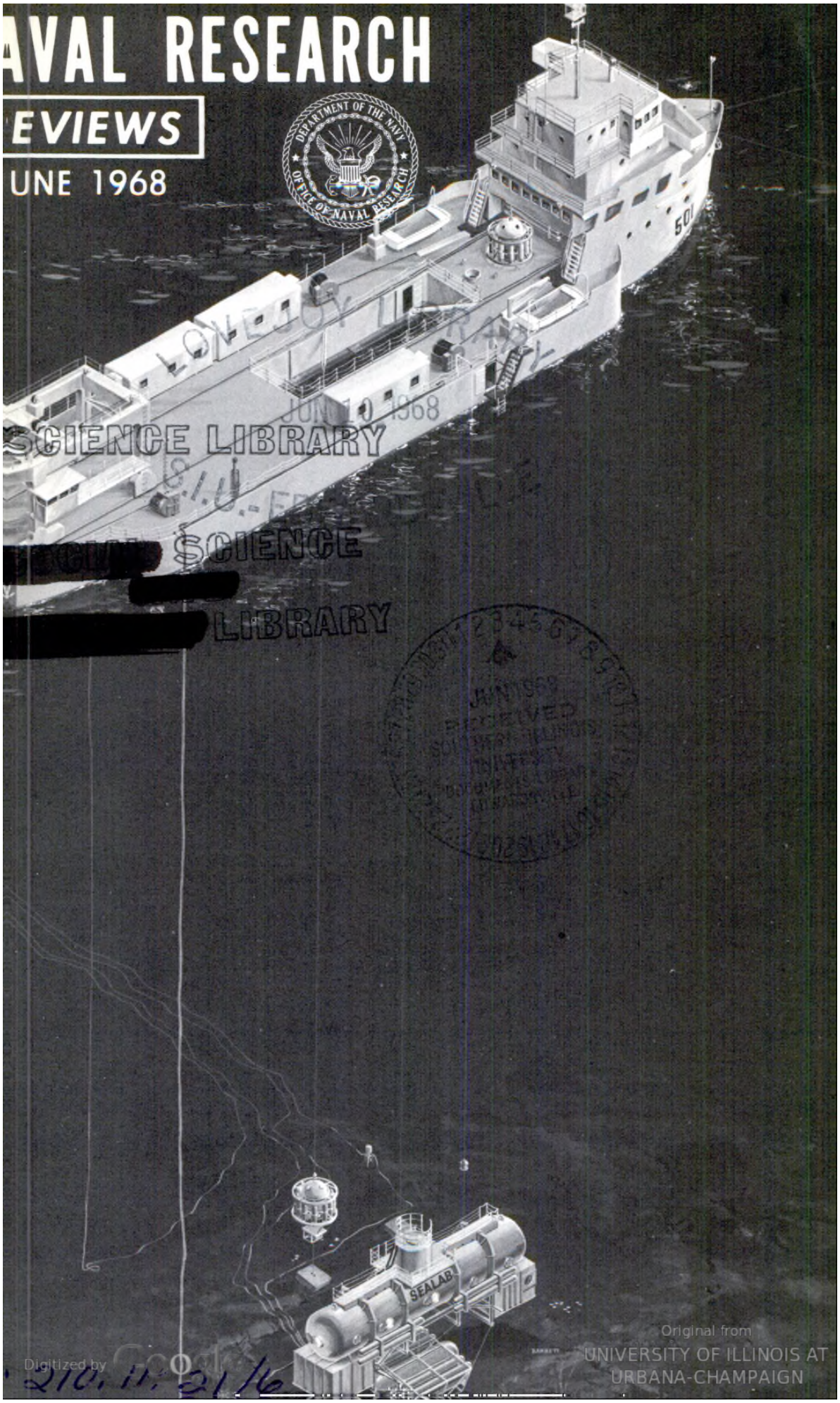
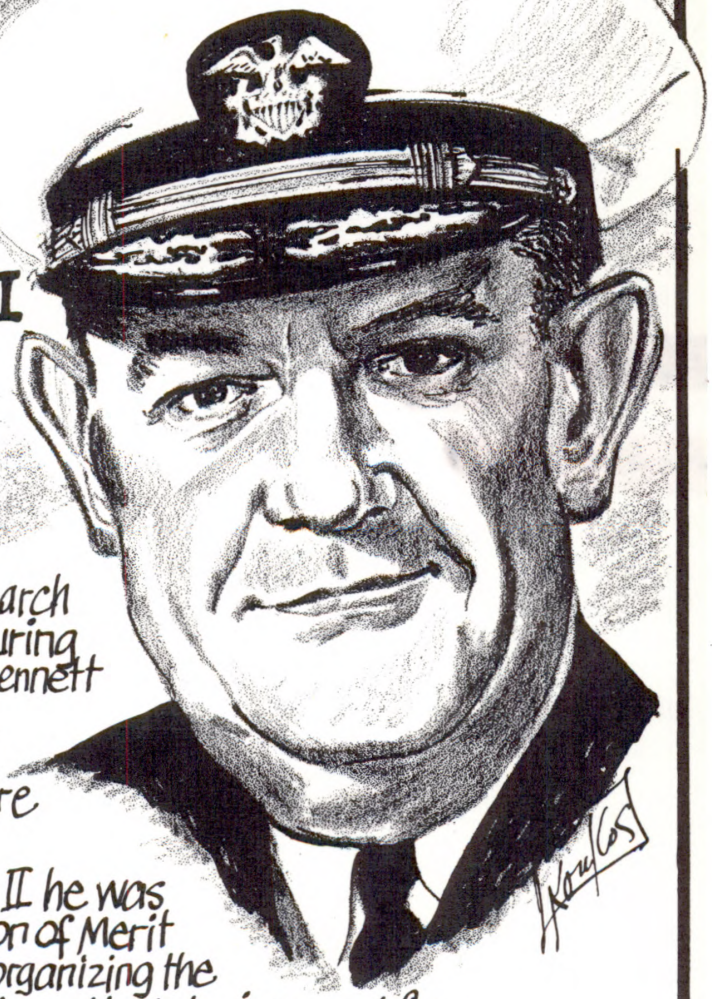


Portraits in Science



RADM. RAWSON BENNETT II U.S.N.

(1905-1967)

Chief of Naval Research from 1955 to 1961. During that period RADM. Bennett was in charge of Operation Vanguard, the first U.S. venture into space.

During World War II he was awarded the Legion of Merit for proposing and organizing the first anti-submarine attack trainer and for designing sonic and supersonic underwater sound apparatus. Other assignments included duty as Director of the Navy Electronics Lab., San Diego; first Director of the Electronics Production Resources Agency; and Assistant Chief of BuShips for Electronics.

Inventions Under ONR Contract Research Programs

W. B. Childs
General Patent Services Division
Office of Naval Research

Navy research and development contracts contain a variety of patent provisions and related technical data provisions. Of these, the provisions which probably require the most time and attention are those which deal with the disposition of rights in inventions made during the course of each R&D contract. One problem area is determining which of three possible patent rights clauses—Title, License or Deferred—should be included in a particular contract. This brief article will explain the main provisions of the various patent rights clauses, and describe a few of the more noteworthy inventions emanating from the contract research program.

The historical role of the Office of Naval Research in sponsoring research of interest to the Navy has incidentally resulted in a proportionate number of inventions, some of which are of general utility, *i.e.,* useful to the general public. In the early days of the program, all contracts contained essentially the same patent rights clause. However, in more recent years, the disposition of rights has become a matter of intense national interest. Consequently, different types of patent rights clauses have been developed. This is particularly important since the government patent policy is to promote the development of inventions resulting from government-sponsored research so that the public can benefit from them as soon as possible.

Three categories of R&D contracting situations, depending on the nature of the work to be done and the relationship of the work to the contractor's commercial position, are recognized. Depending upon the type of situation, ownership of principal rights to inventions may be vested in the government or the contractor.

Briefly, the first type of situation involves contracts for work in which there is likely to be a high level of public interest (*i.e.,* items of public use, or relating to public health or welfare). In such cases, the Patent Rights (Title) clause, which gives the government title to the invention with a mere license (right to use) to the contractor, is inserted in the contract.

The second type of situation is one in which the contractor has acquired technical competence directly related to an area in which he has an established nongovernmental commercial position, This situation arises because the Navy is seeking to build upon or draw from a

technology in which the contractor has competence, know-how, and experience. In such cases, the Patent Rights (License) clause, which gives the contractor title to inventions with a royalty-free license to the government, is employed. Contracts with universities and nonprofit institutions which have an approved patent policy, and contracts with newly established R&D corporations or divisions of older corporations fall into this category. It has been determined that the public interest in the availability of inventions is best served by allowing these contractors to retain title.

The third type of situation is that in which the disposition of rights in inventions is deferred until after the invention is identified. The so-called Patent Rights (Deferred) clause used in this case gives title to the government subject to a possible request by the contractor for greater rights.

To give meaning to the provision relating to disposition of rights, some method must be provided to identify the inventions to which it applies. These inventions, called "subject inventions," must be classified as to whether they are inventions or discoveries, whether they are conceived or first actually reduced to practice in the course of or under the contract, and whether or not they are patentable. Since the contractor is the primary source of information as to work done under the contract, he is obligated to report each "subject invention" and to provide a written disclosure of it within a fixed period after it is conceived or first actually reduced to practice. If the contract contains a license clause, the contractor must file a patent application in the U.S. Patent Office in order to retain title. If the contract contains a title or deferred clause, he may request greater rights concurrently with or shortly after reporting the invention. There are also contract requirements for invention reports annually and for summary reports upon termination of the contract.

A number of other contract provisions are included to preserve the legal interests of the party involved (government, contractor, or public, as the case may be) in the patentable inventions resulting from the research effort being carried out under the contract. Since time is vital in many patent matters, these provisions impose time limitations and penalties for noncompliance within those limitations.

Although the primary obligation to identify and report subject inventions is placed upon the contractor, the government often provides assistance. Some of the difficulties involved in recognizing inventions stem from the evolutionary nature of most R&D efforts, the close relationship between the contractor's private efforts and those sponsored by the government, and rapidly advancing technology.

Inventions From the Navy's R&D Program

Examples of patented inventions resulting from the Navy's contract research program are cited in the following paragraphs.

The early leadership provided by the Office of Naval Research in sponsoring R&D in the field of computers is well known. An outstanding example of the many important patented inventions resulting from this effort is the ferrite memory core unit now used extensively in digital computer memories which was developed by Professor Jay W. Forrester, Massachusetts Institute of Technology, under an ONR contract. While magnetic cores had been used previously for storage, Professor Forrester provided a relatively simple method of locating a particular core in a multidimensional array. The basic element is a core of magnetic material provided with coordinate (x and y) energizing windings and a single winding for "reading" the core's magnetic state. Coincident pulses of one direction (polarity) on the energizing windings drive the core to a magnetic state representing binary 1 while pulses of the other polarity drive the core to a magnetic state representing 0 in the binary system. The magnetic states of the cores are unaffected by magnetizing forces of lesser magnitude than that provided by the coincidence currents in the energizing cores. Reading is accomplished by applying a pulse of the same magnitude as the coincidence currents in the energizing core. Depending on its polarity, the reading pulse will switch the core to its opposite magnetic state, resulting in an induced voltage in the reading core which can be detected by an appropriate output circuit.

The patent for this unit was the subject of lengthy Patent Office proceedings and litigation because of the many problems involved in recognizing and protecting significant advances. In spite of the long delays encountered, however, the patent involved proved very valuable to its developer. In April 1964, International Business Machines paid $13 million to M.I.T. for a license to use the invention. Undoubtedly, similar royalty-bearing licenses were negotiated with other leading computer manufacturers. To give an indication of the amount of time that may elapse between conception of an invention and its payoffs, it should be noted that, while the invention was made in 1948 or 1949 and the patent issued in 1956, the aforementioned royalty settlements took place relatively recently.

Another and earlier example of an invention resulting from the ONR contract research program in the computer field is the magnetic drum storage system invented by A. A. Cohen, W. R. Keye and C. B. Tompkins of Engineering Research Associates, Inc. The history of the patent granted on this system also provides documentary evidence of the difficulty of identifying and protecting inventions in a rapidly developing area of research. The invention itself is a drum which carries

magnetizable material on its peripheral surface and a number of magnets positioned adjacent the periphery which read or write magnetic signals on the drum as it is rotated at high speed. Appropriate timing circuits make it possible to read or write the magnetic state of a discreet address on the drum. This computer storage device has been used extensively in digital computer systems. Incidentally, this patent is one of a number covering the use of a magnetic storage medium. Litigation is still pending involving other patents of similar subject matter.

The R&D carried out under the sponsorship of the ONR Material Sciences Division has been particularly productive in terms of patents. As a result, the government is licensed under many patents concerning the governing and fabricating of new materials, *e.g.*, titanium and titanium alloys, borides, liquid and solid propellants, and organic and inorganic polymers. New devices in ion propulsion and MHD power have also resulted from the program.

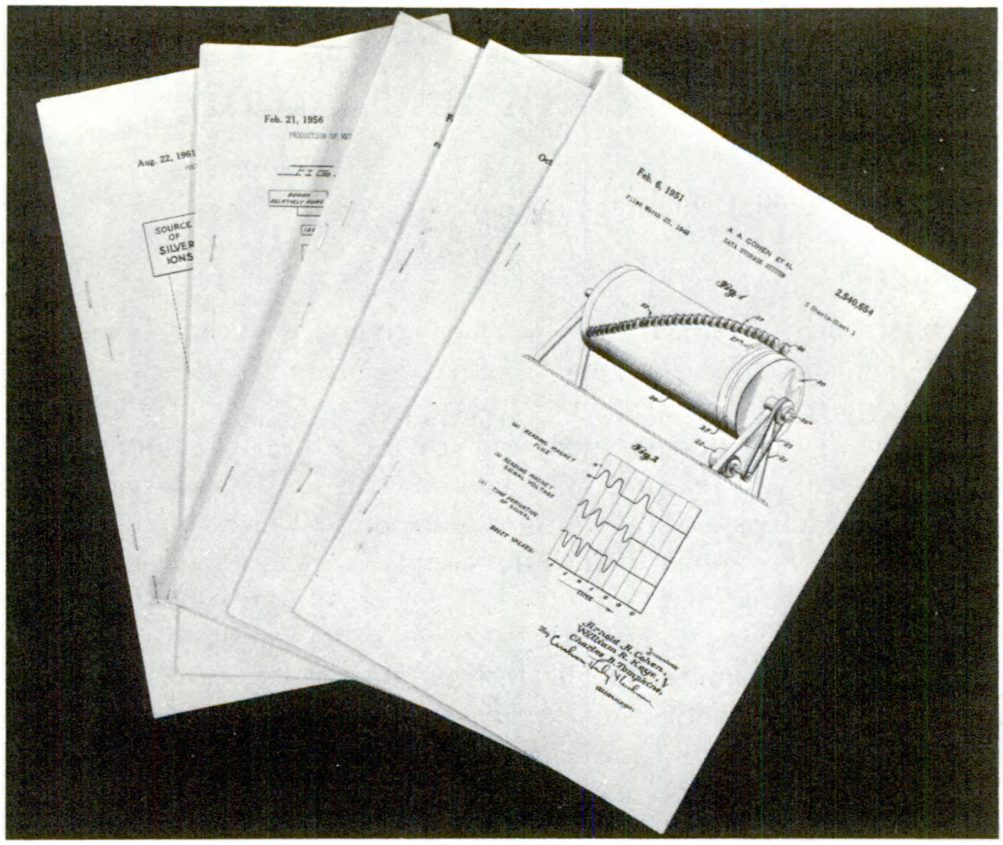
An example of a process patent in the propellant field is that covering an invention of H. Shechter and R. R. Kaplan working under an ONR contract with the Ohio State University Research Foundation. The invention involved more efficient methods of producing polynitro compounds which were the foundation for the early work in solid propellants. Typical in the field of high temperature corrosion resistant materials is the patent granted to F. W. Glaser, Borolite Corporation, for the production of metal boride.

Contractors sponsored by the Physical Sciences Program have also made many inventive contributions. Patents developed encompass a broad range of devices, including those relating to field emission devices, high power klystrons, atomic clocks, traveling wave tubes, and direction-finding equipment.

Patented contributions made by investigators in biological and physiological sciences include the artificial corneal implant, a pump oxygenator used in heart surgery, an ultrasonic irradiation device for use in the treatment of Parkinson's disease, electromagnetic radiation dosimeters, germfree laboratory apparatus, ear plugs, and dental compositions. Also, patents have been obtained for antibacterial compounds, vaccines, and other biological compositions.

From the Naval Applications Programs have come patentable contributions on aerial and undersea vehicles, instrumentation and control apparatus for these vehicles, and sonar apparatus including hydrophones, data processing and oceanographic instrumentation.

The foregoing gives some obvious examples of important patented contributions dating from the early days of the contract research program. Of more recent vintage are the solid state maser invented by Professor N. Bloembergen while working under an ONR contract with Harvard, and the new high-energy oxidizer chlorine pentofluoride



invented by W. Maya and H. F. Bauer of North American Aviation. Also, a substantial number of inventions have resulted from the laser program, the blood preservation program, Project MAC, and others covered in patent applications still pending in the Patent Office. From the foregoing, it is apparent that the level of quality of inventions emanating from the contract research program remains high.

NRL Establishes New Branch

In recognition of the increasingly important and complex role of information systems in scientific research, the Naval Research Laboratory has established an Information Systems Branch within its Mathematics and Information Sciences Division. Formation of the new branch was announced by Dr. Alan Berman, Director of Research at the Laboratory.

Among the functions to be performed by the new branch are to:

- Conduct research and development in those aspects of the information sciences relevant to naval needs;
- Assist in planning NRL projects which require a substantial amount of information handling;
- Develop information-handling portions of systems being developed by other NRL components;
- Provide internal consultative services in the information sciences; and
- Develop or procure and operate information processing facilities for NRL scientists.

Praetersonics - Past, Present and Future

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Surface and Amphibious Programs
Office of Naval Research

Praetersonics, a branch of solid state physics, is the technology of propagating and operating on acoustic signals at frequencies which begin at more than 10,000 times the upper frequency of audibility. Although the term itself is new, the science is nearly a decade old. Much has been written and published about it under such seemingly unrelated headings as "microwave hypersonics" (which implies faster than sound), "ultrasonics" (which implies just above audibility), "microwave acoustics," and many other terminologies, all of which were either cumbersome or misleading. Thus, to create order out of chaos, an administrative subcommittee of the Institute of Electrical and Electronic Engineers Professional Group on Sonics and Ultrasonics proposed the term "praetersonics" to describe this new technology which will require completely new materials and techniques before it can be fully investigated and/or utilized. This new terminology is now familiar to those working in the field.

To gain an understanding of praetersonics, three basic concepts must be established. They are:

- Under most conditions, a signal propagating as a sound wave travels about 100,000 times slower than its electromagnetic wave counterpart;
- Sound propagates with less loss in some substances than in others; and
- For any given substance, a lower frequency acoustic signal will propagate with less loss than a higher frequency signal.

The first concept can best be demonstrated by the observation that thunder is heard a short time after lightning appears. The fact that sound travels slower than light is common knowledge; however, few people realize that the magnitude of the disparity of these velocity ratios is over 100,000.

The second concept can be illustrated by the fact that a sound generated and heard underwater is much "louder" than one generated and transmitted in air, *i.e.,* water is a better propagator of sound than air. Further, laboratory experiments have shown that solids are better propagators of sound than liquids; thus, a hierarchy of substances can be established according to their ability to propagate sound waves.

Hi-fidelity sound, which the public has been exposed to over the past several years, can be used to illustrate the third concept. This exposure has more or less familiarized people with the precepts of fidelity and frequency response. Some can hear notes of higher pitch or frequency than others; however, few can hear notes above 20,000 cycles per second in frequency. Frequency is referred to by the international term "Hertz." Acoustic frequencies above 20×10^3Hz are known as "ultrasonics," which implies "above audibility."

It is interesting to note that the ratio of the lowest frequency of hearing, *i.e.,* 20Hz, to the highest frequency of hearing, *i.e.,* 20×10^3Hz, is 1000. The loss of response above 20×10^3Hz results both from the eardrum's inability to vibrate at these high frequencies and from the fact that the higher frequencies are attenuated or weakened more than the lower frequencies in traveling from the point of origin to the eardrum. In this regard, laboratory experiments have shown that the attenuation rate for higher frequencies becomes increasingly pronounced as the frequency increases. To understand the mechanics of this attenuation, consider a sound wave which propagates by alternately compressing and expanding the air through which it travels. The relatively dense packet of compressed air of the first half cycle of the sound wave strikes the eardrum and forces it in. The next half cycle with its correspondingly less dense, expanded (rarefacted) air allows the eardrum's elasticity to force itself back out. Thus, the eardrum vibrates in and out at a rate corresponding to the frequency at which the dense air packets impact the eardrum. As the frequency goes up, the eardrum vibrates faster which means that either dense air packets of equal size arrive faster as frequency ascends or that these packets are smaller and more closely spaced. Since sound travels at a constant velocity for any given medium, the latter assumption must be correct. To reiterate, then, each compressed packet corresponds to half of a sound wave and each rarefacted packet represents the other half of the sound wave. The total distance between the beginning of one compressed packet and the beginning of the next is known as a wave length. A higher frequency contains more packets and hence more individual wavelengths between sound source and receiver than does a lower frequency. Thus, if each wave suffers a given attenuation, a higher frequency signal will necessarily be attenuated more than a lower frequency signal simply because there are more individual waves between source and receiver to be attenuated. This analogy omits a great deal of the physical constraints actually contributing to the attenuation processes, but it should enable the reader to gain an appreciation for frequency response.

Experiments performed during World War II showed that signals with frequencies up to 20×10^6Hz, *i.e.,* 1000 times the threshold of

ultrasonics, could be readily propagated through such materials as quartz at room temperatures. However, above 20×10^7Hz, the attenuation was so severe that experiments could not be readily conducted. In 1957, scientists at Bell Telephone Laboratories showed that frequencies of 10^{10}Hz and beyond could be readily propagated with very little loss by cooling the quartz to near absolute zero, *e.g.*, 4°K. Because of the impracticality of cooling a piece of quartz to near absolute zero to propagate a signal above 20×10^7Hz, however, very little interest was generated.

Early in the present decade, it was discovered that a material known as yttrium iron garnet (YIG) could readily propagate acoustic signals of 20×10^8Hz and beyond at room temperature. Praetersonics—not the term but the science—thus came into being.

At frequencies above 20×10^8Hz, the wavelength of an acoustic signal in a solid crystal is approximately the same as a wavelength of visible light. As can be imagined, the physical tolerances necessary to fabricate and polish the crystals necessary to carry these signals are quite stringent. Fortunately, these problems have been generally solved by processes developed for the fabrication of laser crystals to similar tolerances.

The fact that some crystals are able to propagate acoustic signals at extremely high frequencies while other crystalline structures cannot is well recognized but not thoroughly understood. Categories of crystalline structures and compositions providing favorable propagation and interaction characteristics are steadily growing by way of empirical measurements, but the basic quest for understanding the various interacting loss mechanisms continues.

Signals of extremely high frequencies are generally encountered only as electromagnetic radio waves. To utilize certain advantages of praetersonics, these electromagnetic waves must first be converted into purely acoustic waves. Early experiments in ultrasonics accomplished this by bonding a piezoelectric quartz disc to the end of a crystalline rod. An alternating electric field applied across the quartz disc causes it to compress and rarefact. Thus, electromagnetic energy is converted into elastic or acoustic energy which is transmitted to the crystalline rod through the bond between the quartz disc and the rod. The phenomena is a reciprocal process, *i.e.*, it may be used at the far end of the rod to convert the acoustic energy back into electric energy in a manner exactly analogous to that used in a phonograph pickup. However, since the thickness of the quartz disc is indirectly proportional to the frequency of operation, extremely thin discs have to be used for frequencies above 10^8Hz. Unfortunately, the problems of fabricating such thin discs and the acoustic losses encountered in the disc to rod bond are so serious as to preclude the use of these classical ultrasonic transducers in praetersonics technology. As a result, praetersonics

transducers are now made by vacuum evaporating or sputtering a thin film of piezoelectric material to a thickness of approximately one micrometer (micron) onto the end of the crystalline rod through which the signal is to be propagated. Thus, the properties of piezoelectricity reported by J. and P. Curie in 1880 have a new application.

Exploitation of the difference in velocity between an acoustic wave and an electromagnetic radio wave has created a very useful technique. By using the aforementioned transducer techniques, a microwave signal can be changed into an acoustic signal and made to travel through a crystal at a speed of 100,000 times slower than it would have travelled through air. Thus, a portion of a microwave signal can be captured by an antenna, converted into an acoustic wave, propagated through a crystal one inch long, and recovered by a transducer at the far end of the crystal while the remaining undiverted portion of the electromagnetic microwave signal has meanwhile travelled one mile farther. By feeding the delay line output into an amplifier input and feeding the amplified output back to the delay line input, the signal can be made to circulate, thus creating a microwave memory. Aside from purely military applications, this concept provides the potential for computer shift registers with information content carried at gigahertz frequencies, very dense storage of digital data, and other advances and concepts in information and signal processing.

With the acoustic wavelength of a transduced microwave signal being of the same order of magnitude as the wavelength of visible light, an interaction is likely to occur. Experiments have shown this to be the case, *e.g.,* coherent light beams have been frequency modulated at microwave frequencies. Other acousto-optical (phonon-photon) interactions have demonstrated auto-correlation techniques with very large figures of merit (time-bandwidth products), cross-correlation techniques, and variable delay lines.

By propagating the microwave acoustic signal through a piezoelectric crystal, the acoustically induced alternate compressions and rarefactions of the crystal lattice structure cause alternate positive and negative electrical charges to be created by the nature of the piezoelectric coupling constant. If the piezoelectric crystal is doped with the proper impurity ions, the crystal can be made to carry an electric current or electrons can be made to drift down the crystal if the proper potential (voltage) is supplied. If the electrons are made to drift colinearly with the acoustic phonons and at a speed just in excess of the velocity of sound, then the phonons are amplified in a manner analogous to the amplification process occurring in a travelling wave tube. Thus, a microwave solid state travelling wave amplifier is born. Such a device is a bulk effect device with no voltage sensitive p-n junctions and no known built-in wear-out mechanisms. This effect, if

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utilized integrally, may well provide the potential for a virtually lossless delay line.

Acoustic signals need not be limited to those which travel through the bulk of the material, but may also be propagated on the surface of a highly polished crystal. Such waves were predicted by Lord Rayleigh in 1885, and are now known as Rayleigh waves. Variations of this phenomena include waves propagating in and between thin films applied to the surface of the crystal. Since such waves are "exposed," they are easier to extract and control than the waves inside the crystal. Further, surface waves not only have the properties previously mentioned for the bulk waves, but also can be guided. Directional couplers, resonators, and other hardware so familiar to the microwave engineer can be adapted (although in a different configuration) to the surface wave "plumbing." The greatest potential for surface waves seems to lie in their easy access and adaption to tapped delay lines and various correlation techniques for signal processing.

A decade has passed since the first microwave signals were converted to phonons and propagated as such. Progress in this field has been in direct proportion to the ability to couple the seemingly diverse sciences of crystallography, theoretical physics, microwave engineering and optical processing. Future payoffs will be determined to a large extent by the ability to couple this team with solid state physics and microelectronics. An inherent compatibility as yet unexploited exists with the latter: there is a tremendous potential for microminiature reliable packages in signal processing, microwave memories, correlation techniques and amplifiers.

ONR Pioneer Dies

Dr. Frederick C. Wiesner, a pioneer of the Office of Naval Research from its inception in 1946, recently died of emphysema at the Naval Hospital, Bethesda. He was the Head of the ONR Power Branch until his retirement in August 1961.

As a Captain in the U.S. Naval Reserve he was a leader in the Research Reserve Program from its beginning in 1948, and was the Commanding Officer of the first unit established—Volunteer Research Unit W-1. He retired as Battalion Commander of the Washington Research Reserve companies in October 1957.

His naval career embraced service in two countries. He was an officer in the Navy of his native Germany in World War I and became a U.S. Naval Reservist, commissioned in 1922.

An Oceanic Turbulence Symposium will be held at Vancouver, British Columbia, in June 1968. Additional information on this symposium, which is cosponsored by the Physical Oceanographic Commission of the International Association of Physical Sciences of the Ocean and the Office of Naval Research, may be obtained from Dr. S. W. Burling, Institute of Oceanography, University of British Columbia.

Approaches to Automatic Speech Recognition

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Man is a very complex processor of information. And, since natural language is man's normal mode of communication, it is reasonable that investigators should direct considerable effort toward the automatic processing of natural language and toward the control of machines by means of natural language.

The two major divisions of natural language are "printed" and "spoken." Since the printed form of language is coded in discrete symbols, this form is somewhat easier to process automatically than the spoken form. However, since speech is a natural, direct, and normally convenient means of communication between individuals, certain advantages should exist in speech communication between man and machine. It thus seems imperative to direct some efforts toward learning to communicate with machines verbally. This, in essence, requires the development of an automatic device to recognize speech.

Much of the technology required for automatic speech recognition is currently available. However, it is still necessary to acquire enough information about the speech process in sufficiently explicit detail to be incorporated in programs and physical devices. In this regard, it is interesting to note that while communication with computers is an ultimate objective of automatic speech recognition, these same computers can be used as powerful tools in the research leading to acquiring the basic information needed to solve the recognition problem.

Efforts must be made to acquire detailed knowledge about the speech act at the physiological, acoustic, perceptual, and linguistic levels. The acoustic speech wave will undoubtedly constitute the imput to a recognizer; however, an understanding of the mechanisms by which the wave is produced and interpreted by the human speaker and listener would appear to be basic to the design considerations. To acquire this understanding will require the combined efforts of physiologists, physicists, psychologists, mathematicians, and linguists.

General Purpose Versus Limited Speech Recognition

Initial efforts in automatic speech recognition have indicated that the problem is exceedingly complex. Consequently, research investigations have been directed to certain problems of a limited nature.

It is a well known fact that each individual speaker has characteristic properties in his speech. Not only are there substantial differences in the acoustic signal from voice recordings of men, women and children, but there are great enough differences among the speakers of any one of these groups to complicate the automatic recognition process. Therefore, certain attempts have been made to build recognizers for an individual speaker with the hope that the device can be extended to others with similar acoustical speech characteristics. If the techniques used in building such a speaker-limited recognition system are basic and fundamental rather than constrained or, at times, *ad hoc*, such extensions may be possible.

In addition to speaker-limited recognition systems, much effort has been and is being directed toward sound-limited or word-limited recognition devices. For example, since much speech information is carried by the vowels of the spoken utterances, some efforts have been devoted to vowel recognition systems. The obvious extension of such systems is to include other types of sounds, *e.g.*, fricatives and plosives.

The first word recognition systems were developed on the ten digits since numerous machines can be controlled by these words, *e.g.*, telephones, cash registers, *etc.* As progress is made, the number of words to be recognized by a limited-vocabulary recognizer is increased. Again, the feasibility of extending these systems to ever-larger vocabularies depends on the types of techniques used in implementation. If they are broad and basic, then extensions to more general purpose recognition systems should be possible.

Basic Acoustic Parameters

Figure 1 is a greatly simplified schematic of the automatic speech recognition process. The input is the acoustic speech wave and the output is the printed or orthographic string representing the speech wave. Obviously, if the recognition system is used to control a machine, the output would be the operation of the machine rather than an orthographic string. Although the schematic is simple, the transformations which are performed in the "black box" between the input and the output are exceedingly complicated.

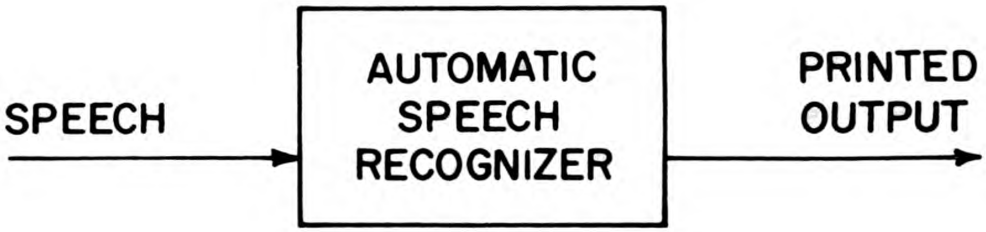

Figure 1

Certain approaches to the problem attempt to determine the necessary functions of the black box on a trial-and-error basis. These approaches employ techniques to convert speech to the desired output without particular concern for the properties of the speech wave input or the linguistic output. Other approaches attempt to determine the necessary functions of the black box by referring to a basic understanding of the speech act and, consequently, *are* concerned with these properties. The latter approaches must, necessarily, rely heavily upon the research findings of speech science studies. For example, a principle inherent in these approaches is that the acoustic speech wave contains basic parameters which must be identified properly before the wave can be converted to an orthographic output. For this reason, speech scientists are attempting not only to identify these basic acoustic parameters, but also to find techniques to derive these parameters automatically from the speech signal.

Many basic parameters have been suggested and accepted as important in speech analysis. However, various studies by speech scientists have determined that the formant frequencies with their associated amplitudes and bandwidths are some of the most, if not the most, essential parameters of the acoustic speech wave, particularly since formants are the natural modes of air vibration in the vocal tract. Thus, considerable efforts have been made to track the formant frequencies in the speech signal automatically. Although these efforts have succeeded in obtaining close approximations to the formant frequencies, a completely automatic and accurate system for tracking the formant frequencies has not been found. For this reason, some investigators are looking for logical operations which do not require the analysis of the formant frequencies to recognize individual speech sounds.

In this regard, utilization can be made of results from perceptual speech studies which indicate that spectral peaks rather than formants are the important parameters in perception. This is especially true in those problem areas where the speech signal contains two formants very close in frequency. Since automatic formant tracking techniques cannot adequately separate these two formants, recognition systems which depend solely upon formant tracking are severely limited. However, since perceptual studies have shown that the listener responds to the one broad spectral peak apparent in the acoustic signal in such cases, it is highly possible that this one identification would be sufficient for automatic speech recognition purposes. Thus, a hybrid system which utilizes spectral peak information when formant frequency information is not available would seem useful.

It is essential that efforts toward obtaining better techniques for automatically tracking the formant frequencies be continued since

they are of fundamental acoustic importance and carry significant information concerning the movements of the articulators. When adequate techniques for automatic formant tracking are developed, hybrid systems can be converted to those employing only formant frequencies, assuming that better results could be obtained with such systems.

The formant frequencies are only some of the basic parameters of the speech signal. Fortunately, many of the other important parameters can be obtained automatically. Although only minimum use has been made of the basic speech wave types, some investigators are now using this wave type information as well as such normally derived parameters as average speech power, broad-band frequency spectrum of fricatives, formant frequencies and amplitudes, *etc.,* in automatic speech recognition. When investigators have gained a maximum knowledge of all the basic parameters of the acoustic speech wave and have developed the ability to derive these parameters automatically (or to use alternative parameters until they are derived), the first transformation necessary in the black box can be accomplished.

Conversion From Acoustic Parameters to Phonemes

Because of the difficulty in converting the acoustic data to the orthographic output, it is generally agreed that an intermediate conversion to the phoneme is necessary before the orthographic representation can be obtained. (A *phoneme* is a more-or-less natural *printed* subdivision of speech which forms a self-sufficient entity; the allowable variations of a particular phoneme when *spoken* are called *phones.*) But not even this conversion is a simple task. As mentioned previously, the printed form of language is coded in discrete symbols and, consequently, is easier to process than speech. To obtain an output of phonemes or orthography, then, the quasi-continuous acoustic functions of speech must be converted into discrete units. This conversion, which is commonly referred to as the segmentation problem in speech analysis, is difficult but not insurmountable. While it is true that the exact boundaries between sounds are almost never specifiable, it is necessary only to ascertain the number of discrete units and not the precise boundaries between these units to resolve the segmentation problem.

While it is possible to state a unique set of physiological parameter values to specify a phone type, such is not the case with a phoneme. The phoneme is comprised of a set of allophones, each of which is specified by a different set of physiological parameter values. Thus, the phoneme itself is not a pronounceable abstraction; and its acoustic identification can be exceedingly difficult if an intermediate identification of each phone type is not obtained first. For example, the orthographic word "fudge" ordinarily has only one phonemic representation,

i.e., /fəʤ/. However, the word can be pronounced in one of two ways—with an initial labiodental fricative or with an initial labiodental voiceless plosive. The acoustic properties of a fricative are quite distinct from those of a plosive; consequently, a phoneme which has allophones of both fricative and plosive sounds can be more easily identified if the phone types are first identified and then related to the the proper phoneme.

In order to convert acoustic parameters to phone types, it is necessary to know the acoustic properties of the phone types of the language under analysis. Unfortunately, the results of the majority of studies made previously on the acoustic properties of speech have been reported by averaging the data of all of the phone types of a given phoneme. However, present studies are being conducted to specify the acoustical characteristics of individual phone types. It appears that the most efficient means for using this information to convert acoustic parameters to phone types would be to incorporate it into simple tables by listing the individual phone types together with their acoustic properties. Thus, for any instant in time, a listing of the acoustic parameter values can be ascertained from the speech signal and a check made against the phone-type tables to determine which phone type is specified by those values. When a phone type has been identified, a second table listing the allowable phone types for each phoneme would be checked to see to which phoneme or phonemes the identified phone type belongs. Fortunately, since there is little overlap of phone types between phonemes, the unique assignment of a phone type to a specific phoneme would usually be possible.

By identifying the phone types before specifying the phonemes themselves, phonetic information is made available for use in later stages of the automatic speech recognition process. For example, in continuous speech a phonemic string such as /ɔlɪz/ ("awliz") may be ambiguous, while the underlying phone-type string such as [ɔɬɪz] ("all is") or [ɔlɪz] ("aw Liz") may not be. In the case cited, the phonetic realization of the phoneme /l/ determines the appropriate word boundaries. The velarized form, [ɬ], indicates a potential *final* /l/, such as in *all,* while the non-velarized form, [l], indicates a potential *initial* /l/, such as in *Liz.*

Higher Level Processing

A conversion from the phonemic string to a proper orthographic string requires considerable higher level processing. The first step, which transforms the phoneme string to a crude orthographic output, can be accomplished in one of two ways. The first is by writing spelling rules for the phoneme strings. However, in most languages, English particularly, these rules are so complex that this approach seems

exceedingly complicated. For example, the English vowel phoneme /i/ can be spelled in many ways as shown in the following words: *me, mi, tea, seek, shriek, quay, mete, receipt,* and *key.*

A more direct approach employs a phonemic-orthographic dictionary search. Each entry of the dictionary is listed in its orthographic form with its associated phonemic transcriptions, *e.g.,* in English *grease* can be represented phonemically by /gris/ or /griz/. A search is then made through the dictionary to associate all phonemic strings of the utterance with all possible words in the dictionary. The output from such a search will usually include many possible sequences of orthographic strings.

The multiplicity of orthographic strings which can generally be associated with a given phonemic string is inherent in the transformation because of two basic facts. First, in nearly all languages there are homonyms, *i.e.,* words which are pronounced similarly but which are spelled differently. Thus, one phonemic string such as /tu/ will give the multiple output of *two, too,* and *to.* Second, a given phonemic string can often be divided into different orthographic strings depending on where the word divisions are made. This was illustrated previously by the phonemic string /ɔlɪz/ which had a potential division of "all is" or "aw Liz." These two basic problems make it necessary to perform further transformations in order to determine the most likely choice of orthographic outputs obtained from the dictionary search. Such operations would include ranking the outputs by minimizing the phonemic residue, and by listing them according to frequency of occurrence. After an initial ranking of likelihood has been determined, both grammatical and semantic analyses must be performed on the more likely candidates. This is necessary in order to resolve the ambiguities and thereby provide an ordered listing of the orthographic strings which are still considered possible outputs from the original phonemic string.

Only limited research has been done on the grammatical and semantic processing which will be required to refine the orthographic output possibilities. The information needed from the field of linguistics for each given language which might be processed is very extensive, and the most relevant properties at the grammatical and semantic levels for use in automatic speech recognition have not yet been determined. Until these properties are defined and a procedure adopted for using them properly in speech analysis, only orthographic outputs of the type shown in figure 2 can be easily obtained.

The homonyms in figure 2 are indicated by "equal" signs. No attempt has been made to resolve the homonym problem because it is assumed that the recipient of the orthographic output can provide his own interpretation and make the proper selection. Figure 2 also presents all orthographic possibilities involving different segmentations of the phonemic strings depending on the word division found

PHONEMIC INPUT : /hɪrminau/

ORTHOGRAPHIC OUTPUTS : =HERE= =ME= NOW
=HERE= MEAN OW

Figure 2

in the dictionary search. Again, it is assumed that the reader can make his own selection.

Automatic speech recognition systems, even in earlier stages, have many practical applications. Thus, it does not seem unreasonable to continue efforts on limited automatic speech recognition goals, such as digit recognition, even though the final output may require further human interpretation. If these efforts are conducted on basic and fundamental principles and continued research is pursued at all levels of investigation, it should be only a matter of time before the limited purposes can be extended to general purpose recognition, and the need for human interpretation of the output will lessen with each advancement in the basic processing of the speech signal.

Random Noise

Mr. Dana C. Parker, ONR contractor from the University of Michigan, was recently awarded the 1967 Photographic Interpretation Award of the American Society of Photogrammetry. Mr. Parker was cited for his role in organizing and managing four Symposia on Remote Sensing of Environment.

Professor Paul Cohen, ONR contractor from Stanford University, recently received the National Medal of Science from President Johnson at the White House, in company with 11 other scientists and engineers. Professor Cohen was cited for his fundamental work on the foundations of mathematics.

Dr. Doran W. Padgett was recently designated as Head, Nuclear Physics Branch, Physical Sciences Division, ONR.

Mr. Irving M. Leising, of NRL's Naval Analysis Staff, has been designated Special Warfare Assistant. In this position he will act as the focal point within NRL for quick reaction support and technical information on counter-insurgency as it applies to special warfare and special naval operations in less than limited war situations.

Dr. John C. Munson has assumed duties as Superintendent of NRL's Acoustics Division. Dr. Munson was previously employed as a consultant to ONR.

Mr. J. Heston Heald, former Director of Project LEX, was recently presented with the Superior Civilian Service Award for his outstanding contributions to that project. Mr. Heald retired recently after completing over 25 years of military and civilian service.

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Fleet Effectiveness Prediction Studies at a Recruit Training Command

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Commanding officers and members of their staffs are frequently required to make decisions regarding the retention or separation from service of "problem" enlistees. For example, John Doe is found to be negligent in the performance of his duties. He is taken to mast and his commanding officer is faced with a decision which may involve the awarding of a court martial, assigning extra duty, or possibly recommending an administrative type of service separation. In the final analysis, the commanding officer hopefully will make that decision which will increase the effectiveness of his operating unit and, at the same time, be of the greatest benefit to the enlistee himself. Couched in somewhat different terminology, the commanding officer will make an estimation of the odds for John Doe becoming an effective sailor if one or another administrative action is taken; and ultimately his decision will reflect the odds for Doe's effective performance which he, the commanding officer, attaches to different courses of action.

Many administrative decisions are made on Navy enlisted personnel which, in part, involve judgments of their future effectiveness or future value to the service. Unfortunately, such predictions of effectiveness are frequently only educated guesses, or at best are based upon the limited personal experiences of the officer responsible for the decisions. In other words, little information exists regarding the eventual military effectiveness of large numbers of enlistees for whom major decisions, *e.g.*, placement, training, or service separation, are made daily.

Determining the actuarial odds for effective naval performance among large samples of enlistees with different behavioral characteristics and in different fleet environments has been the goal of one of the research tasks assigned to the Navy Medical Neuropsychiatric Research Unit by the Bureau of Medicine and Surgery. Enlistee noneffectiveness, in a global sense, frequently involves psychiatric abnormalities. For this reason, it poses a medical problem.

It is generally agreed among personnel specialists that for enlistees to be considered effective they should not only complete their obligated tours of active duty, but also should be recommended for re-enlistment by their commanding officers. While this is not a stringent criterion of effectiveness, many enlistees do fail to meet it. As a matter

of fact, by this definition, only 72 percent of Navy enlistees on their first tour of duty can be considered as rendering effective performances. Conversely, 28 percent are either discharged prematurely or perform so poorly that their commanding officers are not able to recommend them for re-enlistment.

Research has not been completed for specifying the actuarial odds for effectiveness for enlistees in specific fleet environments, as in the example of John Doe. However, sets of probability figures have been derived for forecasting effectiveness during the initial phases of enlistment, *i.e.,* during the recruiting process and in recruit training. Research findings have indicated, for example, that a new enlistee who has completed 11 years of schooling, obtained an Armed Forces Qualification Test percentile score of 23, been expelled or suspended from school on two or more occasions, come from a family in which his parents are separated, and enlisted for four years of active duty has only 411 chances in 1000 of being an effective sailor. In other words, he would have approximately four chances in ten of completing his enlistment with a recommendation for re-enlistment. For other combinations of these variables, the actuarial odds are, of course, different.

Later, after the new enlistee has arrived at the training station and has completed his classification testing, his odds for effectiveness are slightly altered. For example, if he has completed 11 years of schooling, been expelled or suspended from school on two or more occasions, come from a family in which his parents are separated, obtained an Arithmetic Test score of 45 and a Mechanical Test score of 40, his odds are 511 out of 1000 of being an effective sailor during his four years of active duty. In general, as more information becomes available concerning the initial adjustment and performance of the new enlistee, predictions of his eventual naval effectiveness become more precise.

The purpose of this article is to illustrate how enlistees' predicted odds for effectiveness are altered as a result of their adaptation to one facet of the recruit training program. It is as a result of studying the fleet performance and adjustment of groups of enlistees with similar training experiences that information is accumulated which not only may have value for altering predictions of subsequent effectiveness, but which also may supply training personnel with feedback which can eventually be used as a basis for effecting changes in the training program.

As recruits, new enlistees with varying abilities, interests, and levels of emotional maturity are brought together in a training environment which is obviously alien to their former way of living, but one which is designed to mold their behavior into specific patterns which facilitate their eventual fleet effectiveness. Many new enlistees do not make

this transition from civilian to military life easily. Some (approximately three percent) perform so poorly in regular recruit training companies that they require temporary assignment to a special indoctrination company where they receive intensive instruction in the military aspects of training. Enlistees assigned to these companies remain attached to them on an average of ten days; and, following their reassignment to regular training companies, most (80 to 85 percent) eventually graduate from training.

But how well do they perform in the fleet? Are the specialized training experiences which they undergo in training sufficient to increase their motivation to the point where their fleet effectiveness is comparable to that of other enlistees? For the purpose of answering these questions and to illustrate the manner in which research of this type is conducted, the following study is described.

Research Design

In April of 1967, records of the special indoctrination company at the Recruit Training Command in San Diego were reviewed in order to obtain the names of enlistees who were transferred to that unit between October 1 and December 31, 1965. The selection of this time interval was based upon two considerations. First, a redefinition of the goals and purposes of the special indoctrination company and a revision in the standards for selection of the training staff had been made during the period just prior to October 1965. These changes were effected by the Recruit Training Command in an effort to improve the quality of instruction within the unit. Second, in order to provide sufficient time for evaluating the fleet effectiveness of the sample subjects, it was considered necessary for them to have been assigned to commands other than recruit training for a period of at least a year. By selecting the research sample during the last three months of 1965, it was possible to satisfy both of these conditions.

Previous research had indicated that recruits assigned to the special indoctrination company were enlistees having lower probability-for-effectiveness scores than average recruits. This new research study was not designed to compare this group's actual fleet effectiveness with that of average recruits. If it were, and findings indicated that they had a lower rate of effectiveness, it would not be possible to specify whether this difference was due to their initial lower probability scores or to factors connected with their special assignment and training. However, since one of the goals of the study was to assess whether probability scores should be altered for this special group of subjects, it was necessary to match these enlistees with a control group on the basis of their predicted odds for effectiveness.

In keeping with this design, two groups of subjects were selected as the research samples. The experimental group consisted of those recruits who graduated from training after completing an assignment in the special indoctrination company. The control group was comprised of enlistees who graduated from training without having been assigned to the special indoctrination company. Experimental and control subjects were matched on a man-to-man basis, depending upon their predicted fleet effectiveness scores.

The subject-by-subject matching of the experimental and control groups was carried out in the following manner. Data contained in records of the Recruit Training Command was used to calculate predicted effectiveness scores for enlistees in the experimental sample. The number of the regular recruit training company to which each of the experimental subjects had originally been assigned at the time of his entrance into recruit training was noted. Predicted effectiveness scores were then computed for all members of that particular regular training company, and the recruit whose score was nearest to that of the experimental subject was chosen as the matched control. Because both members of a matched pair were taken from the same regular training company, it could be assumed that, at least during the initial stages of training, they had both been exposed to relatively the same standards of instruction.

The variables used for the computation of the predicted effectiveness scores were:

- years of schooling completed prior to enlistment,
- Arithmetic and Mechanical Classification Test scores,
- number of expulsions and suspensions from school, and
- family stability.

The specific formula used in calculating these scores is contained in a report by the authors entitled "The Prediction of Four-Year Military Effectiveness from Characteristics of Naval Recruits" (*Military Medicine,* Vol. 131, No. 8, August 1966).

The actual military effectiveness of the sample subjects was evaluated 15 months subsequent to their graduation from recruit training. Criterion data for those subjects still "on board" consisted of commanding officer ratings of performance and adjustment. For those enlistees no longer attached to active duty commands, information was obtained from the Bureau of Naval Personnel as to the cause of separation and the type of discharge received. The duty status of the sample subjects and the commands to which those still on active duty were attached were ascertained from the enlisted master tape maintained by BuPers. For these latter subjects, commanding officers were requested to supply the following data:

- service schools completed by the subjects,
- commands to which enlistees had been attached since graduation from recruit training,
- all semiannual marks,
- record of disciplinary action,
- present rate and pay grade, and
- recommendation for re-enlistment.

The latter item was worded, "At this time would you recommend this man for re-enlistment? (Yes, No)" For the purposes of this study, a subject was considered to be noneffective if his commanding officer indicated that he was not recommended for re-enlistment or if he was no longer on active duty.

Results

During the period of October 1 through December 31, 1965, 154 recruits were assigned to the special indoctrination company at the Recruit Training Command, San Diego, 127 of which successfully completed training and were graduated into the fleet. Thus, the research sample was comprised of 254 enlistees (127 experimentals and 127 controls). Of these, fleet effectiveness data were obtained on 224 subjects. Missing criterion data of 30 matched pairs of experimental and control subjects necessitated their elimination from subsequent statistical analyses, leaving a sample of 97 pairs for whom fleet effectiveness comparisons could be made.

Approximately 15 months after graduation from recruit training, it was found that 23 of the 97 experimental subjects and 15 of the 97 control subjects were no longer attached to active duty commands. The reasons for their separations are shown in Table 1:

TABLE 1

Reason for Discharge	Experimental Subjects	Control Subjects
Misconduct	4	2
Unsuitability	9	2
Unfitness	3	2
Convenience of Government	4	1
Physical Disability	2	4
Desertion	1	4
Total	23	15

Twenty-eight percent of new enlistees render noneffective performances during their first enlistments. Which men will these be?

Of the 74 experimental subjects still in service 15 months after graduation from recruit training, 37 were rated by their commanding officers as not recommended for re-enlistment. The remaining 37 men were considered to be rendering effective performances. By contrast, of the 82 control subjects still in service 15 months after graduation from recruit training, only eight were rated as not recommended for re-enlistment.

By summing the number of enlistees within each group who had been discharged from service and the number not recommended for re-enlistment, rates of noneffectiveness were determined. For the experimental group, 60 of the 97 enlistees (approximately 62 percent) had rendered noneffective performances. For the control group, 23 of the 97 subjects (approximately 24 percent) were noneffective.

In terms of the subject-by-subject comparisons between the experimental and control groups, there were 48 pairs in which there was no difference in effectiveness; that is, both were classified as effective or both were classified as noneffective. For the remaining 49 pairs, there were 43 instances in which the control subject was classified as effective while his experimental match was classified as noneffective. In six instances, the reverse occurred. This preponderance of noneffectiveness among the experimental subjects is highly significant statistically.

Of the 48 pairs of subjects in which there was no difference in the effectiveness classification, eight enlistees had been discharged from service, leaving 40 pairs for whom commanding officer ratings of performance and adjustment were available. By comparing these 80 enlistees on the basis of the individual items which comprised the performance and adjustment questionnaire, it was possible to ascertain whether or not differences existed in the degree of effectiveness or noneffectiveness between the subjects in the two groups.

Table 2 shows the differences which existed in pay grade, semiannual marks, and disciplinary record. These data show that the

control subjects obtained a significantly higher pay grade and significantly higher semiannual marks than the experimental enlistees; but that no difference existed between the two groups with respect to disciplinary record.

TABLE 2

Measure	Number of Pairs				Approximate* Probability
	Control > Experimental	Control < Experimental	Control = Experimental	Total	
Pay Grade	14	5	21	40	<0.05
Semiannual Marks					
Performance	23	7	10	40	<0.01
Behavior	22	11	7	40	<0.05
Appearance	23	7	10	40	<0.01
Adaptability	19	7	14	40	<0.01
Discipline	10	9	21	40	N.S.

*Differences between the matched pairs of experimental and control subjects were tested for statistical significance by the Wilcoxon Matched-Pairs Signed-Ranks Test (Siegel, S. 1956. *Nonparametric Statistics for the Behavioral Sciences,* New York:McGraw-Hill).

Essentially then, enlistees who require assignment to special indoctrination companies in recruit training do not perform as well in the fleet as do other enlistees with similar background characteristics. Only 38 percent of the former group, as evaluated by commanding officers, render effective performances in the fleet, while 76 percent of the latter group are considered to be effective.

The question arises as to how these findings will alter predicted effectiveness scores. Also, will these scores, which were originally derived for all recruits without respect to special indoctrination company assignment, still be useful for forecasting fleet effectiveness among enlistees who require this special training? The answers are reflected in the following data.

For the 97 experimental and 97 control subjects, the mean predicted effectiveness scores were 695 and 696 (out of 1000) respectively. These means are almost identical because it was on this basis that the subjects in the two groups were matched. For the experimental group, the 37 effective enlistees had a mean predicted effectiveness score of 763, while the 60 noneffective subjects had a mean score of 653. The correlation between predicted effectiveness score and actual fleet effectiveness for the experimental group was found to be .34, a statistically significant relationship.

On the basis of this correlation and on the basis of the actual fleet effectiveness of the experimental group, a new equation for predicting effectiveness for enlistees whose performances in recruit training normally require their assignment to the special indoctrination company has been written. The equation is: Effectiveness = 1.06 (Regular Predicted Eff. Score) − 355.7. Using this formula, an enlistee who begins regular recruit training with a predicted effectiveness score of 511, like the one cited earlier, would have only 185.96 chances, or approximately 186 in 1000, of rendering an effective performance in the fleet if he were assigned to the special indoctrination company and eventually graduated from recruit training (185.96 = 1.06 (511) − 355.7). On the basis of these findings it would seem to be a waste of training efforts to assign to the special training company those recruits who have regular predicted effectiveness scores which are low, say, under 500 or 600.

Conclusions

Data have been presented to illustrate some of the research procedures which are employed in ascertaining the military effectiveness of groups of naval enlistees. In this particular study it was found that a high percentage of enlistees who perform poorly enough in recruit training to require assignment to a special indoctrination company are judged to be noneffective enlistees in the fleet. The results also suggest that some of the enlistees assigned to special indoctrination companies in recruit training, particularly those whose initial predicted effectiveness scores are low, have such meager odds for rendering acceptable performances in the fleet that their immediate release from service would probably be justified.

It should be pointed out that the data from this study do not permit an evaluation to be made of the relative value of the training procedures employed in special indoctrination companies. A determination of the effects of such special training would necessitate the utilization of a control group requiring special training but not permitted to receive it.

Establishing the fact that recruits assigned to special indoctrination companies have fleet effectiveness rates which are considerably below those of other recruits with similar background characteristics is but a first step in arriving at a highly valid formula for predicting service effectiveness. It is quite possible that other background variables may be uniquely valid for this group of enlistees or that different combinations of the same variables would yield more accurate predictions of effectiveness. To carry out such an analysis and to obtain reliable results would require a greater number of subjects than were available in this study. In this regard, separate regression analyses are being derived for predicting effectiveness among subjects grouped together on the basis of duty assignment and occupational specialty.

As more studies are conducted among groups of enlistees in specific training and fleet environments, it should eventually be possible to construct tables of probabilities of service effectiveness for use by commanding officers and personnel administrators in making decisions about enlistees at almost all stages of their service careers.

Dr. Karle Honored at NRL

Dr. Jerome Karle, a pioneer in the analysis of structure of matter by x-ray and electron diffraction has been named to the newly-created Chair of Science for the Structure of Matter at the Naval Research Laboratory (NRL).

In announcing the honor, Dr. Alan Berman, Director of Research at NRL, noted that it recognizes Dr. Karle's unique and sustained research accomplishments at NRL which have led to his international reputation as a leader in his field.

This marks the third time that NRL has created a Chair of Science in recognition of distinguished scientific service. Previous honorees were Dr. James H. Schulman who was named to the Chair of Materials Science in 1964 and is now Associate Director of Research for Materials at NRL, and Dr. Maurice M. Shapiro who was named to the Chair of Cosmic Ray Physics in 1966.

For the past 25 years, including 22 at NRL, Dr. Karle has conducted theoretical and experimental research in electron diffraction, x-ray diffraction, and neutron diffraction as they pertain to structural analysis of matter. With these three distinct but related methods, scientists delve into the infinitesimal world of molecules and crystals in search of interatomic distances and atomic arrangements. This knowledge contributes to fundamental progress in science in such fields as organic and biological chemistry, geology, and solid state physics.

Through Dr. Karle's pioneering work, the ability to determine directly the structure of matter has been extended to highly complex materials.

A frequent collaborator in Dr. Karle's work is his wife, Dr. Isabella Karle, also an NRL scientist. They recently solved the structures of reserpine, 6-hydroxycrinamine, digitoxigenin, and panamine which have curative properties for high blood pressure, heart disease, or mental disturbances. These are among the most difficult crystal structures ever solved.

Dr. Karle has held progressively responsible positions at NRL before being named to the Chair of Science. In 1959, he received a Research Society of America (RESA) award in pure science. The award is presented annually by the laboratory's chapter of RESA.

In addition to scientific stature and accomplishment, award of a Chair of Science recognizes the breadth of Dr. Karle's work which includes interest, awareness and competence in different scientific disciplines, and promotion of their interaction. He also has demonstrated concern for the interaction of NRL with the rest of the scientific community and with the impact of science on society.

An Academic Conference in Qualitative Solutions of Differential and Integral Equations will be held at Madison, Wisconsin, in August 1968. Additional information on this conference, which is sponsored by the Office of Naval Research in conjunction with the National Society for Industrial and Applied Mathematics, may be obtained from Dr. L. D. Bram, ONR Mathematics Branch.

Research Notes

New Launching System Developed by PMR

A blast of compressed air is now being used to speed ARCAS meteorological rockets on their way into the upper atmosphere. The cold gas launching system, which provides positive control and increased altitude for the weather probes, was developed by ordnance engineers at the Pacific Missile Range, Point Mugu. PMR is the world's biggest user of weather rockets, with more than 500 being fired yearly.

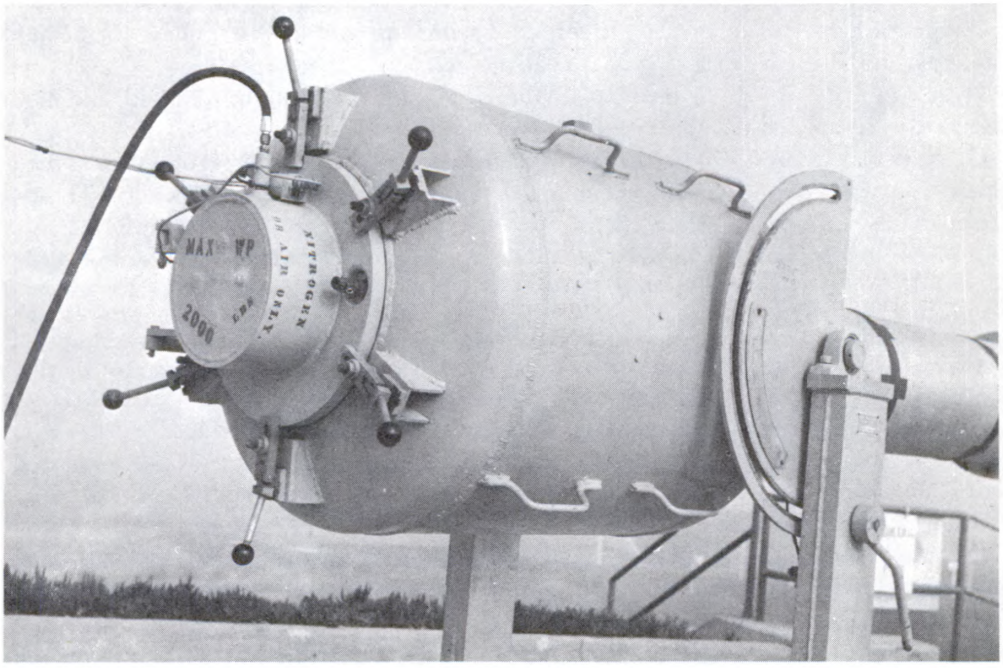
PMR is using the new system to increase the lifting power of 100-pound ARCAS rocket motors. The launcher system used previously, which was very unreliable, employed a mechanically operated device that fired an aircraft seat ejection cartridge to generate additional gas pressures in the launch chamber. The elimination of the ejection cartridge alone is expected to save PMR over $10,000 yearly.

PMR engineers have replaced the standard ARCAS launcher door with a new door which incorporates a 550-cubic-inch tank filled with compressed air. When the rocket motor is fired, the ignition forces open a valve that releases the air into the launch chamber, thus increasing the lift-off power of the rocket. Altitudes can be regulated by lowering or raising the normal pressure (about 800 psi) in the cold gas tank. Through the new system, exit velocities from the launcher have been increased from about 170 to 220 feet per second to attain apogee altitudes of around 225,000 feet.

The temperature-sounding meteorological package is released at apogee and descends by parachute. The signals from the package are monitored and used in weather forecasting.

All PMR ARCAS launchers at Point Mugu, San Nicolas Island and Barking Sands, Kauai, Hawaii have been modified.

Eight hundred psi of compressed air being fed into a cold gas tank, designed by PMR ordnance engineers. The new system increases the lifting power of ARCAS rockets used by meteorologist for weather forecasting.



CIRCE Expedition Begins

A seagoing computer and a satellite navigation system are teaming up to make history aboard the research vessel ARGO during her current year-long, 61,000-mile, scientific exploration of the Pacific, Indian and Atlantic Oceans for Scripps Institution of Oceanography, University of California at San Diego. ARGO departed from San Diego in March to begin the CIRCE Expedition to sail around the world, and will return in March 1969. CIRCE explorations are funded primarily by the Office of Naval Research, with additional support from the National Science Foundation.

This expedition, which is primarily a deep sea, geological-geophysical exploration of the world oceans, marks the first time that calculations of a ship's position at sea will be obtained automatically, using the vessel's speed and direction in conjunction with data received from the satellite, all being fed directly to the computer, to establish her position and thus improve the scientists' knowledge of the exact locations where data are being taken. In distance the expedition will be the second longest in Scripps history, exceeded only by the 15-month LUSIAD Expedition to the Indian, Atlantic, and Pacific Oceans in 1962-63, which logged 77,550 miles.

Scripps Institution purchased an IBM 1800 computer system for the expedition which will be used for geophysical and oceanographic data compilation and data reduction throughout the expedition. The IBM 1800 has a 32,000-word core storage capacity, with a cycle time of two microseconds. The computer is directly connected to scientific instruments on the ship and can gather information from them at rates up to eight million bits a second. Contributing to the ship's versatility are two disk storage cartridges, each of which contains a replaceable magnetic disk for storage of 512,000 words of information.

The satellite navigation system's shipboard receiver was installed in Penang, Malaysia in May, and will function during the remainder of the cruise. Using signals transmitted to the shipboard receiver from three Navy satellites orbiting roughly a north-south course some 600 nautical miles above the earth every 80 minutes, this system enables a ship's navigator to determine his position at sea in any weather and with precision—even substantially greater than a tenth of a mile. This is far better accuracy than can be obtained by the conventional celestial "fix" or by listening to land-based LORAN stations.

Expedition scientists will investigate ocean bottom topography, magnetic patterns, heat flow, thickness of sediments in ocean basins and along continental shelves, distribution and types of hard rock, chemical properties of sediments and the water above them, and variations in the earth's magnetic field near the magnetic equator.

Hydrographic casts will be made, bathythermographic observations collected, and biological tows completed during the expedition.

Of particular interest will be the study of evidence to support, or refute, the current hypothesis of sea-floor spreading from active mid-oceanic ridges, as indicated from observations to be made along the spectacular Ninetyeast Ridge southeast of India, as well as in detail in a portion of the Mid-Indian Ocean Ridge, and as ARGO traverses the Mid-Atlantic Ridge.

Other planned tasks include:

- Exploration of the vast deep-sea fan of the Ganges River that floors most of the Bay of Bengal;
- Detailed geophysical and petrological study of the Ninetyeast Ridge, the longest, essentially straight, mountain range on earth. This ridge is all under water, measures some 2600 miles in length, protrudes 12,000 feet above the sedimented sea floor, and averages 100 miles in width;
- Continuation and extension of a 1965 Scripps survey of the South American shelf and slope between the Amazon River and Trinidad;
- A study of the submarine hills off the Magdalena Delta, Colombia, begun by Scripps in early 1966;

• Investigations of the magnetic lineations of the rock bodies just beneath the sea floor beneath the Galapagos Islands; and

• Continuation of investigations begun by ARGO on the TRIPOD Expedition in late 1966 between Costa Rica and San Diego.

The expedition's participating scientists and graduate students represent the United States, Great Britain, Canada, Australia, Colombia, France, The Netherlands, and South Africa.

NMC Point Mugu Installs Salt-Fog Chamber

A new salt-fog chamber recently installed at the Naval Missile Center's environmental laboratory is being used by the U.S. Army to test Zuni rocket components. The Zuni rocket is presently being fired in Vietnam.

Missiles and rockets up to 14 feet in length and their components can be tested in salt-fog environments ranging from 70 to 120 degrees in the walk-in chamber.

Except for routine maintenance the unit operates automatically for round-the-clock testing without personnel. The chamber shuts off automatically if there is a loss of air, water or electricity. It uses warm air which is sent through a water tower. A salt spray solution is then mixed with air, creating atomized salt spray.

Four nozzles feed the salt spray into the chamber. The nozzles can be controlled so that the tank may be used at half or full operation, depending on the size of the test.

The new chamber is constructed of modern non-corrosive plastics and stainless steel. Test components can be viewed through two large 2×2 ft windows complete with windshield wipers. NMC engineers use it for marine environment testing for all armed services, simulating the high humidity of Vietnam. Missiles which require salt and humidity tests are pretested at Point Mugu before being put into actual operation.

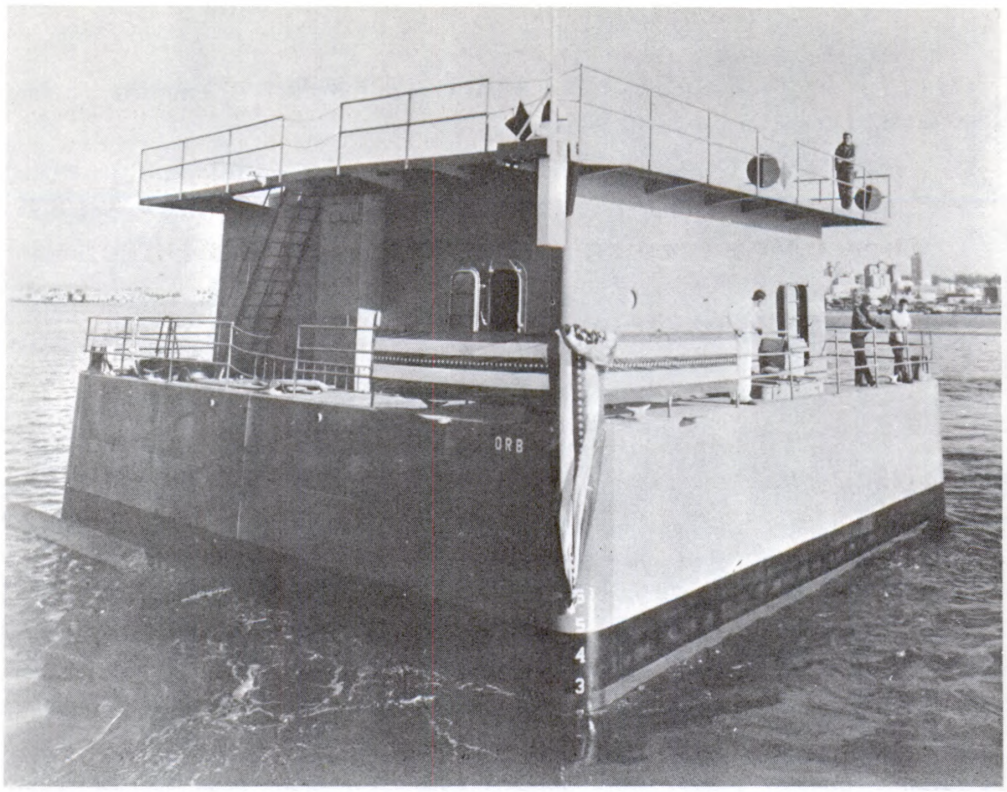
After subjecting parts to 1500 hours in a marine atmosphere, NMC engineers have found that plastic coatings and quick drying paints hold up best in a sea and marine environment.

ORB, New Ocean-Going Research Platform

ORB (Oceanographic Research Buoy) has joined the famed FLIP as the second unique ocean-going research platform serving the Marine Physical Laboratory of Scripps Institution of Oceanography. The 45-ft-square vehicle, which was launched in December in San Diego Bay, was designed to augment MPL's research facilities in ocean engineering. Currently berthed at San Diego's B Street Pier, ORB is being outfitted for her initial oceanic assignment to conduct underwater acoustic research off La Jolla. Her construction was financed by the U.S. Navy through the Office of Naval Research.

ORB is built of steel and measures 24 feet from its keel to its helicopter deck. The vehicle displaces 180 tons and has an open 15×20 ft center well to facilitate operational and scientific requirements. Like FLIP, ORB has to be towed to her ocean work station.

Various MPL projects require handling large payloads in the open ocean. Among these are a two-man deep submersible, the former Deep Jeep given to Scripps Institution by the Navy and now being rebuilt to meet Scripps' requirements; and underwater sonar transducers. For operating these types of equipment, ORB is fitted with a cable-hoist system capable of handling a 30,000-pound payload through the buoy's center well. This specially designed coaxial strain cable also provides for power transmission, control signals, and data reporting between the buoy and sensors on the ocean bottom or between the buoy and any instrumentation below the ocean surface.



Although it has no propulsion machinery, ORB is equipped with two diesel generating sets for power to operate on-board equipment.

After ORB is towed to station, it is moored for whatever scientific projects have been scheduled. The vehicle can remain at sea 45 days without fuel or food replenishment. It has a fuel capacity of more than 5,000 gallons and a fresh-water storage capacity in excess of 5,000 gallons.

Personnel rotation at sea for the crew of four and party of up to six scientists can be accomplished by boat or helicopter. Two laboratories, sleeping quarters, a galley, and a mess hall surround the center well on two levels. ORB combines simplicity of construction and operation, functional utility, and minimum maintenance.

Terry Hoopes, a U.S. Coast Guard reservist and former FLIP crew member, will be officer-in-charge of ORB, which will be operated under contract to the Office of Naval Research.

Lapse in History

Data acquired from the floor of the Atlantic Ocean over the past decade have led to the theory that the sea floor is spreading away from the crest of the mid-ocean ridge.

However, scientists at the U.S. Naval Oceanographic Office, Suitland, Maryland, are studying factual information indicating that a significant lapse in this spreading has taken place. LT Eric C. Schneider, USN and Dr. Peter R. Vogt estimate the length of the lapse to be 15 to 30 million years. They point out that their hypothesis accounts for many previously unexplained characteristics of the ocean floor. Most important of these is the topographic shape of the mid-ocean ridge. The other characteristics are: the thickness of the sediment on its slopes, its heat flow pattern, deviation from its ideal magnetic signature, the varying ages of its rocks and sediments, the character of its sub-sedimentary crust, and its petrological history.

The two scientists have also found evidence indicating other past changes in the rate of the expansion of the sea floor. Because of this evidence, they date the Atlantic Ocean back only to the late Jurassic Period—roughly 180 million years ago.

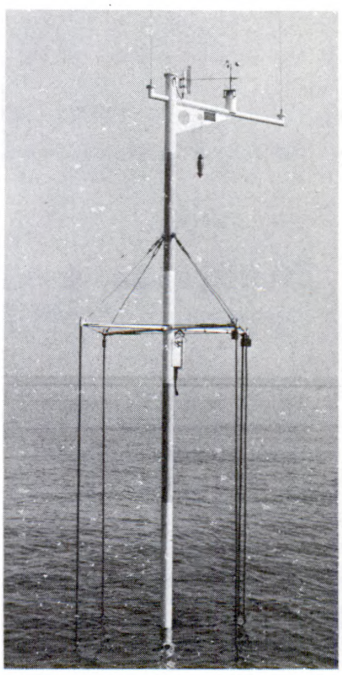
Observation of the Pacific Ocean has been extremely limited, but structural similarities already discovered indicate that the mechanism causing the ocean floor expansion is global rather than local in nature.

Direct Measurement of Wave Height and Direction

It is now possible to accurately measure the height and direction of ocean waves using the Naval Weapons Center (NWC), China Lake, Wave Environment Acquisition System. This oceanographic buoy system has been used successfully in the outer Santa Barbara Passage near San Clemente Island, California in support of an airborne ASW radar evaluation program and has obtained oceanographic and meteorological data at the Sealab III site for the Navy's man-in-the-sea program at San Clemente Island. It was recently utilized for obtaining wave direction spectra for the U.S. Navy Underwater Sound Laboratory, New London, Connecticut to aid in their underwater acoustic research program in Block Island Sound, New York. This oceanographic buoy system will next be used to obtain air/sea interface data in the Hawaiian Islands.

The Wave Environment Acquisition System consists of a telemetering oceanographic data collecting buoy and a mobile shore station. The 50-foot spar buoy is designed to provide a relatively stable platform to which the wave-height-and-direction sensor utilizes five surface penetrating wave staffs: four staffs are used to obtain the wave slope; the other, the reference staff, the wave height. This direct sensor method avoids the normal errors characteristic of such non-direct techniques as measuring pressure or acceleration.

The oceanographic and meteorological data are presently being recorded on an x-y plotter and a strip chart recorder at the shore station. Using digital data processing, an ocean wave spectrum can be obtained. This spectrum is a statistical description of wave conditions at a specified point in time and space. It can be shown in terms of energy versus wave frequency, wave frequency versus direction, or some other combination of parameters.



Navy Ship Modified for Deep Sea Test Operations

The Navy has accepted delivery of its first undersea operations support ship from Avondale Shipyard, Inc., New Orleans, Louisiana. The ship, which was originally designed to support amphibious landing operations, has been refitted to become the Navy's first ship whose mission is to support undersea operations involving Navy Sealab aquanauts and deep submergence vehicles.

The ship (redesignated IX-501) is currently at the San Francisco Bay Naval Shipyard where it is being outfitted for use as the surface support ship for the Sealab III experiment now scheduled to begin in late 1968. The additional equipment to be installed includes precise mooring equipment, two decompression chambers, two personnel transfer capsules, communications equipment, and special portable vans for command and medical monitoring.

The modified ship features a 54-1/2 × 18 foot well in the center of the ship which will be used to raise and lower equipment to and from the sea bottom, including men in the personnel transfer capsules. Also, a traveling gantry crane, which runs on rails the full length of the deck aft of the superstructure has been installed. This large crane and other installed support cranes may be used to lift or lower equipment through the centerwell or over the stern. Since the gantry crane is capable of a 130,000 pound lift, it will be able to handle a Navy Deep Submergence Rescue Vehicle (DSRV).

Diving support includes equipment for deep sea saturation diving with the two large four-man decompression chambers, two four-man personnel transfer capsules, gas stowage, divers' ready room and a diving station for shallow diving, and auxiliary equipment.

The command and medical vans used for monitoring and directing Sealab operations will be installed on the main deck. Also, the ship has been provided with a control room and an instrumentation room.

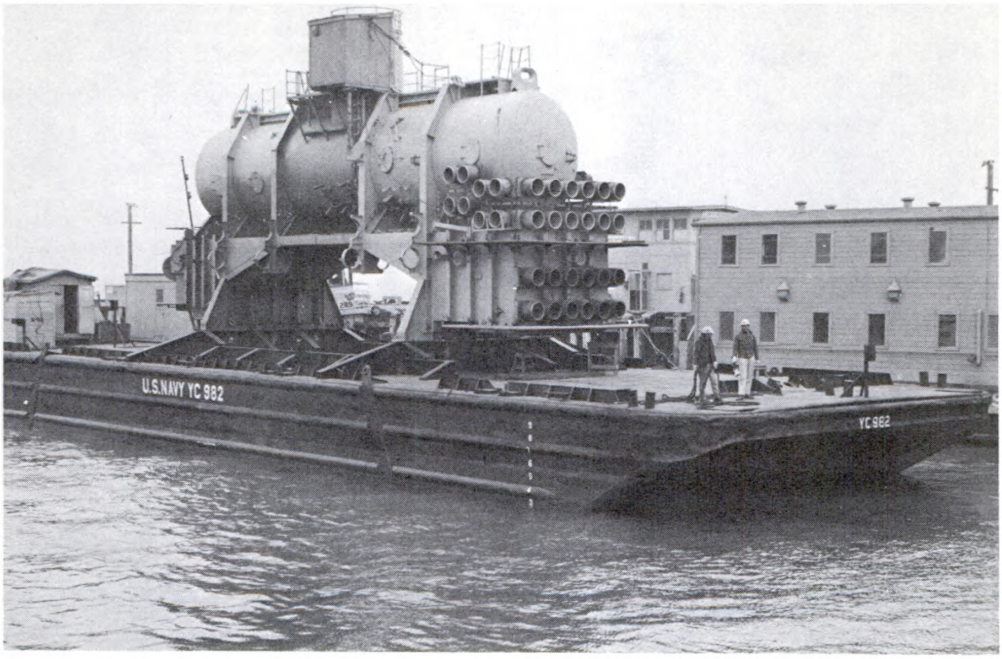
Built in 1945, the IX-501 as modified is 225 feet in overall length, 40 feet wide, draws nine feet of water, and displaces 1800 tons. The ship is diesel powered with a cruising speed of seven knots and a maximum speed of nine knots. It has a range of 3000 miles, and carries a Navy and civilian crew of 45.

The ship will be permanently assigned to the Navy's ocean engineering test range located off the coast of southern California near San Clemente Island. In addition to serving as the Sealab III support ship, it will serve as a general purpose range ship for the test and evaluation of the Deep Submergence Rescue Vehicle (DSRV), Deep Submergence Search Vehicle (DSSV), and Large Object Salvage Systems (LOSS), as well as component testing for these systems, and deep tethered operations. See cover photo.

Australian, British and Canadian Naval Personnel Will Take Part in Sealab III

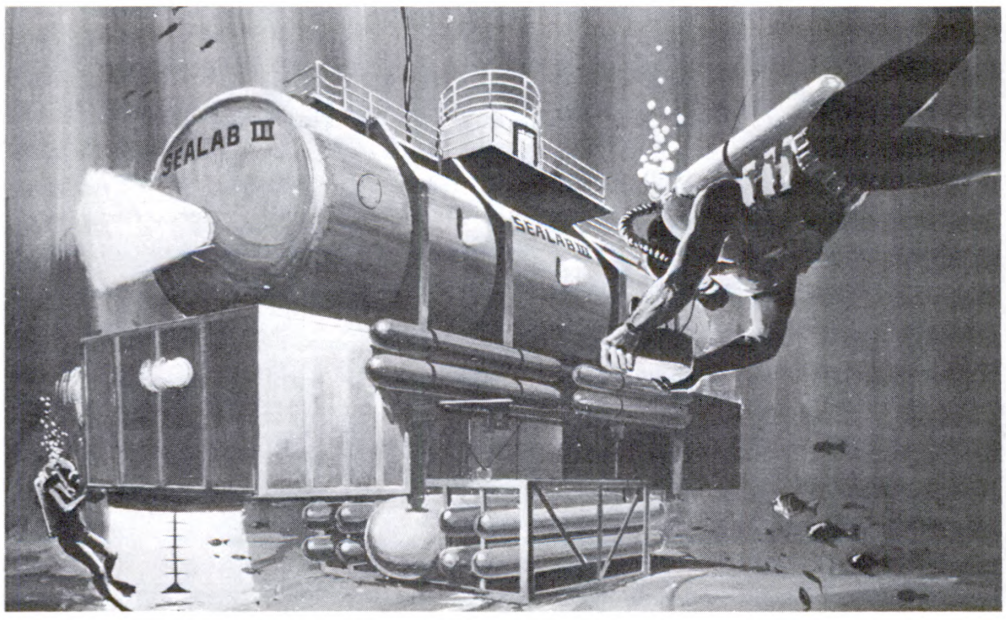
Aquanauts from the navies of Australia, Canada and the United Kingdom will take part in the U.S. Navy's Sealab III. The Sealab series of experiments is directed by the Deep Submergence Systems Project (DSSP) Office of the Navy Material Command.

Sealab III, the most complex, advanced and sophisticated open-ocean engineering experiment ever attempted, is designed to develop the technology and equipment required to adapt man to a deep sea environment. It will be conducted late in 1968 at a depth of 600 feet off the coast of Southern California, near San Clemente Island. Five diving teams of eight men each, including both civilian scientists and Navy divers, will occupy an underwater habitat for successive 12-day periods during the 60-day experiment.



Sealab III habitat in its final stages of fabrication at the San Francisco Bay Naval Shipyard. The right end of habitat shows the spools which will hold aquanaut umbilical cables.

The United States invitation to Australia, Canada and the United Kingdom to take part in Sealab III is part of a broad effort to increase international cooperation in the safe exploration and exploitation of the sea. The plan to invite other countries to participate was developed for and approved by the National Council on Marine Resources and Engineering Development, which is headed by Vice President Hubert H. Humphrey. Invitations were extended to these three nations because of previous cooperation among them and the U.S. in diver training, and because all use similar diving equipment and techniques. In addition, use of a common language will facilitate the undersea experiment.



The U.S. Coast Guard icebreaker GLACIER

Antarctic Expedition Finds Unexpected Marine Life

Contrary to popular notions of a scarcity of plant and animal life in Antarctica, scientists and oceanographers have discovered that great expanses of the ice-covered Weddell Sea in Antarctica have extraordinary concentrations of marine plant and animal life. Examples of animal life in greater than anticipated numbers included penguins, seals and whales. The scientists have just returned from a two-month cruise to the Weddell Sea on board the U.S. Coast Guard icebreaker GLACIER.

Part I of a two-year international program, this year's Weddell Sea expedition included some 50 scientists and oceanographers from the U.S., Norway, Argentina, and West Germany. The Argentine icebreaker SAN MARTIN also took part in the expedition.

Scientists reported that life upon the ocean bottom was far more abundant than had been expected. The sea bottom, in fact, was heavily populated to the depths of 3000 feet.

Scientists and oceanographers from M.I.T., Woods Hole Oceanographic Institution, the Coast Guard, and the University of Bergen (Norway) conducted study of the formation of bottom water. In addition to data collected while on station, data will also be obtained from automatic recording buoys (contributed by Norway) stationed in the Weddell Sea. The data collected and recorded by these buoys will be retrieved next year. Bottom water studies are considered important because the Weddell Sea is believed to be the source of much of the cold bottom waters that flow northward to the Atlantic Ocean.

Oceanographers from the Coast Guard Oceanographic Unit in Washington, D.C. reported taking bottom cores for Florida State University and seawater samples for Yale University trace-metal analysis. These cores may provide significant information concerning the mineral composition and age of the bottom sediments.

Seal population data were collected to satisfy University of Minnesota requirements, and plankton population beneath the ice were sampled for the University of Miami.

NRL Develops Techniques for Detecting Carbon Monoxide

Scientists at the Naval Research Laboratory have developed an ultra sensitive technique for detecting minute portions of carbon monoxide in water. It can also be used in analyzing air samples.

The sensitive gas chromatographic analytical method could become a useful tool in obtaining further information on the ultimate fate of carbon monoxide, a dangerous atmospheric pollutant, and the possible role played by the oceans in absorbing this toxic compound from the air.

Dr. John W. Swinnerton described the development at the American Chemical Society's national meeting held in April in San Francisco. He presented a paper which he co-authored with Dr. V. J. Linnenbom and Dr. Conrad H. Cheek. All three scientists are on the staff of the Ocean Sciences Division at NRL.

According to the authors, the new method is approximately one million times more sensitive than a previously used gas chromatographic technique also developed at NRL. Using the earlier technique, chemists could have detected carbon monoxide in water when it accounted for only one-millionth of the sample being analyzed.

The new analytical method consists of five steps:

- Gases are removed from the solution by purging with helium;
- Gases pass through cold traps where methane and carbon monoxide are separated from other gases which are eliminated from further analysis;
- A molecular sieve chromatographic column is used to separate carbon monoxide from methane and the latter is released for detection;
- Carbon monoxide then leaves the column and is converted to methane; and
- The newly formed methane is detected by a hydrogen flame-ionization detector which also determines its concentration.

The increased sensitivity of the method is based on the conversion of carbon monoxide into methane, a new step in the process of analyzing carbon monoxide in water. The hydrogen flame-ionization detector is much more sensitive to methane, a hydrocarbon, than it is to carbon monoxide.

Use of cold traps in the separation stage also plays a key role in the system's improved effectiveness.

Workshops for Laboratory Problems will be held at Cornell University, Ithica, N.Y., in July 1968. Additional information on these workshops, which are sponsored by the Office of Naval Research, may be obtained from Dr. L. D. Bram, ONR Mathematics Branch.

The Fourth Cryopreservation Conference will be held at Washington, D.C., August 5-7, 1968. Additional information on this conference, which is sponsored by the Office of Naval Research, may be obtained from LCDR V. P. Perry, MSC, USN, Tissue Bank, National Naval Medical Center, Bethesda, Md. 20014.

A Symposium on Body Temperature Regulation will be held at the John B. Pierce Foundation and Yale University, New Haven, Connecticut, August 19-24, 1968. Additional information on this symposium, which is sponsored by the Office of Naval Research, may be obtained from Miss Suzanne Kronheim, ONR Physiology Branch.

On the Naval Research Reserve

Retired Research Reservist Recalled to Active Duty in Pentagon

CDR Grace Murray Hopper, USNR-R, Philadelphia, Penn., is now on temporary active duty in the Office of the Special Assistant to the Secretary of the Navy. On leave from her position as Staff Scientist, DPD Systems Programming, UNIVAC, she is directing her energies in her Navy assignment toward defining procedures for standardization of computer language and implementation of these procedures within the Navy. Dr. Hopper is a pioneer in the world of computers and an expert in computer language.

Until she retired in January 1967, CDR Hopper had been a member of NRRC 4-13 in Philadelphia. She served since 1959 as a visiting professor at the Moore School of Engineering of the University of Pennsylvania. In 1962 she was elected a Fellow of the Institute of Electrical and Electronic Engineers, and in 1964 she received the 1964 Achievement Award by the Society of Women Engineers.

NRRC 13-1 Learns About Bioengineering

A recent meeting held by NRRC 13-1, Seattle, Washington featured a presentation by Dr. Robert F. Rushmer, M.D., who discussed bioengineering, a new multidiscipline which presages dramatic changes in both biology and medicine through the application of engineering science and technology. Dr. Rushmer is Director of Bioengineering Program and Professor of Bioengineering and Physiology and Biophysics, University of Washington.

He pointed out that at the University of Washington, one of six U.S. universities developing a pilot program, a bioengineering program has emerged through combining the talents of members of the College of Engineering and a broad spectrum of health scientists. The program is also being expanded to include participation by members of local industry, *e.g.*, Batelle Northwest, Boeing, Bishop Eye Research Center, *etc.*

The program is operating with a balance of pure and practical research and development in both diagnostics and patient care. In some cases the cooperative relationships are aimed at acquiring new knowledge and concepts; in others, at forming unique task forces to tackle some of the crucial problems of biology and medicine. Some of these problems, *e.g.*, atherosclerosis, multifunctional catheters, nontraumatic

diagnostics, *etc.*, are so complex that only the convergence of highly diverse talents can produce meaningful results.

Dr. Rushmer's comments, plus those made by other participants, made up a very fine and interesting program which illustrated how the fields of research are developing and changing.

As of the writing of this article, NRRC 13-1 is starting its new quarter which will introduce a new technique of planned sequential programming. A series of four sessions will be presented on similar topics. The last session in the series will be a summary and will be coordinated by personnel having specific naval interests in the area being presented. For example, the first series will concern biology, clinical training, and methodology of training and diagnostics. Of particular interest is the utilization and impact of the kidney machine. Other session topics will include ASW, *etc.*

NRRC 13-5 Varies Programs

NRRC 13-5, Corvallis, Oregon currently has 21 members, 13 of which are associated with Oregon State University. The specialties of the members, however, range from home economics to microbiology, from oceanography to economics. The programs have been equally varied in keeping with the objective of broadening the views and backgrounds of the members.

Two recent programs were on the subject of oceanography: the first was a tour of the Oregon State University's Marine Science Center at Newport, Oregon; the second, a presentation by Dr. Stephen Neshyba

NRRC 13-5 members sample foods being tested for astronauts at OSU Food Technology Center

who explained the DOD project Themis and illustrated his talk with movies on the stationing of the new "Totem" buoy. A third program, which was entitled "Food Flavor Research," provided the members of NRRC 13-5 with an opportunity to sample the type of food the astronauts may eat. These foods are currently being tested at the OSU Food Technology Center.

Programs relating to the more immediate environment included presentations on the "Ecology of the Ox-Bow Burn" and "Research on Oregon Lakes." Other programs included a discussion of the problems encountered in establishing the new Linn-Benton Community College by Dr. Eldon G. Schafer, and a discussion of the situation in Vietnam by Major R. J. Kenworthy, USMC, who recently returned from that area after serving as a military advisor.

NRRC 13-5 meets twice a month on the OSU campus. Because of this fact, members are able to take advantage of such programs as the Condon lectures, given last year by Dr. Jacob Bronowski, and the University convocation lecture on the Apollo program, to be given by Mr. Harold R. Bacon, NASA.

The company is commanded by LCDR Richard E. Moffitt.

Promotion Selections

Selections to captain and commander were announced for officers in the Staff Corps. There was only one officer selected in the Naval Reserve for captain in the Medical Service Corps. He was

Mensh, Ivan N., member of NRRC 11-3

Other officers selected in the Research Reserve were as follows:

Commander, Medical Corps	*NRRC*
Allen, William C.	9-8
Clarke, Francis M., Jr.	4-1
Thompson, George R.	9-3
Wallace, Craig K.	5-4
Commander, Dental Corps	
Bahn, Saul L.	3-16
Van Dyke, James A.	12-3
Commander, Medical Service Corps	
Ross, Sherman	5-10
Commander, Supply Corps	
Gross, Martin	13-6
Neumann, Frederick L.	9-2

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research & Development Report 68, No. 4 and 5 of February 25 and March 10, 1968. 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 68, No. 4 and 5.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 21151.

AGRICULTURE

Tree-Rings and Climatic Changes in Western North America; Arizona U.; Schulman; AD-664 014

ASTRONOMY AND ASTROPHYSICS

The Astrometric Program at Yerkes Observatory; Chicago U.; van Altena; AD-662 912

Temperatures of Meteoroids and Meteorites; Ariz. U.; Staley; AD-662 946

Fundamental Determination of the Absolute Spectral Energy Distributions of Stars; CalTech; Oke; AD-663 179

Radio Measurements of Planetary Nebulae; CalTech; Thompson; AD-663 168

ATMOSPHERIC SCIENCES

Experimentation With Weather Control; Calif. U.; Neyman; AD-663 061

Simultaneous Satellite and Balloon Observations of the Same Auroral-Zone Precipitation Event; Calif. U.; Milton and Oliven; AD-663 709

Heat Exchange Between Water and Ice in the Arctic Ocean; Washington U.; Lake; AD-663 610

BEHAVIORAL AND SOCIAL SCIENCES

Advanced Material Systems Planning; Case-Western Reserve U.; Dean and Hauser; AD-663 970

Himalayan Border Countries Project; Calif. U.; Scalapino and Rose; AD-663 581

Human Factors Techniques Employed in Deriving Personnel Requirements in Weapon System Development; Matrix Corp.; Malone *et al;* AD-663 585

Geographic Orientation in Aircraft Pilots: A Simulator Test of a Team Method of Reporting Target Locations; Human Factors Research, Inc.; McGrath *et al;* AD-663 549

Paired-Associates Learning Under Variations in Occurrences of Response Members; Mass. U.; Goss; AD-663 573

Effects of Phrasing of the Issue on Reason Giving in Support of Both Sides of the Issue; Hunter Coll. of the City U. of New York; Weiss; AD-663 867

A Comparative Analysis of Subjective Culture; Ill. U.; Triandis and Vassiliou; AD-663 889

Signal Detection Theory and Psychophysics: A Topical Bibliography; N.A.S.; Egan; AD-663 906

Computer Classification of Documents; IBM Federal Systems Div.; Williams, Jr.; AD-663 178

Toward a Study of Bidding Processes. Games With Unknown Costs; Yale U.; Shubik *et al;* AD-663 187

Criteria for Investment Selection; Stanford U.; Seelefreund; AD-663 194

Recent Revisions to the Digital Simulation Model for Simulating Two-Operator Man-Machine Interaction; Applied Psychological Services; Siegel and Wolf; AD-663 158

Development of Performance Evaluative Measures; Applied Psychological Services; Miehle and Siegel; AD-663 161

Early Retirement and Income Maximization: Some Effects of the Economic Incentives in the Military Retirement System; Stanford; Lenz; AD-663 176

Digital Simulation of Crew Performance: Validation of a Digital Simulation Model for Crew Performance Simulation; Applied Psychological Services; Siegel *et al;* AD-663 291

Physiological and Situational Factors in Psychopharmacological Experiments; Duke U.; Back *et al;* AD-663 157

Cross-Modal Generalization in Human Skeletal and Autonomic Classical Conditioning; Toronto U. (Canada); Furedy; AD-663 160

Effects of Delayed Sidetone, Noise, and Syntatic Structure on the Level and Duration of Speech; Ohio St. Research Foundation; Singh *et al;* AD-663 251

The CS-US Interval in Classical and Avoidance Conditioning; Bryn Mawr Coll.; Bitterman; AD-663 256

Improvement in Habit Reversal as Related to Dimensional Set; Bryn Mawr Coll.; Schade and Bitterman; AD-663 258

Improvement in Habit-Reversal as a Function of Amount of Training Per Reversal and Other Variables; Bryn Mawr Coll.; Gonzalez *et al;* AD-663 260

Reversal Learning and Forgetting in Bird and Fish; Bryn Mawr Coll.; Gonzalez *et al;* AD-663 261

Some Relations Between Emotions and the Prosodic Parameters of Speech; Speech Communications Research Lab, Inc.; Huttar; AD-663 287

BIOLOGICAL AND MEDICAL SCIENCES

Studies on the Respiratory Chainlinked Reduced Nicotinamide Adenine Dinucleotide Dehydrogenase. Transformation of the Dehydrogenase to Reduced Nicotinamide Adenine Dinucleotide-Coenzyme Q Reductase; Calif. U.; Salach *et al;* AD-662 961

Studies on Succinate Dehydrogenase. Reversible Activation of the Mammalian Enzyme; Calif. U.; Kimura *et al;* AD-663 054

Studies on the Respiratory Chain-Link Reduced Nicotinamide Adenine Dinucleotide Dehydrogenase. Interrelations of Reduced Nicotinamide Adenine Dinucleotide-Cytochrome C Reductase and Reduced Nicotinamide Adenine Dinucleotide-Coenzyme Q Reductase; Calif. U.; Biggs *et al;* AD-663 184

Cultivated Food Plants of the Rupununi; Mcgill U. (Canada); Dagon; AD-663 059

Temperature Preference in Golden Hamsters; Mo. U.; Gumma *et al;* AD-663 327

Altered Response to Pneumococcal Polysaccharide in Offspring of Immunologically Paralyzed Mice; Ill. U.; Kerman *et al;* AD-662 966

Variable Role Conceptions in Doctor-Patient Interaction; Duke U.; Garrity; AD-663 166

Solenostomus Cyanopterus Blecker (Teleostei, Solenostomidae) in Elat (Gulf of Akaba); Tel-Aviv U. (Israel); Fishelson; AD-663 403

Genetically Determined Abnormalities in Antigen-Antibody Interaction; Calif. U.; Fudenberg; AD-663 612

Abdominal Surface Potentials and Their Relation to Gastric Motility; Ind. U.; Stevens and Worrall; AD-663 582

The Visual Realm in Space; Kansas St. U.; Brown; AD-663 575

CHEMISTRY

Thermal Rearrangement of B7C2H9(-2)-Ligand Cobalt Complexes; Calif. U.; George and Hawthorne; AD-663 485

A Novel Bidentate Pi-Bonding Ligand Derived From 1,2-Dicarbacloso Dodecaborane (12); Calif. U.; Francis and Hawthorne; AD-663 604

The Optical Constants of Lighium-Ammonia Solutions in the Metallic Range; Texas U.; Thompson and Cronenwett; AD-663 489

The Damped Torsional Oscillator Model for Polymer Molecules; Princeton U.; Tobolsky and DuPre; AD-663 703

Macromolecular Relaxation in the Damped Torsional Oscillator and Statistical Segment Models; Princeton; Tobolsky and DuPre; AD-663 704

Solid 'Liquid Crystal' Films of Polygamma-Benzyl-L-Glutamate; Princeton; Samulski and Tobolsky; AD-663 705

Interactions of Adsorbed Organic Layers With Hydrogen Atoms on Platinum Electrodes; Tyco Labs, Inc.; Brummer and Cahill; AD-663 903

Synthesis and Structure of New Types of Metal Organic Complexes; U. Coll. (London); Nyholm and Tobe; AD-663 164

Molten Salt emf Formation Cells; Rensselaer Polytechnic Inst.; Dijkhuis *et al;* AD-662 914

Pressure Equipment for Polymer Crystallization and DTA Under Pressure; Rensselaer Polytechnic Inst.; Davidson and Wunderlich; AD-807 822

EARTH SCIENCES AND OCEANOGRAPHY

Biological Stations Occupied From Fletcher's Ice Island T-3, June 1966 - May 1967; U. of So. Cal.; Los Angeles; King; AD-663 091

Stability of Biosystems in Sea Water; Columbia U.; Ayres; AD-663 094

Atlantic Oceanography; Woods Hole; Stanbrough; AD-663 101

On the Abyssal Circulation of the World Ocean. An Advection-Lateral Mixing Model of the Distribution of a Tracer Property in an Ocean Basin; Wooster Coll.; Arons and Stommel; AD-663 102

Origin of the Atlantic Equatorial Undercurrent; Woods Hole; Metcalf and Stalcup; AD-663 105

A Compilation of Moored Current Meter Observations; Woods Hole; Webster and Fofonoff; AD-663 108

Geography and the Properties of Surfaces. The Geometry of Mixed Hexagonal Hierarchies in the Context of Central Place Theory; Harvard; Lindgren; AD-663 296

Seismic Reflection Profiles Along the Drill Holes on the Continental Margin Off Florida; Woods Hole; Emery and Zarudzki; AD-662 950

Seismic Reflection Observation on the Atlantic Continental Shelf, Slope, and Rise Southeast of New England; Woods Hole; Hoskins; AD-663 041

Budget for Dissolved Silica in the Mediterranean Sea; R.I. U.; Schink; AD-662 934

Surface Temperature and Salinity Observations at Pacific Northwest Shore Stations for 1965 and 1966; Oregon St. U.; Wyatt and Gilbert; AD-663 140

Research Activities, 1 April 1967 Through 30 September 1967; Oregon St. U.; Kulm and Merten; AD-663 141

Physical, Chemical, and Current Data From Fletcher's Ice Island (T-3): Beaufort Sea Area, June 1965-January 1966; Washington U.; Tripp; AD-663 150

A Study of the Mechanism of Gaseous Transfer Across an Air-Water Interface Using Carbon Dioxide; Texas A&M U.; Hoover and Ibert; AD-663 162

Physical and Chemical Data for Puget Sound and Approaches January 1964 - December 1965; Wash. U.; Collins and Barnes; AD-663 151

Magnetic Anomalies Over the Mid-Atlantic Ridge Near 27 Degrees N; Woods Hole; Phillips; AD-662 967

A Magnetotelluric Investigation, an Electrical Conductivity Anomaly in the Southwestern United States; M.I.T.; Swift, Jr.; AD-663 283

Paleomagnetic Field Reversals and Cosmic Radiation; Minnesota U.; Waddington; AD-663 328

Oceanographic Comment on Apollo 501 Mission Photography; Texas A&M U.; Walsh and Arnold; AD-663 457

Ground Truth Requirements for Remote Sensing of Oceanographic Features; Texas A&M U.; Arnold *et al;* AD-663 458

Bound Halogens in Sediments; M.I.T.; Walters, Jr.; AD-663 583

Geography and the Properties of Surfaces. Energy Flow and Spatial Order, With Special Reference to Mixed Hexagonal Central Place Hierarchies; Harvard U.; Woldenberg; AD-663 910

Studies of Inertial Motion and Associated Waves in Lake Michigan; Wisconsin U.; Mortimer; AD-663 467

T-Phase Sources and Earthquake Epicenters in the Pacific Basin; Hawaii Inst. of Geophysics; Duennebier and Johnson; AD-663 569

Organic Production of Epifaunal Organisms; Texas A&M U.; Pequegnat and Fredericks; AD-663 692

ELECTRONICS AND ELECTRICAL ENGINEERING

A Canonic Translator; M.I.T.; Alsop; AD-663 503

A Program for On-Line Analysis of Nonlinear Electronic Circuits; M.I.T.; Katzenelson *et al;* AD-663 525

High-Speed, Long-Wavelength Coherent Radiation Detectors; Texas Instruments, Inc.; Williams; AD-663 749

The Computer Utility and the Community; M.I.T.; Fano; AD-663 198

An Algorithm for Nonparametric Pattern Recognition; Information Research Associates, Inc.; Henrichon, Jr.; AD-663 109

The Relationship of Magnetic Material Properties to the Operation of a Magnetic Sense Amplifier Device; Purdue U.; Friedlaender and Eaton, Jr.; AD-663 292

MATERIALS

Melting of Polymers; Rensslaer Polytechnic Inst.; Wunderlich; AD-807 823

Surface Melting and Crystallization of Polyethylene; Rensselaer Polytechnic Inst.; Wunderlich *et al;* AD-810 498

Stress Relaxation of Wood at Several Levels of Strain; Yale U.; Manrique; AD-663 691

Shear Deflection of Two Species Laminated Wood Beams; Yale U.; Biblis; AD-663 713

Strength-Weight and Stiffness-Weight Ratios of Two-Species Wood Beams; Yale U.; Biblis; AD-664 004

MATHEMATICAL SCIENCES

Some Experimental Non-Constant-Sum Games Revisited; Yale U.; Shubik and Stern; AD-663 577

Dynamic Deterministic Production and Inventory Models With Piecewise Concave Costs; Stanford U.; Love; AD-663 580

On the Simulation of Dynamic Systems With Lumped Parameters and Time Delays; M.I.T.; Leal-Cantu; AD-663 502

An Explicit Solution of a Special Class of Linear Programming Problems; Northwestern U.; Ben-Israel and Charnes; AD-663 877

Models for Competitive Bidding Under Uncertainty; Stanford; Reichert; AD-663 909

On Medians and Quasi Medians; Calif. U.; Hodges, Jr. and Lehmann; AD-663 173

Elementary Path Counts; Calif. U.; Blackwell and Hodges, Jr.; AD-663 174

Sufficient Statistics in the Case of Non-Constant Carrier; Calif. U.; Barankin; AD-663 175

A Generalization of Newton's Method With an Application to the Euler-Lagrange Equation; Calif. U.; Tapia; AD-663 288

Programming Network Flows Parametrically Via String Analogue; George Washington U.; Rigby; AD-663 095

On Small Sample Probability Limits for Control Charts; Stanford; Yang and Hillier; AD-663 096

Mixed Integer Programming Algorithms for Site Selection and Other Fixed Charge Problems Having Capacity Constraints; Stanford; Gray; AD-663 097

Space Filling Curves and Mathematical Programming; Northwestern U.; Butz; AD-663 170

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Artist's concept of the Sealab III support vessel and the Sealab III habitat. The support ship—a modified LSMR—will supply electrical power and other necessities to the aquanauts living and working in and from the habitat on the ocean floor. *See page 32.*