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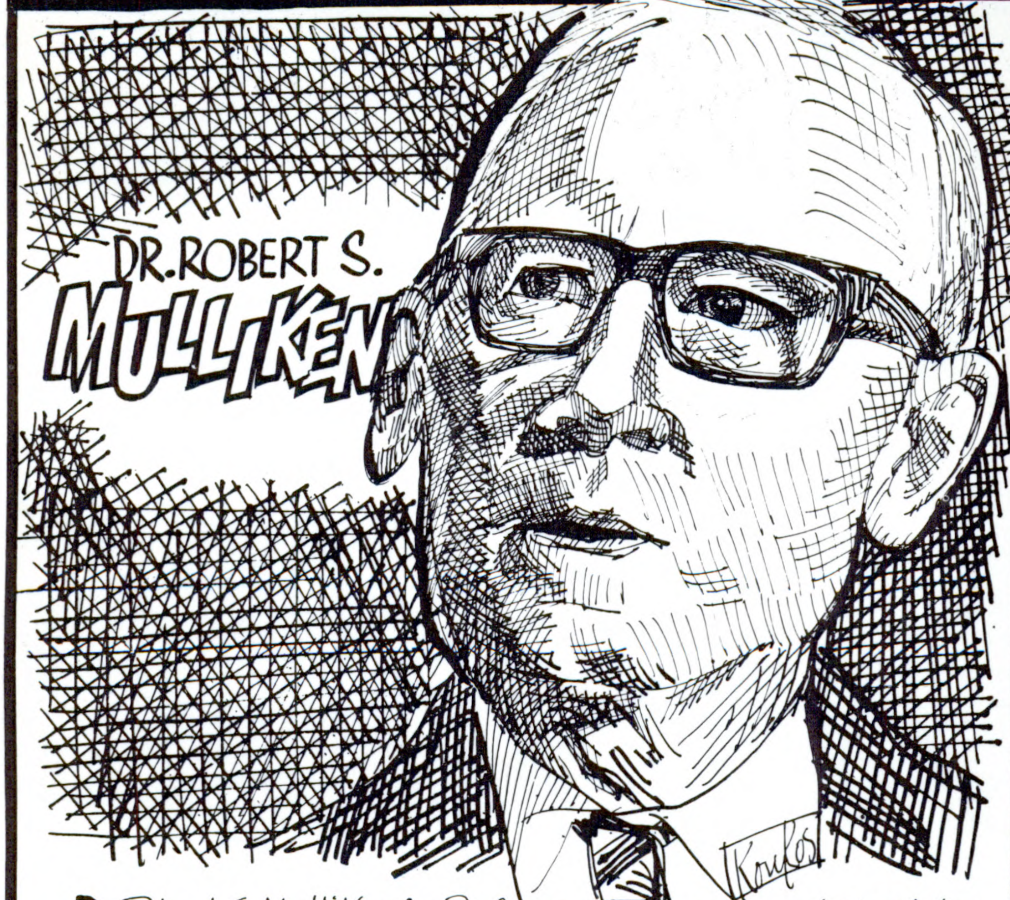

Dr. Robert S. Mulliken is Professor of Physics and Chemistry at the University of Chicago and was the 1966 Nobel laureate in chemistry. A long-time O.N.R contractor, Dr. Mulliken was responsible for the development of the molecular orbital theory. This theory, which describes the paths which electrons travel in complex molecules, aids in predicting the chemical behavior of the molecule. Mulliken's work has permitted scientists to extend the principles of atomic structure to explain molecular structure and has shown how the atom's electronic structure is altered when included in molecules. Dr. Mulliken has five major awards from the American Chemical Society and has the Gold Medal Award for Scientific Achievement from N.Y. City College.

Time-Sharing: A Computer at Your Fingertips

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In less than five years, computer time-sharing has changed from a laboratory curiosity to a thriving national business. The United States Navy has played a key role in supporting some of the earliest research work in time-sharing, and has taken every opportunity to ensure that the benefits of this new development in computer usage have been made available throughout government and industry.

Time-sharing usually means the simultaneous use of a computer by a number of individuals, each working on his own problem and having no knowledge of the jobs and requirements of any other user. Although the words "time-sharing" do not accurately describe what is actually happening inside the computer, the name has stuck. Some have suggested that it be called "simultaneous multiple-access remote computing," but, since SMARC is not a catchy acronym, this label has never caught on. Others prefer to call it "interactive problem solving by computer" or "man-computer partnership" because these terms focus on the crucial question of how a computer system can help men to do their jobs more effectively and economically.

With the appropriate terminal in his office or laboratory (typically a typewriter-like keyboard), a user can dial into any one of a hundred computers across the country and use this machine to help solve scientific problems, manage a complex project, assist in teaching mathematics to a high school sophomore, or perform many other engineering or management tasks.

Time-sharing is important for a number of reasons. Perhaps its greatest benefit is that it permits people to use the computer when and where they need it. They may work according to their own schedules rather than having to adapt to the computer's rigid schedule (which once meant working in the computer room during the wee hours of the morning).

Another important feature of time-sharing is that the computer's answers to a user's problem are obtained "now" when he wants them. He doesn't have to interrupt his thinking until tomorrow for the results to come back from the computer. He may experiment with one approach to a problem to see how it works out, and then modify the approach if he is not satisfied with the results. It is not uncommon for a user to try three or four different approaches before discovering the best method for getting the job done—all in a single session on the computer. The same process might take more than a week on a heavily loaded non-time-shared computer with a long turn-around time.

Other possible benefits from time-sharing stem from the fact that the user can be located anywhere. A terminal that can be dialed into the telephone network will reach most time-shared computers in the country within a matter of seconds. This means that it becomes easier for many people working on the same problem to share data and programs quickly, even though they may be separated by many miles. It also means that the man with a problem to solve can work quietly in his office and not become involved with the mechanical details of setting up a problem to run on a computer.

In many cases, using a time-shared computer can be less expensive than using other computers. The user pays for the computer only when it is actually needed; *i.e.*, the cost is shared by all of the users on an actual-usage basis. When users are entering data, printing results, or scratching their heads while trying to decide what to do next, a very minute portion of the computer's power is required and charged against the user.

This does not mean that time-sharing is the answer to all computer problems. In fact, many jobs are still handled best on the conventional batch-process type of computer operation. In general, however, computing tasks which involve a great deal of human interaction work out better on a time-sharing system.

How Time-Sharing Works

The objective of computer time-sharing is to give each user the impression that he has the entire computer to himself. Since many users all have this impression at the same time, time-sharing is usually interpreted as meaning that all users are being processed by the computer simultaneously. Actually, the computer can process only one (or a few jobs) at any one instant. In order to give the impression of simultaneity, the time-sharing system utilizes extremely high speed to process each user in turn for a very brief period of time and then goes on to handle the next user.

In some respects, time-sharing is analogous to a circus juggler who is balancing many balls at the same time. Each ball represents a user and the juggler's hands are the computer. Most of the time the balls are in the air; only one or two of them may be in his hands at any one moment. The balls in the air are users waiting for their turn at the computer; those in his hands are using it at that instant.

In many time-shared computer systems, the jobs waiting to be processed are stored temporarily on a magnetic drum or disc. When the computer is ready, the new job is brought in from the drum and placed in the computer's internal memory and the old job is written back out onto the drum. This process is called swapping.

To complicate matters a bit more, the various jobs usually cannot be kept in the same order. For example, one job may be waiting for the user to enter some data on his typewriter before it can proceed. To avoid wasting time, the time-sharing system will skip this job and go on to the next one in sequence. When the original user starts typing in the data for his job, the time-sharing system goes back and gets the data before it is lost.

Since most of the activity in a time-sharing system is asynchronous, the system must respond quickly and accurately to all the constantly changing demands being placed on it. In addition, the time-sharing system must protect each user from every other user as well as himself. Although these requirements make time-sharing a fairly complicated procedure to implement, they make it much simpler for the user.

User Programs/Languages

There are various user programs which may be employed in connection with time-sharing systems. Such programs include languages that permit the user to create his own programs, including such powerful compilers as FORTRAN, ALGOL, or PL/1. Languages of this type, however, are of limited interest; *i.e.,* they are of concern mainly to those developing new programs for the system.

Problem-oriented languages, which permit the user to solve a problem by describing it to the computer in much the same way he would discuss it with a colleague, are of more interest to the non-programmer. An example of such a problem-solving language is the JOSS (Johniac Open-Shop System), language which was developed at the Rand Corporation to solve small scientific and engineering mathematical problems. When talking to JOSS, the engineer uses conventional mathematics to describe his problem and a few command words which tell the computer how to proceed. Because of its simplicity, most engineers and scientists can learn to use JOSS within a few hours and can apply it to their work almost immediately.

The BASIC language, very similar to JOSS, was originally developed at Dartmouth College for time-sharing computer users. BASIC, which stands for Beginner's All-Purpose Instruction Code, is a simplified subset of the more complex language, FORTRAN. Dartmouth students have been very successful in learning BASIC and applying it to their classroom work fairly quickly. Examples of the JOSS and BASIC programs are shown on the following page.

Sophisticated problem-oriented languages have been developed for a number of important applications. For example, the STRESS

The following JOSS program computes prime numbers and prints them out, four per line. It starts at 3.1 and the inner loop is done by part 1.

```
1.1     SET K = 1
1.2     SET K = FP(X/A(J)) FOR J = 1 BY 1
        WHILE A(J) ↑ 2 <= X AND K ≠ 0
1.3     DO PART 2 UNLESS K = 0
2.1     SET A(I + 1) = X
2.2     SET I = I + 1
3.1     DEMAND N
3.2     SET A(1) = 3
3.25    SET I = 1
3.3     DO PART 1 FOR X = 5 BY 2 TO N
3.4     TYPE IN FORM 1:A(J) FOR J = 1 TO I

FORM 1: HERE ARE FOUR PRIMES:
    %%%%    %%%%    %%%%    %%%%
```

When it is run, the following dialogue might occur:

```
TO STEP 3.1
N = 25
HERE ARE FOUR PRIMES:  3    5    7    11
HERE ARE FOUR PRIMES:  13   17   19   23
```

The Beginner's Algebraic Symbolic Interpretive Compile (BASIC) is a very simple algebraic compiler that resemble FORTRAN. The program below is the solution for

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

```
10    INPUT A, B, C
15    LET D = B ↑ 2 -4*A*C
20    IF D > 0 THEN 300
30    LET R1 = -B/(2*A)
40    LET R2 = R1
50    IF D = 0 THEN 400
60    LET I1 = SQR(-D)/(2*A)
70    LET I2 = -I1
100   GO TO 500
300   LET R1 = (-B+SQR(D))/(2*A)
310   LET R2 = (-B-SQR(D))/(2*A)
400   LET I1 = 0
410   LET I2 = 0
500   PRINT "ROOTS =" R1; I1, R2; I2
999   END
```

Examples of JOSS (left) and BASIC programs

language, used for structural design, and the COGO language, used for solving problems in coordinate geometry, were created by the Civil Engineering Department at M.I.T. as special program tools for civil engineering. In the same vein, a number of problem-oriented languages are being developed to assist naval architects and engineers in ship design processes. (See *Naval Research Reviews* issue of September 1967, "Computer-Aided Ship Design and Construction.")

One example of this type may be seen in the programs developed by General Dynamics at its Quincy shipyards. In the preliminary phase, the designer specifies in broad detail some of the major design parameters of the vessel. The computer, using these parameters, analyzes some 250 different possible designs and compares their cost and performance characteristics. The designer can then select the few major designs that best meet his specifications and modify them to further improve the design. Through a conversational interaction between man and machine, various levels of detail are added until the vessel is complete. In this manner, time-sharing allows the designer to explore more alternatives than he would otherwise by using conventional manual design methods.

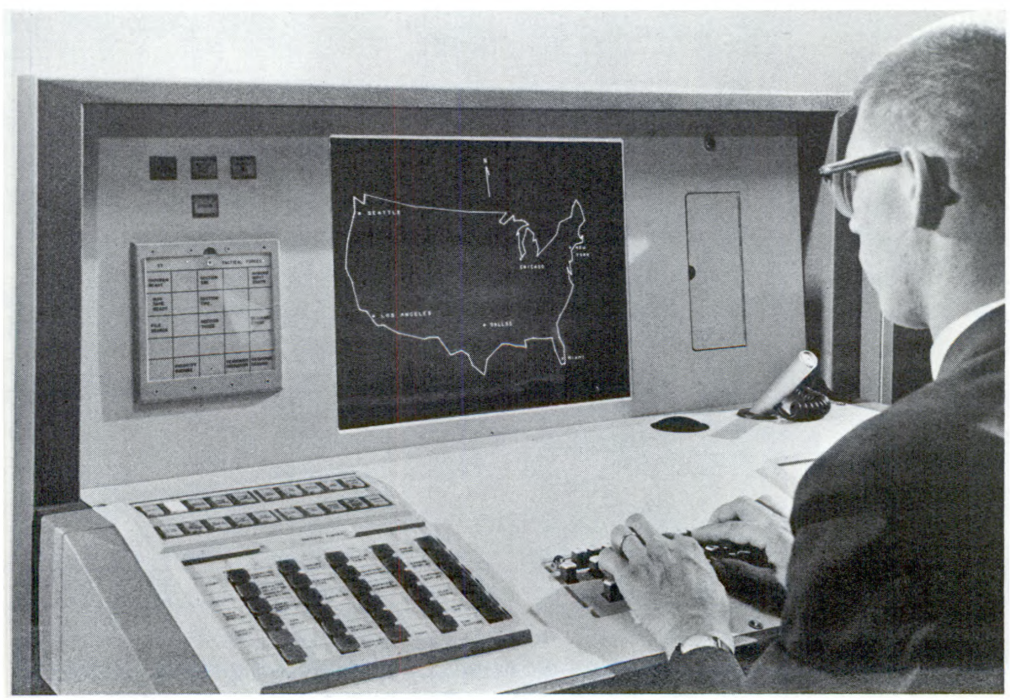
Not all problem-solving languages are oriented to the scientific or engineering user. In fact, considerable work has been done in using the time-shared computer terminal as a management tool. The Bunker-Ramo Corporation, for example, has developed an on-line center for experimenting with problems in command and control. In one version of this program, a naval officer can experiment with different ways of deploying ships to achieve an optimal configuration.

OPS, an on-line language for simulation design, was developed at M.I.T. under an ONR contract and sponsored by the Advanced Research Projects Agency. With the OPS language, a user can quickly build a model of a real-world situation. This model can then be simulated, using data either constructed by the user or obtained by observing the actual operation of the situation under study. To illustrate, OPS might be used to improve the flow of traffic in a complex road network by adjusting the width of certain streets and the timing and placement of traffic controls. After the OPS user has constructed a model of the traffic network, he can run several simulations—each corresponding to a different arrangement of roads, signs, and lights. The statistical analysis features of OPS could then be used to determine which configuration was most effective.

Time-Sharing and Education

Time-sharing is not only useful as a problem-solving or management tool; it can also be applied to education and training. For example, a time-shared computer system is being used in the PLATO project at the University of Illinois as the nerve center of a classroom teaching research project. Each student, working at a special console consisting of a keyboard and visual display, is presented with a programmed sequence of instructional material and questions which he is to answer. The succeeding questions are made easier or more difficult, depending on the student's answers to the previous questions. When necessary, the computer may break off the question sequence and present the student with additional explanatory material. (See *Naval Research Reviews* issue of September 1967, "Research Contributions to Computer-Aided Instruction.")

Display console being used at Bunker-Ramo Corporation



Elementary schoolchildren observing a mathematical demonstration on a display scope

The objective of educational time-sharing systems is not to replace the teacher with a machine, but to give the student an opportunity to supplement his classroom instruction. By working on-line through a terminal, the student is able to proceed at his own pace and explore a wider variety of problems than he would otherwise encounter. For the teacher, the time-sharing terminal can be a powerful demonstration tool which he can use to give mathematical and logical concepts a tangible interpretation in the classroom. For example, high school students at Westwood High in Massachusetts use the computer to get a visual demonstration of approaching a limit and the converging of functions. They are able to understand the underlying basis of the calculus without ever hearing a word.

The United States Naval Academy has been working toward an educational time-sharing system to be used as a teaching tool throughout the Academy. (See *Naval Research Reviews* issue of September 1967, "The Navy's Remote Computing System.") As a first step, the Academy held a summer workshop in 1966 with participants from the teaching staff of every department. Although many of these instructors had never before been exposed to a computer, by using the BASIC language, they were able to develop teaching programs for a wide spectrum of disciplines ranging from physics and chemistry to history and government. At the present time, the Academy uses terminals connected to nearby commercial time-sharing bureaus. However, future plans call for the development of its own internal time-sharing system which will be capable of satisfying the demands of each department, including administrative functions. The computer will also provide an experimental facility for developing curricula and new techniques in computer-assisted education.

In addition to the direct educational benefits, there are a number of intangible advantages that may be derived from computer-assisted instruction. Perhaps the most important advantage is that the computer, unlike any other tool known to man, forces the student to take a step-by-step logical approach when planning the solution to a problem.

The Growth of Time-Sharing

Although the earliest demonstrations of practical time-sharing systems took place in 1961, only six years ago, commercial time-sharing centers already are springing up across the country. There are currently over 20 different organizations which offer service to business and scientific users, many of which have computer centers in more than one city.

In addition, there are presently about 40 time-sharing systems being used for research purposes in educational, scientific, and military organizations in the United States. This number has doubled every year since 1963. One consulting firm has estimated that by 1972 time-sharing will account for almost 60 percent of all computer usage.

Many computer manufacturers are now developing off-the-shelf time-sharing systems to go with their larger computers. It appears to be only a matter of time before time-sharing will pass from the research and development stage to the stage where a customer can order a time-shared system tailored to his specific needs and have it delivered in fully-working condition in a matter of months.

Time-Sharing Research

Despite the progress being made in the development of advanced time-sharing systems, work has only begun in learning how to develop successful applications. A great deal more must be learned about the problem-solving process when the user is working on-line with a computer. The time-sharing user of tomorrow will need better problem-oriented languages and more sophisticated console devices. Although an architect can doubtless be more effective with a large-scale computer at his fingertips, he cannot be expected to work conveniently with the typewriter terminals that are generally available today. Since he is trained to deal with graphical data, he will surely need some type of display terminal that will allow him to work with lines and figures. Present-day devices of this type are relatively expensive and waste a great deal of computer capacity.

Considerable research is currently being aimed at developing less expensive and more flexible display terminals. However, a great deal remains to be done before graphical processing can be accomplished conveniently and efficiently on a remote time-shared computer system.

Time-sharing is a powerful and challenging new tool which can make men more productive as they pursue their intellectual, administrative and managerial functions. By linking the advances in computer technology with modern communications techniques, a tool has been produced which frees the user from any direct concern about the computer. Thus, he can turn his attention fully to the problem and its solution. The human's insight and cleverness, combined with the incredible computational and logical capability of the computer, can satisfy the human's natural impatience and desire to get the job done now. It is safe to predict that the advent of time-shared computing will have as profound an effect on the world as the introduction of the telephone at the turn of the century.

COMFAIRWESTPAC Helo-Lift Program

"Helo-Lift," a program initiated to transport A-4 aircraft between repair facilities, has resulted in substantial savings—both time and moneywise—for Commander, Fleet Air Western Pacific (COMFAIRWESTPAC) Repair Activities.

H-46 helicopters from Helicopter Combat Support Squadron One Detachment, Atsugi (HC-1) are being used to transport the A-4 "Skyhawk" back and forth between Naval Air Station, Atsugi, Japan and the Japan Aircraft Company (Nippi) plant at Sugita, Japan. Major aircraft repair work is carried out for COMFAIRWESTPAC at the Sugita plant, which is about 16 miles from NAS Atsugi.

Using the helicopters to airlift A-4's between Sugita and Atsugi has reduced the time-out-of-service for each plane by about 16 days per aircraft. Under the old system, contractor personnel at the Nippi plant first completely assembled the aircraft and checked its flight readiness—a process which took about four days. Next, the aircraft was barged to Auxiliary Landing Field, Kisarazu, where military personnel trimmed the engine at high power and performed necessary checks and inspection to prepare the aircraft for flight to Atsugi. A period of 16 days was usually required from the time repairs were completed at Sugita until it arrived at NAS Atsugi, where it had to be disassembled for a major inspection. Adverse weather and a lack of ferry pilots could further lengthen the process.

The Helo-Lift program eliminates the need to completely assemble, function check, barge, re-inspect, and fly the aircraft to Atsugi. Now, the A-4, while still disassembled in two major sections, is directly airlifted from Sugita to the Aircraft Maintenance Department at NAS Atsugi for major inspection—all in about 15 minutes flight time. The work formerly done at ALF Kisarazu is omitted altogether.

The A-4, known as the "vest-pocket bomber," costs the Navy over $300 for each day it is out of service. The Helo-Lift program airlifted 54 A-4 aircraft during the first half of 1967, resulting in an additional 2.96 aircraft per day being made available for operational use and 1080 more working days being added to the Skyhawk schedule. This amounts to an intangible savings of $342,965. Also, the program has made a substantial reduction in repair costs: when factors such as barging costs, manhours saved, and fuel costs are considered, the out-of-pocket savings equal $39,479.

The man largely responsible for the Helo-Lift program at COMFAIRWESTPAC Repair Activities is LCDR Morris K. Terry. See cover photograph.

Inanimate Intellect Through Evolution

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The old saw, "The computer only does what the programmer tells it to do," is no longer true. It is now possible to program a computer so that it can discover new and different means for solving problems—logical procedures which the programmer had thought were inappropriate. In truth, here is artificial intelligence.

Most computer programs are deterministic; that is, the programmer can, in principle, exactly duplicate the prescribed data processing upon any sequence of input symbols. Such programs follow the general tenet that randomness disturbs; therefore, "noise is bad." However, it is possible for a computer program to include noise as an essential ingredient, as a source of desirable randomness, and/or as a means for generating new logic which can be evaluated and preserved if it appears to be of value in solving the problem at hand.

One way to create such stochastic programs is to replicate the fundamental experiment of nature—evolution—wherein iterative mutation and selection has, through millenia, produced creatures of increasing intellect. The availability of modern high-speed digital computers opens the door to such simulation, allowing the time scale to be compressed from millenia into minutes. Hopefully, such "fast-time" evolution will yield superior logic and thus prove instructive to man.

Intelligence may be considered as a measure of an entity's ability to achieve success with respect to a wide diversity of goals in a wide variety of environments. Surely man, with all his versatility, is a most intelligent creature. Thus, by the same token, any machine which proves to be equally versatile should also be called "intelligent."

The criterion for the existence of artificial intelligence might be made even more stringent; *i.e.,* a machine might be called intelligent if, and only if, it can solve problems that man has not been able to solve—not because of its sheer speed and accuracy, but because it can discover for itself new techniques for solving these problems. Evolutionary programming appears to offer such a capability.

Evolutionary Prediction

Intelligent behavior may be viewed as the ability to predict one's environment coupled with an ability to select a suitable response in the light of that prediction. Traditionally, attempts to predict each next symbol in a sequence of environmental observations initiate with some assumption concerning the nature of the environment; *e.g.*, whether it is periodic, stationary (invariant in a statistical sense), *etc.* Further, it is generally assumed that the environment is independent of the predictor, thus eliminating the possibility that the predictor is competing with or gaming against the environment. Such assumptions are of distinct value; however, there is always the danger that a false assumption will be accepted.

Also, in this type problem attention is usually restricted to the loss function of the minimum mean-squared error. However, this loss function is rarely encountered in real-world situations. The all-or-none loss function is much more common; *i.e.*, all errors are equally costly. To illustrate, if the missile misses the target in a one-shot situation, it doesn't matter how close it came. In most situations, equal errors and equally correct predictions may *not* be of equal worth.

For meaningful research, the investigator must be permitted not only to specify arbitrary values for all possible correct and incorrect predictions at any point in time, but also to allow the loss function to be a function of time and/or of achieved performance. In fact, it might be necessary to predict the environment's behavior at various time intervals projected into the future, each with a different loss function and weighting of relative importance. Stated in these terms, the prediction problem becomes highly realistic but falls well beyond conventional techniques. Evolutionary programming makes it possible to address this problem.

Briefly stated, the computer is instructed to evaluate an arbitrary logic which describes the stimulus-response behavior of an initial "organism" in terms of its appropriateness with respect to the given goal in the face of the observed environment. In other words, the organism's suitability to survive and its demonstrated ability to solve the given prediction problem are assessed. Next, the initial organism representation is mutated logically to produce an offspring which is similarly evaluated. If the offspring is less appropriate than its parent, it is discarded and another offspring is generated from the same parent. If, however, the offspring appears to be more appropriate than its parent, the parent is discarded and the offspring is preserved to become the new parent.

Such nonregressive evolution continues in fast-time until some allowable expenditure for computation has been reached, some threshold of confidence has been attained (as measured by the survivability score), and/or some instruction is received in real-time to accept the organism which has been found most appropriate as the basis for the next prediction. Thus, there is a gradual "drawing together" of an inheritance which reflects the logic underlying the data base as it concerns the given goal. The evolved organism furnishes a rationale for the prediction and, at the same time, provides a first approximation for solving similar problems in the future. In other words, it becomes the progenitor of the succeeding geneology evolved in the light of the extended data base which includes additional measurements.

This procedure is carried out in simulation. The organisms themselves never appear; rather, each is described simply in terms of its stimulus-response behavior. Since offspring are produced in microseconds, tens of thousands of generations pass in minutes. The randomness of mutation makes the process essentially unpredictable. The evolved logic may well be a surprise to the programmer—one which may prove to be very useful in predicting previous environmental observations.

The maxim of parsimony may be built into the evolutionary program by introducing a cost for the complexity of each organism. Thus, if two logics appear equally suitable as predictors of the past, the simpler logic is considered to be superior. By adjusting the relative importance of this parameter, a point of view can be selected which combines the deterministic extreme (where cyclic properties form the basis for prediction) and the statistical extreme (where some level of conditional dependency is presumed to exist). It is, of course, possible to allow this parameter to vary as required during the course of events.

Nature preserves more than one of a kind. Similarly, it is of value to preserve the best few organisms at each point in time. However, more attention should be devoted to mutation and selection of the highest scoring organism than to studying each as a function of its score. In fact, it is advisable to simulate evolution across species, with each having a different length of environmental recall. When the lengths are allowed to vary, it is possible to identify gross changes in the logic of the environment as evidenced by the particular specie which appears most appropriate. In this manner, internal competition can provide protection against nonstationarity of the environment or sudden changes of the goal.

In the present computer program, the logic of each organism is represented by a finite-state machine, *i.e.*, a description of the transduction from a finite alphabet of alternative stimuli into a finite set of alternative responses for each of the organism's possible states. If the organism can only assume one internal state, it is represented by a one-state machine where each stimulus has a corresponding response. If the organism can assume three states, its transduction is fully represented by a state diagram which depicts the individual transduction associated with each state and the transitions between states as a function of their stimulus and associated response.

A man can be described by a three-state machine. In the first state, "asleep," he responds to many input symbols with no output. There are, however, certain stimuli which cause him to respond by bringing him to the second state, "awake." Such stimuli would possibly be associated with a verbal commentary (the associated response symbol). While he remains in the "awake" state, each stimulus would have a particular response. However, some stimuli might cause him to change his state into "panic," causing him to behave in a still different manner. Many stimuli may cause him to remain in that state while others may cause him to return to the "awake" state, or even move to the "sleep" state by fainting. This is, of course, a very gross description; but in a finite-state machine, any level of specificity could be achieved by increasing the number of states, the alphabet of possible stimuli, and the alphabet of possible responses.

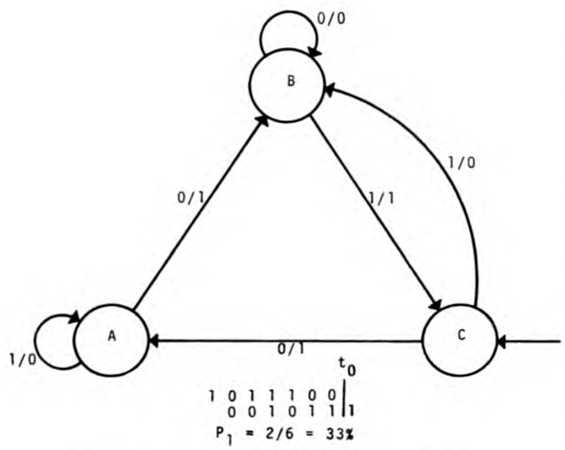

Figure 1 — A finite-state machine and its predictive transduction

Figure 1 illustrates a three-state machine—A, B, and C—in a binary environment. The stimuli and responses are separated by a slash. As indicated, when the organism is in state A and the input symbol is a 1, it will remain in state A and respond with a 0. If, however, the organism is in state A and the input symbol is a 0, it responds by emitting a 1 and changing its internal state into B. The diagram indicates the organism's behavior when it is in each of its states and when it receives each of the possible input-stimuli. The arrow pointing to state C means that this is the organism's initial state, that which exists when the environment is first encountered. It is important to note that the state diagram is not a flow diagram; here, the input and output are implicit.

Suppose the goal is to predict each next symbol of the environment, the symbol to be that which has the greatest score for being correct on the average. If the environment experienced consists of the sequence 1011100, the machine responds with the sequence 0010111, as shown in the figure. Comparing each response to the succeeding symbol from the environment yields the prediction score (P_1) of 33 percent.

The organism is mutated by randomly selecting one of the following modifications: changing an output symbol, changing the initial state, adding or deleting a state, or altering the transition from one state to another. The resultant offspring is then evaluated as before and a comparison made of the prediction scores in order to determine whether it is worthy of retention as the new parent. The process continues until a preset criterion has been reached. Since the predictive-fit score may reflect any expression of a goal, rather than being just a determination of whether it is right or wrong, the sequence of retained machines actually becomes a reflection of the given goal. In other words, the evolutionary program produces a succession of predictive logics which generally tend toward increasing suitability over a wide variety of environments and goals, each prediction being based on whatever evidence is available and apparently found to be worthwhile within the allowed computation. Comparing the results of predicting the same environment with respect to various loss functions permits a sensitivity analysis, *i.e.,* the extent to which the predictions depend upon the specified goal.

Initially, evolutionary programming was restricted to a two-symbol alphabet. However, when the feasibility of the program had been demonstrated, the alphabet was increased to eight, and then to 64 symbols. Throughout its development, this research program has received the encouragement and support of the Information Systems Branch, Office of Naval Research. Portions of the progress reported below were accomplished under the additional sponsorship of the Air Force Cambridge Research Laboratory and the Langley Research Center, NASA.

One series of experiments required the prediction of each next symbol in an arbitrary eight-symbol cyclic environment which was corrupted by increasing levels of noise in the form of an equally likely addition of $+1$ or -1 to randomly chosen symbols (arbitrarily, it was assumed that the addition of $+1$ to 7 and subtraction of -1 from 0 left the symbols undisturbed). A recall of 40 symbols was allowed before the initial prediction was required. The following table indicates the percent correct of the first 81 predictions as a function of the percent of the symbols left undisturbed. It should be noted that, when every symbol of the signal was disturbed, the prediction score increased to 70.4 percent, *i.e.,* the evolved predictor-machine had a characteristic cycle which was almost identical with the probabilistic boundaries of the original signal.

Level of corruption	None	Single	Double	Triple	50%	100%
Percent of symbols left undisturbed	100	82.5	69.6	60.4	56.2	0
Percent correct of first 81 predictions	100	59.3	39.5	23.5	22.2	70.4

Any finite-state machine can be viewed as representing the periodicity or the most probable transitions within the logic which underlies the environment. In the latter regard, the evolutionary program demonstrated prediction of zeroth-order and first-order Markov environments

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in a manner which rapidly approached the optimal asymptote. It should be noted that such a predictor extracts only relevant information—the modal transitions. It was also shown that higher-ordered Markov environments could be similarly addressed, provided the memory of the evolving organism is extended by changing the alphabet to include all sequences of appropriate length.

Various nonstationary environments were predicted with considerable success. For example, a deterministic environment was created by taking the successive residues of the increasing powers of two and three after these powers were rank-ordered, and reduced modulo seven. Of the first 216 predictions of this environment, 56.6 percent were correct (78 percent of the last 50 predictions were correct). Certainly this was far better than chance; to illustrate, prediction of the most frequent symbol at each point in time yields a score of only 8.5 percent.

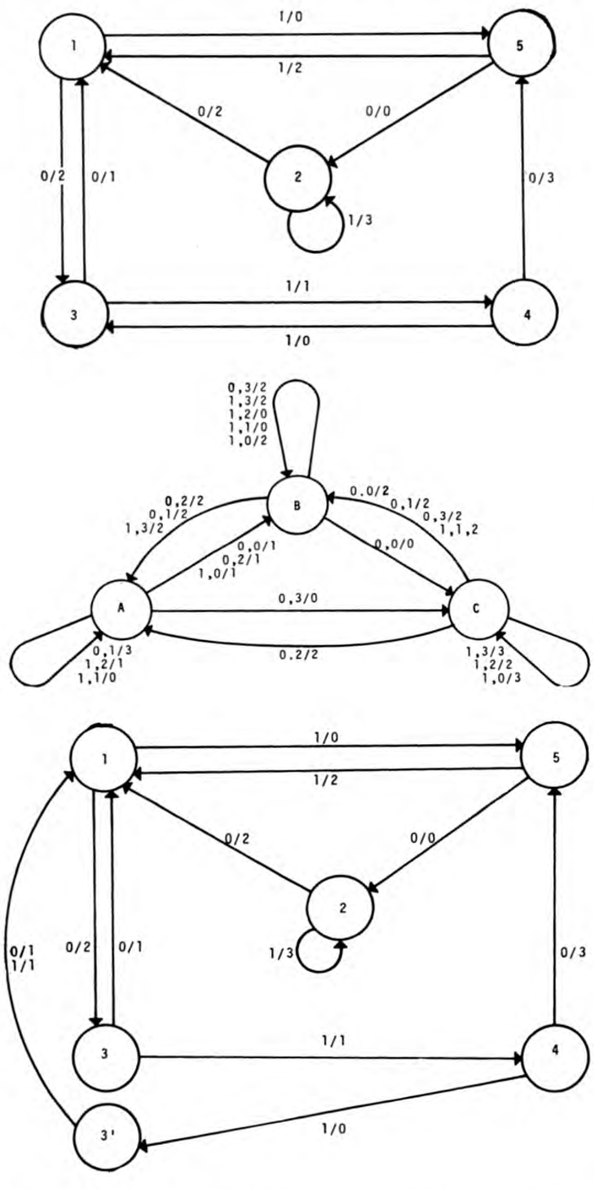

Figure 2 — Top: An arbitrary transducer in the form of a finite-state machine. Center: The evolved predictor-machine. Bottom: Representation of the transducer as derived from the predictive logic.

Decision-Making and Modeling

As indicated above, intelligent behavior also requires the selection of a suitable response in the light of the prediction. The evolutionary program can be used in this regard simply by substituting an appropriate loss function, and expressing both this function and the output alphabet of the finite-state machines over the set of alternative response symbols. Such optimization is performed without the necessity of any overt consideration for prediction of the environment. If the environment is continuous, quantization may be accomplished by imposing arbitrary class intervals on the amplitude or in any other unique manner. Similarly, a continuous range of response must be described within a finite alphabet of mutually exclusive alternatives.

As indicated previously, the evolutionary program makes decisions by developing successive models of the logic which underlies the observed environment. The program can also be used in an inverse way; *i.e.*, successive models of the relationship among sensed variables can be developed in a manner which reflects the nature of the investigator's goal. To illustrate, the finite-state machine shown at the top of figure 2 was driven by a binary random variable having equal likelihood for both values. The evolutionary program was required to predict each next output on the basis of the preceding input and output symbols. After 160 predictions, the predictor-machine shown in the center had evolved. Translating this offspring into a representation of the unknown logic results in the finite-state machine shown at the bottom of figure 2. There is a distinct similarity between this machine and the actual logic, the primary difference being the extra state "3′" which presumably would be lost at some further point in the evolution.

Consider the related problem of developing a mathematical representation for the human operator in flight control. As a first step in this regard, it was necessary to develop a finite-state machine representation for an unknown deterministic model of the man, a nonlinear (phase-plane switching) transducer which served as the forward element in a closed-loop system. The left-hand side of figure 3 indicates the degree to which the output of the transducer corresponds to the output of the developed finite-state machine, with both being driven by the same input invariable and expressed in the same 64-symbol alphabet. The right-hand side of the figure illustrates the result of a similar experiment performed on data taken from the human operator. The man is more difficult to model, primarily because of his statistical variability.

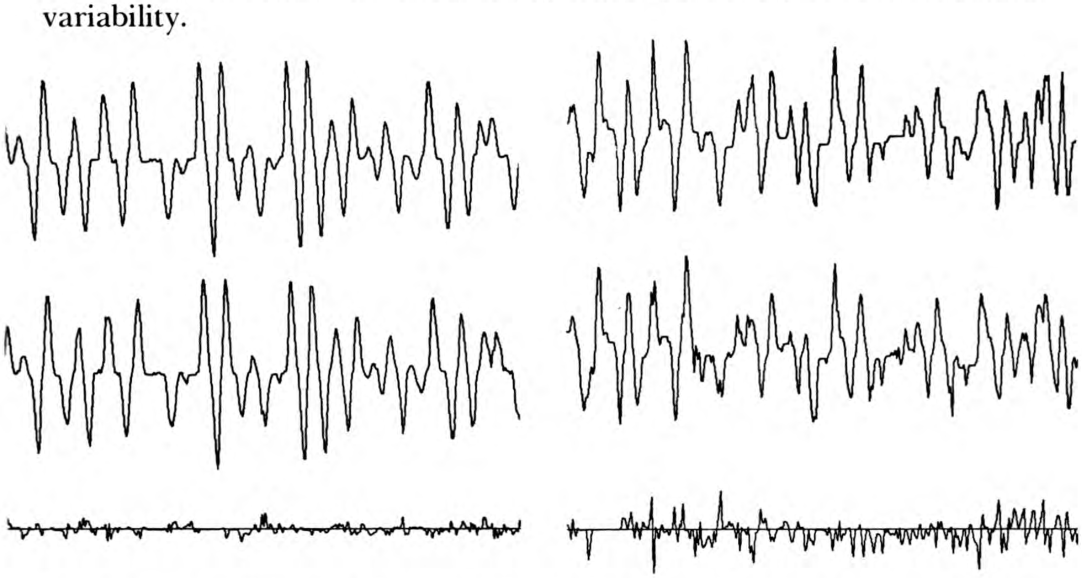

Figure 3 — Left: The outputs of the nonlinear transducer, the finite-state machine model, and the difference-error. Right: The outputs of the human operator, the finite-state machine model, and the difference-error.

Having an ability to model an unknown transducer opens the door to the control of that transducer. At each point in time, the evolved representation is examined to reveal that transition which will minimize the cost of tracking error with the machine being in its present state. Thus, the reference symbol is translated into that input symbol which will presumably cause the desired transition.

A number of experiments were conducted in which unknown plants were required to track a uniformly distributed reference signal randomly generated on eight symbols, the goal being to minimize the magnitude of the error. To illustrate, figure 4 indicates a completely controllable five-state machine which served as the unknown plant. Twenty of the first 50 control decisions were correct; 16 were incorrect by only a single symbol. The last evolved machine had 23 of its 40 output symbols in common with the plant.

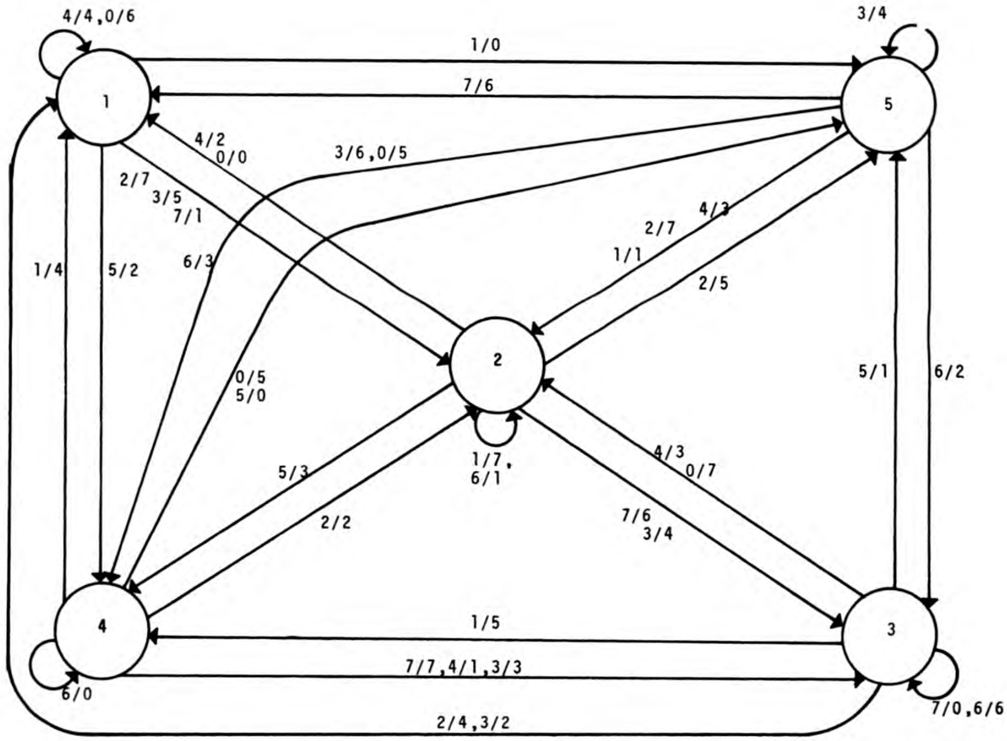

Figure 4 — Logic of the five-state plant

If this plant had been driven directly by the reference signal, the output variable would have tracked correctly only 20 percent of the time and would have fallen within a single symbol of the reference variable 24 percent of the time. In other words, system control through evolutionary programming, although it was accomplished on the basis of a limited experience where none of the evolved models had yet reached a truly superior representation of the plant, provided an improvement of 100 percent in correct tracking of the random reference signal.

It is not necessary for the plant to be time-invariant, as long as the sampling rate is sufficient in terms of the rate at which the logic of the plant changes. In fact, the plant might take the form of an intelligent adversary, *i.e.,* a transducer anxious to remain uncontrolled. In this case the evolutionary program then proceeds to develop a succession of models of the logic of the opponent without concern for whether that opponent is active, passive, antagonistic, acquiescent, or cooperative.

According to game theory, the minimax strategy is optimal in a two-person zero-sum game. If, however, the opponent deviates from minimax in any orderly manner, there should be some better strategy than minimax—a strategy which takes advantage of these particular deviations. Unfortunately, game theory fails to indicate how such a strategy can be found. In contrast, the evolutionary program tends to overcome this difficulty when applied as described previously in the control experiment. Any consistent behavior of the opponent is modeled, and this model is referenced in the selection of each next move. In experiments with two-person nonzero-sum games of the prisoner's dilemma type where both players take the form of an evolutionary program, both players evolved finite-state machines which corresponded to an equilibrium position of the game. Also, a variety of tactical pursuit-evasion games were simulated where one player referenced the evolutionary program as the basis for his decision-making. This actually gave him a significant advantage.

Playing a game might well modify the range of alternatives open on successive moves. It is, therefore, of interest for the player to develop models of his own stimulus—response behavior as well as his opponent's, using both of these to minimize the error with respect to the given goal. However, such self-referencing introduces new difficulties in the sense that "The cat can never taste its own tongue." Similarly, the evolutionary program can never be completely "self-aware." However, experiments in this regard still appear to be worthwhile since it is this particular ability which forms the prerequisite to consciousness, *i.e.,* the ability to selectively manipulate alternative models of self, referencing only the most suitable model at each point in time.

Evolutionary programming appears particularly appropriate in this regard. Simply stated, it manipulates alternative logics in such a way as to preserve for further use only those logics found to be of greatest worth. If these include models of the self, it may well provide a foundation for reaching higher levels of artificial intelligence. In fact, retention, mutation, and recombination of only those models which were found to bear upon survival constitutes a replication of evolution within the organism. Here is artificial intelligence: inanimate intellect achieved through simulated evolution.

Conclusion

The versatility of true intellect results from an ability to generate new and useful models within the organism. At a rudimentary level, this is accomplished through the random mutation of models; at higher levels, through the random combination of selected models into new logics which hopefully bear upon the immediate situation. Here is creativity through the preservation of those aspects of randomness which appear worthwhile to the organism. Here, in generic form, is the scientific method—induction being performed through a non-deterministic manipulation of the data base (comprised of previous observations of consistencies, including observations called "facts," and of consistent relationships among these facts called "models") into models of the environment and of the self to serve the survival of the organism. The evolutionary process borne within the organism replicates the scientific method. Its overt expression by man has yielded the technology which has become the fabric of civilization.

Although modern technology has been widely used to extend human sensory and motor capabilities, relatively little attention has been devoted to enhancing the decision-making process by which man translates sensed information into selected response. The advent of high-speed computing equipment makes it possible to relieve man of the drudgery of routine decision-making. As progress is made toward the realization of artificial intelligence, greater responsibility for decision-making can be allocated to the machine.

Recognition that the scientific method is an evolutionary process that *can* be simulated opens the possibility of finding new techniques for the solution of problems which have long remained unresolved. Such evolutionary programming constitutes the useful use of uncertainty in the modeling of the environment—and the self as part of that environment. When this is demonstrated, it becomes possible to seriously consider programs that might provide machines with self-awareness and, ultimately, with an ability to generate their own goals.

With any advance of technology, there comes the danger of its misuse. The automation of intellect can pose a significant threat to society—directly, through the removal of the challenge required to maintain human intellect in the face of continuing biological evolution and, indirectly, in the form of societies which tend to preserve their structure in spite of the changing goals of their members. In essence, any intercommunicating network of organisms *is* a machine.

The evolution of artificial intelligence began with the creation of society. We now witness the major impact of technology. Society is being restructured through the use of transportation which, in turn, is being displaced by the availability of communication. Communication itself is being replaced by high-speed computation—the manipulation and integration of information. Here is an important extension of natural evolution—an extension which promises to have a profound effect upon mankind in the years to come.

The Navy as a Catalyst in Biomedical Engineering*

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The Navy's interest in biomedical engineering has been amply demonstrated by the long list of contributions made in this field, both through its own laboratories and through other research institutions supported by the Office of Naval Research. The broad range of this interest meets requirements for operations in many different media. It meets obligations for protection, maintenance, and medical care of personnel in unique environments and unusual circumstances. It addresses itself to biological problems ranging from micro implants to macro merry-go-rounds for biomedical research. This article describes some of the Navy's accomplishments in this field. However, many remaining problems may be potentially soluble through biomedical engineering approaches.

High-intensity noise from aircraft and engine rooms demanded that consideration be given to its effects on hearing and that something be done about it. Although this problem is shared by all the military services, it is especially critical on aircraft carriers where, as Joe Lewis said about the boxing ring, "There's no place to hide." As a result of Navy efforts, a "noise cumulator" was developed which records frequencies and durations of noise fields. This device, which can be worn by a person during his normal duty hours, provides a history of his exposure to noise. By analyzing the data obtained by this device, the jointly supported Committee on Hearing and Bio-Acoustics was able to establish, for the first time, standards for audiometers and audiometry.

The Navy is also concerned with the radiation problem. In this regard, photographic film badges which monitor levels of radiation have been developed for shipboard and research personnel. In recent months, a new thermoluminescent dosimeter was developed at NRL which discloses the effective energy level as well as the amount of x or gamma radiation to which a person has been exposed.

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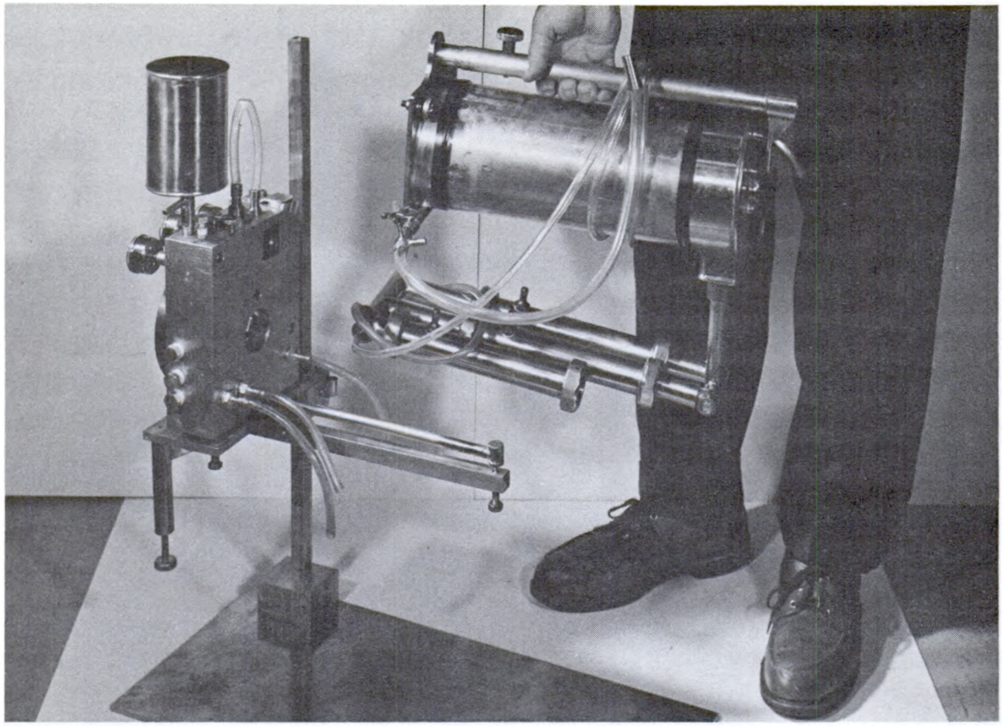
*Based on a paper presented by Dr. Trumbull at the San Diego Biomedical Engineering Symposium, June 13, 1967

†Since this paper was written Dr. Reid has retired from federal service. He is now serving as Professor of Biology, University of West Florida, Pensacola.



The portable heart-lung machine developed at MIT

Naval personnel are often subject to prolonged submergence. Since conditions encountered during submergence are comparable to those encountered during long-term space missions, both the Navy and NASA will continue to support research to develop sensing devices capable of detecting small concentrations of radiation over long periods of time. This, in turn, will lead to air monitoring for other purposes and, ultimately, to scrubbing and regeneration. The Naval Research Laboratory has played a major role in this area by pursuing the results of contamination generation in Polaris-type submarines by paints, wire coatings, and personnel practices.

When the Navy turned to Sealab studies, with their new air mixtures and pressures, it was found that other equipment had to be modified. Biotelemetry in hospitals is not the same as biotelemetry on the ocean floor. Contacts placed on the body cannot be allowed to interfere with operations or interact with body secretions or atmosphere. Also, they must be powerful enough to transmit a signal through water and still allow for processing. The Naval Medical Research Institute has taken a first step in modifying this equipment by producing a six-pound system which can transmit EEG, EKG, respiration, and temperature data for periods up to 100 hours. Although this device has been used under pressure suits in flight tests, it has not yet been in the Sealab environment.

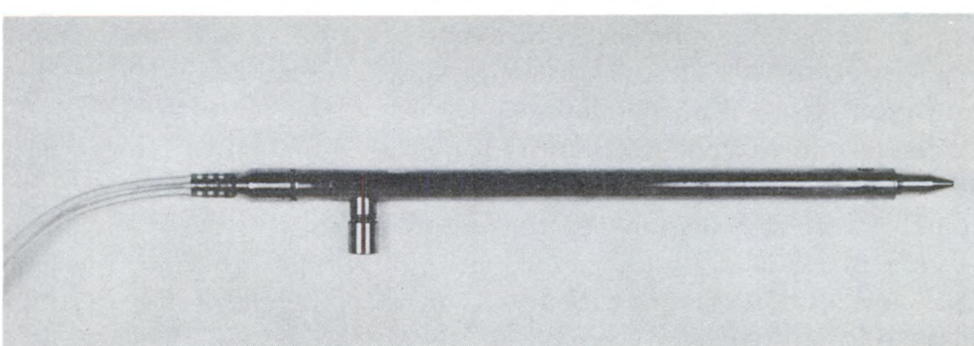
In order to provide and maintain an axenic or "sterile" environment in which to rear and maintain germ-free animals at the Laboratories of Bacteriology, University of Notre Dame (LOBUND), many bioengineering problems had to be overcome. Environmental control is also an aspect of the Navy's blood preservation program, a long-range project where the constant search for blood preservatives, expanders, and substitutes led to the development and application of cryobiological techniques. Determining the correct rate of freezing, the optimum preservative, and the final rate of thaw required to reconstitute a useful product has been and continues to be a challenging venture. When current problems have been resolved, miniaturized, power-independent field or shipboard units will be installed. (See *Naval Research Reviews* issue of May-June 1967, "Research on Biomedical Problems.")

The easily operated pump-oxygenator or heart-lung machine, which was developed by the Massachusetts Institute of Technology under ONR sponsorship, is particularly suitable for use aboard naval ships and at small field hospitals. This completely portable unit, which weighs only 50 pounds and occupies only 1.5 cubic feet, is sturdy and can be handled by one person. Also, since logistics is of primary concern, the fact that it has a one-liter priming volume as opposed to previous requirements for five or six liters is important. (See *Naval Research Reviews* issue of October 1963, "A New Heart-Lung Machine.")

Another item with much potential is the color-translating ultraviolet microscope which allows analysis of unstained tissue and enhances anatomical detail through differential absorption of ultraviolet wavelengths by the chemical compounds in biological tissues. A counterpart to this device is found in holography, an extension of laser applications which provides not only three-dimensional aspects but also accurate representation of rapidly moving bodies through the pulsing light energy. (See *Naval Research Reviews* issue of March 1967, "Holography and the Third Dimension.")

A technique for obliterating brain aneurysms—bubble-like deformities that appear at weakened points in artery walls—was developed by Dr. J. Gallagher, Georgetown University, under a contract with ONR. An airgun, called a "pilojector," which was devised by Mr. H.

The airgun or "pilojector" developed at NRL



Sealab II aquanaut wearing a battery-operated, electrically-heated suit which was evaluated by the Navy in the Sealab II experiment

Hagemeyer at the Naval Research Laboratory, propels a shaft of mammalian hair into the aneurysm, causing the blood in the interior to clot and permanently close the opening. This development was a happy merger of the talents of a contractor and a Navy laboratory. (See *Naval Research Reviews* issue of August 1962, "A New Method for Obliterating Dangerous Aneurysms of the Brain.")

In the field of vision, various types of goggles and binoculars have been developed for protection against and compensation for environmental conditions at sea and in the antarctic. In this regard, perhaps the best protection against snow glare is the goggle designed in connection with Project Deep Freeze.

Contact lenses were an early product of research sponsored by the Navy. However, since they have a tendency to pop at high altitudes and permit sediment and salt water easy access to the eye, they are not adaptable for Navy use. There is still a need for better eye protection and vision enhancement in underwater operations. However, vision has profited from a plastic cornea, designed to replace corneal loss through surgery or trauma, which has been developed under ONR sponsorship (see *Naval Research Reviews* issue of May 1962, "The Future of Tissue Transplantation").

Present efforts to develop visors for protection against intense flash illumination draw upon optics, materials, and light sensors with extremely short response or reaction times. In this research, advantage is being taken of crystal structure and polarization, thermopane concepts, and other techniques. (See *Naval Research Reviews* of August 1965, "Flash Blindness.")

Optimum garments for use in oceanographic projects such as the Sealab experiments still need to be developed. There are two problems here: determining the type of protection required and reducing the length of time it takes to don the gear. The Navy has come a long way in both of these areas, *e.g.,* experimental thermally heated suits were evaluated during Sealab II. However, much needs to be done before Navy divers can enjoy relative comfort and confidence while living on the ocean floor.

Cooking on the ocean bottom under increased pressure with a high level of helium introduces problems concerning acceptable types of food and food preservation and preparation. In this regard, plans are being made to include an infra-red oven in the Sealab III experiment, now planned for late 1967. This $4 \times 21 \times 16$ inch oven will speed the preparation of meals in the habitat: frozen prepackaged meals will be cooked, ready-to-serve, in ten to 12 minutes. Other problems in the man-in-the-sea program include closed loop systems of appropriate gas mixtures and decompression techniques.

Many other contributions to bioengineering have arisen from research interests that were not so Navy-oriented. For example, the Navy has been interested in determining how the EEG is affected by the various states of alertness or vigilance. Current research being conducted at the Naval Hospital, San Diego, and a major symposium held on sleep and sleep loss last May have provided new stimuli to this area (see *Naval Research Reviews* issue of August 1967, "Sleep and Sleep Loss-Their Effect on Performance"). There is evidence that the phasing of sensory input in relation to the Alpha wave can result in different responses. Thus, the gross state of alertness and the finer phase of Alpha demand improved techniques for determining fatigue levels in addition to the development of either a closed-loop compensation or a read-out warning. Such a system might evolve from extending the work mentioned above, from improved biochemical on-line assay, or from some other direction.

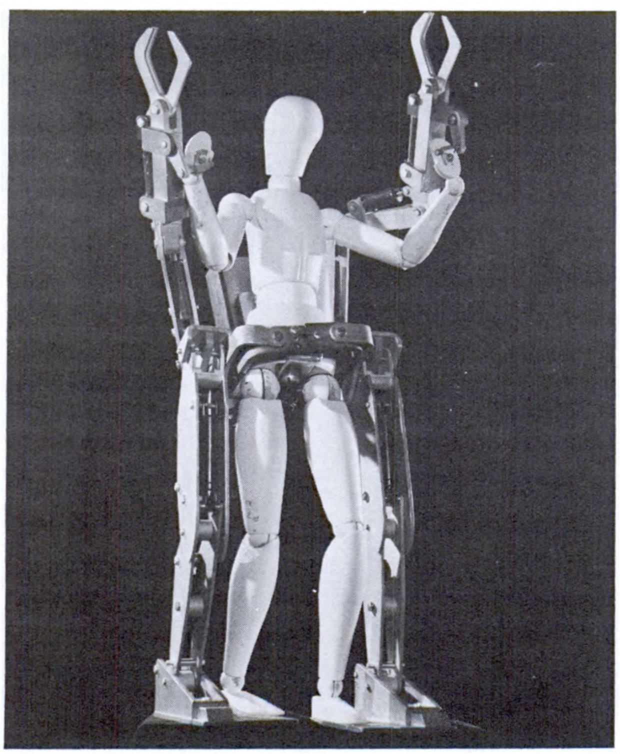
A similar need, though at a different level, concerns chronic brainstem implants aimed at imparting phasing in hopes of dealing with thalamic pain. The major purpose of this work is an attempt to understand the output and potential avenues of input for the cortical system. The development of such implants for picking signals from the brain and intercepting them, as it were, for amplification, translation, or other processing has many operational implications. Further, the development of implants for picking up and telemetering signals, *e.g.,* small button transmitters which can be implanted under the skin, is of interest to the Navy since they provide a means for improving the general level of output from animal research.

A suggestive area of such cortical influence might be the pituitary. It has been demonstrated that the elimination of the pituitary function allows rats to withstand accelerations three to four times greater than normal, due to the change in distribution of available oxygen. Once the site involved is understood, there is reason to believe that extirpation can be replaced by stimulation. This same basic hypothesis should be tested as other control areas are discerned.

The Navy has also been involved in controlling animals though this avenue, *e.g.*, providing support to Delgado for his work with bulls. These animals, even when they are in full charge, can be stopped or turned by transmitting a signal to the appropriate implant.

The military has long been in the forefront of merging bioelectronics with controls. For example, an ONR contractor developed an extremely strong but flexible electrode which could be implanted into eye muscles. This implant permitted the appraisal of coordination, excursion, and other parameters of optic control while the subject was reading or performing other visual functions. Since it indicated quantitative pick-off eye position, a function of particular interest in tracking, this device is of major value to ophthalmology.

Many other research projects which concern full utilization of the visual system are being supported by the Navy. These include a head-mounted camera which measures eye movements under various conditions and displays the results in real time; a special TV camera/optical system which records eye position during visual search tasks and



"Hardiman" combines man's dexterity, brainpower, and all-around versatility with a machine's strength, size, and ruggedness

displays the results on a map, TV monitor, or other display, thus enabling the experimenter to see where the eye is looking; and a head-mounted cathode-ray-tube display capable of presenting TV, radar, or sonar data to an observer while, at the same time, permitting him to move freely instead of being tied down to a particular display location.

The exoskeleton or "Hardiman" bioelectronic control system, the development of which is being jointly sponsored by the Army and the Navy, is due for prototype production later this year. The limits of this system will be determined only by the imagination of the engineering world. After years of studying the normal muscle and joint functioning of man's arms and legs and determining the degrees of freedom necessary to reproduce the majority of movements, man is being employed as the feed or input to a system rigid enough to support heavy loads over long periods and rough terrain. By simply following man's normal movements, the "hands" are positioned for picking up and holding objects weighing in excess of 1000 pounds. The lifting and holding are accomplished by booster systems which are activated by muscle groups. This device was originally designed to meet military needs for handling large and heavy objects in limited space areas; however, the basic techniques of control through muscle group coordination and input have many implications for heavy machinery control. (See *Naval Research Reviews* issue of July 1967, "ONR's Role in Human Factors Engineering.")

The Navy, because of its unique competence in certain areas, has also turned its attention to solving problems of primary concern to other government agencies. For example, disorientation, of prime concern to NASA, is usually associated with the Naval Aerospace Medical Center at Pensacola. Here, a human disorientation device, looking like a giant cement mixer, is used to rotate man through three degrees of freedom around one plane of his vestibular apparatus. At the same time, it records as much physiological data as possible. All of this is done with an accuracy of placement and control that is phenomenal. Also, there is a circular room at NAMC that starts, accelerates, rotates, and stops at imperceptible speeds. Finally, a "moon-room" where the magnetic environment is controlled to a level of one thousandth of that on earth is used to test the influence of that variable upon performance.

To retrogress a bit, the Navy had no idea, when first faced with the problem of protecting personnel from jet noise, that it would eventually measure the sound levels or decide the standards for audiometers. The same problem exists in developing polygraphs for stress measurements, for which no specifications or standards exist. The Navy, in cooperation with the Bureau of Standards, is currently developing those standards while, at the same time, continuing to seek better techniques for appraising the bodily state. This is parallel to the vigilance aspect of cortical activity.

In this regard, many people feel that a means for recording and weighting physiological functions must be developed in order to provide an index of fatigue. This index would be of value in deciding crew replacement or allocating critical decision-making functions. In the meantime, those indices which have been obtained during periods of stress, during group interactions, and in clinical settings where nature has short-circuited a system are being studied. Also, the bodily centers that control temperature and other functions are being sought.

It is possible that man's normal homeostatic capability may be extended by using implanted, microminiaturized sensing and feedback devices. If so, he may be able to adapt to a much wider range of environmental stresses. The concept of a cell-sized, self-contained biosensor arranged to elicit an autonomic response from a stimulating or regulating mechanism could make the human body an in-line element in man-machine or man-computer complexes. The potential for improving on nature, either through the extension of normal capabilities or correction of pathological states, well illustrates the type of benefits which can be expected to accrue from the interaction of biological sciences with nonbiological technology.

Coast Guard Conducting Search for Torpedoed WWII Tanker

The U.S. Coast Guard is currently conducting at-sea operations in search of the tanker S.S. GULFTRADE, which was torpedoed off the New Jersey Coast in 1942. If the hulk can be found, divers will descend in an attempt to obtain samples of the ship's hull plating, fittings, and oil cargo. These samples will be analyzed in an attempt to determine if the nearly 100 tankers sunk off the American shores during World War II are a potential oil threat to United States coasts.

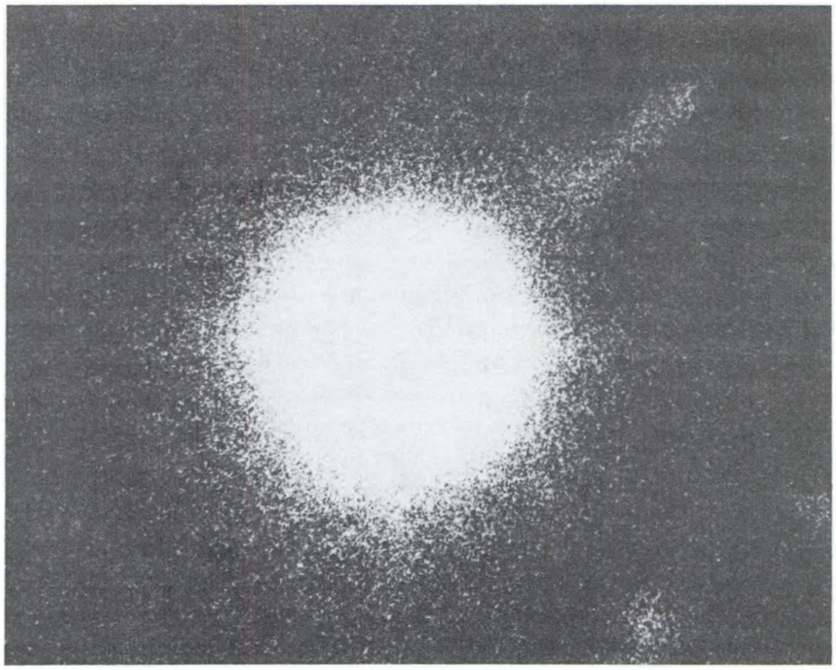
Although some of the oil cargo has undoubtedly leaked from the tanks of the sunken ships, it is felt that a considerable amount of oil is still trapped in these containers. The undersea examination, which is being conducted in response to President Johnson's order for a water pollution study, is expected to determine the extent of potential pollution from the trapped oil.

The Coast Guard ship SWEETGUM is being used as the operations platform for the project. A decompression chamber and diving boxes were put aboard the SWEETGUM at its home port in Mayport, Florida and additional equipment, including fathometers and sonar gear, was installed at the St. George Coast Guard Base, Staten Island, New York.

GULFTRADE's position is approximately 12 miles offshore, some 38 miles northeast of Atlantic City, New Jersey. Once the hulk is found, SWEETGUM will moor directly overhead and act as a work platform for the divers. After scuba divers have assured the identity of the hulk, "hard-hat" divers will descend to obtain samples to be used for analysis. Underwater television cameras will be used to monitor the scene on the ocean floor, and a tape recorder will be used to maintain a continuous recording of the findings as described by the divers.

The Coast Guard hopes to complete the at-sea operations before the annual hurricane season begins. Any further activity in connection with sunken hulks will be determined after samples taken from GULFTRADE have been analyzed.

Research Notes



New X-Ray Sources Discovered

Dr. Herbert Friedman, Chief Scientist of NRL's E. O. Hulburt Center for Space Research, recently disclosed three significant findings from a recent x-ray astronomy experiment: the identification of quasars as producers of great masses of x-rays, the detection of three x-ray sources not coincident with any known quasar or radio galaxy, and the confirmation of the existence of a smooth background of x-rays which is believed to be isotropic over the entire sky. The findings, which are the result of measurements by instruments carried aloft by an Aerobee rocket launched from White Sands, New Mexico on May 17, give new support to the theory that the entire universe is bathed in a virtual sea of background x-rays.

Quasars (quasi-stellar radio sources) are star-like objects. However, they seem to emit visible light at a greater rate than a whole galaxy. Also, they emit radio waves at rates comparable to the strongest radio galaxies.

X-ray emissions were detected from four sources during the rocket flight. The quasar 3C-273, which consists of a stellar core of the 13th magnitude and a jet which spans about 130,000 light years, is the most powerful x-ray emitter thus far observed. Its x-ray luminosity is about 50 times that of its radio luminosity and about twice its visible luminosity. It is possible that continuing explosive activity in this quasar, which is about 1.5 billion light years from earth, repeatedly produces clouds of relativistic electrons in periods ranging from a few days to many years.

The signals from the other three x-ray sources, comparable in flux to 3C-273, suggest that these emitters are extragalactic.

Airglow Research at NRL

Orbiting vehicles have greatly increased the opportunities for research into the nature of the upper atmosphere. One such opportunity is the study of the night airglow layer, which emits a faint light from several atmospheric constituents at an altitude of approximately 60 miles. The layer can be observed "edge on" from orbiting altitudes and, for the first time, can be studied on a truly global scale.

A major difficulty in photographing the layer has been its dimness. Very fast photographic systems and exposures of one minute or more were required when color filters were used on the camera to isolate specific emissions. One solution to this problem is using a low-light-level television system developed by GE for the Naval Air Development Center, Johnsville, Pa. It was successfully used with short exposure times to record the airglow from Gemini XI last September in a joint experiment by the University of Minnesota and Dudley Observatory.

Direct photography of the layer has been successful in airglow experiments designed for the Mercury and the Gemini orbiting vehicles by the University of Minnesota and the Naval Research Laboratory, respectively. A new and more compact tool for night airglow study was successfully used by NRL in an Aerobee rocket flight from White Sands Missile Range on June 19. The equipment consisted of a conventional (*f*/2.8) camera and film with an image intensifier tube interposed between. Narrow band interference filters were used to isolate both the oxygen green emission and the sodium yellow emission on the film. Small altitude and intensity differences between the two emissions were easily measurable from a four-second exposure. The photographs also verified the presence of peculiarities in the layer, such as an apparent splitting into a double layer. This had been indicated in earlier photographs, but was doubted because of the long exposures and consequent blurring involved.

With the present easy availability of high aperture lenses (*f*/1.0) and fast film, the image intensifier will allow "snapshot" exposures of the airglow to be made from orbiting vehicles with hand-held cameras. This should greatly simplify global airglow studies from manned spacecraft.

Navy Announces Establishment of Maury Center for Ocean Science

The Navy recently announced the establishment of the Maury Center for Ocean Science at the Naval Research Laboratory, Washington, D.C., to bring together a number of ocean science activities under a single director. The Center is named for CDR Matthew Fontaine Maury, USN, pioneer Navy oceanographer, whose book, *Physical Geography of the Sea,* published in 1855, was the first textbook in modern oceanography.

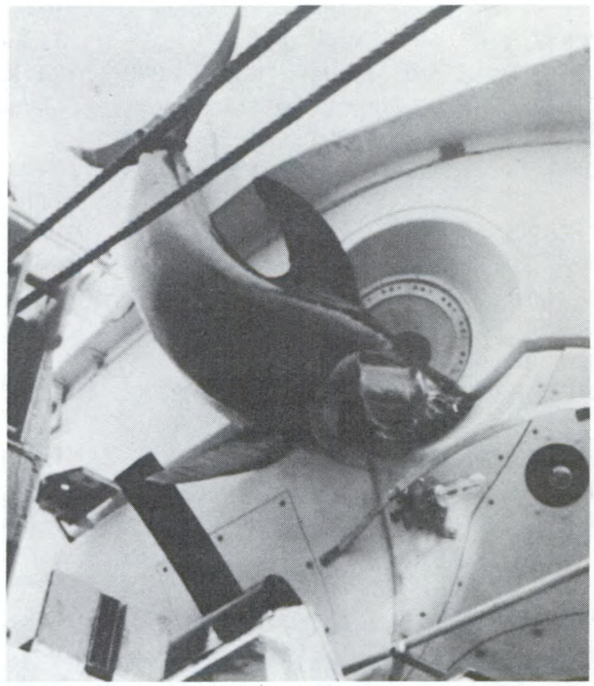
The Oceanographer of the Navy, RADM O. D. Waters, said the purpose of the center is to achieve maximum use of available resources; increase interaction between Navy contract and internal programs; improve information exchanges; and provide a broader basis for definition, review and assessment of the total Navy ocean science program, its response to Navy needs, and relationship to other national programs.

The Maury Center is under the jurisdiction of RADM Thomas B. Owen, Assistant Oceanographer of the Navy for Ocean Science. The director is Dr. J. Brackett Hersey, Deputy Assistant Oceanographer for Ocean Science. Prior to August 1966, Dr. Hersey was Chairman of the Geophysics Department, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

The nucleus of the Center, which is primarily a coordinating facility, is made up of four groups now at the Naval Research Laboratory. They are the Ocean Science and Technology Group, Office of Naval Research; elements of the Ocean Science and Engineering Division, Naval Research Laboratory; the Research and Development Department, Naval Oceanographic Office; and the Undersea Surveillance Oceanographic Center, Naval Oceanographic Office. Each group will remain under the administrative and management control of its parent organization.

Other organizations involved with the Navy's ocean science programs will be associated with the Center. A coordinating council will be set up, headed by the director of the Center. Its members will be directors of participating groups and representatives of the Navy's Systems Commands and Offices.

Swordfish Attacks ALVIN



The day began normally enough. It was Thursday, July 6, 1967. Skies were clear; the sea, calm. ALVIN, the Navy's unique underwater research submarine, was launched from its catamaran and began its 202nd dive. Pilots Marvin McCamis and Valentine Wilson and Observer Edward Zarudski, a geologist from the Woods Hole Oceanographic Institution, made up the crew.

Once on the bottom—a depth of 1985 feet—the crew held ALVIN in a stationary position while various scientific measurements were taken and recorded. McCamis had the conn; Wilson stood near the starboard window. Suddenly Wilson observed what looked like a six-foot-long black rock 30 or 40 feet away. When, a few minutes later, the pilots lifted ALVIN off the bottom to an altitude of about five feet, the black "rock" came to life. As the dark shape charged the submarine at high speed, the crew could see that it was no rock but a swordfish, apparently angered at ALVIN for disturbing its habitat. The fish closed in on the offending submarine, striking it in the joint between the forebody and afterbody immediately forward of the starboard window. Indeed, the force was so great that the fish's sword was driven in up to the hilt, about two and one half feet. As a result, the fish was securely wedged in the submarine. It was stunned for several minutes and then violently tried to withdraw.

When the crew saw what had happened, they checked out all systems to determine whether any damage had occurred. The only abnormal indication was a slight intermittent leak detector indication. With the concurrence of Observer Zarudski and the surface controller, the pilots decided to terminate the dive immediately.

When ALVIN broke the surface, the swordfish was still securely trapped. However, in its efforts to free itself, the fish had nearly broken its sword through. Swimmers passed a line over its tail, thence to ALVIN's sail, and hoisted submarine, fish, and all aboard the catamaran.

After a complete inspection and postdive checkout, it was determined that ALVIN had not been damaged; there were only a few scratches in its fiberglas skin. The sea denizen's attack had nothing to do with the slight leak detector indication.

The swordfish was removed; succulent steaks were enjoyed by all. ALVIN, shaken but unharmed, returned to the sea.

On the Naval Research Reserve

Roster of Research Reserve Companies

There are 97 Research Reserve companies located throughout the United States. These companies are listed below by Naval Districts. The time and place of meeting, address, and name of the commanding officer are included.

FIRST NAVAL DISTRICT

NRRC 1-1
1930, 1st & 3rd Mondays; Room 4-270, M.I.T., 77 Massachusetts Ave., Cambridge, Mass. 02138. (CDR Paul St. George, USNR, 58 Elmhurst Road, Newton, Mass. 02158)

NRRC 1-2
1930, 1st & 3rd Wednesdays; U.S. Naval & Marine Corps Reserve Training Center, Fields Point, Providence, R.I. 02905. (LT Raymond B. Larter, USNR, 147 Harbor Road, So. Swansea, Mass. 02777.)

NRRC 1-3
1930, 1st & 3rd Tuesdays. (No meetings during July and August.) Room 214, Dickinson Hall, University of Massachusetts, Amherst, Mass. 02103. (LT Edward A. Walsh, USNR, 194 Notch Road, North Adams, Mass. 01247.)

NRRC 1-5
1930, 1st & 3rd Mondays. (No meetings during July and August.) Higgins Library, Seminar Room, Worcester Polytechnic Institute, Worcester, Mass. 01609. (LCDR Joseph C. Curtis, USNR, Putnam Road, Holden, Mass. 01520.)

NRRC 1-7
2000, 1st & 3rd Tuesdays. (No drills scheduled First Quarter.) Dartmouth Medical School, Room 524, Hanover, N.H. 03755. (LT Paul W. Chapman, USNR, RD #1, Box 494-B, Springfield, Vt. 05156.)

THIRD NAVAL DISTRICT

NRRC 3-1
1830, 1st & 3rd Thursdays; 820 United Nations Plaza, New York, N.Y. 10017. (CDR Martin A. Rizack, USNR, 318 Warwick Ave., Teaneck, N.J. 07666.)

NRRC 3-2
1930, 2nd & 4th Mondays; U.S. Merchant Marine Academy, Kings Point, N.Y. 11024. (LT Ralph F. Ghetti, USNR, 311 Andrews Road, Mineola, N.Y. 11501.)

NRRC 3-3
2000, alternate Mondays; Room G14A, School of Medicine, University of Buffalo, Buffalo, N.Y. 14214. (CDR Maurice E. Taylor, USNR, 5363 Elm Drive, Lewiston, N.Y. 14092.)

NRRC 3-4
2000, alternate Mondays; Bausch & Lomb Hall, Room 106, University of Rochester, Rochester, N.Y. 14627. (LCDR Edward R. Schickler, USNR, 990 Pear Tree Lane, Webster, N.Y. 14580.)

NRRC 3-5
2000, alternate Thursdays; Hartford Electric Building, Wolcott Hill Road, Wethersfield, Conn. 06169. (LCDR Edward C. Toops, USNR, 179 Westledge Road, West Simsbury, Conn. 06092.)

NRRC 3-7
2000, 2nd & 4th Thursdays; U.S. Naval Reserve Training Center, Scotia, N.Y. 12302. (LCDR Frederick G. Baily, USNR, Jockey St., RD #1, Ballston Spa, N.Y. 12020.)

NRRC 3-8
1900, 2nd & 4th Tuesdays; Young & Rubicam, Inc., 40th St., 16th Floor, 285 Madison Ave., New York, N.Y. 10017. (LCDR Vincent J. Gentile, USNR, 100 B. Cedar Lane, Highland Park, N.J. 08904.)

NRRC 3-9
1930, 2nd & 3rd Wednesdays; Brookhaven National Laboratory, Upton, L.I., N.Y. 11973. (CAPT Victor P. Bond, USNR, Cedar Lane, Setauket, L.I., N.Y. 11785.)

NRRC 3-14
1800, 1st & 3rd Tuesdays; U.S. Naval Reserve Training Center, 75 Oakley St., Poughkeepsie, N.Y. 12601. (CDR William W. Lang, USNR, Hornbeck Ridge, Poughkeepsie, N.Y. 12603.)

NRRC 3-16
2000, 1st & 3rd Thursdays; Yale University, NROTC Unit, Hammond Laboratory, 14 Mansfield St., New Haven, Conn. 06511. (LCDR C. Marshall Davidson, USNR, 22 Lawrence Road, Hamden, Conn. 06514.)

NRRC 3-17
1730, alternate Tuesdays, Columbia University Club, 44 West 43rd St., New York, N.Y. 10028. (LCDR Philip B. DeVries, USNR, 3 Old Oak Road, Port Chester, N.Y. 10573.)

NRRC 3-18
1945, 1st & 3rd Mondays; Marshall Hall, State University College of Forestry, Syracuse University, Syracuse, N.Y. 13210. (CDR John B. Simeone, USNR, 839 Cumberland Ave., Syracuse, N.Y. 13210.)

FOURTH NAVAL DISTRICT

NRRC 4-1
2000, alternate Wednesdays, 10 Guyot Hall, Princeton, N.J. 08540. (CAPT David M. Jewett, USNR, 22 Sunset Boulevard, East Brunswick, N.J. 08816.)

NRRC 4-3
2000, alternate Thursdays; U.S. Naval & Marine Corps Reserve Training Center, 4902 Forbes St., Pittsburgh, Pa. 15213. (LCDR Howard B. Finley, USNR, 392 Sabbath Drive, Pittsburgh, Pa. 15236.)

NRRC 4-4
1900, alternate Mondays; 316 Wagner Building, Pennsylvania State University, University Park, Pa. 16801. (LT John D. Sink, USNR, 100 Oakmont Road, State College, Pa. 16801.)

NRRC 4-5
2000, alternate Mondays; U.S. Naval & Marine Corps Reserve Training Center, 3920 Kirkwood Highway, Wilmington, Del. 19808. (LCDR James S. Linderman, USNR, 1515 Brandywine Boulevard, Wilmington, Del. 19809.)

NRRC 4-7
1930, alternate Thursdays. (No meetings during August.) Battelle Memorial Institute, South Conference Room, 505 King Ave., Columbus, Ohio 43201. (LCDR Robert D. LaRue, USNR, 3574 Paris Boulevard, Westerville, Ohio 43081.)

NRRC 4-8
1800, alternate Mondays; U.S. Naval & Marine Corps Reserve Training Center, 1089 East 9th St., Cleveland, Ohio 44114. (LCDR Gordon D. Pred, USNR, 23401 Effingham Road, Euclid, Ohio 44117.)

NRRC 4-11
1900, alternate Tuesdays; U.S. Naval & Marine Corps Reserve Training Center, Gilbert Ave. at Victory Pkwy, Room 37, Cincinnati, Ohio 45227. (LCDR William R. Crawford, USNR, 6973 Miami Bluff Drive, Cincinnati, Ohio 45227.)

NRRC 4-12
1930, alternate Tuesdays. (No meetings during July and August.) Technical Training Building, U.S. Naval Air Station, Willow Grove, Pa. 19090. (CDR John P. Burich, USNR, 123 Waverly Road, Wyncote, Pa. 19095.)

NRRC 4-13
1930, 1st & 3rd Mondays; Franklin Inst., 20th St. and Parkway, Philadelphia, Pa. 19112. (LCDR William W. Dickhart, USNR, 6613 Emlen St., Philadelphia, Pa. 19119.)

FIFTH NAVAL DISTRICT

NRRC 5-2
2000, Mondays. (No meetings during July and August.) Room 310, Hutcheson Hall, Virginia Polytechnic Institute, Blacksburg, Va. 24061. (LT William P. Harrison, Jr., USNR, P.O. Box 747, Blacksburg, Va. 24060.)

NRRC 5-3
1930, 1st & 3rd Tuesdays; Building 560, Fort Detrick, Frederick, Md. 21701. (LCDR Robert E. Boyle, MSC, USNR, Route #7, Eastview, Frederick, Md. 21701.)

NRRC 5-4
1945, 1st & 3rd Thursdays; Board of Education Building, 3 East 25th St., Baltimore, Md. 21218. (LT John M. Backer, USNR, 1913 Cedric Road, Baltimore, Md. 21216.)

NRRC 5-8
2000, 1st & 3rd Thursdays; National Academy of Sciences, 2102 Constitution Ave., N.W., Washington, D.C. 20418. (CDR Julian C. Nall, USNR, 4631 N. 27th St., Arlington, Va 22207.)

NRRC 5-9
1630, 1st & 3rd Fridays (except during First Quarter, meetings are alternate Wednesdays); U.S. Naval Research Laboratory, 4555 Overlook Ave., Washington, D.C. 20390. (LCDR Herschel L. Smith, Jr., USNR, 6464 Hemlock Place, S.E., Temple Hills Park, Md. 20031.)

NRRC 5-10
2000, 2nd & 4th Tuesdays; Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md. 20014. (LT Alexander J. Barton, USNR, 3818 N. Vernon St., Arlington, Va. 22207.)

NRRC 5-11
2000, 2nd & 4th Tuesdays; Conference Room, Naval Ship Research and Development Center, Annapolis, Md. 21402. (CDR William B. Huckenpoehler, Jr., 1947 Fairfax Road, Annapolis, Md. 21401.)

NRRC 5-12
1900, 2nd & 4th Mondays; Building 1200, Room A135, U.S. Naval Weapons Laboratory, Dahlgren, Va. 22448. (LCDR Don J. Ammerman, USNR, P.O. Box 501, Dahlgren, Va. 22448.)

SIXTH NAVAL DISTRICT

NRRC 6-1
1930, 1st, 2nd & 3rd Thursdays. (No meetings during First Quarter.) U.S. Naval & Marine Corps Reserve Training Center, 274 Fifth St., N.W., Atlanta, Ga. 30318. (LT Donald A. Reddicks, USNR, 5320 Roswell Road, N.E., Apt. J-2, Atlanta, Ga. 30305.)

NRRC 6-2
1900, 1st & 3rd Mondays; 204 Funchess Hall, Auburn University, Auburn, Ala. 36830. (LT Robert E. Hammett, USNR, P.O. Box 1069, Auburn, Ala. 36830.)

NRRC 6-3
1930, 2nd & 4th Wednesdays; U.S. Army Reserve Armory, Elza Gate, Oak Ridge, Tenn. 37830. (LCDR Samuel G. Campbell, USNR, P.O. Box N, Oak Ridge, Tenn. 37830.)

NRRC 6-4
1915, 1st & 3rd Tuesdays; U.S. Naval Reserve Training Center, 1300 N.E. 8th Ave., Gainesville, Fla. 32601. (LCDR Harry F. Hollien, USNR, 1000 N.W. 39th Drive, Gainesville, Fla 32601.)

NRRC 6-5
1930, 1st, 3rd & 5th Mondays; U.S. Naval & Marine Corps Reserve Training Center, P.O. Box 1180, Broad Ave., Gulfport, Miss. 39502. (LCDR Walter R. Congdon, USNR, 113 Beach Drive, Pass Christian, Miss. 39560.)

NRRC 6-6
1800, Mondays. (No meetings during First Quarter.) NROTC Building, University of North Carolina, Chapel Hill, N.C. 27514. (LCDR Howard M. Harper, Jr., USNR, 718 Caswell Road, Chapel Hill, N.C. 27514.)

NRRC 6-8
1930, 1st & 3rd Tuesdays; U.S. Naval Reserve Training Center, Livingston & Parramore Sts., Orlando, Fla. 32801. (CDR Clarence R. Bachmann, USNR, 1121 Willowbrook Trail, Maitland, Fla. 32751.)

NRRC 6-9
1900, 1st, 3rd & 4th Mondays; Smith Hall, U.S. Navy Supply Corps School, Athens, Ga. 30601. (CAPT William T. Chambers,

SC, USNR, Cabin Lane Drive, Athens, Ga. 30601.)

NRRC 6-16
1700, 1st & 3rd Tuesdays; PAFB Chapel Annex, B St., Patrick Air Force Base, Fla. 32925. (LCDR Carroll A. Schory, USNR, 125 Eighth Ave., Indialantic, Fla. 32901.)

NRRC 6-17
1900, Tuesdays; U.S. Naval Reserve Training Center, 203 Leeman Ferry Road, S.W., Huntsville, Ala. (LCDR William R. Mixon, Jr., USNR, U.S. Naval Reserve Training Center, 203 Leeman Ferry Road, S.W., Huntsville, Ala. 35801.)

NRRC 6-18
2000, 1st & 3rd Mondays; Room 311, S-R Building, Peabody College, Nashville, Tenn. 37203. (LCDR Charles W. Hawkins, III, USNR, 904 American Trust Building, Nashville, Tenn. 37201.)

NRRC 6-19
1930, 1st, 2nd & 3rd Thursdays; U.S. Naval Reserve Training Center, 12 Meadow St., Chattanooga, Tenn. 37405. (LCDR Oscar M. Wilson, Jr., USNR, 12 Fairhill Drive, Chattanooga, Tenn. 37405.)

EIGHTH NAVAL DISTRICT

NRRC 8-1
1930, alternate Tuesdays; Richardson Memorial Building, Room 213 Tulane University, 6823 St. Charles Ave., New Orleans, La. 70118. (LCDR C. W. Unangst, USNR, 1758 Pressburg St., New Orleans, La. 70122.)

NRRC 8-3
1930, Mondays; Biological Science Bldg., Texas A&M College, College Station, Tex. 77843. (LT Robert M. Olson, USNR, 209 Redbud St., Bryan, Tex. 77801.)

NRRC 8-4
1930, 1st & 3rd Wednesdays; U.S. Naval Reserve Training Center, Houston, Tex. 77025. (LCDR Gerald L. Glahn, USNR, 301 Tose Land Drive, P.O. Box 3614, Baytown, Texas 77520.)

NRRC 8-5
1900, Mondays. Experimental Science Bldg. 115, University of Texas, Austin, Tex. 78712. (LT Loy E. England, USNR, 1101 Anderson Lane, Austin, Tex. 78757.)

NRRC 8-7
1930, Wednesdays; NROTC Bldg., University of New Mexico, Albuquerque, N.W. 87106. (LT Robert P. Baker, USNR, RR Box 150-1, Alameda, N.M. 87112.)

NRRC 8-8
1930, 1st & 3rd Tuesdays. Post Office Bldg., Bartlesville, Okla. 74003. (LCDR Vernon A. Cawi, USNR, 5815 S.E. Harvard, Bartlesville, Okla. 74003.)

NRRC 8-9
1700, 1st & 3rd Tuesdays; Lecture Room, Administration Bldg., Los Alamos Scientific Laboratory, Los Alamos, N.M. 87544. (LCDR Charles A. Linder, USNR, 232 Dos Brazos, Los Alamos, N.M. 87544.)

NRRC 8-12
2000, 1st & 3rd Tuesdays; Santa Fe Bldg., 114 Commerce St., Dallas, Tex. 75202. (CDR F. D. Colegrove, Jr., USNR, RR 5, Box 664-A, Dallas, Tex. 75240.)

NRRC 8-13
2000, 2nd, 3rd & 4th Mondays; Room 358, Union Bldg., Oklahoma State University, Stillwater, Okla. 74075. (CDR Gordon L. Nelson, USNR, 402 S. McFarland, Stillwater, Okla. 74074.)

NINTH NAVAL DISTRICT

NRRC 9-1
1900, 2nd & 4th Tuesdays; Naval Armory, Randolph at The Lake, Chicago, Ill. 60601. (CDR Theodore C. Dunn, USNR, 415 Fulton, Geneva, Ill. 60134.)

NRRC 9-2
1930, Mondays; Law Bldg., University of Illinois, Urbana, Ill. 61803. (LCDR Frederick L. Neumann, USNR, 502 E. Washington St., Urbana, Ill. 61801.)

NRRC 9-3
1930, Mondays. (Varied dates July, August, and September.) 62 N. Hall, University of Michigan, Ann Arbor, Mich. 48104. (LCDR Richard L. Carmon, USNR, 859 Watkins St., Birmingham, Mich. 48009.)

NRRC 9-4
2000, 2nd & 4th Tuesdays; U.S. Naval & Marine Corps Reserve Training Center, Milwaukee, Wis. 53207. (CAPT Robert E. Best, USNR, 3124 N. 103rd St., Wauwatosa, Wis. 53213.)

NRRC 9-5
1900, 1st, 2nd, & 3rd Wednesdays; USNROTC Bldg., Iowa State College, Ames, Iowa 50010. (LCDR Burton J. Gleason, USNR, 4623 Dover Drive, Ames, Iowa 50010.)

NRRC 9-6
1930, 2nd & 4th Mondays; Room 302, Mechanical Eng. Bldg., University of Minnesota, Minneapolis, Minn. 55414. (LCDR Theodore E. Molitor, USNR, 1286 Burke Ave., St. Paul, Minn. 55113.)

NRRC 9-7
1900, Tuesdays; Room 1, New Heavilon Hall, Purdue Universary, Lafayette, Ind. 47907. (CDR William J. Kay, USNR, 695 Sugar Hill Drive, W. Lafayette, Ind. 47906.)

NRRC 9-8
1900, 2nd & 4th Wednesdays; Webster Groves Public Library, Webster Groves, Mo. 63119. (LCDR Charles W. Blood, USNR, 9125 Sioux Drive, Afton, Mo. 63123.)

NRRC 9-10
1800, alternate Tuesdays; Elder Hall, Northwestern University, Evanston, Ill. 60201. (CDR Benedict J. Jaskoski, USNR, 6336 Magnolia, Chicago, Ill. 60626.)

NRRC 9-12
1930, Thursdays; Room 112, Agriculture Bldg., Colorado A&M College, Fort Collins, Colo. 80521. (LCDR Glenn L. Simpson, USNR, P.O. Box 96, Fort Collins. Colo. 80521.)

NRRC 9-14
1930, alternate Mondays; State Lab of Hygiene, University of Wisconsin, Madison, Wis. 53706. (LCDR Fred H. Koenecke, USNR, 1640 Capital Ave., Madison, Wis. 53705.)

NRRC 9-15
1900, 2nd & 4th Wednesdays; Midland Community Center, Midland, Mich. 48640. (LT William E. Pearson, USNR, 1200 Glendale St., Midland, Mich. 48640.)

NRRC 9-16
1930, Tuesdays; 221 Computing Center, Michigan State University, E. Lansing, Mich. 48823. (LT Thomas W. Jenkins, USNR, 304 Wayland Ave., E. Lansing, Mich. 48823.)

NRRC 9-19
1930, Mondays; Chemical Bldg., State University of Iowa, Iowa City, Iowa 52240. (LT John K. Stille, USNR, 10 Ridgewood Lane, Iowa City, Iowa 52240.)

NRRC 9-20
1930, Tuesdays; 104 Military Science Bldg., University of Kansas, Lawrence, Kans. 66045. (CDR W. B. Allmon, USNR, 2010 University Drive, Lawrence, Kans. 66044.)

NRRC 9-21
2000, 1st & 3rd Thursdays; Student Union, University of Denver, Denver, Colo. 80210. (LT Allen L. Miller, USNR, 843 S. Vivian St., Lakewood, Colo. 80228.)

NRRC 9-22
1930, Tuesdays; New Ag. Library, Room 11-17, University of Nebraska, Lincoln, Nebr. 68508. (LCDR Kenneth E. Mahlin, USNR, 1214 No. 9th St., Beatrice, Nebr. 68310.)

NRRC 9-23
1930, 2nd & 4th Wednesdays; Naval Ordnance Plant, 7500 West Roosevelt Road,

Forest Park, Ill. 60130. (LCDR Donald J. Keefe, USNR, 127th & Archer, Lamont, Ill. 60439.)

NRRC 9-25
1930, 1st & 3rd Wednesdays; U.S. Naval Reserve Training Center, Indianapolis, Ind. 46208. (CAPT Robert O. Jackson, USNR, 1 E. 73rd St., Indianapolis, Ind. 46240.)

NRRC 9-26
1930, Tuesdays; U.S. Naval Reserve Training Center, Colorado Springs, Colo. 80906. (LCDR Henry W. Elkins, USNR, 1214 Mount View Lane, Colorado Springs, Colo. 80907.)

NRRC 9-27
1930, Thursdays; Bldg. 1, Great Lakes, Ill. 60088. (CAPT Lawton H. Crosby, USNR, 303 Center Ave., Lake Bluff, Ill. 60045.)

NRRC 9-28
1900, Wednesdays; NROTC Armory, 6th St. & Stewart Road, Columbia, Mo. 65201. (LCDR Howard W. Heding, USNR, 105 Gipson St., Columbia, Mo. 65201.)

ELEVENTH NAVAL DISTRICT

NRRC 11-2
2000, 1st & 3rd Thursdays; U.S. Naval & Marine Corps Reserve Training Center, Pasadena, Calif. 91107. (LCDR Thomas D. Bair, USNR, 1240 Journey's End Drive, La Canada, Calif. 91011.)

NRRC 11-3
2000, 1st & 3rd Mondays; U.C.L.A. Center for the Health Sciences, 1st Floor Conference Room (1-3-105), Los Angeles, Calif. 90024. (LCDR George F. Forbes, USNR, 13745 Eldridge Ave., Sylmar, Calif. 91342.)

NRRC 11-5
1930, 2nd, 3rd, & 4th Tuesdays; U.S. Naval Reserve Training Center, Camp Decatur, San Diego, Calif. 92133. (LCDR Robert E. Lawrence, USNR, 4971 September St., San Diego, Calif. 92110.)

NRRC 11-7
2000, 1st & 3rd Thursdays; U.S. Naval & Marine Corps Reserve Training Center, Tucson, Ariz. 85711. (CDR Douglas E. Bryan, USNR, Route 2, Box 760T, Tucson, Ariz. 85715.)

NRRC 11-8
1645, 2nd & 4th Wednesdays; Pacific Missile Range, Conference Room, Bldg. 1, Point Mugu, Calif. 93041. (LCDR Robert L. Nifong, USNR, 1340 Ivywood Drive, Oxnard, Calif. 93030.)

NRRC 11-9
2000, 2nd & 4th Wednesdays; Pitzer College Conference Room, Administration Bldg., Claremont, Calif. 91712. (LCDR David F. Scheets, USNR, 127 W. Rancho Road, Corona, Calif. 91720.)

NRRC 11-11
2000, 1st & 3rd Mondays; U.S. Naval & Marine Corps Reserve Training Center, Santa Monica, Calif. 90405. (LCDR Robert L. Shafer, USNR, 989 Mesa Verde Road, Pasadena, Calif. 91103.)

TWELFTH NAVAL DISTRICT

NRRC 12-1
1930, 2nd & 4th Mondays; California Medical Center, San Francisco, Calif. 94104. (LCDR Norman T. Allen, USNR, 515 Manzanita Ave., Corte Madera, Calif. 94925.)

NRRC 12-2
1700, 1st, 2nd, & 3rd Mondays; Lawrence Radiation Laboratory, Room A, Bldg. 111, Livermore, Calif. 94550. (CDR Bernard G. Olsen, USNR, 680 Mojave Ave., Livermore, Calif. 94550.)

NRRC 12-3
1930, 1st & 3rd Wednesdays; Stanford University, Room 101, Physics Lecture Hall, Stanford, Calif. 94305. (LCDR William P. Jones, USNR, 11721 Putter Way, Los Altos, Calif. 94022.)

NRRC 12-4
2000, Wednesdays as scheduled; Room 119, Agriculture Bldg., Fresno State College, Fresno, Calif. 93726. (LCDR Leland R. Illingworth, USNR, 1526 W. San Madele, Fresno, Calif. 93705.)

NRRC 12-5
1930, 2nd & 4th Wednesdays; Room 247, Cory Hall, University of California, Berkeley, Calif. 94721. (CDR Gordon W. Hamilton, USNR, 2637 San Benito Drive, Walnut Creek, Calif. 94596.)

NRRC 12-6
1930, 1st, 2nd, & 4th Thursdays; Room 192, Young Hall, University of California, Davis, Calif. 95616. (LCDR Charles L. Alward, USNR, 5604 Greenbrae Road, Sacramento, Calif. 95822.)

NRRC 12-8
2000, 2nd & 4th Wednesdays; Room S-136, USN Postgraduate School, Monterey, Calif. 93940. (CDR Sydney H. Kalmbach, USNR, P.O. Box 727, Pebble Beach, Calif. 95670.)

NRRC 12-9
1715, Tuesdays as scheduled; Main Conference Room, Bldg. 2001, Aerojet-General Corporation, Sacramento, Calif. 95801. (LCDR Robert B. Lynch, USNR, 10219 Malaga Way, Rancho Cordova, Calif. 95670.)

THIRTEENTH NAVAL DISTRICT

NRRC 13-1
1930, 1st, 2nd, & 3rd Mondays; U.S. Naval Reserve Training Center, Seattle, Wash. 98111. (CDR Phillip H. Stern, USNR, 16500 S.E. 28th St., Bellevue, Wash. 98004.)

NRRC 13-3
1930, 1st, 2nd, & 4th Mondays; Todd Hall, Room 202, Washington State University, Pullman, Wash. 99163. (LCDR Arthur B. Coffin, USNR, 1910 Monroe St., Pullman, Wash. 99163.)

NRRC 13-4
2000, 2nd & 4th Tuesdays; U.S. Naval & Marine Corps Reserve Training Center, Swan Island, Portland, Ore. 97208. (CAPT Edward J. Warchol, USNR, 6425 N.E. 39th Ave., Portland, Ore. 97211.)

NRRC 13-5
1930, 2nd & 4th Mondays; USN ROTC Armory, Oregon State University, Corvallis, Ore. 97331. (LCDR Richard E. Moffitt, USNR, 8 Mountain View Drive, Corvallis, Ore. 97330.)

NRRC 13-6
1930, 2nd & 4th Thursdays; Reserve Center Armory, Idaho Falls, Idaho 83401. (CAPT Thomas J. Wadsworth, USNR, 256 Third St., Idaho Falls, Idaho 83401.)

Random Noise

Mr. Henry A. O'Neal was recently designated as Director of ONR's Ocean Science and Technology Group. He relieves Dr. J. B. Hersey, who has been named Director of the newly established Maury Center for Ocean Science at NRL.

CDR Robert B. Hayman was recently named NRL's Engineering Services Officer. He relieves CDR George Maragos, who has been designated NRL's Director of Support Services.

Dr. Maxwell E. Britton, Head, ONR Arctic Program, has been designated Acting Director, Earth Sciences Division (Code 410).

CAPT H. E. Van Ness, USN, has assumed the position of ONR's Assistant Chief for Research (Code 400). Dr. Richard Trumbull, who has been Assistant Chief for Research (Acting) has resumed his fulltime position as Research Director (Code 402).

Selected Contract Research Reports

The contract research reports listed below have been extracted from the Technical Abstract Bulletins 67-15 and 16 of August 1 and 15, 1967. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in TABs 67-15 and 16.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 22151.

ASTRONOMY AND ASTROPHYSICS

Are Young Galaxies Visible? The Integrated Background; Princeton; Partridge and Peebles; AD-652 777

Solar Oblateness and General Relativity; Princeton; Dicke and Goldenberg; AD-652 778

Accurate Positions of Selected 4C Sources; CalTech; Olsen; AD-653 260

The East-West Structure of Radio Sources at 1425 MHz; CalTech; Fomalont; AD-653 261

Stability of Axisymmetric Figures of Equilibrium of a Rotating Charged Liquid Drop; Chicago U.; Rosenkilde; AD-653 395

Observations of Taurus A and the Quasi-Stellar Source 3C 273 at 1.53 Cm; Calif. U., Berkeley; Williams *et al;* AD-653 437

Observations of Jupiter, Saturn, and Mercury at 1.53 Cm; Calif. U., Berkeley; Welch *et al;* AD-653 438

A Measurement of the Cosmic Microwave Background Temperature at 1.5 Cm Wavelength; Calif. U., Berkeley; Welch *et al;* AD 653 449

Suppression of the Jeans Instability in Collisionless Media; Chicago U.; Lee; AD-653 420

Upper Limits on Liquid Water in the Venus Atmosphere; Calif. U., Berkeley; Welch and Rea; AD-653 452

Are Young Galaxies Visible; Princeton U.; Partridge and Peebles; AD-653 677

The Gravitational Instability of the Universe; Princeton U.; Peebles; AD-653 678

Interplanetary Sector Structure, 1962–1966; Calif. U., Berkeley; Ness and Wilcox; AD-653 747

The Primeval Fireball; Princeton U.; Peebles and Wilkinson; AD-653 756

ATMOSPHERIC SCIENCES

Atmospheric Ozone Investigations at Barrow, Alaska, During 1965; Wash. U., Seattle; Kelly, Jr.; AD-653 745

Measurements of Radiative Flux Divergence in the Arctic; Wash. U.; Lieske and Stroschein; AD-653 808

Isotropy and Homogeneity of the Universe From Measurements of the Cosmic Microwave Background; Princeton; Partridge and Wilkinson; AD-652 779

Numerical Simulation of Cumulus Convection; Rand Corp., Santa Monica, Calif.; Murray; AD-652 812

An Approach to the Analysis of Sea Surface Temperature Data for Utilization in Hurricane Forecasting in the Gulf of Mexico; Texas A and M U., College Station; Taylor; AD-653 269

BEHAVIORAL AND SOCIAL SCIENCES

Optimal Allocation in a Pure Capital Model With Withdrawals: Asymptotic Properties and Algorithms; Stanford; Seelenfreund; AD-653 746

Post-Training Performance Criterion Development and Application; Applied Psychological Services, Wayne, Pa.; AD-653 712

The Effects of Thiazesim, LSD-25, and Bilateral Lesions of the Amygdalae on the Release of a Suppressed Response; Texas U., Galveston; Barratt; AD-653 423

Pulse Rate Comparisons Between Flicker and Intermittent Tone; Hofstra U.; Hempstead, N.Y.; Wilde; AD-653 457

A Factor Analysis of Symbolic Memory Abilities; U. of S. Calif., Los Angeles; Tenopyr *et al*; AD-653 602

Influence of Source and Number of Exposures on Communication Effectiveness; Hunter Coll. of the City U. of N.Y.; Weiss and Solomon; AD-653 744

Experimental Retrieval Systems Studies. Systems Manual for Experimental Literature Collection and Reference Retrieval System; Lehigh U., Bethlehem, Pa.; Anderson *et al;* AD-653 279

Experimental Retrieval Systems Studies; Lehigh U.; Anderson *et al;* AD-653 280

The Evaluation of Non-Marketable Investments; Center for Naval Analyses, Wash., D.C.; Broussalian; AD-652 821

The Cournot Equilibrium in a Nonsymmetric Oligopolistic Market; Yale U.; Levitan and Shubik; AD-653 086

The Nonsymmetric Game: Joint Maximum, Efficient Solution and Measures of Collusion and Welfare; Yale U.; Levitan and Shubik; AD-653 087

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The 20th Military Operations Research Symposium will be held at the Department of State, Washington, D.C., October 24-26, 1967. Additional information on this symposium, which is sponsored by the ONR Naval Analysis Programs, may be obtained from the Executive Secretary, Military Operations Research Society, Landmark Towers, Room 1500, 101 Lincolnia Road, Alexandria, Va. 22304.

The 1967 ONR SKYHOOK scientific balloon program at Fort Churchill, Canada was completed on August 1. In all, 25 launches were made, with all but five successfully recovered. Balloons in a variety of sizes were flown.

Dr. George R. Irwin, a pioneer in the field of fracture mechanics, retired on August 11 from his position as Superintendent of the Mechanics Division at the Naval Research Laboratory. He will join the faculty of Lehigh University.

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Dr. Reid Receives Superior Civilian Service Award

Dr. Roger D. Reid, former Director of the ONR Biological Sciences Division, recently received the Superior Civilian Service Award, the highest award that a bureau or office chief can bestow upon a member of his staff. The award was presented by RADM Thomas B. Owen, Chief of Naval Research, during a ceremony held in his office on July 28, 1967.

Dr. Reid, who served as the Director of the Biological Sciences Division from 1957 to 1967 and as Head of the Microbiology Branch from 1948 to 1957, was cited for the many contributions he made during that period.

In 1953, Dr. Reid conceived and developed the first issue of *Progress Report Abstracts* for the Microbiology Branch. These abstracts are now published regularly by all branches of the Biological Sciences Division. They provide not only a yardstick of progress for the benefit of both contractor and scientific officer, but also a readily available reference manual for coordinators, negotiators, analyzers, and nontechnical personnel.

In 1963, Dr. Reid organized and conducted the first Navy-wide Workshop in the Biological Sciences at the Naval Medical Research Institute, Bethesda. These workshops, which are now held on an annual basis, have been eminently successful in bringing civilian and military biologists together to discuss approaches to common problems. Also, they have served as an avenue for military applications experts to present their general and specific operations requirements to Navy biologists and medical personnel.

Dr. Reid is a diplomate of the American Board of Microbiology and a member of the American Academy of Microbiology and the Governing Board of the American Institute of Biological Sciences. In 1964, the Maryland Branch of the American Society of Microbiology presented him with the Barnett L. Cohen Award, citing him for his "contributions, devotion, diligence and interest in the promotion of the Science of Microbiology." Also, he coauthored the text book entitled *Microbiology,* which has been adopted by over 200 universities and colleges in the United States and translated into Spanish for use in South American countries.

Dr. Reid is currently serving as Professor of Biology at the University of West Florida, Pensacola.

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Fifteen minutes flight time is all it takes for this HC-1 helicopter to airlift the front half of an A-4 "Skyhawk" between NAS Atsugi, Japan and the Nippi repair plant at Sugita. The Helo-Lift program replaces the former ferry system which usually took about 16 days. *See page 8.*