same time try to detect the plan of action of the opposition.

While perhaps the major effort in recent years on the Theory of Games has been to bring out concepts of strategy and related military problems, there are also applications in the fields of screening and training. Personnel readily adept in complicated problems of strategy could perhaps be selected out of groups through the use of games combined with other criteria. The training possibilities for those who face problems of strategy continue to grow as more work is done on the Theory of Games and additional games are invented to bear on situations increasingly diverse and complex.

As an example of a game with applications to modern warfare, a description and rules for playing are given along with a chart which sets up the basic field of play.

The game described here is the simplest one of a battery of simulated war games developed at the University of Michigan.* This is a game with incomplete information. The equipment consists of two identical boards with hexagonal fields (see top of next page); a removable

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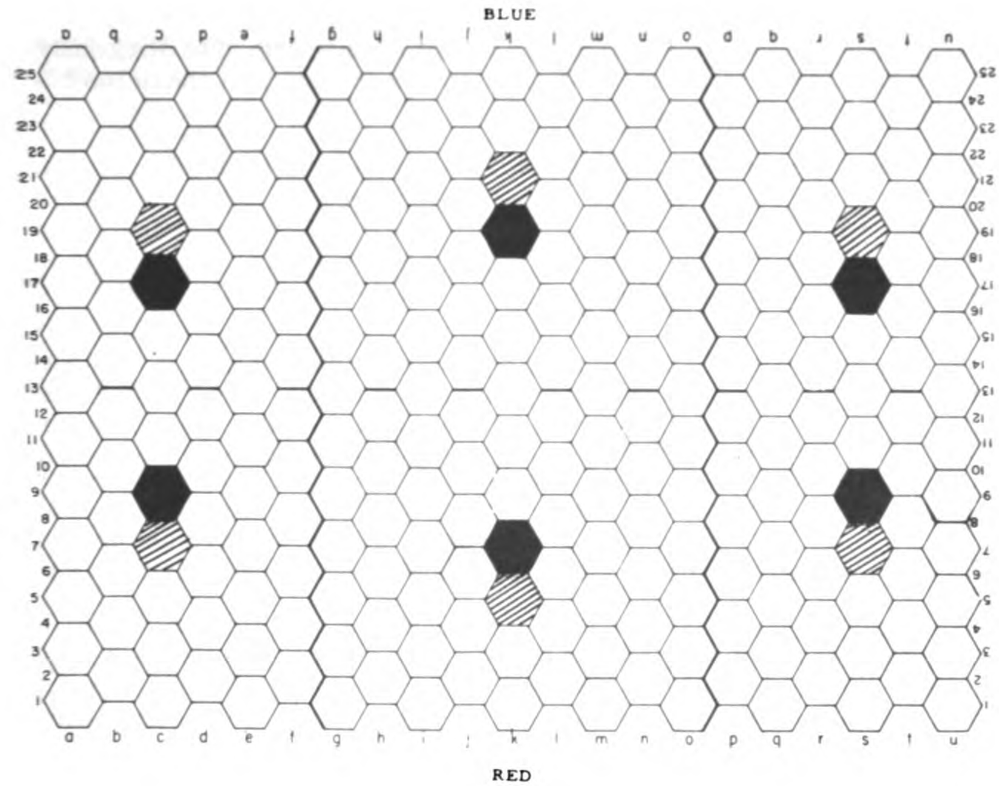
*See R. Lowell Wine, Report No. M965 R2, Some Air War Games, Engineering Research Institute, University of Michigan, Ann Arbor, Michigan.



The board (greatly reduced in size). Two of these are used in playing the air war game.

barrier; and plastic disks or small poker chips—one hundred of each of two contrasting colors, say red and blue.

At the beginning of the game the playing territory is divided into three regions. Horizontal layers 1 - 11 belong to player Red, layers 12, 13, 14 constitute no-man's-land, and layers 15 - 25 belong to player Blue. The two vertical lines, which divide the play areas into three parts, are there solely to facilitate location of fields. Each player initially is given 30 units (chips) of his own color and with the barrier set up (for secrecy) he places these units at will in his own territory, subject only to the condition that there be no more than three units on any one field. The barrier is then removed and each player duplicates his opponent's position on his own board. The game now proceeds in cycles each of which has the following stages:

(1) Moves, with barrier in place
(2) Information stage
(3) Aim fire
(4) Remove dead
(5) Production

The object of the game is to kill all of the opponent's units. In practice a player will resign if he loses possession of a city without adequate compensation. Each player has three cities and three adjacent airports. Fields c9, k7, s9 are the Red cities and fields c17, k19, s17 are the Blue cities—the solid-shaded fields on the board. The diagonally-shaded hexagons are airports—fields, c7, k5, s7 are Red and fields c19, k21, s19 are Blue airports.

The stages of play within each cycle are now described.

(1) MOVES

With the barrier in place the two players move simultaneously in accordance with the following rules.

Infantry units. Each unit is an infantry unit unless it has been designated (for one move only) as an airborne unit. In a "move" each infantry unit is moved to an adjacent field or allowed to remain where it is. Two fields are said to be adjacent if they have a boundary in common.

Airports. Airports may be contested or uncontested and may be possessed by either player (see (6) below for airport activity rules).

Airborne units. If a player possesses an uncontested airport he may either designate one unit on that airport as airborne and then move it to any field not adjacent to an airport or city possessed by the enemy, or he may designate two units on that airport as airborne and then move them to any other airport in his possession.

When a move is complete there cannot be more than three units of one color on any field.

(2) INFORMATION STAGE

At this stage the barrier is removed and each player justifies his move to the other by playing his units on the opponent's board.

(3) AIM FIRE

A field is said to be bound if it is occupied by units belonging to both players. All units on a bound field must direct fire to that same field. A unit on an unbound field may direct fire to any adjacent field. A convenient way of "directing fire" is to push a chip or chips up to the boundary of the field at which fire is aimed. If either player requests secrecy the aiming of fire must be done in writing. (Ordinarily, this will be required for at most a few fields.)

(4) REMOVE DEAD

Let x denote the number of units of fire power directed by one player at a field occupied by t enemy units. Let y(x) be defined by the table

x	1	2	3	4	5	6
y(x)	0	1	1	2	2	3

If $t \le y(x)$ then t units are killed. If $t > y(x)$ then y(x) are killed. Putting it another way: An attacking force must have 2:1 superiority in one field to effect a kill there, but a defending or counterattacking force (t) need have only numerical superiority. Killed units are removed from both boards.

The killing is done simultaneously in theory so there is no real distinction between attack and defense. In practice, in one turn Red aims, kills, and removes the dead Blue units from his board; then Blue aims, kills, and removes the dead Red units from his board, and finally each removes his own dead from his own board. The next turn Blue aims before Red and so on. It seems to make little difference who kills first.

(5) PRODUCTION

Any uncontested city (see (6)) in the possession of its original owner has one new unit of his color placed on it provided that he has less than 3 chips on it after the stage immediately above.

(6) POSSESSION AND ACTIVITY RULES FOR CITIES AND AIRPORTS

A city is said to be contested if its field is bound after the "remove dead" stage. An airport is said to be contested if either its field or that of the adjacent city is bound after the "remove dead" stage. A city is possessed by whichever player last had uncontested occupation of it. Any airport belongs to that player who possesses the adjacent city.

We illustrate the aim fire and kill stage with some examples. We may indicate a position on the board by symbols such as $b10B_3R_2$ which means that there are three Blue units and two Red units on field b10. Consider the configuration $B8R_2$, $b10B_3$, $c9R_3$, $c11B_3$, $d10R_2$. Blue may direct all six units of firepower at c9 and kill the three Red units there. Red may direct four units at c11 and two units at b10 and remove three Blue units altogether. The seventh Red unit can contribute nothing at this cycle, but would be effective if the combat is continued in the next cycle. A second group $f16B_3R_1$, $g15R_2$, $g17B_3R_1$, $h18B_3R_1$ illustrates the bound-unit rule. Here each Blue unit lies on a bound field and must fire at the field it occupies. On the other hand Red can direct two units of firepower at each of the Blue piles and hence the kill is three each even though Blue outnumbers Red. The group $m17R_2$, $m19B_3$, $n14R_2$, $n16R_1$, $n18B_3$, $o15R_1$, $o17B_3$ is similar except that the Blue units are one field back relative to the Red units. This time Blue can kill all four adjacent Red units and loses only two of his own units. The group $r10B_1R_2$, $s7R_2$, $s9B_3R_2$, $t8R_2B_1$, $t10B_2$ illustrates the capture by Blue of a Red city. The best Red can do is to remove two Blue units from the city and one unit from each of the bound squares adjacent. Blue can remove both Red units in the city and one Red unit on t8. This leaves Blue with the only unit in the city and so he wins possession of it.

This game and others of the same general type are designed with the view of use for screening and training purposes. The equipment and rules have been kept simple so that the games are inexpensive and easily learned. They have been tried out on grade school children and were enthusiastically received.

The game has several features which make it resemble actual warfare more closely than most parlor games. The incomplete information in the game corresponds to incomplete intelligence in warfare. The features of simultaneous play and potential movement of each unit every cycle are realistic. The complete initial symmetry between the opponents is unrealistic, but the game can be varied—for example, by giving the opponents unequal number of cities, or unequal number of chips, and by allowing cities to be placed in unsymmetric locations. Indeed, some of the variants are so unsymmetric as to require aggressive play by one opponent while the other must play conservatively. The limitation of airpower to troop carrying is unrealistic, but more complicated versions of the game now under consideration introduce more variety.

John McDonald, whose "Strategy in Poker, Business and War" ran in Fortune and was later published in book form, concludes his treatise by saying, "The theory of games may sometime have practical application in many social fields. And yet even as theory, it has performed a service in defining the meaning of strategy."

ONR Contractor Receives

Albert Lasker Award

Dr. George Wald, Harvard University, a scientific investigator under contract with the Physiological Psychology Branch, ONR, is one of five individuals to receive the eighth annual Albert Lasker Award for his achievement in medical research. Dr. Wald has been under contract with ONR since October 1946 conducting research on the photochemical processes which control the response of the eye to light. He has been able to reproduce in the "test-tube" all the chemical processes which occur biologically in the retina in the bleaching of the visual purple and the reversible reactions in its transformation into retinene and vitamin A. He has also been able to identify the chemical composition of the various pigments of the retina and choroid and to show how these light-absorbing materials affect color perception.

In accouncing the awards, the American Public Health Association referred to Dr. Wald as having ". . . . given mankind a new picture of one of the most treasured gifts of life--the capacity to see."

CORRECTION

An error--the editor's--was made in Dr. M. G. Sevag's article on "Drug Resistance and Related Problems" which appeared in the October issue. The quantities on pages 21 and 22 should read mg/l and not mg/ml.

Electronic Photography

Kurt S. Lion

Associate Professor of Applied Biophysics at M.I.T., has done extensive work on physical instrumentation in medical research and on short-wave dosimeters.

The problem of electronic photography came to me many years ago in a very peculiar way. I was working on the development of a powerful tube for the acceleration of protons. Little was known at that time (1932) about the techniques of handling such accelerators, and to say that my tubes had short lifetimes is an understatement. They usually shattered with a crash as soon as the applied voltage exceeded 100 or 200 kilovolts, and only slowly did I get to the point of designing a tube that could withstand the voltage long enough to obtain a spectrograph of the discharge light. But every exposure was a suspense drama, and one never knew whether the experimental setup would stand up or what would give first: the tube, the high-voltage equipment, or the nerves of the experimenter. I would have given a lot at that time for a method to increase the photographic sensitivity by a factor of, say twenty or even two.

It appeared that I was not the only one in need of such a method. Increase in photographic sensitivity at low level of incident light is desirable for many uses. In the fields of spectroscopy or astronomy the available light levels are frequently so very low that costly optical systems must be employed to make up for the limited sensitivity of the photographic emulsion. In the field of X-ray radiography this problem is even more pressing. In some cases of industrial radiography the difficulties can be overcome through the use of powerful X-ray generators. But where only small X-ray machines are available (e.g. portable equipment) or where the object does not permit the use of large X-ray doses (as in medical radiography) this method cannot be applied, and the only possible solution of the problem lies in the sensitivity increase of the radiation detector.

These limitations are of equal importance in the field of X-ray diffraction applied to biological objects. The X-ray dosage necessary to furnish a diffraction pattern of a nerve can be large enough to destroy the nerve completely. Shortening the exposure time would not only enable one to get a correct picture of the molecular orientation in a living nerve, it might even give us the opportunity to study a nerve during the passage of an impulse through it, or a muscle fiber during the process of contraction.

For an increase of the photographic sensitivity, it is necessary to amplify the effect of the initial incident photons. In other words, rather than using the initial photons to do the blackening themselves, they would be used only to trigger or set off some more effective mechanism. Such a mechanism is well known in the usual Geiger counter, where every electron liberated by the incident radiation triggers a discharge, which in turn can liberate in the order of 10^8 electrons, which then are available to act on the photographic emulsion.

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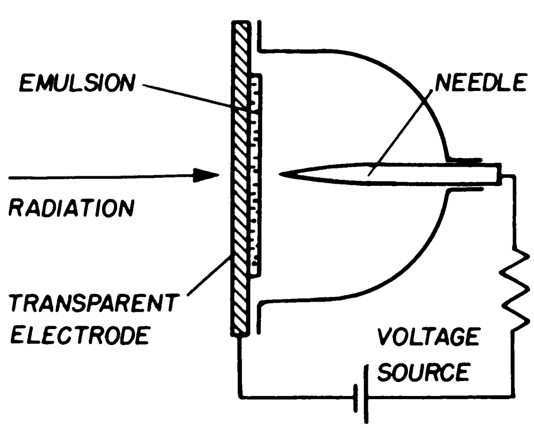
An arrangement of this kind for a single point is shown below. An electrode carries a photographic emulsion. The electrode may be transparent; for X rays it may be an aluminum or magnesium plate. A short distance from the emulsion is a needle electrode connected to a voltage source of, say 1,000 volts. The whole arrangement is enclosed in a vessel filled with an appropriate gas. If radiation enters the space between the emulsion and the needle electrode and liberates an electron in this region, then a powerful discharge will be set off like the one in a Geiger point-counter. This discharge would furnish a single picture point many times more intense than the tiny speck which the original photon could produce. By using multiple needle points in the form of a mosaic, a complete picture may be obtained similar to the one in the half-tone printing process.

In the beginning of our experiments nothing was known about the operation of such an arrangement. No Geiger counter had ever been built with a layer such as an emulsion in the discharge path, and it was very questionable whether such a counter would operate at all. Other problems entered the picture. Would the discharge produce a large blot on the photographic emulsion, or would the blackening be limited to a small point that permitted high resolving power of the picture?

It turned out that the discharge could be made to behave reliably. It furnished a picture point on the photographic emulsion that was almost miraculously small, like a pin point, and that showed a regular increase in blackening with increased exposure time. But one great difficulty remained: the discharge process seemed contagious and spread from one picture point to the other. This disease remained for a number of weeks, when one day by the proper choice of gas we succeeded in avoiding this spreading completely. Only those needle elements which were met by an incident X-ray radiation showed a discharge and produced a mark on the photographic emulsion. Two such pictures taken with a mosaic electrode are shown on the next page.

Once the idea appeared to be workable, we tried to replace the series of points with a simple flat plate, and trust the discharge itself to produce a well localized photographic effect without any help from concentrating points. It was found that in a setup such as a plane-parallel Geiger counter with film on one of the electrodes, the discharge tended to produce a well localized blackening, occurring just where the X rays entered the counter. With such a counter camera it was possible to take pictures in one hundredth the time required for the X rays themselves to produce the same image. Thus the plane-parallel-counter camera was developed for achieving large increases in the sensitivity of photographic emulsions. At this point we began to devote all our efforts to studying



Experimental set-up for single point counter camera.

Radiograph picture (left) taken with mosaic electrode. The object is a "T" shaped opening in a lead block. X-ray radiograph (right) taken in the plane-parallel-counter camera. The object is a fine mesh bronze screen and a square steel nut.

this form of camera, as it is simpler and more useful than the earlier mosaic electrode.

What produces the remarkable intensification and resolving power of this method? In order to answer this question it was necessary to study the phenomena occurring in a plane-parallel-counter camera using the arrangement shown on page 19. If the voltage applied to the electrodes of such a camera is low, one observes in the oscilloscope a sequence of small sharp pulses. These pulses are all of different magnitude and in the order of several millivolts. They are triggerable; that means they occur only when radiation enters the camera, and they disappear when the X-ray machine is turned off. At a somewhat higher voltage these discharges begin to grow into much larger, still sharp pulses which eventually are all of equal amplitude in the order of several volts. With further increase of the applied voltage, these pulses attain the form of sparks if both electrodes are of metal, or if there is only a thin film of emulsion on one electrode. As with the small pulses, the larger ones also appear only when radiation enters the camera and disappear when the X-ray machine is turned off. Finally, if the voltage is raised too high, the discharge will not cease once it has been initiated. Even with the X-ray machine turned off, it will continue.

For an understanding of the mechanism leading to the formation of a picture it is necessary to explain this rather complicated behavior. First there are the small pulses; they are evidently due to a moderately simple process. An X ray enters the chamber and ionizes a gas molecule (or liberates an electron from the walls of the electrode). The resultant electron and ion go off towards the attracting electrodes. They collide with other neutral molecules, ionize them by collision, thus producing new electrons and ions which in turn produce further ionization. Thus an avalanche develops, which appears as a sharp pulse in the oscilloscope. The eventual size of the pulses is proportional to the amount of original ionization, and once the charges are collected on the electrodes, the discharge ceases.

If the voltage applied to the camera is now raised, a new process sets in. The electrons and ions acquire more energy between two consecutive collisions, a fresh supply of electrons is made available from the discharge mechanism itself, and the discharge becomes self-sustaining. The new electrons may be liberated from the cathode by photons generated in the discharge, or they may be generated in the gas itself by photoionization. The result of this ionization is a continuous growth of the pulse to a size which has now become independent of the primary amount of ionization.

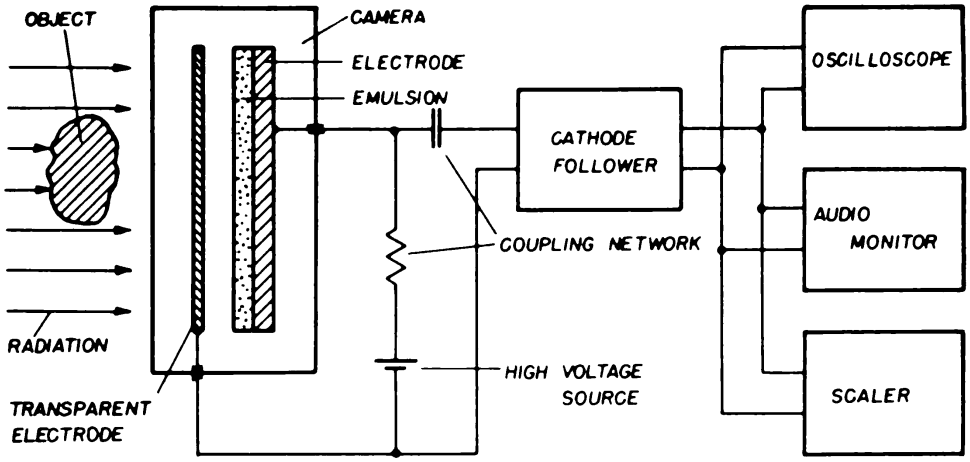
This describes the genesis of the so-called Geiger pulse. What now terminates the discharge? There are various reasons why a discharge may be choked off somewhere in its development. In the plane-parallel-counter camera the reason is the resistance in the photographic material. The larger the current in the discharge, the larger the voltage drop in this resistance, and the smaller the fraction of voltage which is available to maintain the discharge. Finally this voltage gets so small that the discharge can no longer sustain itself and ceases; and since this occurs for any one counter arrangement at the same voltage level, it is evident that all Geiger pulses are of equal size.

If the resistance in the circuit is small, the voltage available for the discharge remains above a critical value long enough to permit the pulse to grow before it is choked off so that the discharge assumes finally the brilliant glow and the character of a spark.

If the voltage is raised further, with or without adequate resistance in the circuit, new effects will enter into the process, which will re-initiate the discharge. A continuous discharge form will then be observed.

As to the actual process of picture taking, there are two important facts to consider. First, the proportional pulses do not appear to have any photographic effect, only the Geiger pulses (and, of course, the sparks) affect the emulsion. (The spark produces a very intense blackening of the photographic emulsion, but the pictures thus produced show little resolving power.) Second, whatever produces the picture does not penetrate very deeply into the emulsion. This could be demonstrated by a simple experiment. A photographic film was exposed to several discharges in the counter camera. After development, cross sections were made through the film and observed under the microscope. It appeared that about one-third of the emulsion thickness was exposed, indicating that the exposure did not result from electrons and ions (which could never have penetrated the emulsion to any depth) but was very probably due to the impact of ultraviolet photons originated in the gas discharge, very likely the same radiation which is responsible for the propagation of the Geiger discharge.

One miraculous effect that needs some further explanation is the strict localization of the discharge process which causes the astonishing resolution of the pictures. In a Geiger counter of cylindrical geometry a discharge usually spreads in the form of a sheath along the entire anode wire. If this would happen in the counter camera, a picture would never be possible, but a blurred general balckening would result. A closer analysis shows that in a parallel-plate counter the discharge does not spread along the electrodes but is rather self-concentrating; the positive ion cloud which forms in a single avalanche tends to increase



Experimental arrangement for the study of the plane-parallel-counter camera.

the field strength in the direction of the force lines. Thus, a regular discharge canal is formed which is strictly localized in the immediate vicinity of the entering and discharge-initiating radiation.

The occurrence of the picture-producing Geiger discharge depends, of course, upon a great number of experimental parameters, such as applied voltage, electrode distance, gas type and gas pressure, the presence of a quenching agent and its concentration, the material of anode and cathode, the resistance of the photographic substance, and—as is generally known—upon the presence of traces of impurities. This does not mean that the operation of the counter camera is less reliable than an ordinary Geiger tube, but rather that the investigation of the effect is a slow and laborious process.

A great number of practical applications are expected from further development of this work. Most experiments so far have been made in the X-ray region, not only because of the considerable practical value of the method in this particular field, but because of experimental simplification. Yet in the field of X rays, a considerable improvement over our results obtained to date can be anticipated. We have worked so far only with unprepared metal plates from which the initial electrons are emitted. The electron yield per incident photon on such a plate is very low (order of magnitude 10^{-2}). By covering the metal surface with a luminescent substance which converts the energetic X-ray quanta into a great number of less powerful light quanta, thereby liberating electrons from these light photons, we anticipate a further gain in sensitivity in the order of 100 to 1,000 so that adequate radiographs may be obtained with very small X-ray units or even radioactive isotopes as radiation sources.

It is obvious that the liberation of electrons can also be accomplished by incident light if an appropriate photoemissive surface is used as electrode. In this case, it should be possible to obtain pictures at low light intensities, a process which is expected to be of help in spectroscopic and astronomic work, or in night photography.

However, it is not necessary to use photographic material of the silver halogen type. The discharge can be made powerful enough to produce traces on other substances which require no chemical development and processing of the usual type. Instead of photosensitive, luminescent materials can be used, and a fluorescent screen intensification could be obtained. Preparatory experiments in this field have been very encouraging. Such screens might be of considerable value not only for X-ray fluoroscopy but also on television screens, cathode-ray tubes, electron microscopes, and as image converters where an increase in light output is of value.

It is not necessary, of course, to produce the avalanche initiating electrons by photoelectric effect. Such electrons can also be obtained from cathode-ray tubes through Lenard windows so that the long-expected, high-speed oscillographic recording method may become a reality.

Besides all these practical applications, we expect a furtherance of the theory of the counter action primarily because the counter camera is an ideal means of studying the general counter discharge characteristic and its properties.

Navy Evaluates the Largest and Fastest Air Rescue Boat

The largest and fastest boat ever built for Air Rescue was delivered last month to the Air Force's Air Research and Development Command for technical evaluation by the Navy. The 94-foot craft was built by Detroit Basin, Inc., Detroit, Michigan. Pre-acceptance trials, conducted in the Detroit River on October 2, gave encouraging results. The new craft, capable of delivery to any part of the world under its own power, which eliminates deck loading on larger vessels, is now in Norfolk, Va. for further testing.

Powered by three 1500-horsepower marine gasoline engines, the boat has a 16-man crew. Evaluation will primarily consist of comparison between Navy P-T boats and 85-foot boats, used in World War II and Korea, to determine the most suitable rescue boat for Bureau of Aeronautics and Air Force rescue support.

The boat features a specially designed timber hull to provide increased speed and improved maneuverability. To decrease underwater drag, the propeller shaft and bearing are housed in streamlined casing. The craft is equipped with the very latest in electronics, including search radar for better navigation and to assist in the rescue of crash survivors in water.

It also features a transom gate across the stern, which can be lowered to water level to provide rapid means for rescue of injured survivors. To take care of survivors who need immediate first aid, a dispensary with complete medical facilities is an important added feature.

Expected to have a cruising speed of 25 knots and a maximum speed of approximately 35 knots, the boats will be placed in operation at the Air Proving Ground Command at Eglin Air Force Base, Florida.

The Bleeding Manikin

. . . a training aid designed and developed at the National Naval Medical Center, Bethesda, Md.

A new type of training aid has been developed for the use of naval dental officers in learning emergency casualty treatment so that they can assist the medical profession in case of necessity. A life-size manikin made of plastic reinforced with fiberglass, the training aid was fabricated from a sculptured model and so positioned on its base as to facilitate demonstrations of various first aid problems. Chiefly responsible for its development was CDR John V. Niiranen, Dental Corps, USN (shown in the photograph) of the Naval Dental School, National Naval Medical Center, Bethesda, Maryland.

Six problems likely to be encountered in cases of emergency or mass casualties can be visually demonstrated on the manikin, and the accepted first aid care administered. The problems are: A leg wound, an arm wound, an abdominal wound, a penetrating chest wound, choking caused by a foreign body in the throat, and bleeding from the mouth caused by a fracture of the jaw.

Making the manikin more lifelike, the "skin" over the body is vinyl (resilient) plastic cured by dry heat in metal molds. A fluid of glycerin, water, and red vegetable dye is used to simulate blood. A centrifugal pump sends the fluid from a storage tank in the base of the manikin to the sites of the simulated wounds. Individual valve adjustments control the rate of flow to each. The fluid is collected in drains and is returned to the storage tank to be used over and over again. The clothing for the manikin is fitted with snap fasteners to facilitate removal for laundering.

ONR's Support of Dental Research

Joseph F. Saunders

...Assistant to Head of the Dental Branch,
Biological Sciences Division, ONR

In the early days of "dentistry" it was believed that the most beneficial and desirable treatment often meant the extraction of all the teeth of the individual who had reached maturity. This attitude possibly resulted from the belief among many in the medical profession—which considered dentistry as nothing more than a "medical cult"—that infections of the teeth were basically responsible for most of the ailments of the human body. Enthusiastic pioneers of dentistry began investigations to prove or disprove this common belief and the impetus for formal research in dentistry was developed.

Later, the study of the mouth or oral cavity was focused primarily on mechanical principles of mastication and facial conformation. Little application of the principles of basic disciplines such as biochemistry or bacteriology was made to increase fundamental knowledge of the mouth, its structure, functions, and role in systemic diseases.

Today studies have broadened to extend into many fields previously uninvestigated. Many dentists are continuing postgraduate work in the basic sciences, and the fact that scientists of other disciplines are entering the field serves to expand the approach. The structure and function of the various parts of the oral cavity, the composition of its fluids and their relation to general health, its ability to ward off disease through enzymic and other defense mechanisms, improvement of clinical and surgical treatment procedures, and response to mechanical and chemical stimulae are only a few of the many pathways dental research now follows. Improved statistics and experimental design are also being applied to improve research methods.

Dental problems have been one of the major concerns to the Navy in its efforts to maintain proper health standards among its personnel. Little research in the problems of oral health was being conducted or supported by the Navy, however, prior to World War II. Naval dental research, at that time, was concentrated on clinical phenomena, although some coarse attempts were made at epidemiologic studies on caries prevalence. With the rapid expansion of the military services in World War II, the Navy and other services were faced with dental problems of a tremendously greater magnitude than had been known previously. Mounting evidence convinced dental personnel that greater support and consideration should be given to research in dental problems, for it would contribute materially toward curtailing many of these problems, treatment costs, and expenditure of dental man-hours.

Dental research by and for the Navy experienced a tremendous stimulus when the establishment of the Office of Naval Research was authorized by the 79th Congress on August 1, 1946. During the initial months of the Office of Naval Research, dental research proposals were submitted to the Medical Sciences Division. A naval dental officer from the Bureau of Medicine and Surgery was assigned additional duty with the Office of Naval Research in February 1947, to serve as a consultant on dental research proposals received by this Office. Later in 1947, the Secretary of the Navy approved the sponsorship of a full-scale dental research program by the Office of Naval Research to become effective in fiscal year 1949. Thus, the Dental Branch was created within the Medical Sciences Division and the dental officer consultant was appointed as Head of the Branch.

The responsibility of the Dental Branch is to encourage, promote, plan, and coordinate a firm program in fundamental research in the various fields of dental or oral health. The application of results of this basic research in dentistry should serve to promote better standards of oral health among personnel of the Navy, bring about the use of improved clinical and surgical techniques for the treatment of oral diseases and injuries, and permit better selection of personnel for the naval service. Further, the benefits of dental research promoted by the Office of Naval Research will contribute toward better standards of oral health in civilian populations.

The dental research program of the Office of Naval Research is carried out through contracts with non-profit civilian institutions such as dental schools, universities, hospitals, independent dental clinics, and others. A newly received dental research proposal is reviewed and evaluated by the Dental Branch and by the members of an appropriate advisory committee to determine the scientific adequacy, the feasibility, and the naval applicability of the proposed research. The advisory committees to the Dental Branch consist of eminent scientists in the various fields of dentistry and other basic sciences. Even though a proposal receives the approval of the advisory committees, final action is dependent upon a number of administrative conditions. Those proposals which are disapproved by the advisory committees normally do not receive support by the Office of Naval Research, although exceptions have been made.

The dental research program of the Office of Naval Research is made up of three major categories or programs. These are (1) treatment procedures and oral standards for service entrance, (2) oral effects of ionizing radiations, and (3) the role of oral tissues, fluids, and structures in air, fluid, and food-borne infections.

The first of these programs includes such studies as (1) the development of improved scientific aids for the diagnosis, evaluation, and prognosis of the oral health of personnel about to enter the service; (2) furthering the knowledge of tooth decay, the disease requiring the greatest expenditure of dental man-hours for clinical treatment in the Armed Forces; (3) investigations of other oral diseases; (4) development of improved treatment techniques; and (5) testing and development of new and improved materials for use in dental restorations and other treatment. Improvement of dental materials for dental treatment will result in an appreciable decrease in annual dental treatment costs. In this category great emphasis is placed on the solution of the problem of tooth decay from the aspects of tooth structure analyses, enzymatic effects on teeth and the supporting structures, bacteriologic action, nutritional deficiencies, and others. Doubtless, enzyme studies will present new avenues of approach to the diagnosis of oral disease and, perhaps, of systemic disorders.

Investigations of the influence of ionizing radiations on salivary and bacteriologic defense mechanisms of the oral cavity are being pursued

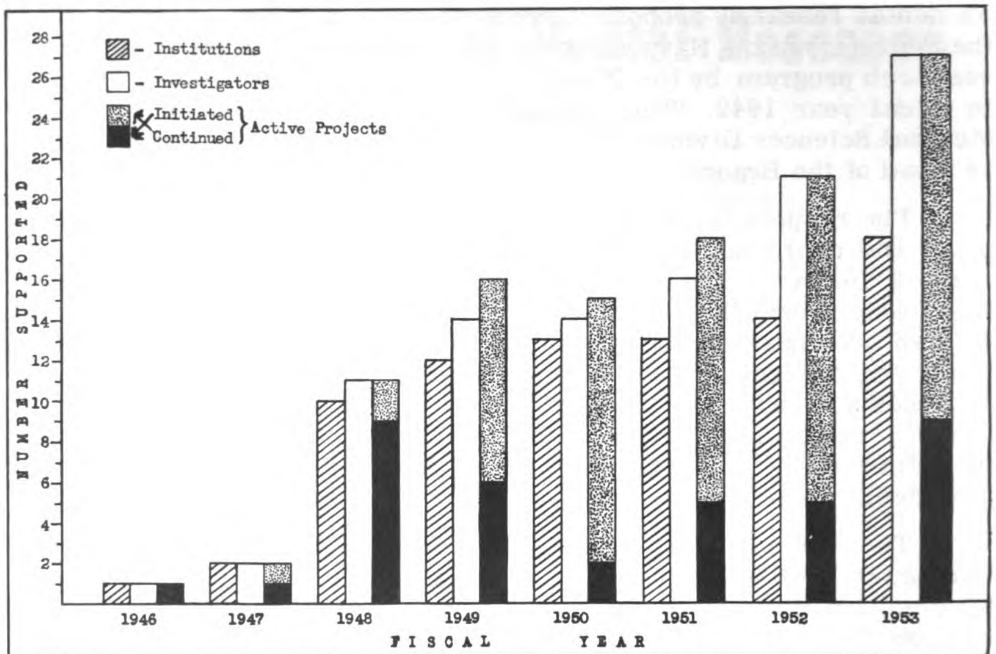


FIGURE 1:- Institutions, Investigators, and Projects in the ONR Dental Research Program

under the second program. Oral and alimentary effects of ingestion of radioactive elements through food and drink are of considerable importance in this category. Knowledge of the effects of radiation on bone and tooth structure and metabolism, on the lymphatics, and on other tissues is also being sought.

The primary objective of the third program is to determine the ultimate fate of bacteria that find entrance to the body through the mouth. Through studies relating to the identification and classification of the microbiota of the oral cavity, improved methods for detection and diagnosis of diseases of a bacteriologic etiology are being advanced. The significance of the oral defense mechanisms in disease prevention is being investigated. Germ-free animal studies are being conducted with the prospect of shedding new light on the role of bacteria in the decay process.

During the fiscal period 1946 to 1953, some 76 dental research proposals were received by the Office of Naval Research. Of this total, more than one-third are currently active (fiscal year 1954) and several have been successfully completed. Many projects have been rejected for scientific or other reasons, while a number have been transferred to other government agencies whose programs appear to be more related to the studies concerned.

The size of the dental program has increased steadily from one active study in fiscal year 1946 to 27 in fiscal year 1953, with the exception of fiscal year 1950 (see graph above). The number of institutions participating in the dental program of the Office of Naval Research, however, did not show marked change during the period 1949 to 1952, but did increase substantially thereafter. Further, in 1946 only one dental investigator was receiving support by the Office of Naval Research as compared to 27 in 1953.

The interest in and support of dental research by the Navy has increased tremendously since pre-World War II days. Thus the importance of the oral cavity and its relation to individual health is receiving more recognition. Furthering the knowledge of oral diseases, particularly tooth decay, will eventually result in savings to the military and civilian population in both man-hours and cost of treatment.

Revised Chart of Physical Constants and Conversion Factors Compiled by ONR

A new, completely revised and up-to-date edition of the ONR chart of "Physical Constants and Conversion Factors" has just been published and made available for distribution. Since 1947, when the last edition of the chart to receive wide distribution was issued, our knowledge of the fundamental constants of nature has improved considerably. Hence the current revision, edited in the Physics Branch of the Research Group of ONR, is expected to be a timely aid to workers in the physical sciences.

Prominent on the new chart is a list of numerical values of some 30 of the more important fundamental constants. Most of these values, with their associated standard errors, are taken from the recent precise determination of the least-squares adjusted values of the atomic constants by Jesse W. M. DuMond and E. Richard Cohen. (Revs. Modern Phys. 25, 691 and 709 (1953).) These authors have carefully appraised the more reliable experimental determinations of such constants as c (the velocity of light) and F' (the Faraday constant) and have calculated, using known interrelations among the independent physical constants, a mutually consistent set of "best values" for these constants. This painstaking effort of DuMond and Cohen is a distinct service to scientists everywhere and marks a big forward step in our efforts to achieve exactness in scientific calculations.

Another large portion of the 21" by 28" chart is devoted to a tabulation of the more important physical conversion factors, e.g., from the metric system to English units, for quantities of angular measure, length, area, volume, time, velocity, mass, density, force, pressure, work and energy, and power. Additional information frequently needed by physicists and engineers includes a tabulation of important properties of the standard atmosphere at selected altitudes up to 200,000 feet. Space is provided for users of the chart to jot down special data often used in their own work.

Distribution of the new charts to governmental scientific agencies is being handled by the Physics Branch of ONR. Copies desired for use by educational institutions and research laboratories may be requested from the nearest Branch Office of the Office of Naval Research.

On The Naval Research Reserve

First Naval District Says

Au Revoir to CDR Rohrman

Above, CAPT Louis M. Smith, CO of Company 1-1 (Boston) wishes good luck to CDR H. Wray Rohrman, Program Officer for the First Naval District who was returned to inactive duty, on 31 October, as the result of the cut-back of Naval Reserves on active duty. The combination radio-phonograph was a parting gift from the Company. Below are a few words written by CAPT Smith which show the great contributions made by CDR Rohrman and which express the sentiment of the whole Research Reserve group. CDR Rohrman also wished to send a message to the Research Reserve and his remarks follow CAPT Smith's.

Captain Smith's remarks. "The establishment of the Naval Reserve Research Program in the First Naval District began with the arrival of CDR Rohrman on duty there in November 1948. The interest in the program among the scientific personnel was immediate. Many scientists who had never been in the military service joined the Naval Reserve in order to become eligible for the Reserve Research Program. The first company activated was located at the Massachusetts Institute of Technology. Because of the large number of surrounding colleges and industrial research laboratories, it soon became the largest Naval Reserve Research Company in the country and still has that distinction.

"When the Korean conflict started, it became necessary to disestablish the University of Maine and the Lowell Textile Companies because of the large number of members returning to active duty. Each of the seven companies had farewell dinner parties for CDR Rohrman with CDR F. L. Edmondson, Director of the Reserve Research Program attending two of them."

<u>CDR Rohrman's farewell remarks</u>. "I wish to take this opportunity to say goodbye to my many friends in ONR which includes the Washington and Boston offices and all the members of my companies in the First Naval District. It was a great pleasure to be associated with such officers as Admiral Solberg, Admiral Bolster, Captain Grimes, Captain Cook in Washington and Captains Johns, Pleasants, and Eggers in Boston. I wish to point out for special commendation CDR F. L. Edmondson, Director of the Naval Reserve Research Program, for it has been under his excellent leadership that the program has grown to its outstanding proportion in the Naval Reserve Training Program. The many seminars that he has instituted have proven the most instructive training possible for our naval scientists. It is to be hoped that more funds will be forthcoming so that these may be resumed on a large scale.

"It was always a source of pleasure to attend the Program Officers' meetings in Washington and "get the word" to bring back to my companies. It is too bad that BuPers found it necessary to return the Program Officers to inactive duty with no permanent reliefs for us to train before leaving, but I am sure that all our companies will retain their interest and cooperation and will be ready for any emergency when the Navy calls upon them.

"I will miss you all and just can't realize that my service with the Navy has ended now for all times. Good luck to you all and I hope our paths will cross often." . . . CDR H. Wray Rohrman, USNR, RPO, Boston.

Research Reserves Appear on Television Program

The Research Reserves were recently in the limelight when they were invited to appear on the first of a series of television programs on "Careers Ashore and Afloat." The group of twelve programs, all dealing with the Naval Reserve, are sponsored by the University of Houston's KUHT—the oldest educational television program. LCDR L. J. Castellanos, Commanding Officer of Company 8-4 (Houston), representing the Research Reserves, discussed the training of particular members of his Company. Appearing with him was CDR R. L. Fischer, USNR, Administrative Officer of SupInsMat Houston. The series of programs was conceived and organized by Professor R. M. Uray, Program Director, with the cooperation of CDR Carlos Gardeza, USNR, Inspector-Instructor Naval Reserve, Houston.

Commendations Received by Three Companies

The following letters of commendation have been received by CAPT Louis M. Smith, CO of Company 1-1 (Cambridge, Mass.), LCDR Frank D. Hansing, CO of Company 5-2 (Blacksburg, Va.), and CDR John M. Dundon, CO of Company 12-5 (Berkeley, Calif.).

From: Chief of Naval Personnel
CAPT Louis M. SMITH, 77998/1405, USNR
Massachusetts Institute of Technology
Room 4 - 370
Cambridge, Mass.
Via: (1) Office of Naval Research
(2) Commandant, FIRST Naval District
Subj: Commendation

1. I note with pleasure that Naval Reserve Research Company 1-1, under your command, was evaluated OUTSTANDING by the Commandant, FIRST Naval District, for fiscal year 1953.

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

/s/ J. L. HOLLOWAY, JR.

From: Chief of Naval Personnel
To: LCDR Frank D. HANSING, 227108/1105, USNR
Commanding Officer
U. S. Naval Reserve Research Company 5-2
204 Turner Street
Apartment #8
Blacksburg, Virginia
Via: (1) Office of Naval Research
(2) Commandant, FIFTH Naval District
Subj: Commendation

1. I note with pleasure that Naval Reserve Research Company 5-2, under your command, was evaluated OUTSTANDING by the Commandant, FIFTH Naval District, for fiscal year 1953.

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

/s/ J. L. HOLLOWAY, JR.

From: Chief of Naval Personnel
To: CDR John M. Dundon, USNR, 073007/1405
Commanding Officer, Naval Reserve Research Company 12-5
Berkeley, California
Via: (1) Office of Naval Research
(2) Commandant, TWELFTH Naval District
Subj: Commendation

1. I note with pleasure that Volunteer Research Company 12-5 under your command, was evaluated OUTSTANDING by the Commandant, TWELFTH Naval District for fiscal year 1952.

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

/s/ J. L. HOLLOWAY, JR.

Auburn Company Praises Sonar Training

Above, members of Research Reserve Company 6-2 (Auburn, Alabama) receive instruction on a Dead Reckoning Tracer Plot at the Fleet Sonar School in Key West, 15 to 17 October. A group of seven officers from the Company were sent there on training duty by the Commandant, Sixth Naval District, to learn about the latest developments in sonar. Helping the group with a problem of simulating an attack on a submarine are LCDR S. O. Miller (left), Officer-in-Charge Integrated Instruction Section, Fleet Sonar School, and R. A. Hines, Sonarman 2/C, Sonar School Instructor. Members of the research group are (left to right) LCDR W. H. Coppedge, LT W. G. Eden, LCDR R. D. Rouse, LT K. H. Garren, LT J. E. Land, LCDR C. A. Buist (Research and Ordnance Program Officer, Sixth Naval District), LCDR D. H. Malone, and LT K. S. Kirkwood.

Reservists were enthusiastic in their praises of the excellent instruction given by LCDR Miller of the Sonar School and of the hospitality extended to them by the Fleet Sonar School and the Naval Base. LT James E. Land, Commanding Officer of NRRC 6-2 says "Despite the fact that only eight hours were devoted directly to training, the Officers of NRRC 6-2 felt that they had benefited as much as they have from some training which lasted for days."

The Research Reserves Go to Sea

During the recent West Coast Research Reserve Seminar, the Scripps Institution of Oceanography put on an interesting demonstration for members aboard the "Crest." Some of the Reservists who took part are pictured on the inside back cover.

NRRC 3-1 Announces Duty Officers

Captain H. B. Stevens, USNR, Commanding Officer of Research Reserve Company 3-1 (Cornell University), has requested that all elected and appointed officers and Senior and Junior duty officers wear their uniforms to scheduled meetings, particularly meetings where there are guest speakers or people outside the Company in attendance. Duty officers have been announced as follows:

SENIOR WATCH LIST

Date	Senior Duty Officer	Standby
10 Sep	CDR Gurin	LT Borup
17 Sep	CDR Moffat	LT Zampella
1 Oct	CDR Kulman	LT Langworthy
15 Oct	CDR Hertz	LT Albin
5 Nov	CAPT Exton (Sr. watch officer)	LT Scanlon
19 Nov	LCDR Hyde	LT Santorelli
3 Dec	LCDR Heller	LCDR Sragow
17 Dec	LCDR Wolf	LCDR Feskoe
7 Jan	LCDR Brussel	LCDR Kahn
21 Jan	LT Scanlon	CAPT Exton
4 Feb	LT Borup	CDR Gurin
18 Feb	LT Zampella	CDR Moffat
4 Mar	LT Langworthy	CDR Kulman
18 Mar	LT Albin	CDR Hertz
1 Apr	LT Santorelli	LCDR Hyde
15 Apr	LCDR Sragow	LCDR Heller
6 May	LCDR Feskoe	LCDR Wolf
20 May	LCDR Kahn	LCDR Brussel

JUNIOR WATCH LIST

Date	Junior Duty Officer	Standby
10 Sep	LT Wohl (Jr. watch officer)	LT Richter
17 Sep	LT Mateson	LT Tuckerman
1 Oct	LT Gross	LT White
15 Oct	LT Koperberg	LT Schubert
5 Nov	LT Beck	LT Howlett
19 Nov	LT Maclaren	LTJG Bick
3 Dec	LT O'Connor	LTJG Lidsky
17 Dec	LT Stage	LTJG Oppenheimer
7 Jan	LT Quirk	LTJG O. W. Haines
21 Jan	LT Richter	LT Wohl
4 Feb	LT Tuckerman	LT Mateson
18 Feb	LT White	LT Gross
4 Mar	LT Schubert	LT Koperberg
18 Mar	LT Howlett	LT Beck
1 Apr	LTJG Bick	LT Maclaren
15 Apr	LTJG Lidsky	LT O'Connor
6 May	LTJG Oppenheimer	LT Stage
20 May	LTJG O. W. Haines	LT Quirk

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*Articles are arranged chronologically under the ONR Division and Branch which have cognizance of the research described.

†Written by the editorial staff of Research Reviews.

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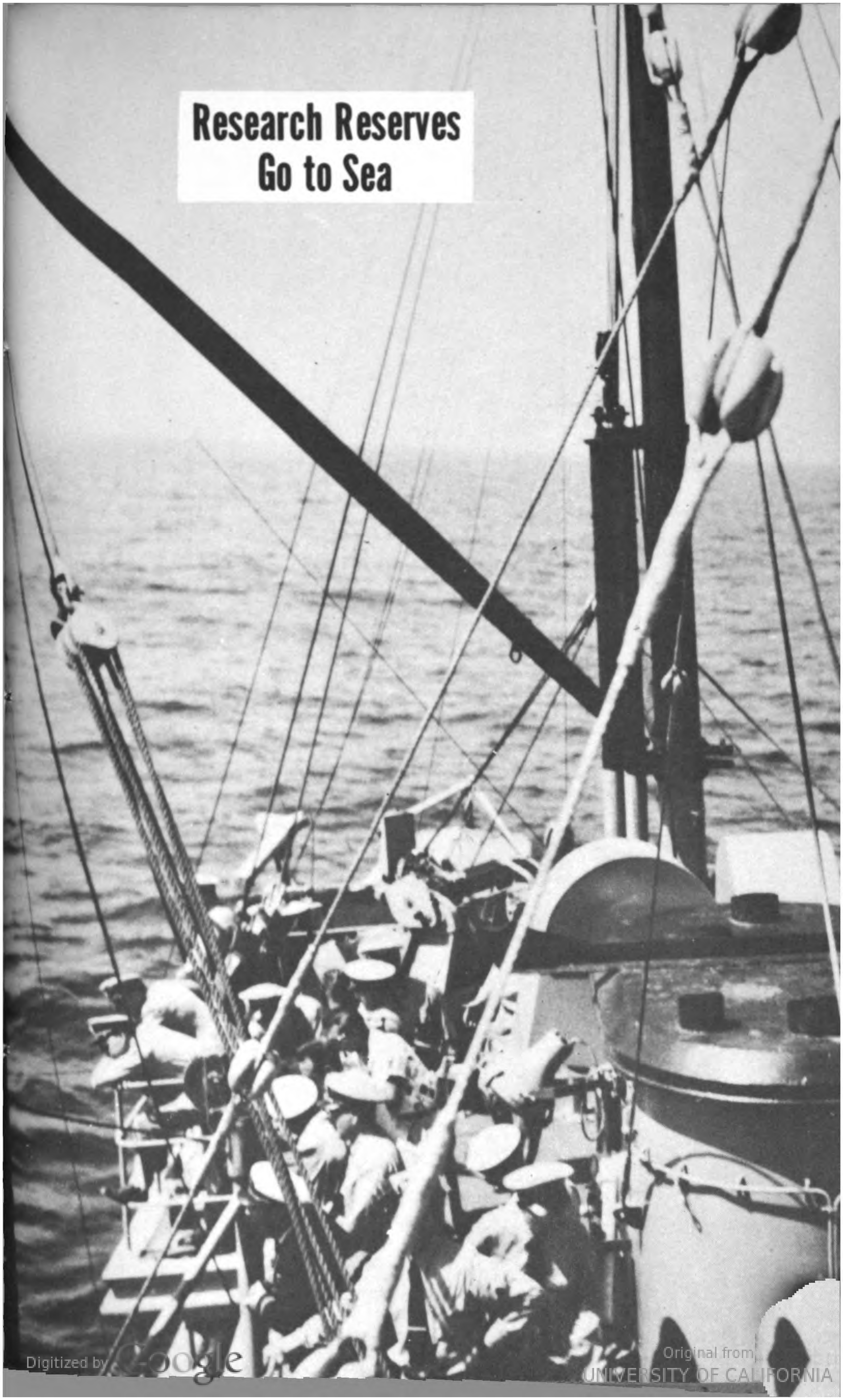
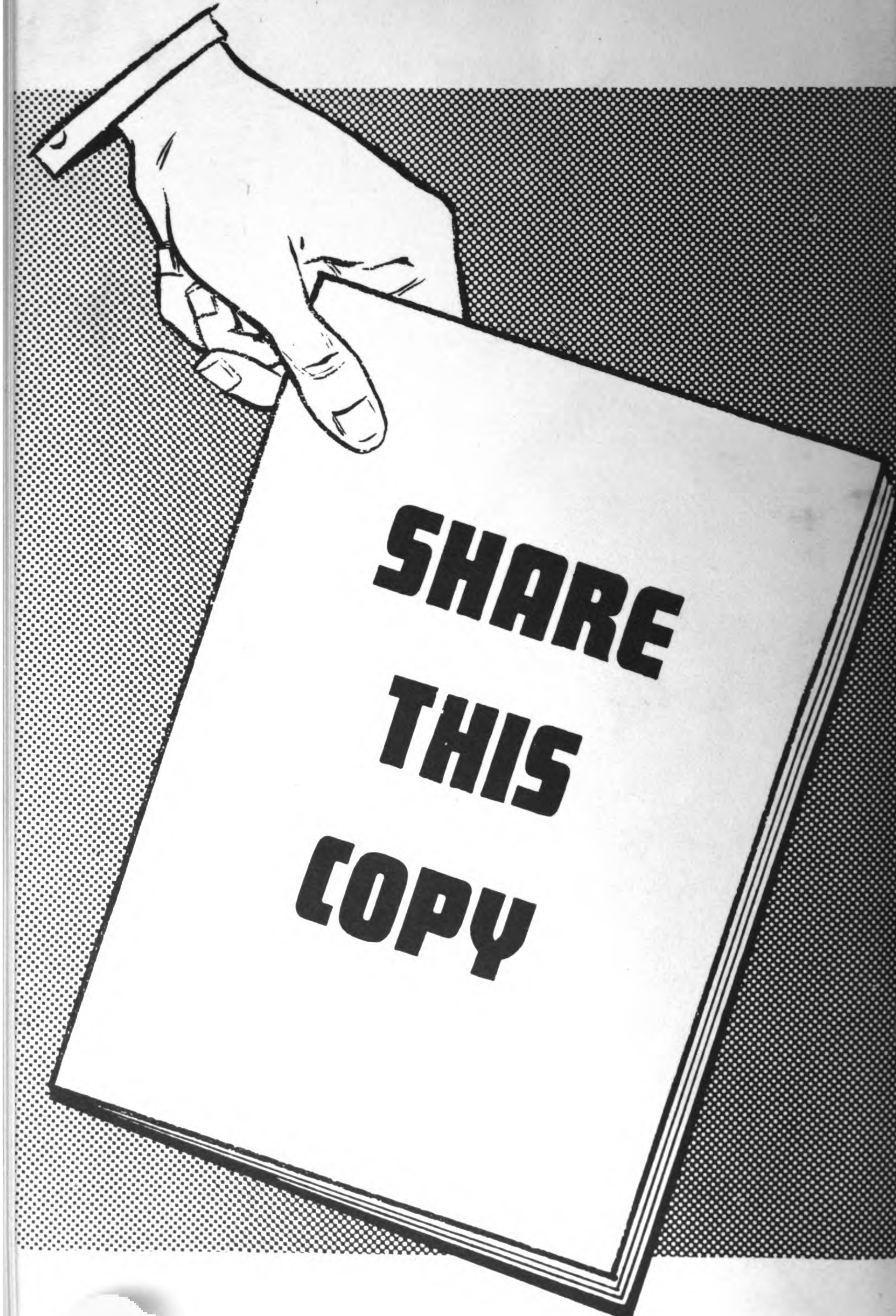
Research Reserves Go to Sea

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