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Portraits in Science

PROFESSOR

EDWIN BIDWELL

WILSON

(1879-1964)

After completing his careers as educator and administrator, Prof. Wilson joined the O.N.R. Branch Office in 1948 as consultant in general science. He had great influence on the scientific operations being conducted by the then fledgling office.

Because of his remarkable fund of knowledge, encyclopedic memory and catholicity of interests, his colleages called him a "modern Renaissance man." His contributions to aeronautical theory, naval aviation and O.N.R. were recognized in May 1964 when he was awarded the Navy Distinguished Civilian Service Award.

The ONR Boston Story

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A great deal has been written regarding the origin and history of that unique agency for sponsoring research—the Office of Naval Research. However, the story of the field offices which have played such an important role in carrying on the mission of ONR at the local level is not quite so well known. Originally there were five such branches in the Continental United States—in Boston, New York, Chicago, San Francisco, and Pasadena. The ONR London Office, which was established at the close of World War II to maintain scientific liaison activities in Europe started during hostilities, continues to serve as a two-way information exchange across the Atlantic. (See *Naval Research Reviews* issue of March 1967, "ONR London – The Navy's International Scientific Exchange.")

In July of 1966, the Boston and New York Branch Offices were consolidated with Boston as headquarters. Similar action on the West Coast resulted in a merger of the Pasadena and San Francisco field offices with Pasadena in charge. This article will be limited to an account of the role played by the Boston Branch Office in developing ONR's unique scheme of field research project administration. The story of the New York office will be left to another time.

Ideas for the creation of an agency to support basic research within the Navy Department had their inception in the minds of a number of scientifically inclined people who were engaged in monitoring and administering research programs during World War II. It was apparent to these farsighted individuals that much of the high-level talent assembled to conduct research during the emergency would be dispersed after the war and the programs terminated. Therefore, it was evident that prominent officials in the Navy Department, Congress, and the Executive Branch had to be convinced of the importance of long-range research to the maintenance of future military strength. Among the leaders who clearly saw their responsibility in this matter were Professor Jerome C. Hunsaker of the Massachusetts Institute of Technology, the first to serve as Coordinator of Research and Development in the Navy Department; RADM J. A. Furer, USN, who succeeded him in that post; CAPT R. D. Conrad, an officer with a truly remarkable understanding of the Navy's technical needs; and RADM H. G.

Bowen, who became the first Chief of Naval Research. A group of bright, young Naval Reserve officers with technical backgrounds, assembled by Dr. Hunsaker to work with him on research planning, administration, coordination and evaluation, materially assisted in the development of the concept of a basic research agency in the Navy. Hunsaker applied the term "Bird Dogs" to these young men to characterize metaphorically the way in which he was using them.*

Other forces were at work officially within the Navy Department; and, on May 19, 1943, the Office of the Coordinator of Research and Development was joined with the Naval Research Laboratory and the Special Devices Division of the then Bureau of Aeronautics to form the Office of Research and Inventions (ORI). This predecessor organization to the Office of Naval Research created the five continental branch offices which later became the cornerstones of ONR's field operations. Several of the Bird Dogs, notably Dr. James H. Wakelin, Dr. Bruce S. Old, and Mr. Ralph A. Krause, helped provide advice in the formulation of the Boston Branch Office of ORI. RADM's H. G. Bowen and Luis deFlorez, along with CAPT Conrad, also played an important role in initiating the new branch office.

The Boston Branch Office of the Office of Research and Inventions was established on October 22, 1945 at the 150 Causeway Street office building where many wartime Navy activities were located. Its first personnel roster included the names of officers who had been assigned to former National Defense Research Committee (NDRC) and Office of Scientific Research and Development (OSRD) projects that had been transferred to the new agency. On opening day of the Boston ORI Office, there were 99 Navy officers, 76 enlisted personnel, and one civilian on board (contrast this with the present roster of 86 civilians and three officers). During the early months of operation, many wartime activities were gradually disestablished and replaced by functions of the new ORI branch office. Also, during this period those military personnel who wished to be demobilized obtained their discharges; and, in some cases, stayed on in equivalent civilian billets. As late as July 1946, the personnel roster of the Boston ORI Office showed that ten of 15 key staff members were still in uniform, including three of the five scientists then on board.

Among the early employees of the Boston Office of Research and Inventions who remained for a considerable period of years and

*"The Evolution of the Office of Naval Research" by the Bird Dogs, *Physics Today,* August 1961, pp. 30-35.

played an active role in the development of ONR Boston were: Mr. Kenneth C. Bernstein, Administrative Officer; Mr. Robert W. Hart, Electronics Engineer; Miss Margaret Connolly, Personnel Assistant and Assistant to the Administrative Officer; Mrs. Pauline (nee Sullivan) Cassidy, Secretary to the Commanding Officer; Mrs. Jean (nee Connelly) Donovan, Secretary to the Head of the Contract Administration Department; Miss Dorothy Mercier, Correspondence Supervisor; and Miss Mary Jorgensen, Secretary to the Head of the Patents Department. More than half of these people are still with ONR Boston in the positions cited; Mrs. Cassidy, Miss Connolly, and Mr. Hart left a few years ago.

The Right Man

The right man always makes the difference when a new venture is undertaken. CDR Thomas H. Morrin, who was the first Commanding Officer in Boston during the period November 5, 1945 to August 18, 1947, was just such a person. He possessed the necessary perceptiveness and administrative ability to pull the operations together after the war and help sell the new agency to the local scientific community. Tom Morrin vigorously attacked the organizational problems of the infant office and provided much of the impetus that gave ONR early acceptance in the Boston area. He effectively handled the complicated tasks of phasing out the local Navy liaison offices, building the new ORI office from scratch, formulating rules and regulations for its operation, and gradually effecting a changeover from military to civilian personnel. He was responsible for establishing smooth working relationships with ORI headquarters in Washington and, from August 1946 on, for providing a smooth transition from the Office of Research and Inventions to the Office of Naval Research. During CDR Morrin's regime, many of the OSRD tasks which had identifiable long-range research potential for the Navy were rescued and converted to ONR projects. Much was done to organize an effective ONR contract research program in the New England area and to provide for its efficient administration.

The Scientific Staff

The recruitment of scientists was an important activity in the early life of the Boston Office. Dr. Harry Goheen, a brilliant young mathematician who had served as a naval officer in the war, remained for a time as a civilian specialist in mathematics and was also appointed Acting Chief Scientist. Robert J. Bergemann, Jr. and Frederic J. Eppling, two young naval officers with scientific backgrounds, stayed with the

Boston Office Scientific Section as civilian staff members for several years after the war. Dr. Eppling is presently a physics lecturer and Associate Director of M.I.T.'s Laboratory for Nuclear Science, and Mr. Bergemann is a staff engineer at the Lincoln Laboratory.

The search for a more permanent Head of the Scientific Department resulted in the selection of Dr. J. Horace Faull, Jr., who was prominent in research on rubber and elastomers and who was in the U.S. Government Synthetic Rubber Program as a technical manager during the Second World War. Both he and Dr. Carl F. Muckenhoupt, who succeeded him as Chief Scientist, joined the Boston Office in 1946.

Dr. Faull, a long-time resident of the Boston area, was well acquainted with the local scientific community and its potential for conducting research of interest to the Navy. He was also well qualified for the post of Chief Scientist because of his fine understanding of the value of basic research in providing the new knowledge required for the intelligent prosecution of applied research and development programs leading to useful end items. Also, his experience during World War II had heightened his interest in helping to rebuild the basic research program of the country.

In the summer of 1946, Dr. Faull was working for the Baytown, Texas plant of the General Latex and a Chemical Company and the General Tire and Rubber Company—a joint corporate entity. Dr. Arthur Sloan, a friend of Faull's and later the founder of the Atlantic Research Corporation, had just accepted the position of Head of the Scientific Section of the New York Branch Office of ORI. He suggested Dr. Faull as a candidate for the equivalent position in the Boston Office. A trip to Washington followed where Faull was offered the post by Dr. Alan Waterman, the first Chief Scientist of the Office of Naval Research. He accepted tantamount to working out a satisfactory agreement with his industrial employers. This problem was satisfactorily resolved when Faull was granted a leave of absence with retainer to strengthen the technical staff and to establish a scientific development program at Baytown.

Dr. Faull ultimately reported to the Boston Office in late October 1946, and immediately set himself to the task of establishing policy for the Scientific Section and helping to formulate the mission for the young office. He was instrumental in persuading a number of reluctant scientists at Harvard and M.I.T. that ONR provided a new kind of Navy contract operation that permitted just the degree of flexibility they required to conduct basic research under government support. Also he vigorously attacked the problem of staffing the Scientific Section

which was a somewhat worrisome situation in the general postwar rush to recruit scientists and engineers for all sorts of positions in industry and the universities. Well prepared advertisements drew in a surprising number of applicants, including Dr. A. L. Powell, currently Deputy Director and Chief Scientist, and Mr. T. B. Dowd, currently Deputy Chief Scientist, who were selected in June 1947 as junior chemist and junior physicist, respectively. Not long afterward, Mr. Arthur H. Healy, who soon became Head of the Contract Administration Department, transferred from ONR Washington.

Dr. Faull did not remain long with the Boston Branch Office. His industrial commitments led to an invitation to return to the General Latex and Chemical Corporation to assume direction of their research programs. Acceptance of this post culminated in his resignation as Chief Scientist of ONR Boston in September 1948. However, he never really left ONR; rather, he stayed on as a part-time consultant in elastomer and polymer science, and returned to full-scale duty as Elastomer Scientist and Chemist in 1961. Indeed, one of the underlying factors for the success of the Boston Branch Office has been the quality of the key people it has been able to attract and to retain for long periods of time.

Dr. Carl F. Muckenhoupt, who had been Assistant Head of the Scientific Section under Dr. Faull, became Chief Scientist in September 1948 and served in that capacity until August 1959 when he accepted a staff position at Northeastern University.

Two Senior Scientists

Two senior scientists, who were persuaded to join the Boston Office in 1948 as consultants after having completed distinguished careers, had much to do with shaping the scientific mission and setting the tone of the young operation. One of these eminent contributors was Professor Edwin Bidwell Wilson, a distinguished educator and administrator whose remarkable mind appeared to encompass all knowledge as its province. He had served as Chairman of the Department of Physics at M.I.T. from 1911 to 1922, and then became the first Professor and Head of the Department of Vital Statistics at the Harvard School of Public Health—a post he retained until his retirement in 1945. After a year as Stevenson Lecturer on Citizenship at the University of Glasgow, he returned to Boston and soon became part of the ONR family.

E. B. Wilson graduated from Harvard in 1899 *summa cum laude* in mathematics, and continued his studies at Yale, receiving his Ph.D.

there in 1901. His mentor was J. Willard Gibbs who many experts regard as America's greatest scientist of the nineteenth century. The mantle of the great Gibbs fell upon Dr. Wilson: he taught some of Gibbs' courses and collaborated with him on the textbook *Gibbs-Wilson Vector Analysis.*

After a year at the Sorbonne, Professor Wilson became a mathematics instructor at Yale and Harvard. Later, while at M.I.T. with Professor Jerome C. Hunsaker, he helped develop the first Department of Aeronautics in the United States. The organization of this department was brought about by the intercession of the British government, and E. B. Wilson's participation was requested by President Woodrow Wilson. The first textbook on aeronautics, published in 1920 by Wiley, was written by E. B. Wilson based on his fundamental knowledge of hydrodynamics and the lecture notes he developed for this first course.

During the period 1920-22, he served as secretary of an administrative committee that ran M.I.T. in an interim period between two presidents. He even served as a Professor of Economics at Harvard while at the School of Public Health.

It is difficult to count the number of careers E. B. Wilson had: if the diversity of his publications is a criterion he had seven—mathematics, physics, aeronautics, statistics (both theoretical and applied), economics, epidemiology, and sociology. He was a member and an officer of numerous scientific organizations representing a wide variety of disciplines. Because of his remarkable fund of knowledge, encyclopedic memory, and catholicity of interests, his colleagues described him as a "modern Renaissance man."

One can easily imagine the impact the arrival of such an intellectual giant had on the fledgling Boston Branch Office. Younger staff members literally became apprentices at his knees; and the office grew in stature as this "Consultant in General Science" brought wisdom and experience to bear on ONR's blossoming scientific mission. The office was most fortunate in having him aboard in his final, post-retirement career which lasted to the day of his death—December 28, 1964. Dr. Wilson's outstanding contributions to the development of aeronautical theory, to the founding of naval aviation, and to ONR were recognized in May 1964 in the bestowal of the Navy Distinguished Civilian Service Award by the Honorable Paul H. Nitze, then Secretary of the Navy.

During his years of service, E. B. Wilson made it clear to his colleagues on many occasions, both within and without the office, that he found his latest career the most satisfying. The Boston Branch Office memorialized its beloved Professor E. B. Wilson by dedicating and renaming its library and conference room in his honor.

A second eminent senior scientist joined the Boston Office at about the same time as E. B. Wilson. Dr. Roy G. Hoskins, who was often

referred to as the "Father of Endocrinology" because of his many important contributions to neuroendocrine research, served ONR Boston as Medical Sciences Consultant from 1948 to 1964. A kindly, soft-spoken person, Dr. Hoskins endeared himself to the hearts of all those associated with him. Prior to casting his lot with the Navy, Roy Hoskins held the post of Director of the Memorial Foundation for Neuroendocrine Research at Harvard University (1927 to 1947). During that period he achieved international repute as an authority on the endocrine glands—the thyroid, pituitary, adrenals, and gonads.

Dr. Hoskins was the possessor of two doctorates: he received a Ph.D. from Harvard Medical School in 1911; and, after World War I service as an Army Major, obtained his M.D. degree from Johns Hopkins University in 1920. One of the founders of the Worcester Foundation for Experimental Biology, he served as secretary for a number of years and was a trustee at the time of his death. In the academic field Dr. Hoskins held professorships at Starling-Ohio Medical School, Northwestern University, Ohio State University and Tufts Medical School. He held research associateships at Harvard Medical School and Worcester State Hospital and served as a research consultant to the Boston State Hospital.

One of Roy Hoskins' key scientific achievements was his early recognition that the methods of physical science could be applied productively to the problems of mental illness. He was especially well known for his insight into the causes and possible cure for dementia praecox and for the interdisciplinary team approach he applied to research on this disease. In 1935 he gave a lecture series at Harvard on the relationship between gland factors and personality. That series has since culminated in the book entitled *The Tides of Life.* He was a pioneer in the field of gerontology at a time when the problem of an aging population was a widely neglected subject.

Hoskins and Wilson, as sagacious senior advisors and consultants, provided much of the sound foundation upon which the scientific operations of the Boston Office now exist. Both men had a remarkable knack for providing advice to men in supervisory positions in Boston in a manner that did not arouse a hint of resentment. They were truly great scientists and wonderful human beings.

Moving Ahead

Under Dr. Carl Muckenhoupt, the Boston Office began to expand its contract research operations and soon had implemented, within the assigned five-state area, a very broad program of basic and applied research covering nearly all the disciplines that were relevant to Navy interests. The scientific staff set itself to the task of becoming acquainted with the research being conducted on these projects, with the

investigators involved, and in making a variety of contacts with the local scientific community for the overall benefit of naval research.

The Contract Administration Department, under the leadership of Arthur H. Healy, began to build up its unique expertise in dealing with basic research contracts in colleges, universities, and non-profit research foundations. ONR's remarkable success in this new kind of contract administration is evidenced by the fact that the ONR Branch Office Contract Administration Departments have been recognized as *the* agencies for field administration of all Department of Defense and NASA research contracts and grants in educational institutions. The Patent Section, under the direction of Mr. Joseph Weingarten, began to tackle the tremendous backlog of invention disclosures inherited from the wartime government agencies.

The Commanding Officers who succeeded CDR Morrin provided a variety of contributions to the development of the Boston Office, each from his own background of experience in the Navy. Some were a bit "at sea" in the research environment in which they found themselves and underwent early periods of adjustment. Most became fascinated with the people with whom they came into daily contact, and the unparalleled opportunity to acquire broad knowledge in scientific and technological areas. All found their duty period in Boston a rewarding one and were proud of the performance of the strong civilian staff which conducted the work of the office so well.

The second Commanding Officer was CAPT John G. Johns of World War II submarine fame who stayed until December 20, 1948. Succeeding him were CAPT's A. L. Pleasants, F. B. Eggers, D. C. Beard, J. F. Benson, V. H. Soucek, G. K. Williams, W. C. Hilgedick, G. W. Okerson, and the present incumbent, CAPT John H. Terry. CDR William S. Adami served as Commanding Officer for a short period in 1963 before CAPT Okerson came on board.

CAPT Terry is exceptionally well qualified scientifically to be Director of the Boston Branch Office. He possesses the Bachelor of Science and Master of Science degrees from Rensselaer Polytechnic Institute, and an M.S. degree in Mathematics from George Washington University, which he earned when assigned to the then Bureau of Aeronautics in Washington. He also had three years of graduate study in biophysics at the University of California, Berkeley, in connection with a Navy policy to train officers in nuclear weapons effects. In 1954-1955 he attended the Oak Ridge School of Reactor Technology and was then assigned as Project Officer on the Naval Aircraft Nuclear Propulsion Program in the Division of Reactor Development of the Atomic Energy Commission. He has also held Navy assignments as Head of the Electronics Laboratory, Pilotless Aircraft Division, Naval Air Development Center, Johnsville, Pennsylvania; Chief of the Research Division of the

Defense Atomic Support Agency; and Director, Nuclear Applications Division, Bureau of Naval Weapons.

With E. B. Wilson and Roy Hoskins opening doors in the New England region, the Boston Office began to make its presence felt in the halls of research. Large projects of broad scope, as well as smaller ones on specific topics, began to accumulate on the ONR Boston Contract and Proposal List. Many outstanding scientists, some of whom later became Nobel Laureates, received ONR contract support.

The great majority of the research projects were clustered around Boston and Cambridge, with satellite concentrations at Woods Hole, Mass.; Providence, Rhode Island; and the Connecticut Valley in Western Massachusetts. A few tasks were scattered over the Northern New England States of Maine, Vermont and New Hampshire. This situation alleviated the travel obligations of the staff, making it possible for ONR Boston to build unusually close and cordial relations with university officials, project directors, working scientists, and business office staffs of the region's varied institutions. Up until the time of the consolidation with the New York Branch Office in July 1966, less than 200 ONR contracts were handled in the Boston Branch Office. Thus it was possible to do a rather thorough job in all phases of cognizance. (It should be pointed out in this connection that one of the original six New England States assigned to ONR Boston—Connecticut—was removed from Boston responsibility in 1946, transferred to the New York Office, and not returned to Boston until the merger twenty years later.)

Stars of the Research Galaxy

Of the galaxy of great research programs which the Office of Naval Research fostered in its first twenty years of existence, many stars of the first magnitude developed in the Boston area

M.I.T.'s Research Laboratory of Electronics, which succeeded the famous wartime Radiation Laboratory, produced not only great research but a coterie of investigators who grew into the front ranks of science. Julius A. Stratton, one of the early directors, later became President of M.I.T. His successor, Jerome B. Wiesner, served for several years as scientific advisor to President Kennedy and is presently Provost of M.I.T.

RLE's accomplishments in electronics and physics are too numerous to mention here. Many basic contributions to circuitry, components, microwave spectroscopy, radio astronomy, plasma dynamics, communications, and molecular beams have resulted. A sizeable portion of the laboratory's present program is devoted to work on neurophysiology, man-machine interactions, speech communication, and cognitive information processing, including development of sensory aids for the

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blind. ONR Boston scientists have been close to these programs from the beginning and have provided much valuable advice and counsel to the directors and working scientists.

The Boston Office played an important role in the initiation and guidance of many research programs which have been very beneficial—in terms of both scientific accomplishments and naval applications. Professor Nicolaas Bloembergen of Harvard University conceived the idea for the three-level solid state maser while performing research under an ONR contract. Jay W. Forrester, the inventor and developer of the Whirlwind I Computer, was supported by ONR under a contract through the Naval Training Device Center. This grandfather of the present-day computer was a major breakthrough in the state-of-the-art in computer technology and paved the way for the more sophisticated models that came later: its magnetic core memory has found many important applications in the last twenty years.

J. A. Pierce of Harvard contributed much to navigational aids while supported by ONR. He laid the foundation for the advanced navigational system OMEGA which shows great promise for operational service.

Professor Fred L. Whipple of the Harvard College Observatory was an ONR contractor. His pioneering research on meteors has led not only to a scientific understanding of meteors but also has contributed to the solution of re-entry problems, ballistic missile detection, and the development of the Baker Super-Schmidt meteor cameras.

Frederick V. Hunt, also of Harvard, has been a prime contributor to scientific and technological progress in underwater acoustics. The ARTEMIS concept (named for the goddess of the "hunt") was his brainchild. Also he did a great deal to develop the application of correlation techniques to acoustic receiving systems.

C. Stark Draper of M.I.T. devised an inertial navigation technique which ultimately resulted in the guidance system currently employed with so much success in POLARIS submarines.

William Stone, Jr., while with the Massachusetts Eye and Ear Infirmary in Boston, developed plastic corneas that may eventually be transplanted successfully into humans.

Warren Rohsenow of M.I.T.'s Mechanical Engineering Department provided some valuable technological information in the course of his boiling water transfer studies at high heat flux which contributed significantly to the development of nuclear reactors for submarine propulsion.

ONR did a great deal to stimulate cryogenics research after World War II. In the Boston area, Samuel Collins of M.I.T. was one of the most creative of the pioneers: his particular accomplishment was the development of the helium cryostat, now a commercial product of

Arthur D. Little, Inc. This was the first practical device that permitted physicists, chemists, and engineers to study materials and reactions at temperatures close to absolute zero.

Early work in weather modification stemmed from sponsored research at Arthur D. Little, Inc. under the direction of Bernard Vonnegut who collaborated with the late Irving Langmuir in developing cloud-seeding techniques to induce rainfall. Pioneering investigations by A. H. Woodcock under ONR sponsorship at Woods Hole Oceanographic Institution may eventually make it possible to grow clouds at will.

Today's computerized weather services, utilized by the military and civilian establishments alike, grew out of research programs initiated more than twenty years ago. Early work (1947) was done by a team directed by the late Professor J. von Neumann at Princeton. The modern weather service is centralized with all working charts generated by the computer at an operational center and the finished product transmitted by facsimile to the users. Jule Charney of M.I.T. developed many of the techniques for weather forecasting by computer under contract support by ONR.

Professor George Wald of Harvard University, who conducted research on the physiology and biochemistry of vision, was supported by ONR for many years. He began during World War II with work on eye pigments and color vision. After cessation of hostilities, support was picked up by ONR and the project was continued for about 18 years. Important basic information was obtained on the identification, characterization, and synthesis of visual pigments and related substances. Wald's advanced techniques made it possible to make *in vivo* observations of the presence and behavior of the receptors that control color vision in man. These sensitive methods are being employed to investigate color vision variations among the human population and to elucidate the biochemistry underlying the deviations. Wald's work is leading to a complete biochemical explanation of color blindness, including an understanding of the genetics down to the level of the genes and DNA association involved. For these major scientific achievements with their long-range implications for complete understanding of the biochemistry of human vision, Dr. Wald was awarded a share of the Nobel Prize in Medicine for 1967.

As a result of the Japanese conquest of the Philippines in the early years of World War II, there was a critical deficiency in the availability of Manila hemp (abaca). After the conflict ended, it was recognized that measures should be taken to avert any future shortages in the supply of natural fibers for naval use. An ONR research program with the objective of finding a feasible substitute for Manila abaca for naval cordage was assigned to Fabric Research Laboratories, Inc., Boston,

a recognized leader in the textiles field. After seven or eight years of intensive study, this group demonstrated that substitute fibers could be successfully employed and that, by improved design and construction procedures, the mechanical strength of Manila abaca cordage could be appreciably enhanced. Of great practical importance was Fabric Research's finding that domestic (Guatamala and Honduras) abaca fiber could be used as a satisfactory substitute for Manila hemp. Also, the research program contributed significantly to the development of nylon cordage for naval applications.

A color-translating ultraviolet microscope was designed by Dr. Edwin H. Land and his associates at the Polaroid Corporation and developed under the support of ONR and the American Cancer Society. (This project was initiated as a result of the personal interest of CAPT Conrad who was suffering from leukemia.) At the Scientific Specialties Corporation in Boston, the prototype of this instrument was fashioned into a working model for laboratory use. The instrument that resulted from these efforts not only makes it possible to observe the geometry of biological cells but also to observe the distribution in tissue of the nucleic acids which have a bearing on the cancer problem. The novel principle incorporated in this device is a color translation from the ultraviolet into the visible whereby differences in ultraviolet spectral absorption characteristics are revealed directly as variations in hue. These distinctions can be observed even for specimens which appear colorless when viewed by ordinary light; the differentiation is achieved for individual biological cells, including living cells. This novel microscope has proved valuable for cell and tissue examination, particularly in cancer research. The instrument was especially useful to Dr. Shields Warren in investigations that he conducted at the Deaconess Hospital in Boston.

Research conducted under the direction of Dr. Philip Solomon of the Harvard Medical School has provided much valuable information regarding the effects of sensory deprivation on human behavior. Such effects, which have long been known in accounts of explorers, shipwrecked sailors, prisoners, and others, take the form of boredom, restlessness, oppression, reduced mental efficiency, aberrations, and hallucinations. Understanding the psychological phenomena encountered in situations where subjects are deprived of the normal sensory environment over significant time periods is important for prolonged residence in enclosed environments, *e.g.*, submarines, space vehicles, sealabs, and prisoner-of-war camps. Elucidation of the neurophysiological mechanisms involved in man's response to stressful environments can do much to alleviate symptoms not otherwise understood that might damage a mission or provide resistance to "brainwashing."

Professor George B. Kistiakowsky of the Harvard University Chemistry Department was one of the early ONR project directors in the

field of shock waves and detonations. He was with the Manhattan Project during World War II where he made important contributions on detonation modes in nuclear fission. He has served the federal government as a consultant in the field of explosion and detonations, as Science Advisor to President Eisenhower, and in numerous other important posts. He continues to supervise research under ONR support on high temperature gas reactions in which he is identifying the transient species produced in the ionization accompanying oxidation in hydrocarbons.

Dean J. Harvey Brooks of the School of Applied Science of Harvard University has long been associated with ONR and other government agencies. He is a member of the Naval Research Advisory Committee and the Committee on Undersea Warfare of the National Research Council, Chairman of the Solid State Advisory Panel of ONR, and a former member of the President's Science Advisory Committee. He was active in research in the area of underwater sound during World War II and later made a number of important contributions to nuclear reactor theory. Under partial ONR support, he has done extensive work in solid state physics on transport properties, band theory, and the effect of hydrostatic pressure on electrical and optical properties in solids.

No discussion of major contributors to the advancement of naval research would be complete without some mention of the Woods Hole Oceanographic Institution. This important facility for marine research was founded in 1930 as a private organization. During its first ten years it underwent slow but steady growth under the distinguished leadership of Henry B. Bigelow, its first director. In World War II the Navy began to realize the need for more complete knowledge of the marine environment, and support began to pour into the institution from this source. Early studies included prevention of marine fouling of ships, intensive research on the effects of ocean salinity and temperature on the transmission of underwater sound, and the investigation of underwater explosives, a project supervised by the present director, Dr. Paul M. Fye. ONR funding of Woods Hole research activities mushroomed after the war and growth continued unabated until NSF, AEC and other government agencies came into the picture as contributory sponsors. The Navy through ONR continues to be the major sponsor of a wide variety of oceanographic research projects which are of the utmost importance in maintaining America's preeminence in naval strength and in solving the problems of antisubmarine warfare.

Summer Studies

During the early years of the Boston Branch Office, summer study groups and similar high level conferences devoted to research on

important naval problems were very much in fashion. (See *Naval Research Reviews* issue of August 1966, "The Summer Study," J. R. Marvin and F. J. Weyl.) Boston became involved at the outset because of comfortable conference facilities and its renowned academic community.

The Boston Branch Office participated in these programs by supplying administrative services and liaison activities. The first summer study group was convened in the town of Lexington, Massachusetts in 1948. Its purpose was to assess the difficulties to be overcome in developing nuclear powered flight and the operational gains to be expected if the desired results were achieved. M.I.T. accepted a proposal to conduct the study from the Atomic Energy Commission, which had been encouraged by ONR to make an intensive investigation of this problem. Accordingly, a team of about 20 scientists, together with consultants and some visitors, spent the summer in Lexington deliberating on the pros and cons of nuclear aircraft. Professor Walt Whitman of M.I.T. directed the survey.

Project HARTWELL, the second summer study, because of its concern with an operational problem, became a determining influence in the planning of future surveys. This conference was conducted in 1950 under contract with M.I.T. at its Lexington Field Station. It was devoted to an overall evaluation of the period's technology with regard to its utility in improving a particular mission performance. Specifically, the study was addressed to the detection of submerged submarines, a problem which was critical at that time because of the known size of the Soviet undersea fleet and the NATO alliance's dependence on United States supplies transported across the Atlantic. The study group, led by Dr. Jerrold Zacharias, produced a monumental report entitled "The Security of Overseas Transport."

The next summer study was conducted in 1951-2 under an ONR contract with Brown university. The purpose of the study, called Project METCALF, was to survey the technological implications of infrared for military applications. This investigation proved very successful—both in terms of research program commitments and in the development of useful military hardware. The group included the Air Force infrared effort in its deliberations, and recommended the development of the SIDEWINDER missile at NOTS, China Lake. It is worth noting that the leader of this study was Dr. Donald F. Hornig, presently Science Advisor to the President.

The problems of undersea warfare were further surveyed in Project MICHAEL; those of continental air defense, in Project CHARLES, conducted by the Air Force, under M.I.T. sponsorship. The results of Projects CHARLES and MICHAEL led to the creation of Lincoln Laboratory in Massachusetts under Air Force sponsorship and the Hudson Laboratories in New York under a Navy contract. The Lincoln

Laboratory, which was placed under M.I.T. management, devoted itself broadly to the science and technology required to build an effective system for continental air defense. The Hudson Laboratories, which were organized under Columbia University supervision, were directed to investigate surveillance and undersea warfare problems. The Boston and New York Offices of ONR have been intimately involved in a variety of liaison activities with both laboratories since their inception.

Scientific contact with the M.I.T. Lincoln Laboratory has been particularly close throughout the years. In this context, it should be remembered that, until a few years ago, ONR contributed a fair amount of support to this facility. Although it was operated under a specific Air Force contract, early funding was tri-service. Also, a Navy Commander was appointed as a Resident Representative at Lincoln Laboratory, and the billet was maintained until the Air Force assumed sole support.

Lincoln Laboratory first addressed itself to the development of the SAGE system for intercontinental defense, and, later, when ballistic missiles became a greater threat than aircraft, to the engineering of the BMEWS early-warning network. When the SAGE system reached the hardware stage, the Mitre corporation was organized to handle equipment, production and further developments. Lincoln Laboratory then gradually changed its emphasis from a few large projects to applied research on a variety of systems and equipment required by the Armed Services. Direct contracting for development of end items soon came into the picture; and the three Services and NASA began to supplement support of the broad program with money tied to particular projects.

The pattern established by Project HARTWELL was extended to Project LAMPLIGHT in 1954 when the Navy decided that it must analyze its own role in the air defense of the United States. This study was conducted at M.I.T.'s Lexington Field Station under the leadership of Jerrold Zacharias. The meeting was very large in scope and in the number of participants (87 full-time). This meeting was not a "summer" study; rather, it was conducted from October 1954 to February 1955.

Involvement in National and International Programs

During the middle 1950's, ONR Continental Branch Office scientists became more closely involved with assisting in program planning, organizing and running research meetings, and a variety of other activities assigned by the ONR Research Codes. These programs were not always limited to the geographical area in which an individual branch office scientist resided; rather, they were sometimes nationwide, even international, in scope. Each staff member became involved to whatever extent his capabilities and interests meshed with the desires of a Code

400 Branch Head to utilize his services. Some were more successful than others in making working arrangements; but, as time passed, all Boston scientists became active in ONR national programs up to 50 percent of their working time. In spite of this, regional coordination and administrative duties were not neglected; rather, they were buttressed by the individual's keener interest and enthusiasm resulting from his feeling of being "on the team." Professional activities, such as on-the-job research and participation in scientific meetings, were encouraged as a means for sharpening the staff scientists' specialized knowledge and improving their rapport with the scientific community. As a result of this policy, some ONR Boston scientists have made research contributions which have enhanced their reputations and added luster to that of the office. Many of the staff members which have been active in their professional societies have gained recognition by being appointed to important committees and officerships.

One of the first major assignments that required participation by ONR Boston was in connection with the Infrared Information Symposiums (IRIS). Mr. Thomas B. Dowd was assigned as Deputy Chairman in November 1955, with duties involving the organization of large DOD technical meetings on all phases of military infrared and the publication of the proceedings resulting from these meetings. These conferences, which were originally held biannually alternating between East Coast and West Coast sites, are presently being held on an annual basis. However, the output continues to be of prime importance to the military, and the scope of the technical effort has broadened through the years.

Mr. Dowd assumed the role of Chairman in 1961, upon the resignation of Dr. Arthur B. Laufer of ONR Pasadena from this post. He also became Editor-in-Chief of *Proceedings of the Infrared Symposium* and Editor of the *IR Directory*. Mr. Dowd has received many awards and other forms of recognition for his outstanding services to IRIS. He has succeeded in performing this important function while maintaining his assignments in general physics for ONR Boston and the responsibility of Deputy Chief Scientist, a post to which he was appointed in August 1959. A few years ago, Tom Dowd assumed an additional major national responsibility, that of operating the DOD Laser Technology Conferences.

Dr. Carl F. Muckenhoupt was relieved as Chief Scientist in August 1959 by Dr. A. L. Powell who had served ONR Boston as staff chemist since 1947 and Assistant Chief Scientist since 1954. He is active for ONR in certain areas of organic chemistry and physical organic chemistry. Also, he maintains a part-time research program in physical organic chemistry, having received the Ph.D. degree in chemistry in 1956 while working for the Boston Branch Office. He is a Guest of

M.I.T. for research in physical organic chemistry, and spent a sabbatical half-year at Oxford University working with R. P. Bell on a research problem in acid-base catalysis.

Dr. Powell has participated in international scientific meetings and conducted chemical research surveys in such foreign countries as the Soviet Union, Japan, England, Austria, Canada, Czechoslovakia, Finland, and Sweden. The results of most of these surveys have been covered in ONR London Technical Reports. Dr. Powell has presented scientific papers at several of these international meetings, as well as at conferences in this country, and a number of publications have resulted. He has assisted the ONR Chemistry Branch in organizing and operating meetings in areas of chemical science of importance to the Navy, particularly a Conference on Inorganic Polymers held at Harvard University in 1958 and the Boron Chemistry Conference convened in ONR Boston in December 1962. In June 1967 he was appointed Deputy Director and Chief Scientist of the ONR Boston Branch Office.

As indicated earlier, Dr. J. Horace Faull, Jr. served for many years as a consultant to ONR and other DOD agencies in elastomer and polymer science and in related fields such as drag reduction and rocket propellants. As a member of the Quadripartite Committee Working Group (United States, United Kingdom, Canada and Australia) for organic materials, he conducted extensive short-term surveys of polymer and elastomer research in Western Europe in 1960 and 1963 that resulted in two important series of ONR London Technical Reports. These reports have become widely recognized by American and European polymer scientists as sources of broad information in this field.

In 1961 Dr. Faull became a full-time staff member in ONR Boston, adding a responsibility for administration of chemical science in the local area to his long-established polymer consulting activity for ONR and other DOD agencies. He has been active in the organization and management of numerous DOD meetings in polymer and elastomer science, in particular a long series of joint services conferences on elastomer research and development. The proceedings of these conferences constitute a history of military activity in this important technological area. In 1966 he spent several weeks in Japan attending an international polymer conference and gathering information for a technical report on polymer research in Japan.

Integrated Research Programs

In the 1960's the trends in ONR research support continued in the direction of integrated programs such as military infrared, underwater

sound, laser technology, inorganic polymers, and fuel cells. Administration and coordination of these broad technological areas required closer contact and scrutiny of the ongoing programs and deeper involvement by continental branch office scientists. These objectives were reflected in the criteria applied for recruitment of staff scientists during this period.

Dr. Fred W. Quelle, Jr. was hired in the spring of 1960 when emerging technologies resulting from solid state physics research made it apparent that a staff scientist would be needed in Boston to administer and coordinate efforts in this field for the Navy. At the time, Dr. Quelle was completing his studies for a Doctor's degree in physics from Harvard, but—since Dean Harvey Brooks of Harvard was on sabbatical leave—performing his research under the direction of Professor John C. Slater at M.I.T. Arrangements were made so that Fred Quelle could work part-time at ONR Boston until he completed his doctoral requirements. He met the last of the academic requirements in 1963 and received the Ph.D. in physics from Harvard in June 1964.

Dr. Quelle's interests range from theoretical work in energy band calculations and quantum electronics to the development of lasers for military purposes. He is a member of the ONR-ARPA Laser Technology Team with particular responsibilities in glass laser materials, semiconductor lasers, non-linear optics, Raman lasers and high-power CO_2 gas laser systems. He has made important personal contributions to laser technology, published a number of papers and technical reports in the field, and has received two awards for patent applications that have promising implications for military use.

Dr. Frank S. Gardner was engaged during the fall of 1960 as a materials scientist with particular emphasis on metallurgy. An M.I.T. Ph.D., Frank Gardner brought with him a wealth of industrial research experience acquired while working for the General Electric Company and Nuclear Metals, Inc. Although assigned primarily to research projects in physical metallurgy, he has displayed a lively interest in composites, whiskers, energy conversion and materials fatigue. He served as Acting Head of the ONR Metallurgy Branch for five months in 1963 and ran a regional corrosion workshop in Boston in 1966. He is currectly interested in transducer materials and is coordinating research and development information in this particular field relative to naval applications.

Mr. Paul Twitchell joined the ONR Boston Scientific Department in January 1962 after resigning from Melpar, Inc., an industrial concern with wide-ranging interests in electronics, physics, and geophysics. He is a meteorologist with a strong background in seismology and geophysics. While with ONR he has developed a deep interest in oceanography and has become the moving spirit in the organization of the

Massachusetts Association for the Marine Sciences, a consortium of university and private groups united to better utilize their combined staffs and facilities for oceanographic research. He has maintained an active interest in research on interactions of the solar atmosphere with that of the earth relative to identifying influences on global weather patterns, an effort which has resulted in publication of several scientific papers in the field. He is currently on sabbatical leave at the University of Wisconsin where he is conducting meteorological research towards the Ph.D. degree in meteorology.

In the fall of 1965 Dr. Nicholas T. Werthessen joined the ONR Boston Scientific Department as senior bioscientist. He came from the University of Oklahoma Medical School where he filled the post of Associate Research Professor in the Department of Physiology and the Department of Gynecology and Obstetrics. He had previously held a staff position at the Worcester Foundation for Experimental Biology in Shrewsbury, Mass. and served as Director of Research at the Southwest Foundation for Research and Education in San Antonio, Texas. He is the author or coauthor of over sixty publications on biological subjects.

While with ONR Boston, Dr. Werthessen has become deeply involved with Navy research programs on preservation of blood and tissues, working closely with the ONR Medicine and Dentistry Branch and with the Bureau of Medicine and Surgery. The blood preservation and storage program is vital to the delivery of viable whole blood to the wounded in the field and hence is of practical importance to present operations in Southeast Asia. Dr. Werthessen has provided much valuable guidance in coordinating the blood research effort in ONR and the Navy laboratories. He has also played an active role in promoting and coordinating research on deep submergence physiology, particularly stress and pathophysiology, and the effects of prolonged exposure to high atmospheric pressure.

Recent staff additions to the ONR Boston Scientific Department include Dr. Charles M. Harsh, a psychologist, and Mr. Stanley R. Curley, an electronics engineer. Dr. Harsh brings with him a varied background of experience in the psychological sciences, having served as a college professor, a staff member in the then Navy Electronics Laboratory, and an analyst with the Institute of Naval Studies. He is concentrating his early efforts on human factors research programs and in the vital area of cross-cultural foreign relations.

Mr. Curley has acquired considerable knowledge and experience in physics and electronics and has worked in these fields at both the Naval Research Laboratory and the Air Force Cambridge Research Laboratories. He is an expert on large radars with particular reference to their use in over-the-horizon communications and detection, and is

continuing his interest in this technological area by working with the ONR Electronics and Field Projects Branches. By agreement with the Air Force, he is completing a research project on missile exhaust tracking that he had started under their sponsorship. Mr. Curley is presently extending his expertise to fleet problems involving radars and underwater sound.

The ONR Boston Scientific Department, which now includes four staff members working out of the New York Area Office, is conducting a wide variety of scientific activities in response to its mission of representing the Chief of Naval Research in the local region. The staff "live with the scientific community" to elicit from it the research results needed to develop the materials and equipment for the fleet of the future. To carry out this responsibility, the scientists exercise critical scrutiny over ongoing ONR research projects, look for new research programs of potential use to the Navy, identify new technologies which appear promising for naval applications, and coordinate these efforts with related programs of Navy Laboratories and Systems Commands.

Undersea Radioisotope Generator Delivered

An undersea radioisotope generator to power an oceanographic buoy platform which will beam scientific data to ships, planes and satellites has been delivered to the U.S. Naval Oceanographic Office, Suitland, Maryland.

The buoy platform, containing an Interrogation Recording Location System, is part of an experiment being conducted by the Oceanographic Office to determine the feasibility of locating and obtaining scientific surface data from ocean platforms by unmanned satellites. It is one of several such experiments being conducted in connection with the Nimbus-B weather satellite program.

The radioisotope generator is a 25-watt undersea model produced commercially. Attached to a taut wire moored buoy 250 feet beneath the Atlantic Ocean's surface, the generator will supply electrical power to the Interrogation-Recording-Location-System (IRLS) surface spar float.

The buoy platform, moored off the coast of Puerto Rico, will be instrumented with sensors for making environmental measurements such as sea states, ocean currents, and wind velocities. The IRLS transmitter will telemeter the data from a specially designed antenna mounted on top of the spar float. As the Nimbus-B satellite passes overhead (twice a day), it will interrogate the platform and store the data for later playback as it passes over a central ground command station at Fairbanks, Alaska.

If the IRLS experiments are successful, similar unmanned scientific data collection stations using radioisotope power could be placed at remote spots throughout the world. Data from these surface stations coupled with that from orbiting satellites will provide a modern technique in data collection and telemetering for oceanography as well as permit precise global location of data stations without the need for sophisticated navigational aids.

Machine Translation in Review

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The primary aim of machine translation research is to produce the best possible translation, automated wherever feasible, from one language (the source language) into another (the target language) through the combined efforts of linguists, programmers, and research associates involved in related fields. A secondary aim, more an outgrowth of early research than an objective in itself, is to develop, as far as possible, a complete linguistic description of the grammars of certain languages. Accumulation of such data is invaluable for subsequent efforts to refine and develop machine translation output. Also, it is of great interest to linguists and teachers of the respective languages.

Historical Background

The idea of machine translation dates back to 1946, when Warren Weaver and A. D. Booth of the Massachusetts Institute of Technology began discussions on the technical feasibility of machine translation. A great deal of progress has been made since that time. In 1954, International Business Machines conducted a demonstration of machine translation in cooperation with the Georgetown University. An IBM 701 general purpose computer, using a total vocabulary of 250 words and six rules for determining the relationships that exist among sentence constituents, was programmed to translate Russian sentences into English. This highly publicized demonstration provided a marked impetus for interest growth and active research in the field. Machine translation research groups were organized not only in the United States, but also in countries throughout the world, *e.g.,* Great Britain, France, Italy, Germany, the Soviet Union, and Japan.

These pioneer researchers realized that, if any real progress were to be made in machine translation, linguists and programmers would have to devise a system to store and retrieve vast quantities of natural data in the form of dictionary entries and text, and to create algorithms to perform analysis and synthesis. Also, they realized that high-speed hardware with vast memory capacity would have to be developed simultaneously with that system. The main tasks confronting the researchers, in ascending order of difficulty, are listed below:

- Compiling automatic dictionaries and developing procedures for efficient storage and retrieval of language data and translation rules or instructions (lexicon);

- Encoding the grammar of words and their constituent parts (morphology);
- Writing word order rules for sentence analysis (syntax or sentence structure determination or recognition); and
- Developing procedures for analyzing and codifying the meanings of words (semantics).

By 1960, about a dozen federally sponsored research groups in the United States were investigating problems connected with compiling automatic dictionaries, development storage and retrieval procedures, and morphology. Indeed, not until investigations were actually underway did the researchers realize just how little was known about the structure and usage of given languages or just how incomplete the descriptions of these languages were.

In order to minimize duplication of tasks and to establish a basis for cooperative exchanges of information, a series of machine translation conferences was organized by Wayne State University. The first such conference was convened at the request and with the support of the Information Systems Branch, Office of Naval Research. Support for subsequent meetings was provided by the National Science Foundation, the United States Air Force and ONR.

The first machine translation conference, held in Princeton in 1960, concentrated on dictionary design and general questions of grammar. The second, which convened at Georgetown University in 1961, was devoted to problems of grammar coding. The third meeting, held in 1962 back at Princeton, was syntax-oriented; and the fourth, held in Las Vegas in 1965, dealt with semantics.

It was generally felt that these meetings benefitted all participants in terms of the climate of cooperation created, the informal exchange of views, and the precise definition of problems to be resolved. Various independent scholars and key representatives of research groups were able to examine together the problems, of either a linguistic or computational nature, that have confronted serious researchers. Also, conference participants were able to compare solutions, question one another on particular points, and, in general, pool the results of individual endeavors.

ONR-Sponsored Research at Wayne State University

ONR-sponsored research in computer-aided Russian→English machine translation at Wayne State University has led to the development of an experimental system which presently comprises three basic operations—dictionary lookup, syntactic blocking, and hyperparse (see figure 1). At the current stage of development, these three operations are coordinated through the interaction of both human and machine procedures.

FIGURE 1 — MT PROCESSING OF A RUSSIAN SENTENCE

INPUT

УСТАНОВЛЕНИЕ ГИДРОЛОКАЦИОННЫХ СТАНЦИЙ ВОЕННИМ ФЛОТОМ ОБЛЕГЧИТ ОБНАРУЖЕНИЕ ВРАЖЕСКИХ ПОДВОДНЫХ ЛОДОК.

DICTIONARY LOOKUP
(grammar codes and English equivalents are retrieved)

e.g., УСТАНОВЛЕНИЕ – 1.00.401.343.02.000.0.0.0.0.00.0.0.0. – ESTABLISHMENT

Part of Speech	Homograph Code	Agreement Code	Person, Gender, Number	Case Government	Preposition Government	Motion Gov't	Infinitive Gov't	ЧТО, ЧТОБЫ Gov't	Complex Gov't	Name	Pronoun/Proper	Animation	Non-Pred. Formula	Pred. Formula
1	00	401	343	02	000	0	0	0	0	00	0	0	0	0

SYNTACTIC BLOCKING
(analysis of sentence constituents in order to group related members)

nominal block 1: УСТАНОВЛЕНИЕ
nominal block 2: ГИДРОЛОКАЦИОННЫХ СТАНЦИЙ
nominal block 3: ВОЕННИМ ФЛОТОМ
predicate block 1: ОБЛЕГЧИТ
nominal block 4: ОБНАРУЖЕНИЕ
nominal block 5: ВРАЖЕСКИХ ПОДВОДНЫХ ЛОДОК.

HYPERPARSE
(automatic parsing of sentence – specific function(s) is assigned, to each of above blocks)

Predicate Candidates	Subject Candidates	Object Candidates	Adjunct Candidates
predicate block 1	*nominal block 1* *nominal block 4*	*nominal block 1* *nominal block 4*	*nominal block 2* *nominal block 3* *nominal block 5*

MATRIX REDUCTION YIELDS TWO POSSIBLE INTERPRETATIONS:

Subject	Predicate	Object	Adjunct
nominal block 1 *or* *nominal block 4*	*predicate block 1* *predicate block 1*	*nominal block 4* *nominal block 1*	*nominal block 2,3,5* *nominal block 2,3,5*

OUTPUT

(THE) ESTABLISHMENT (OF) SONAR STATIONS (BY) (THE) (MILITARY) FLEET WILL FACILITATE (THE) DETECTION (OF) ENEMY SUBMARINES.

Input to the system generally consists of a technical Russian language text which has been keypunched and read onto magnetic tape. One sentence at a time is analyzed. Each sentence item is looked up in a computer-stored dictionary (a compilation of words as they occur in a text comparable to the input text) and its encoded grammatical characteristics and English equivalent(s) are retrieved. The resultant output tape of looked-up text is used as input to the next operational phase—syntactic blocking or analysis. This procedure endeavors to recognize and to record the functional (grammatical) role played by each sentence constituent.

In syntactic analysis, sentence items (sometimes only one word) which serve the same function in the sentence, *e.g.*, subject, predicate, object, are put into blocks or groups. Each block has a kernel word (noun, verb, preposition) on which other sentence items may be said to depend. For example, blocks would be formed by a noun and its modifiers, a verb and an adverb, a preposition and its object noun, *etc.* An output tape of blocked sentences is then created and serves as input to the third operational stage, *i.e.*, where the blocked sentence is automatically parsed. This procedure entails determining the functional role (*e.g.*, subject, predicate, object) played by each of the blocks.

In the example shown in figure 1, a grammatically ambiguous sentence offers two possible interpretations for the computer to discover. However, a single, logical interpretation would be deduced by a human translator, for the simple reason that he has more information stored in his brain than a computer has in its memory. To resolve this problem, a computer program has been written which would reduce grammatically ambiguous sentences to the fewest possible interpretations. This was done by means of a mechanically generated matrix which seeks to discover distinctions among the apparently ambiguous blocks. Those noun blocks which do not qualify as either subject or object candidates are grouped as so-called "adjuncts."

The system's presently obtainable output is represented by the non-parenthetic items in figure 1. Information shown in parenthesis will be produced automatically when translation rules are revised in the near future to include provisions to rearrange word order and to insert articles and prewords. This latter task is still being done by a human post-editor. However, even in its present form, the telegram style output can be easily understood.

Experimentation in machine translation at Wayne State University is continuing with two primary objectives: first, to automate additional analytic procedures; and second, to refine previous routines according to insights gathered from each successive experiment. At the same time, translation rules are being formulated which, when written into the system, will improve the quality of the output.

Machine Translation Research Objectives

In order to attain the long-range research objectives of machine translation, it is important that research be continued on such short-range objectives as straightforward linguistic analysis of the lexicon and the grammar of various languages. Information to be gained from such research is necessary to successfully implement machine translation procedures and to overcome those problem areas or stumbling blocks that stand in the path of completely successful machine translation. These problem areas are primarily concerned with syntax (the structural interrelationships of sentence constituents) and semantics (the meaning of words and groups of words). There is reason to believe that sound theoretical bases have been established which will eventually resolve syntactic problems. However, a great deal remains to be done in semantics.

In any system of machine translation, there are many points of intersection in the areas of lexicon, morphology, syntax, and semantics. The boundaries are not clearcut but have had to be mapped and defined. The machine translation research process has been a heuristic one, where the knowledge and experience gained at a given stage of development has been applied to the refinement of preceding stages. The converse is also true. In this regard, the initial exploration of semantic problems, in many instances, has been based on syntactics.

Conclusion

Although fully automatic, high-quality machine translation is still a remote objective, machine-aided translation (*i.e.,* translation produced through a symbiosis of man and mechanical devices) is indeed workable and productive. This is especially true in scientific areas for which mircroglossaries and mircrogrammars have been compiled.

To date, five organizations have been conducting effective computer-aided translation operations:

- Atomic Energy Commission at Oak Ridge, Tennessee;
- Foreign Technology Division, United States Air Force, Dayton, Ohio;
- National Physics Laboratory, Teddington, England;
- EURATOM at Brussels, Belgium and Ispra, Italy; and
- Central Research Institute for Patent Information, Moscow, USSR.

It is interesting to note that the last-named institute is translating the *Official Gazette,* the weekly publication of the United States Patent Bureau.

The operational machine-aided translation programs being conducted at the above organizations continue to produce a good deal of

useful output. However, there is still a need for computer-aided linguistic investigations such as those being conducted at Wayne State University and at the Linguistic Research Center of the University of Texas. The results of these investigations are needed to refine further machine-translation-oriented linguistic analysis and to implement those refinements into operational programs.

Dr. Mutch Receives Award

A Naval Research Laboratory scientist has been accorded the highest honor given by the British Society of Environmental Engineers.

Dr. William W. Mutch, head of NRL's Shock and Vibration Information Center, has been awarded a Fellowship of the Society for significant contributions to the field of environmental engineering involving simulation of natural and created environments for testing hardware and machines. The center provides a single source from which scientists and engineers throughout the United States can obtain up-to-date information on shock and vibration. In addition, the center staff points out gaps in the field where further work is needed.

Mr. Helvestine Receives Navy Distinguished Civilian Service Award

Mr. Albert H. Helvestine, Patent Counsel for the Navy and an employee of the Office of Naval Research, has been awarded the Navy Distinguished Civilian Service Award. One of Mr. Helvestine's major achievements is the important role he has played in the Rickover copyright case. A suit was brought which argued that speeches made by VADM Hyman Rickover are federal government publications and thus cannot be protected by copyright. The Navy and the government contended that the literary work of a government official that is not prepared as part of his official duties is not an official document, and therefore can be copyrighted by the employee-author as a protection against unauthorized use.

Mr. Helvestine was a key government expert witness in a trial held last spring in the U.S. District Court, District of Columbia, in which the government's contention was upheld by the court. The case is now pending before the Court of Appeals and may eventually reach the Supreme Court.

New Laboratories Dedicated at Lamont

Two new buildings—a core laboratory and an instrument laboratory—were dedicated in October at the Lamont Geological Observatory of Columbia University. The two laboratories have added more than 50,000 sq ft of teaching, research, and stowage space to the Lamont facilities. The two-story core laboratory houses the core library (consisting of about 5,000 core samples), and provides areas for lecturing, study, and offices for the personnel of the Submarine Geology Department. The instrument laboratory contains equipment for making new underwater cameras, coring devices, pneumatic guns for seismic work, heat flow measuring instruments, and equipment for the observatory's research ships.

Funds for these buildings were provided by the National Science Foundation and the Alfred P. Sloan Foundation.

Research Notes

Source of Increased Protection Against Tooth Decay Explored by Navy

Navy studies have indicated that there is something in the water and soil of three small areas of the country, especially northwest Ohio, which combines with fluoride to provide increased protection against tooth decay. This indication is based on the discovery that significant numbers of new Navy recruits from those areas have teeth completely free of caries (cavities).

As a result, a research program sponsored by the Office of Naval Research is now underway at the Eastman Dental Center, Rochester, N.Y. The objective is to find out what is present in the water and soil of the areas involved which can work with fluoride to achieve a greater reduction in the number of new cavities the average person gets.

The Navy is concerned about the high incidence of dental caries found in new recruits, who have, on the average, 12 active lesions requiring treatment. Since Navy personnel receive regular dental care throughout their careers, the Navy has for some time conducted research in the prevention of dental caries.

Since 1957, the Naval Training Center, Great Lakes, Ill., has made records of recruits who report there free of dental caries. A total of 360 such recruits have turned up. Some of these cavity-free cases can be explained by excellent individual dental care plus fluoridated water. Groups of the recruits, however, were noted to have come from specific geographic areas. Apparently, in those areas, fluoride in the water and chemicals peculiar to local water and soil absorbed by local food stuffs combine to inhibit the development of cavities.

One large group comes from the northwestern part of Ohio, an area of small farming communities where the inhabitants consume local food products to a great extent. It is also known that the water there has a high mineral content. Investigation has shown that the residents of this area have on the average three times fewer cavities than other areas of Ohio.

For this reason the Eastman Dental Center will concentrate on analyzing the local water and food products in that area. Vegetables will be grown there under controlled conditions and then fed to rats, both in raw form and cooked in the local water, to determine what beneficial effects this food may have on their teeth. Analyses of the chemicals contained in the local food and water are being made through the cooperation of the U.S. Geological Survey and Ohio State University.

The two other low-cavity areas to be studied are Hillsborough and Polk counties in west central Florida, particularly Plant City and Lakeland; and Horry county in northeastern South Carolina, particularly Conway and Myrtle Beach. Both of these areas have produced several caries-free Navy recruits.

NELC Develops Mini-Range for Theodolite Operator Training

A mini-range for training theodolite operators has been developed at the Naval Electronics Laboratory Center, San Diego, California. A theodolite is an instrument similar to a surveyor's transit, but capable of a higher degree of accuracy. The mini-range, which was designed by L. C. Thompson, will be used in connection with NELC's Fleet Operational Readiness Accuracy Check Sites (FORACS) program.

Instead of sending personnel to remote FORACS tracking stations for training, theodolite operators and newly-hired test engineers who must know detailed range operations can now be given preliminary training in target tracking and radio communication procedures at NELC. Local training will eliminate the costs and delays of sending students and instructors to FORACS stations on San Clemente Island; Guantanamo Bay, Cuba; Oahu, Hawaii; and Cape Cod, Mass. Also, the mini-range target is always available when needed.

The FORACS program was established to provide ranges to measure the alignment and calibration of ships' ASW and navigational sensors. An important part of this operation is knowing the exact location of the ship in the range. At present, engineering theodolites are used to provide this information.

The NELC mini-range duplicates actual range conditions, but is scaled down by a factor of 100 to one. FORACS computer programs were used to reduce data for the mini-range. Theodolites identical to those found in the field are employed.

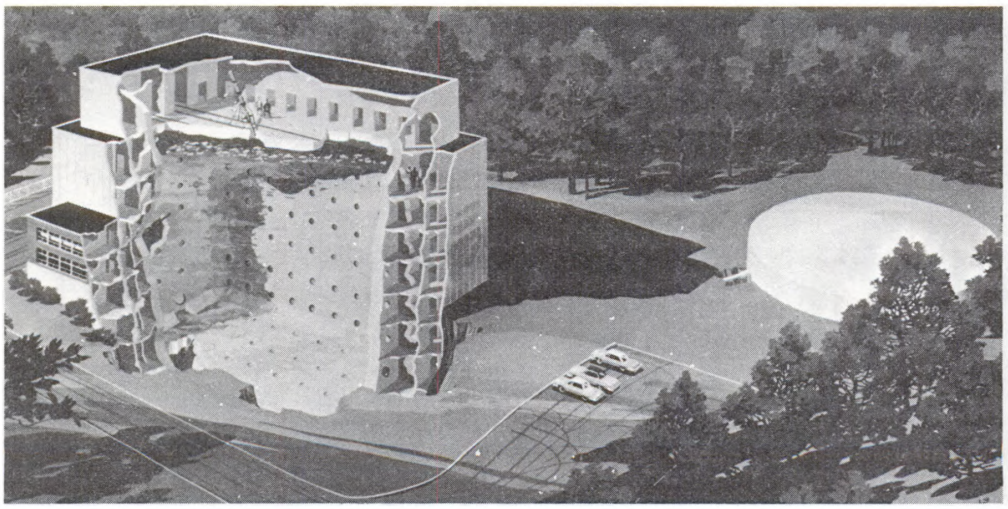
NOL's Hydroballistics Facility

New ASW weapons that re-enter the water at extremely high speeds have spawned a variety of vexing hydrodynamic problems. Before design parameters can be established for such weapons, the forces they will experience at water entry and the shape of the water-entry cavity must be known.

The Hydroballistics Tank at the Naval Ordnance Laboratory, Silver Spring, Md., with its capacity for 1,750,000 gallons of water and its special associated instrumentation is unique in its capability to provide the U.S. Navy with just this information. The instrumentation includes a fire control unit to synchronize launcher-camera operation, a multichannel tape recorder system to monitor telemetry signals, an optical whip recorder to measure angular motion of water entry, and high-speed 16 mm and 35 mm cameras to record the entire model trajectory. The purpose of this facility, which was dedicated on October 31, 1967, is to provide an environment for simulating the performance of missiles which enter the water after supersonic flight. It will be used to make studies of underwater launching and water exit and of powered, maneuverable, scaled models of submarines and torpedoes.

The massive, reinforced concrete honeycomb around the tank is designed to permit reduction of air pressure above the water for cavitation scaling. Also, the tank has 157

Model of the Hydroballistics Tank building showing the honeycomb construction around the tank. Storage tank at right holds total amount of water from main tank.



armored-glass view ports which permit excellent visual and photographic observations, and 15 gun ports which permit mounting and training of launchers from almost any angle for water entry, underwater travel, and water exit studies.

The tank is 100 ft long, 35 ft wide, and 75 ft deep. It is constructed of reinforced concrete and lined with 1/8-inch stainless steel to preserve water clarity. The 1,750,000 gallons of water can be completely filtered by three diatomaceous earth filters in two days. A separate storage tank has been provided to facilitate the filtering process and to make it possible to change the water level in the main tank, or to drain the tank for maintenance without loss of the filtered water. The tank can be emptied into the storage tank through a three-foot diameter pipe in less than 25 minutes.

Three-inch diameter models can be launched at 3000 feet per second. Other size models can be launched at appropriately higher or lower speeds. The tank is large enough to contain whole trajectories.

New Satellite Navigation Technique

NRL scientists, under sponsorship of the Naval Air Systems Command, are conducting exploratory development on a new satellite navigation technique with which a ship or airplane can instantaneously obtain a highly accurate fix of its position.

A pilot or navigator would make direct, simultaneous measurements of UHF (ultra-high frequency) signals from two or more satellites with known positions. Time from transmission to receipt of signals from these beacons in the sky would be converted into distance. Position can be determined by applying standard navigation techniques.

The same highly accurate information could be obtained by direct measurement of two signals from a single satellite. With this approach elapsed time is required for a fix.

A satellite experiment was conducted by NRL personnel on May 31, 1967 to verify principles of the techniques and test component performance. The satellite equipment weighs 85 lbs and is powered by solar cells.

The NRL technique is compatible with Doppler equipment for low altitude satellites. In addition, it can be used in very high altitude satellites.

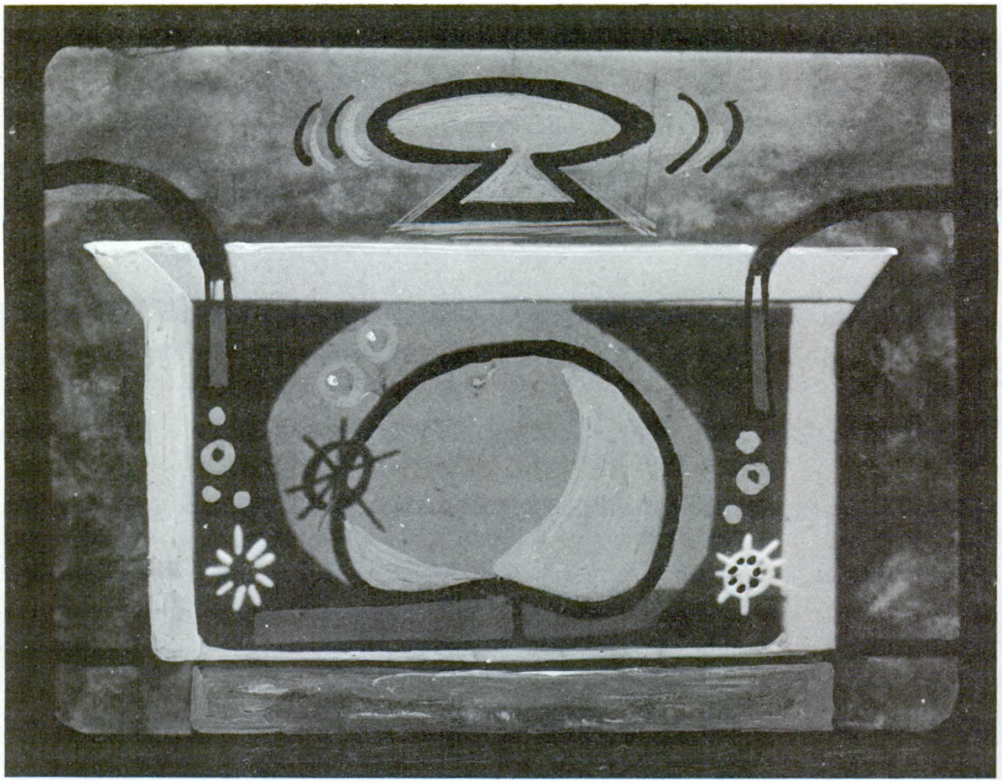
According to NRL scientists who directed development of the new technique, it is as easy to use as celestial navigation and more accurate.

NADC Develops New Wet Suit

The Naval Air Development Center, Johnsville, Pa. has developed an air-ventilated wet suit (VWS) that may replace the anti-exposure suit (MK5A) now being worn by naval aviators for short duration protection. Fleet pilots and crewmen will evaluate the new wet suit this winter.

The wet suit, which is designed for use where quick pick-up of the aviator is probable, such as on a carrier-based operation, will provide protection to an uninjured man for approximately 90 minutes in 32°F water, 20 mph wind, and an air temperature of 20°F. A special non-absorbent two-piece insulation underwear, exposure mittens, and an inflatable exposure hood must be worn with the suit. A Nomex flight coverall is worn over the assembly to provide storage pockets, tear protection, and additional fire protection. A pilot can connect the suit to an aircraft air source or to a portable blower in order to remain comfortable under varied conditions.

The conventional MK5A dry suit consists of an impermeable outer suit and a bulk insulation-ventilation liner. While it gives longer protection than the new wet suit, it is much more cumbersome, and provides little protection if leaks develop. The new wet suit provides greater reliability and has a more efficient ventilation system than the MK5A.



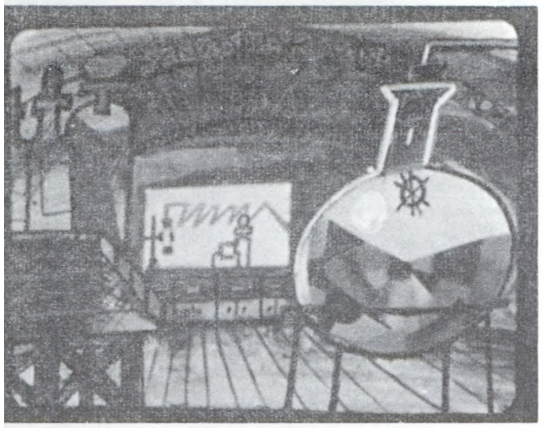
This brain has just given birth to a unique scientific conception. It has produced that most valued product of human intuition and intelligence—a creative thought.

The Care and Feeding of the Research Brain — Navy Style

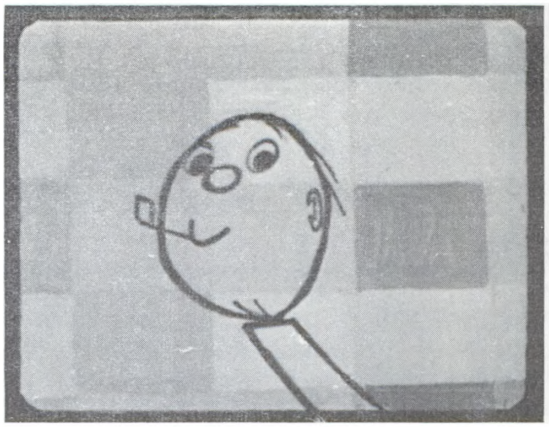
The Office of Naval Research, aware that new developments occur in the visual arts as well as in the sciences, has adopted that most contemporary and potent form of visual communication—the motion picture—in an attempt to define the thought processes which are the substance of creative thinking. The resultant film, sponsored by the ONR Public Affairs Office, is entitled "The Care and Feeding of the Research Brain—Navy Style." It is 16mm color, and runs approximately 25 minutes.

ONR, the Navy's representative in science, deals extensively in innovative scientific thinking. Accordingly, Mr. James C. Koukos, who produced the picture, has attempted to make the tone and texture of the film reflect both modernity and an awareness of new cinematographic techniques.

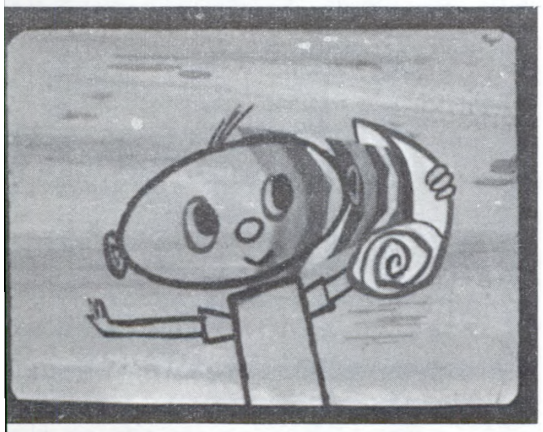
This picture, designed to help explain basic naval research, is available for short-term loans from the Public Affairs Office (109), Office of Naval Research, Washington, D.C. 20360.



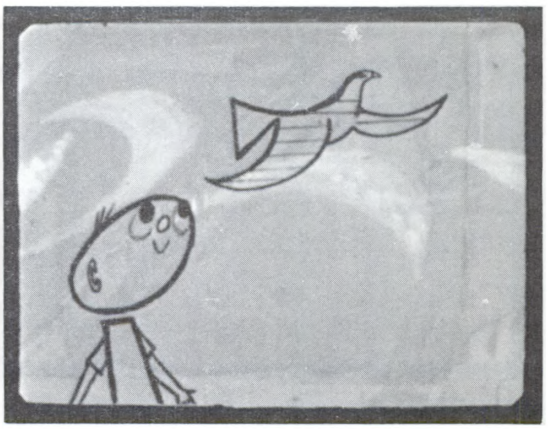
A moment ago that thought was locked in the labyrinth of a basic research scientist's mind where it boiled and fermented...now it gushes forth, laden with possibilities.



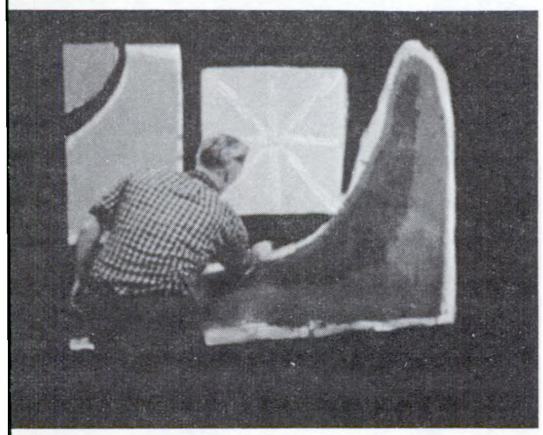
To understand more about its origin, let us consider the physical container from whence it came—Hardy Simms, Ph.D., basic research scientist working under Navy support.



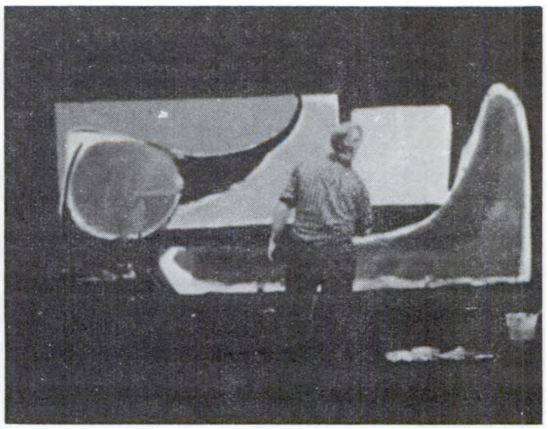
When Hardy was a boy, he was fascinated by a world full of wonders. All small boys are curious...but Hardy even more so...a little more curious than the rest.



And that creative spark he had to begin with was nourished and stimulated. The years pass and Hardy Simms becomes a research scientist—a man capable of creativity.

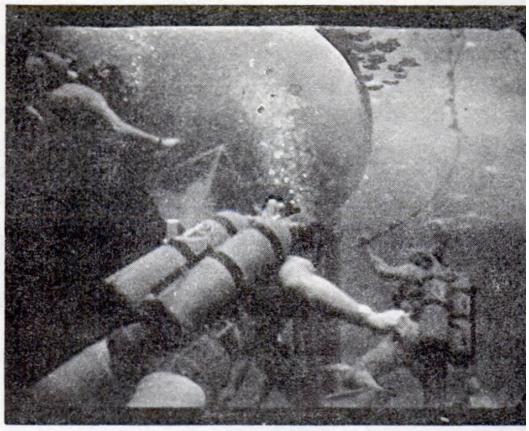


And what is creativity? Well, the creative processes in the sciences and arts have a common root. The artist abandons conventional notions, experiments to find something new.



All the while, he works toward a goal. Finally, a new concept evolves which has never before been seen in this exact form—and so it is with creative scientific thinking.

The Navy has long realized the importance of creativity. It recognizes original ideas with naval applications and then encourages the research scientist to develop them.



The Navy's Sealab program, for example, converted specula tion into reality. As the first prototype of an underocea living-working facility, it translated thinking into actio

The Navy knows that the smallest creature—on land or sea— has much to teach us. Through basic studies, we are learning about locomotion, communications, homing instincts.

Then there is the laser—a great contemporary example a field of research that has burst into existence overnig and has many important naval applications.

And who is responsible for encouraging the basic research scientist to develop his naval-oriented original idea?—the Navy's representative in the field of science, the Office of Naval Research.

On the Naval Research Reserve

New Unit in Sixth Naval District

Chattanooga, Tennessee, with its great variety of industrial research, technical, and educational facilities, offers a wide range of activity within the mission of the Research Reserve. This is the home of NRRC 6-19, the newest member of the Research Reserve family in the Sixth Naval District. The Company was established on July 1, 1967.

The majority of the nucleus of 15 members were former members of a Composite Company who are highly interested in the Research Reserve Program. The group represents varied military experience and designators as well as diversified civilian backgrounds and areas of responsibility. These resources have been of great value in the transition to "research orientation."

NRRC 6-19 is anxious to make some contribution to the Research Program and was very pleased to have been rated in first place in the Sixth Naval District competition for the first quarter.

Sixth Naval District Research Reserve Units Visited

Miss Eleanor F. Kehoe, CDR, USNR, Sixth Naval District Research Reserve Liaison Officer, completed fall visits to all 12 Research Reserve units in the Sixth Naval District on December 19, 1967. There are 170 Naval Reserve officers participating in these units.

While in Atlanta, Georgia, Miss Kehoe discussed the Research Reserve Program with CAPT Gerald B. Rogers, USNR, the new Commanding Officer of the Naval and Marine Corps Reserve Training Center. CAPT Rogers has two Research Reserve units under his direction—NRRC 6-1, Atlanta and NRRC 6-9, Athens, Georgia. He expressed great interest and enthusiasm for their training programs and, further, has initiated action to assist in the recruitment of qualified officers for both units.

Joint Army—Navy Research Reserve Seminar

A Southeastern Research Reserve Seminar, sponsored by NRRC 6-1 and the 3251st U.S. Army Reserve R&D Unit, both of Atlanta, was held at the Lockheed-Georgia Research Laboratory, Marietta, Georgia last spring.

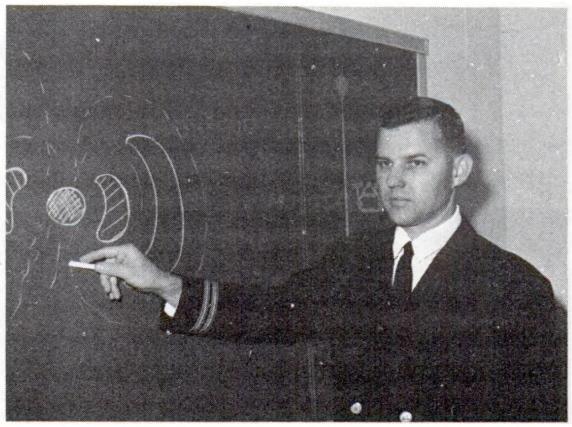
The seminar was opened with a welcoming address by Glen P. Robinson, President of Scientific Atlanta and Chairman of the Georgia Commission on Science and Technology. Technical presentations were given by prominent scientific and engineering speakers on scientific and technological activities in the Atlanta area.

The seminar included a tour of Lockheed-Georgia's research laboratories, the C-141 aircraft production lines, and the C-5A aircraft mock-up. Also, tours were made of the new nuclear reactor facility at Georgia Tech, the U.S. Public Health Service's National Communicable Disease Center, and the manufacturing facilities of Scientific Atlanta. A Saturday evening banquet was held with an address being given by the Hon. H. McKinley Conway, Georgia State Senator, and President of Conway Research.

Seminar attendees were members of Navy and Army R&D Units from all parts of the southeastern area. The civilian occupations of these Reserve Officers represent just about all branches of the scientific community.

The seminar was under the general direction of LCDR Ray B. Levine, USNR, Commanding Officer, NRRC 6-1, who is a staff scientist at the Lockheed-Georgia Research Laboratory. The seminar coordinator was LCDR Robert S. Duggan, USNR, a member of NRRC 6-1.

LT Pierce Johnson Discusses Recent Studies



Are there other explanations for the origin of life on a planet? Could the rebounding of electromagnetic waves between the earth and the ionosphere be a requirement for life to be catalyzed?

LT Pierce Johnson, USNR, a member of NRRC 6-2, Auburn, Alabama, briefly presented a portion of the theory answering these questions at a meeting of NRRC 6-2. An exploration of this alternate condition for a beginning of life is partially given in three papers co-authored by LT Johnson, a candidate for the Ph.D. degree in electrical engineering, and Dr. E. R. Graf, both of Auburn University. These three papers, "Radiation Noise Energy and Human Physiology in Deep Space," "A New Criterion for the Quest for Life in our Solar System," and "The Source of Decametric Radio Emissions from Jupiter," are a part of Dr. Graf's planetary resonator hypothesis.

This hypothesis states that any planet with a high axial rotation will foster on electromagnetic phenomenon whereby the planet, its magnetic fields, atmosphere and Van Allen belts, actually constitutes a concentric, spherical resonator. The characteristic electrical discharges in the upper atmosphere and the strong electromagnetic field at the surface of the

planet provide the catalytic energy source for the spontaneous generation of life from the nonliving millieu.

At a future meeting of NRRC 6-2, Dr. E. R. Graf will discuss some of his latest work on the prediction of sunspot activity, a part of his overall theory.

NRRC 6-3 Conducts Weekend Seminar

NRRC 6-3, located in Oak Ridge, Tennessee, sponsored a weekend seminar December 8-10, 1967. This unit, which has been in existence since 1949, has sponsored 16 two-week nuclear science seminars in the past which have been attended by well over 1000 Research Reserve officers. Also, NRRC 6-3 placed first for Research Reserve Companies in the Sixth Naval District for two years in a row—FY 1966 and FY 1967.

This year's seminar began on Friday evening, December 8, with a movie and discussion on the "Oak Ridge Operations." The program on Saturday commenced with a welcoming address by LCDR Sam Campbell, Commanding Officer, NRRC 6-3. A brief description of the program is provided to show the breadth of the seminar. Speakers are all members of NRRC 6-3.

LCDR W. J. Leonard, a metallurgist at the Oak Ridge National Laboratory, spoke on the Army pulse reactor. The address was principally an engineering description of the Army pulse reactor and an interesting account of the experience in Oak Ridge in manufacturing, testing, and performing a criticality test on the reactor prior to shipment to Aberdeen, Maryland. In addition, a complete review of the pulse reactor program within AEC, its importance to research, and future trends were presented.

LT H. O. Guberman, a research physicist of the Solid State Division of the Oak Ridge National Laboratory, presented his paper dealing with the "Effects of Radiation on Mechanical Properties of Metals." LT Guberman is engaged in research concerning plastic deformation of metals, with particular emphasis being placed on dislocation behavior in body-centered-cubic (bcc) metals. His talk dealt with the general defects one observes in metals and those defects produced by radiation. In addition, he discussed the effects of irradiation on tensile properties of face-centered-cubic (fcc) and bcc metals and the effects of irradiation on low and high temperature embrittlement.

LCDR C. E. Sage, a staff member of the Union Carbide Corporation Nuclear Division, presented a review of the AEC/NASA Rover Program, which is concerned with nuclear reactors for space propulsion. LCDR Sage covered the Rover Reactor Development Program being conducted by the Los Alamos Scientific Laboratory, and discussed the analysis and testing required in the assembly and disassembly

sequence. The pecularities regarding the personnel capabilities, equipment, and environmental conditions were of special interest to the group. LCDR Sage also presented a complete description of the testing area at the Nuclear Reactor Development Station in Nevada, including its current and planned facilities.

CDR C. L. Yarbro, a biologist with AEC's Oak Ridge Operations Office, discussed "Developmental Research in the Life Sciences." He presented a briefing on AEC-supported applied research in the life sciences areas including plant breeding, insect control, food preservation, and nuclear medicine applications. He also discussed development of the liquid zonal centrifuge at ORNL under joint AEC and National Institutes of Health support and its application in vaccine production.

CAPT R. B. Martin, the Deputy Director of the Laboratory and University Division of AEC's Oak Ridge Operations Office, addressed the seminar on "AEC-Oak Ridge-University Cooperation." CAPT Martin's talk centered around the needs and interests of colleges, universities, research centers, and the government; and how LUD coordinates these interests and brings the appropriate resources into focus on the problems. AEC provides direct support of research at many universities and research centers. The personnel assistance program for professors and graduate students is a very interesting facet of the LUD program. CAPT Martin's presentation clearly explained how AEC's LUD is functioning to develop the leaders in the scientific community.

LT James M. Jacobs, Chief, Reactor Technology Section of AEC's Division of Technical Information Extension, presented a review of the technical information services his organization makes available to the scientific community and the general public. LT Jacobs discussed the statutory requirements for the development of working systems for the dissemination of research development information. He elaborated on the type of information available, the services provided, and the methods for providing them. The relatively new technical information retrieval program, including Nuclear Science Abstracts and Response, and their interrelationships were also discussed. DTIE services have been increasingly important to the scientific community.

CAPT William T. Zumwalt, Chief, TVA Power System Operation, arranged for a briefing and tour of the free world's first super-critical steam plant, TVA's Bull Run Power Plant, located about three miles from Oak Ridge. Mr. George Wheaton, the assistant plant superintendent, conducted the tour. This power plant, completed about one year ago, is capable of delivering 1000 megawatts to the TVA grid. The Bull Run staff is currently working on a computer system that will allow completely automatic operation of the plant.

The plant can go from a completely cold condition to full power in about 12 hours. It consumes about 7500 tons of high-grade coal per day and has a coal yard capable of storing a 60-day supply of coal. Coal is delivered by special train, each carrying approximately 72,000 tons of coal, from the mines to the coal yard about four times per week. The entire trainload can be dumped in 20 minutes: the coal cars are remotely commanded to dump the coal as the train moves at one to two miles per hour.

On Sunday afternoon, a tour of the American Museum of Atomic Energy, located in Oak Ridge, was arranged. This concluded the scheduled events for the NRRC 6-3 weekend seminar. Forty Research Reserve officers participated.

NRRC 6-8 Increases Recruiting Effort

NRRC 6-8 of Orlando, Florida, which meets at the Reserve Training Center, has instituted a plan to attract new members from the community, local colleges and industry. Also, since two new naval activities will be opened in the Orlando area during 1968—the Naval Training Center and the Recruit Training Center—it is expected that a number of the civilian staff personnel will be eligible for Research Reserve membership.

Prospective members are contacted personally, with follow-up by meeting, invitation, and newsletter. Posters have been prepared inviting inquiries regarding the Research Reserve program. Newspaper coverage also has been obtained. These efforts are, of course, in addition to those to recruit qualified officers from the list of officers in the area who are not affiliated with a Naval Reserve program.

Activities of NRRC 6-9

NRRC 6-9 of Athens, Georgia feels that its series of very interesting programs has been largely responsible for its 25 percent increase in membership in the past three months.

Many of the featured speakers have been nationally recognized educators and scientists associated with the University of Georgia or the federal government research activities in the Athens area. Two typical recent programs featured the director of all the Agricultural Experiment Stations in the state and a recognized history scholar. The program featuring the Experiment Stations gave an unusual insight into the reason why modern agriculture, through research, is probably the most stabilizing influence in our economy. Not only was the program of keen interest to the entire group, but it gave each member points whereby his own garden and yard could benefit.

The last program of the quarter was an in-depth study of how the living standards of the average Russian citizen has progressed in the past ten years. The speaker, a former member of NRRC 6-9, spoke from personal studies made in Russia in 1956 and 1967.

NRRC 6-18 Drill Program

NRRC 6-18 of Nashville, Tennessee, is fortunate in being located in a community of wide business and industrial diversification. Thus, to avail itself of the opportunities at hand, the company has scheduled one field trip per quarter as a uniformed drill to visit a plant site. In this manner, the Naval Reserve has been kept before the public and the members have had an opportunity to keep abreast of the rapid changes taking place in the areas of business and technology.

Uniformed drills for the past year included visits to the Western Electric Company plant, the Southern Bell Telephone and Telegraph Company Central Office, and the Nashville Bridge Company facilities. The visits to Western Electric and Southern Bell permitted members to view the latest advances in the field of telephone communications. The Nashville Bridge Company tour enabled members to observe the latest techniques being employed in marine construction.

The regular company drills include lectures by authorities in their various fields of endeavor. Typical programs this past year included lectures on economics, including balance of payments and gold flow; Civil Defense; communism; research in heart maladies; and bio-engineering research. LCDR Charles W. Hawkins, III commands NRRC 6-18; LT Larry Wilson is the Executive Officer and Program Officer.

Random Noise

Mr. Robert J. Bobber was recently appointed as Chief Scientist of NRL's Underwater Sound Reference Division, Orlando, Florida. Mr. Bobber's vocational interests lie in the fields of acoustics, undersea warfare and technology, and electroacoustic transducers and measurements.

Dr. Joseph P. Pollard, who served as Assistant to the Chief of Naval Research in Medical and Allied Sciences from May 1960 to November 1964 as Captain, USN, has recently returned to ONR to assume the position of Director, Biological Sciences Division. Prior to returning to ONR, Dr. Pollard served as Director, Research Division, BuMed.

Mr. Murray Rogofsky, formerly of the Information Management Department, Vitro Laboratories, was recently appointed Special Assistant for Technical Information Systems at the Naval Oceanographic Office, Suitland, Md.

Mr. Don Pollock, formerly of ONR's Information Systems Branch, recently accepted a position with the National Science Foundation.

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research & Development Reports 67, No. 22 of November 25, 1967 and No. 23 of December 10, 1967. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in USGRDR 67, Nos. 22 and 23.

AERONAUTICS

Integrated Cockpit Research Program; Litton Systems, Inc.; Murphy *et al;* AD-658 753 and AD-658 754

ASTRONOMY AND ASTROPHYSICS

A Statistical and Astrophysical Investigation of Emission-Line Stars and Planetary Nebulae in the Southern Milky Way; Dearborn Observatory; Henize; AD-658 513

An Analysis of the Distribution of Radio Sources; CalTech; Wagoner; AD-658 691

Final Stages of Evolution; CalTech; Shaviv; AD-658-692

On the Fine Structure of Absorption Lines; CalTech; Bahcall *et al;* AD-658 693

The Microwave Spectrum of Venus in the Frequency Range 18-36 Gc/SEC; Calif. U.; Griffith *et al;* AD-658 708

The Corona Far From the Sun; Calif. U.; Wilcox; AD-658 811

Isentropic Models for Final Stages of Stellar Evolution; CalTech; Rakavy and Shaviv; AD-659 048

Research in Astronomical Photometry and Polarimetry Concerning W Serpentis and the Orion Nebula, NGC 1976; Northern Arizona U.; Hall; AD-659 202

ATMOSPHERIC SCIENCES

The Interaction of Internal Gravity Waves With the Ionosphere at the F1 and F2 Levels; Columbia U.; Bugnolo; AD-659 173

Solar Particle Observations Inside the Magnetosphere During the 7 July 1966 Event; Iowa U.; Krimigis *et al;* AD-659 325

Observations of VLF Hiss at Very Low L Values; Iowa U.; Gurnett; AD-659 479

Observations of Low Energy (0.5 MeV) Trapped Protons With Injun IV; Iowa U.; Krimigis; AD-659 480

On the Distributions of Low-Energy Protons and Electrons in the Earth's Magnetosphere; Iowa U.; Frank; AD-659 481

Simultaneous Dust and Ozone Soundings Over North and Central America; Minnesota U.; Rosen; AD-658 546

Spectral, Spatial, and Temporal Variations Observed for Outer Zone Electrons From 10 to 100 keV With Satellite INJUN 3; Iowa U.; Fritz; AD-658 710

Recent Observations of Low-Energy Charged Particles in the Earth's Magnetosphere; Iowa U.; Frank; AD-658 728

BEHAVIORAL AND SOCIAL SCIENCES

Parallel and Sequential Strategies for R and D Projects; Harvard U.; Rosenbloom and Abernathy; AD-658 544

Program of Research on the Management of Research and Development; Northwestern U.; Rubenstein; AD-658 897

Annual Report: Automatic Indexing and Abstracting; Lockheed Missiles and Space Co.; AD-659 057

Experiments in Display Evaluation; Franklin Inst. Research Labs; Landis *et al;* AD-658 733

The Development of Specifications of a Standard Display Board for Army Field Forces; Dunlap and Associates Inc.; Weigandt *et al;* AD-658 739

Computer-Assisted Instruction (CAI); Harvard Computing Center; Stolurow; AD-658 869

A Dynamic Input-Output Model of the California Educational System; Calif. U.; Nordell; AD-659 050

Multimode Factor Analysis of Interpersonal Perceptions; Ill. U.; Davis and Grobstein; AD-658 515

Molecular Neurochemistry of Rat Brain During Water Maze Performance; York U.; Gaito *et al;* AD-658 723

Reciprocity and Credit Building in Dyads; State U. of N.Y.; Pruitt; AD-658 880

Reaction Systems and Instability in Interpersonal and International Affairs; State U. of N.Y.; Pruitt; AD-658 901

Quality and Quantity of Contributions as Determinants of Perceived Ability; State U. of N.Y.; Regula and Julian; AD-659 039

Reactions to the Group Spokesman as Influenced by his Perceived Competence, Source of Authority, and Task Success; State U. of N.Y.; Julian *et al;* AD-659 040

The Evolution of Perceptual Frames of Reference; Johns Hopkins U.; Bevan; AD-659 058

The Mathematical Structure and Implications of Ghiselli's Moderator Variable; Ill. U.; Conger; AD-659 059

Evaluation of Factor Analytic Research Procedures by Means of Simulated Correlation Matrices; Ill. U.; Tucker *et al;* AD-659 060

Relationships Between Sensitivities of Blood-Volume Change, Pulse-Volume Change, and the GSR; Ind. U.; Gagnon and Furedy; AD-659 063

Investigation of CAPER (Computer Aided Pattern Evaluation and Recognition) Techniques Using NCAT (Navy College Aptitude Test) and BTB-7 (Basic Test Battery 7) Data to Forecast School Performance; Lockheed Missiles and Space Co.; Mangelsdorf *et al;* AD-659 525

BIOLOGICAL AND MEDICAL SCIENCES

Extraction, Purification, and Properties of the Bioluminescence System of the Euphausid Shrimp Meganyctiphanes Norvegica; Princeton; Shimomura and Johnson; AD-659 606

The Size of Genetic Programs Versus Their Effectiveness and Adaptability; Calif. U.; Bermermann; AD-659 198

Lengths of Cycle Times in Random Neural Networks; Cornell U.; Sloane; AD-659 508

Recent Work on Theoretical Models of Biological Memory; Cornell U.; Rosenblatt; AD-659 611

Evaluation of Sensory Nerve Conduction From Averaged Cerebral Evoked Potentials in Neuropathies; Brussels U. (Belgium); Desmedt *et al;* AD-659 436

Whole Organ Freezing and Thawing Heat Transfer and Thermal Properties; Geoscience Ltd.; Poppendiek *et al;* AD-659 471

Localization Mechanism of Calcification in Transplants of Aorta; Calif. U.; Urist *et al;* AD-659 637

Cardiovascular Effects of Bilateral Common Carotid Occlusion in Hemorrhagic Shock; Loyola U.; Glaviano and Yo; AD-659 656

Reaction of Myoglobin With 3,3-Tetramethyleneglutaric Anhydride; State U. of N.Y.; Atassi; AD-658 417

Periodate Oxidation of Sperm-Whale Myoglobin and the Role of the Methionine Residues in the Antigen-Antibody Reaction; State U. of N.Y.; Atassi; AD-658 644

Leukocyte Counts of Germ-Free Neonatally Thymectomized CFW Mice; Notre Dame U.; Bealmear and Wilson; AD-658 526

Programmed Control of Purposive Movement; Tulane U.; Pinneo; AD-658 888

Feasibility of Intra-Service Standardization of Audiometric Tests and Testing Procedures. Current Status and Recommendations for Standardization; National Academy of Sciences; Glorig *et al;* AD-658 725

Electrical Coupling and Normal Modes of Oscillation in Dense Excitable Cellular Structures; Aerojet-General Corp.; Stewart; AD-658 519

Couplers for Calibration of Earphones; National Academy of Sciences; Zwislocki *et al;* AD-658 726

CHEMISTRY

External Flows of Viscoelastic Materials: Fluid Property Restrictions on the Use of Velocity-Sensitive Probes; Delaware U.; Metzner and Astarita; AD-658 523

New Hypofluorites Containing Nitrogen; Idaho U.; Shreeve; AD-658 735

High Yield Synthesis of the Smaller Closo-Carboranes, C2B3H5, C2B4H6, and C2B5H7; Aerojet-General Corp.; Ditter; AD-659 044

Scattering of High-Velocity Neutral Particles, He-H2; M.I.T.; Amdur and Smith; AD-658 758

Almost 'Head-on' Collisions in the Scattering of Fast Argon Atoms by Hydrogen Isotopes; M.I.T.; Jordan and Amdur; AD-658 759

Lifetime of Fluorescence From the Lowest Electronic State in Sulfur Dioxide Vapor; Rochester U.; Caton; AD-658 520

The Characteristics of Several New Metal Phosphinate Complexes; Olin Mathieson Chemical Corp.; Pitts *et al;* AD-659 067

Carborane Formation From Alkynes and Boranes. Slow Reactions of B4H10 and B5H11 With Acetylene, Methylacetylene and Dimethylacetylene; Va. U.; Grimes *et al;* AD-659 319

Phenylphosphonous Isocyanates; Olin Mathieson Chemical Corp.; Pitts *et al;* AD-659 068

Hyperfine Separation of Tritium; Harvard U.; Mathur *et al;* AD-659 505

Spectroscopy of EDA Complexes at High Pressures. Absorption and Fluorescence of Crystalline TNB and TNF Complexes; Calif. U.; Kadhim and Offen; AD-659 533

EARTH SCIENCES AND OCEANOGRAPHY

Implicit Map Projections in Computer Print-Outs; Harvard U.; Warntz; AD-659 457

Oceanography Using Remote Sensors; Texas A and M; Capurro; AD-659 174

An Objective Method for Determination of the Stream-Function for the Non-Divergent Part of Observed Oceanic Surface Currents; Texas A and M; Garcia and Reid; AD-659 175

Laboratory Studies of Wind-Wave Interactions; Hydronautics, Inc.; Wu; AD-659 178

Tidal Variation of Hydrography of Block Island Sound Observed in August 1965; Lamont; Ichiye; AD-659 503

Oxygen-18 Variations in Sulfate Ions in Sea Water and Saline Lakes; Scripps; Longinelli and Craig; AD-659 438

Geography and the Properties of Surfaces. A Nomographic Representation of the Geoid; Harvard U.; Messcher; AD-659 456

Holocene Changes in Sea Level: Evidence in Micronesia; Scripps; Shepard *et al;* AD-659 655

Comparison of M. Koizumi and M. K. Robinson Computations of Seasonal Variation of Mean Sea Surface Temperatures in the East China Sea; Scripps; Robinson; AD-659 078

A Flame Photometer for Small Amounts of Cesium; Scripps; Folsom *et al;* AD-659 210

Coccolithophorids From Two Caribbean Deep-Sea Cores; Miami U.; Cohen; AD-658 694

Late Pleistocene and Holocene Sedimentation in the Laurentian Channel; Lamont; Conolly *et al;* AD-658 697

Pleistocene Age Determinations From California and Oregon; Lamont; Richards and Thurber; AD-658 703

Marine Dolomite of Unusual Isotopic Composition; Oregon State U.; Russell *et al;* AD-658 707

Electrolytic Conductance of Sea Water and the Salinometer. An Addenum to the Review; Oregon State U.; Park and Burt; AD-658 704

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The Fifth Annual Navy Symposium on Military Oceanography will be held at the Navy Mine Defense Laboratory, Panama City, Florida, May 1-3, 1968. Additional information on this symposium, which is sponsored by the Oceanographer of the Navy, can be obtained by contacting the Office of the Oceanographer of the Navy, 732 N. Washington Street, Alexandria, Va. 22314.

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The creative processes in the sciences and in the arts have a common root: the basic requirements for creativity are inherent in both.

- A REAL PROBLEM WHICH REQUIRES SOLUTION — *The artist's challenge is the blank canvas calling for paint and texture, line and form; the researcher's challenge is the missing piece of data, the unsolved problem, the incomplete formula.*
- OPPOSITION TO CONVENTION — *A painter may abandon naturalistic forms for abstraction; the researcher may violate accepted theories to produce new data.*
- EXPERIMENTATION — *The artist is confronted with many combinations of shapes and colors; the researcher with an infinite variety of combinations for study.*
- DEVELOPMENT OF SIGNIFICANT FORM — *In art, details are organized into the overall pattern; in science, a new concept emerges from a maze of data.*

Finally, a new conceptual scheme is achieved, in both arts and sciences, when something is presented which has never before been seen in that exact form. *See page 30.*