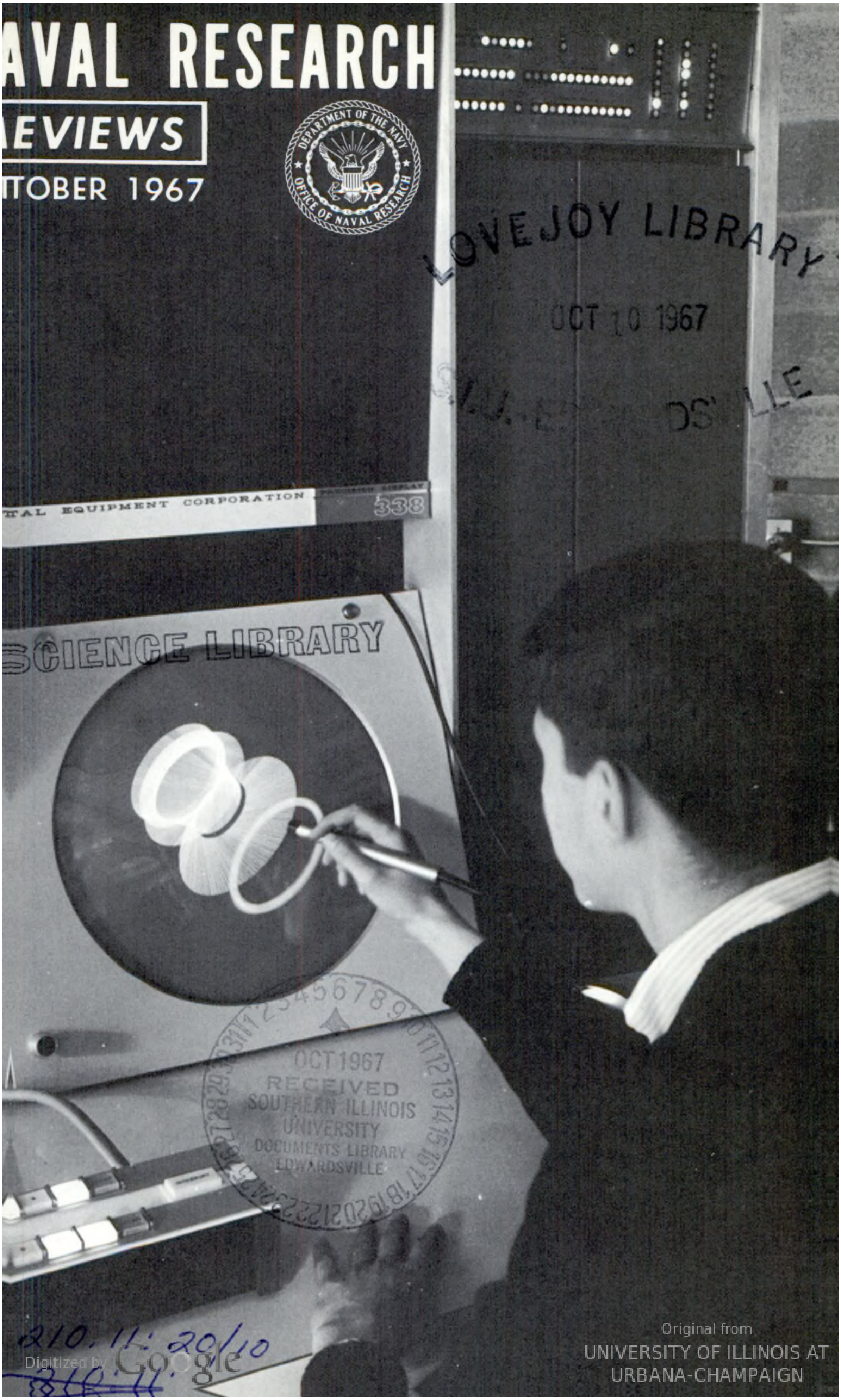
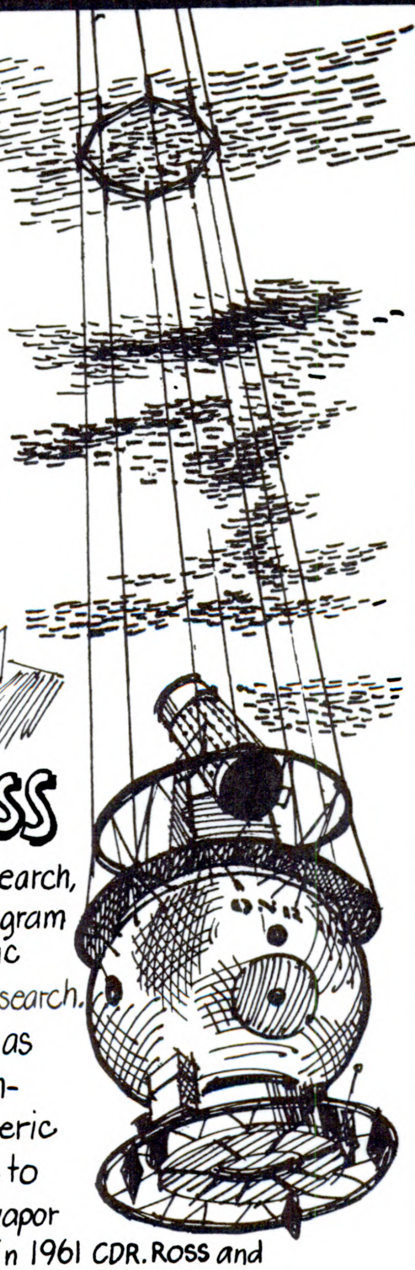
AVAL RESEARCH

EVIEWS

TOBER 1967



Portraits in Science



CDR. MALCOLM D. ROSS

Formerly of the Office of Naval Research, Cdr. Ross, U.S.N.R., initiated O.N.R.'s program of using high altitude manned plastic balloons for upper atmospheric reasearch.

In 1959, with a massive telescope as part of a specially designed balloon-gondola complex, Ross and atmospheric physicist Charles Moore were able to confirm the existence of a water vapor atmosphere on the planet Venus. In 1961 CDR. ROSS and LCDR. Victor Prather achieved an altitude of 113,500 ft., a world record for a manned balloon flight.

Pattern Recognition and Machine Learning

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Computers can do many tasks with amazing speed and accuracy. Their ability to outperform people at repetitive computation or at exhaustive file searching is common knowledge. Yet there are other tasks—tasks that people do quite routinely—that have proved to be frustratingly difficult to automate.

The common feature of many of these tasks is that they require the ability to recognize patterns—an ability that is necessary if computers are to respond to information from the outside world the way people do. Computers have no trouble reading holes punched in cards or sensing magnetized areas on tapes; however, it is remarkably difficult to program them to read legible handprinting or to recognize reasonably clearly spoken words. Even more difficult problems are encountered when researchers want computers to read unconstrained cursive script, recognize blood cells as seen through a microscope, analyze aerial photographs, or identify signals from sonar returns.

It should be emphasized that the problems considered here have little to do with being able to get the needed information into the computer. It will be assumed that satisfactory transducers are available. The problem is what to do with the data once it is in, *i.e.,* how to program a computer to recognize patterns.

A Problem in Pattern Recognition

What makes writing successful recognition programs so difficult? There are many answers to this question, but the basic ones are that there are no hard and fast rules and that the data are extremely variable. Consider, for example, the problem of recognizing handprinted letters and numbers. A surprising amount of resolution is needed to reproduce such characters faithfully. Figure 1 shows how a typical handprinted upper-case "B" appears when reproduced with different degrees of resolution. Clearly, one could not go much below 24-line resolution and still retain enough fidelity to tell that this character is a "B" and not an "8."

At this point, one problem emerges clearly. A 24×24 black and white picture has 576 resolution cells, which represent 576 bits of data. The total number of different pictures that could be drawn on such a grid is a staggering 2^{576}, which exceeds a billion to the 19th power. Although

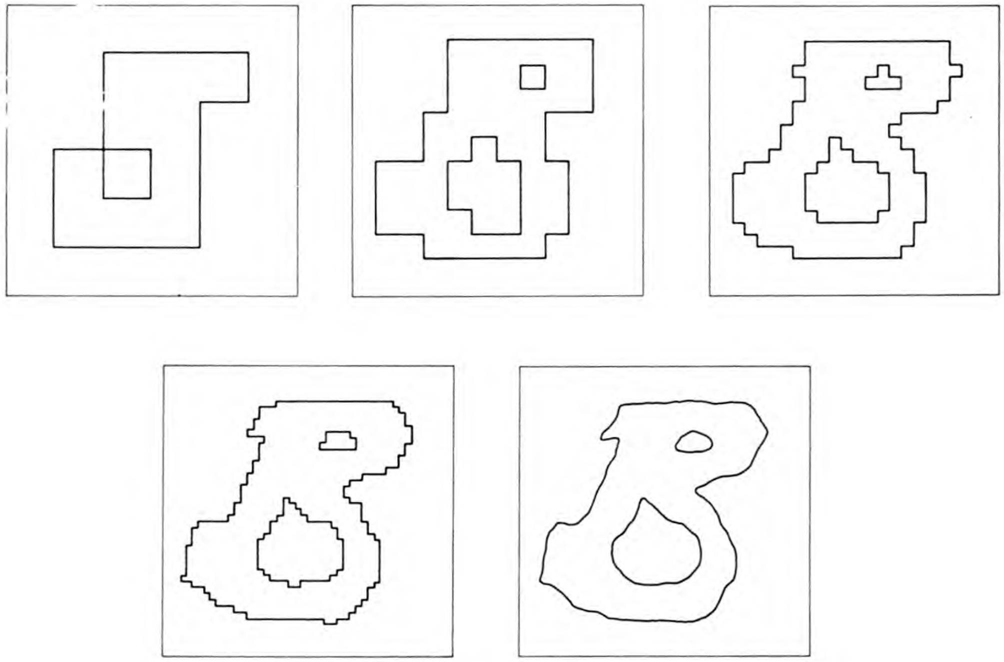


Figure 1—A handprinted B reproduced with 6-line, 12-line, 24-line, 48-line, and unlimited resolution

most of these pictures would be meaningless salt-and-pepper patterns, a large number would be significant. For example, most of the patterns formed by switching ten randomly selected cells in the letter B from black to white or *vice versa* would still be recognized as B's; almost a billion billion different B's can be formed this way. Most of the B's shown in the left half of figure 2 differ by more than ten bits; however, they are still recognizable. Yet, in every case, by changing only a few critically placed bits, the characters would become 8's. Thus, two of the major problems in pattern recognition are the great variability of patterns of the same type and the similarity between patterns of different types.

If a researcher wants to program a computer to tell B's from 8's,* he will have to develop decision rules—definite procedures for telling the two apart. One characteristic that should differentiate B's from 8's is the fact that B's have a straight stroke down the left side. Thus, a plausible procedure would be to measure, for example, the straightness of the middle third of this side. If it is sufficiently straight, the figure can be called a B; if not, it can be called an 8.

Two technical problems remain. One is to decide how to measure straightness, and the other is to decide how straight is "sufficiently"

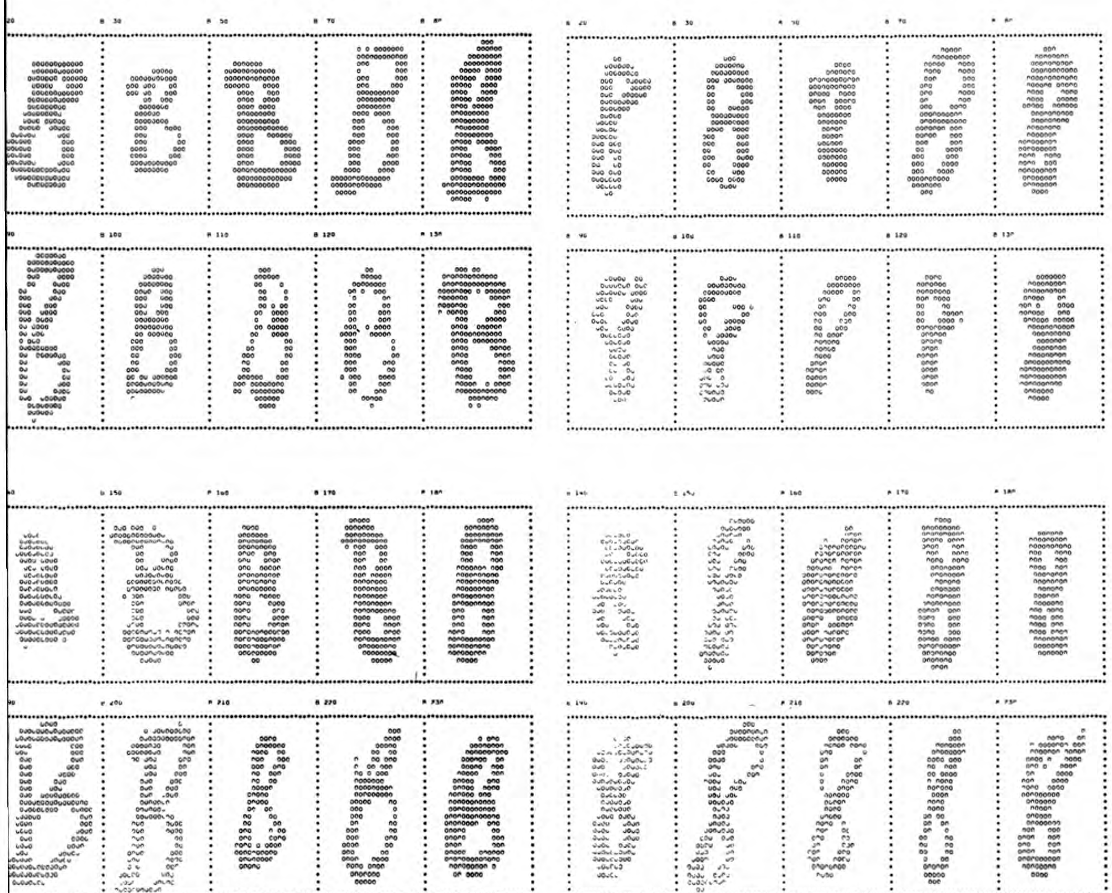
*This problem is used throughout the article to illustrate various features common to a great many pattern recognition problems. It should be viewed as just an illustrative example rather than a problem of intrinsic interest.

straight. One measure of straightness of a curved line is the ratio of the distance between its endpoints to its arc length. This will yield a number between zero and one—the larger the number, the straighter the line. Another measure is the average radius of curvature, or even just the average second derivative. Other measures can be suggested, but, for the sake of illustration, the first one mentioned shall be used here.

To decide how straight is "sufficiently" straight, typical values of this measure of straightness for B's and 8's must be obtained. Measuring the straightness of the middle third of the left side of the B's in figure 2 results in an average value of 0.92; of the 8's in figure 2, 0.85. Thus, it is reasonable to select an intermediate value such as 0.89 and use the following rule: If the measure of straightness exceeds 0.89, the left side is sufficiently straight for the character to be called a B; otherwise, it is called an 8.

Unfortunately, the results obtained by applying this rule are rather disappointing. About 25 percent of the characters are misclassified—most of these being 8's that are called B's. One possible reason for this large percentage of errors could be that the 24-line resolution used is inadequate. It might be desirable to look again at the raw data and see

Figure 2—Samples of handprinted B's (left) and 8's reproduced with 24-line resolution



if higher resolution would solve the problem. Another possibility is that a better measure of straightness is needed. The measure selected was arbitrary; a more careful choice might yield improved results. A third possibility is that more care should be taken in selecting the threshold value used in separating B's from 8's. Ideally, a thorough statistical analysis should be made and the threshold which minimizes the error rate selected.

Representation, Measurements and Classification

These three suggestions are directly related to three distinct operations: obtaining a representation, making measurements, and performing classification. These operations are fundamental, and they appear in one form or another in most pattern recognition problems. Clearly, all three operations must be done well in order to get good results.

What is the state of the art in pattern recognition regarding these problems? What theory or theories are available to help obtain representations, select measurements, and design classifiers? By far the most progress has been achieved in the theory of pattern classification. Techniques from statistics, particularly statistical decision theory, have been applied with considerable success. In addition, machine-learning methods have been developed that allow the computer to learn good decision rules.

The problem of obtaining a satisfactory representation is rarely fundamental. In some applications, considerable engineering effort may be needed to develop adequate transducers; programmers are sometimes faced with shortages of time and/or memory. Nevertheless, they are usually able to tell whether or not a given representation is adequate for the task, or what must be done to improve an inadequate representation.

The least understood problem is that of measurement selection. There is little theory available for guidance in this area; success depends largely on the ingenuity of the man doing the job. Although some clues have been obtained by studying how living creatures recognize patterns and some mathematical methods for evaluating the usefulness of proposed measurements have been developed, no effective methods are known for generating good measurements. This area of pattern recognition research needs a great deal of imagination and creativity.

Multiple Measurements

Which of these problems is responsible for the poor results obtained in the B-8 example? While the representation could be improved, only three or four of the characters in figures 2 are so ill-formed that they cannot be correctly identified by humans as B's or 8's. Thus, inadequate resolution can hardly be blamed for a 25 percent error rate.

An examination of the right half of figure 2 indicates most of the errors were due to misclassifying 8's as B's. Many of the 8's have the expected "dimple" on the left side. However, in almost half, this indentation is very small—not really larger than the irregularities on the left side of the B's. Thus, the measurement used was unable to separate these 8's from the B's. Changing the decision procedure, by raising the threshold, for example, would not improve the situation but would only exchange the errors: instead of 8's being called B's, B's would be called 8's. Thus, if any real improvement is to be obtained, it must be the result of finding better measurements.

One such measurement is the ratio of the maximum width of the top half of the figure to the maximum width of the bottom half. This measurement exploits the fact that handprinted B's tend to be larger at the bottom, while 8's tend to be larger at the top. This measurement could merely be substituted for the straightness test used previously. However, better results can be obtained by using both tests together, for in a case where one measurement is poor, the other may be very good. If both measurements are made for each of the characters in figure 2, and the results plotted on a piece of graph paper, the scattering of points shown in figure 3 is obtained. Each point corresponds to one character and represents the two measurements considered jointly.

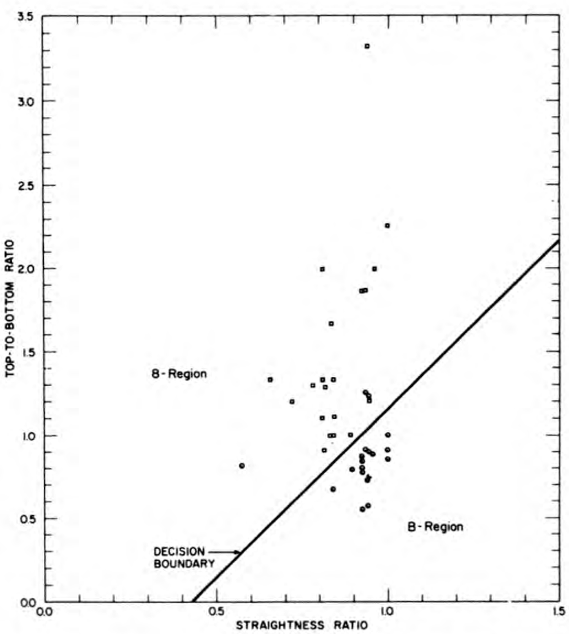


Figure 3 — Measurement values for B's and 8's

Although there is a certain amount of intermingling of the data, most of the points obtained from B's are separated from those obtained from 8's. Moreover, the straight line shown does a very good job of separating the two groups. It does make three errors—identifying three B's as 8's—but this is essentially as well as humans can do with these characters. Thus, a major improvement in performance has been achieved by finding better measurements and using a slightly more complicated classifier.

It should be mentioned that it is certainly possible to draw a more complicated boundary than a straight line—one that would thread itself through the points and classify all of the patterns correctly. However, such a boundary would be considerably more difficult to compute. Even more important, there is no guarantee that a more complicated boundary would actually be any better than a straight line for classifying new B's and 8's—characters other than those used to determine the boundary. The important question is not how well the classifier performs on the design data, but how well it works on independent test data. In general, the more complicated the decision boundary, the greater the number of patterns needed to fix that boundary and to ensure that good performance on design data will lead to good performance on the test data.

Learning Methods

In the example just considered, the straight-line boundary was determined by sketching a few candidate straight lines and selecting the one that looked most reasonable. This amounted to a trial-and-error search for the straight-line boundary that made the fewest errors.

This process of finding optimal linear decision boundaries can be programmed and done completely automatically. As the result of research on self-organizing systems sponsored by the Office of Naval Research, effective learning procedures have been developed for dealing with various types of data. These methods allow any number of measurements to be considered jointly, and allow the classification of patterns into any number of categories.

Most of these procedures work by making repeated corrections. They start with some arbitrary initial boundary and examine the patterns one by one. As long as the decision boundary gives the correct classification, it is left alone. If an error is made, however, the boundary is moved to correct the mistake. At first a great many corrections are made, since the initial boundary is totally inappropriate. With repeated corrections, however, the boundary drifts toward the desired position.

If it is possible to obtain an error-free linear boundary, these procedures will enable the programmer to do so. In such cases the patterns are said to be linearly separable. If they are not linearly separable, the boundary will, nevertheless, often hover about a low-error-rate solution. The various learning procedures that have been developed differ in their behavior on nonseparable problems, but the fundamental ideas behind their operation are the same. In terms of theoretical completeness, generality of application, and practical utility, the development of this learning technique has been one of the most successful results of pattern-recognition research.

System Considerations

Although determining how to program a computer to categorize patterns is a basic problem, it is often only part of the story. The need to recognize patterns usually appears as a part of the larger job, the demands of which may significantly modify the design of the pattern-recognition subsystem.

Consider, for example, the design of a system to read computer programs that have been handprinted on standard coding sheets. Part of the problem is to be able to classify isolated characters, such as B's and 8's. But there are other problems, ranging from document handling and scanning to providing the output in the most useful form.

These other considerations often yield opportunities as well as problems, one of the most important being the opportunity to employ context. Figure 4 gives a simple illustration of how context can influence a decision in character recognition. The decision is influenced by the fact that a string of letters or numbers is more likely than a mixture of letters and numbers. In designing a system to read handprinted computer programs, much richer contextual relations can be exploited. Often only certain characters or constructions are allowed, permitting many ambiguities to be resolved with great confidence. Other constructions may be so common that they can be anticipated, thus greatly reducing the number of possibilities to be considered.

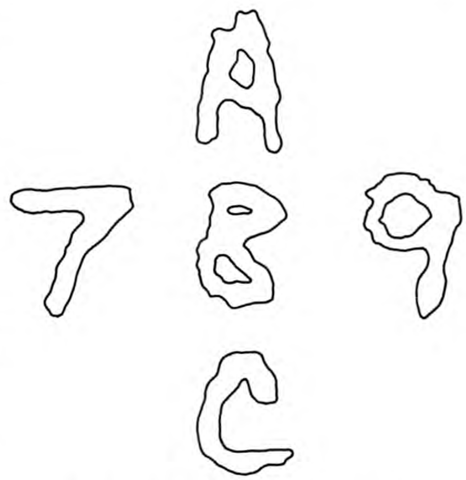


Figure 4 – The effect of context on pattern recognition

If context is to be exploited, however, the pattern recognition problem will change. It is not enough to decide whether a given character is a B or an 8. Instead, a measure is needed of how much the character resembles a B, an 8, or any other likely character. This is the kind of information needed for a context subsystem to make a final decision.

In more difficult pattern-recognition problems, it is sometimes hard to divide the system into subsystems for making measurements, computing tentative classifications, and using context to arrive at decisions. One such problem is visual scene analysis. Here the problem is not classifying a visual scene, but finding objects of interest in the scene, determining relationships between various objects, or more generally, providing a relevant description of a visual scene. To avoid an exhaustive and tremendously time-consuming search for all possible objects in all possible positions, it may be desirable to have an executive direct the search, looking first for likely objects in likely positions. When ambiguities arise, the executive may call for a higher-resolution representation, additional measurements, or a more thorough consideration of contextual relationships.

At this point the problem begins to change from one in pattern recognition to one in artificial intelligence. Too little work in this area has been done to predict its future with confidence. However, the potential of this work is clear, and future research in pattern recognition can be expected to move in this direction.

Navy West Coast Laboratories Reorganized

In an effort to improve the utilization of its research resources, the Navy has reorganized, effective July 1, several of its West Coast laboratories.

Three new centers have been established:

- *The Naval Command Control Communications Laboratory Center (NCCCLC), San Diego* has been created from the former Navy Electronics Laboratory (NEL), San Diego, less its Underseas Technology Directorate.

Commander:	CAPT William R. Boehm
Technical Director:	Dr. Ralph J. Christensen

- *The Naval Undersea Warfare Center (NUWC), Pasadena* has been created from the former Pasadena Annex of the Naval Ordnance Test Station (NOTS), China Lake; the several NOTS Pasadena Annex auxiliary sites; and the NEL Underseas Technology Directorate. No facility moves anticipated.

Commander:	CAPT Grady H. Lowe
Technical Director:	Dr. William B. McLean (Acting)

- *The Naval Weapons Center (NWC), China Lake* has been created from the former NOTS China Lake and the Naval Ordnance Laboratory (NOL), Corona. The Corona portion will be referred to as the NWC Corona Laboratories.

Commander:	CAPT Grady H. Lowe
Technical Director:	Mr. H. G. Wilson (Acting)

OASU Patuxent River Redesignated VX-8

The Oceanographic Air Survey Unit (OASU), NAS, Patuxent River, Maryland has been redesignated Air Development Squadron Eight (VX-8). The change was effective July 1.

VX-8 has three basic missions: The first is to conduct oceanographic and magnetic research survey flights (Projects BIRDSEYE, MAGNET and ASWEPS); the second, to provide airborne radio and television to the Republic of Vietnam (Project JENNY) (see *Naval Research Reviews* issue of February 1967, "Project JENNY—The Navy's Blue Eagle Television Network"); and the third, to conduct student training for the C-121-type aircraft.

Research in On-Line Real-Time Information Systems

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University of Pennsylvania

Through new computer technology, human memorizing and recall processes can be extended to vast amounts of information formerly confined to the shelves of a library or the drawers of filing cabinets.

The new technology takes on a number of aspects: "on-line," which means that a human user can communicate with a central computer through a remote keyboard, visual, or audio terminal; "real-time," which means that the terminal is continuously monitored by a central computer which can respond, make changes, and/or delete information at speeds matching human thought; and "mass memory," which means that the computer has a storage capacity of billions of characters with fractional-second access. Thus, the memory of a human problem-solver can be augmented with vast amounts of information which, if well organized, can be selectively recalled at speeds matching human thought.

An information system consists of networks of computers with their related information banks and consoles interconnected by communication lines. The users, through their related terminals, provide new information and receive output on demand. Furthermore, users at remote consoles may utilize a variety of aids when browsing in the information bank.

In 1960, the University of Pennsylvania, with support from the Information Systems Branch of the Office of Naval Research, began a research program aimed at developing new techniques in experimental and operational information systems. It was apparent from the outset that a number of problems had to be resolved before the envisaged systems became feasible.

The first problem was automatic organization and reorganization of information in the mass memory. Every "chunk" of information which came into the system had to be properly filed away, indexed, and adequately cross-referenced so that it would be immediately available on demand. To this end, the Multilist File Organization, a system which can be applied to a hierarchy of mass memories of varying storage capacities and response speeds, was developed. It achieves the effect of an "associative memory" where information chunks may be stored and retrieved by referring to interrelating associations.

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Another problem involved the language by which the user addresses the system. The non-programmer may easily "describe" the operations he wants performed and their objectives by providing the respective appropriate associations. These descriptions of operations or their objectives, after being reduced to the essentials, are viewed as logical expressions composed of natural language or mnemonic words which convey associations or relationships between words.

Finally, the research was concerned with the orderly automatic management of the computer and memory resources in order to assure continuous monitoring of terminals, rapid response, and protection of information privacy (when required).

The man-machine system under study needed an environment for experimentation, testing, and measurement. Such an environment was provided initially through an operational system which was implemented for inventory control at the Naval Aviation Supply Office in Philadelphia. This system, which became operative in 1962, is the forerunner of large real-time, on-line management systems. It includes an IBM 1410 central processor and a total of 12 IBM 1014 printer consoles and Information Products Corporation Model 1501 cathode-ray tube display units.

Integration of Inventory Control Functions

Inventory management consists of several diverse functions which conventionally have been separate and semi-independent. In reality, they are closely related and significant advantages can result from integrating the total information in joint support of all functions. The main functions are:

- Initial acquisition and replenishment of material through procurement, overhaul, and repair. These functions are carried out in response to depleted inventory reports and projections of future needs.

- Inventory management proper, which includes receiving requests for material from "customers," issuing shipping or receiving orders to warehouses, updating inventory status for each warehouse and for each type of material, maintaining usage statistics, and indicating replenishment requirements.

- Technical information management, which includes updating the technical information for each inventory item and preparing and publishing catalogs.

Using the Multilist File Organization, the total information in support of all functions was integrated by placing all the information about an inventory item in a record. The total information (all the records, one for each item) was placed on two IBM 1301 disc units with a capacity for 112 million characters.

Statistics regarding this information base illustrate the magnitude of the problem: A record ranging in size from 200 to 10,000 characters is needed to contain the information regarding a single inventory item. The file consists of approximately 450,000 small and medium-sized records for consumable items (which contain only inventory management information), and approximately 50,000 more extensive records for higher cost and repairable inventory items. The latter group, which also contains engineering data, requires the majority of updating.

The table below illustrates the contents of a record for an inventory item. The key elements are the "associations" that can be used to secure expeditious access to records.

Element Name	**Explanation**
Key Elements	
Federal Inventory Number (FIIN)	A seven digit number—primary key
Management class and stock number (FSN)	Consists of four alphabetic characters plus the FSN
Codes of immediate larger assemblies where part is used (application)	FSNs of larger assemblies make up keys
Cognizant manager (COG)	Code of manager responsible for the class of items. Used to assess performance by higher level management
Manufacturers' part numbers	Several numbers are possible—for several manufacturers
Interchangeable parts	Identification of acceptable substitutes
Name	Functional names, *e.g.*, gyroscope, amplifier, *etc.*
Additional Non-Key Elements	
Inventory by warehouse	
Quantity in repair by repair facility	
Total inventory	
Total in repair	
Usage statistics—this month, last month, last year, *etc.*	
Price	
Date of part entry in system, *etc.*	

Approximately 10,000 additions, deletions, and/or revisions are made each day to the half-million records in the computer files. These changes are entered into the files, transaction by transaction, as soon as they are received over the communication lines. Thus, the information in the computer is always up-to-date. Whenever human judgment is not required, appropriate decisions are made automatically and an appropriate response is produced. For instance, inputs such as requests for inventory items may be received over the communications lines. After the messages are interpreted (cards are taken from a transceiver and placed into a card reader), the records for the inventory items requested are retrieved. Next, the warehouse nearest the requester is selected (subject to transportation availability), shipping instructions are sent automatically to that warehouse (in the form of a punched card communicated *via* the transceiver), and the inventory is adjusted accordingly. In the event that the supply of the requested inventory item is exhausted, output is prepared for a technician who then performs further investigation to locate material either from a vendor or from a repair facility. After completing his investigation, he uses the console to issue shipping instructions. Similarly, when inventory at a warehouse reaches a replenishing level, output is automatically prepared for a technician who then investigates the shortage with the aid of the console and issues shipping instructions to transfer inventory items from one warehouse to another.

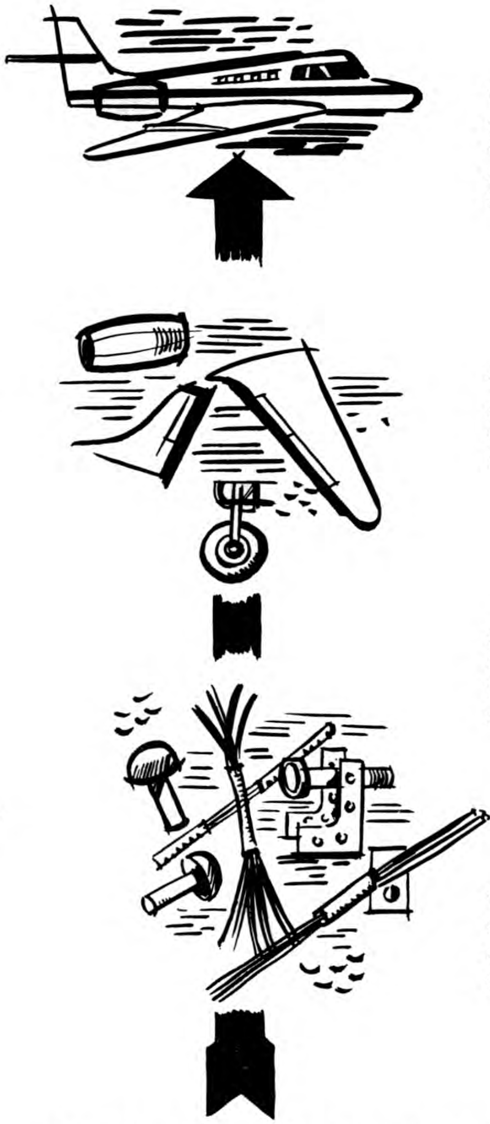
Retrieval by Hierarchical Position

Retrieval by hierarchical position is generally requisite in an information system. This can be illustrated by examining the hypothetical, somewhat simplified, three-layer hierarchical network of aircraft assemblies shown in figure 1. At the top level, there are 100 "largest" assemblies, *e.g.,* an aircraft or a major system receiving support. Each of these largest assemblies consists, on the average, of 2000 component "intermediate" assemblies, making a total of 200,000 instances of such assemblies. Some intermediate assemblies are used in more than one largest assembly. Thus, assuming there are only 50,000 different intermediate assemblies, each is used, on the average, in four largest assemblies.

Similarly, the intermediate assemblies break down, on the average, into 45 "bits and pieces," making a total of 2,250,000 instances of bits and pieces. Again, assuming there are only 450,000 different bits and pieces, each is used, on the average, in five intermediate assemblies.

As indicated previously, each record includes an application key (third element in table on page 11) which identifies each of the larger assemblies into which the inventory item fits. Thus, in the aircraft assembly illustration, the average intermediate assembly record would have four application keys and the average bits and pieces record would have five application keys.

Two functions which provide retrieval based on the position of a record in a hierarchical structure are "retrieve higher (RETHI)" and "retrieve lower (RETLO)". The function of RETHI is to retrieve all the records of the assemblies containing the subassembly or part whose record is specified in the operand (defined, for instance, by its FSN).



"Largest" Assemblies

There are approximately 100 types of aircraft and other major systems which use about 2000 intermediate assemblies each, making a total of 200,000 such assemblies.

"Intermediate" Assemblies

Thus, assuming there are 50,000 different intermediate assemblies, each is used, on the average, in four different largest assemblies.

Similarly, the intermediate assemblies break down, on the average, into 45 bits and pieces, making a total of 2,250,000 bits and pieces.

"Bits and Pieces" Consumables

Thus, assuming there are 450,000 different bits and pieces, each is used, on the average, in five different intermediate assemblies.

Figure 1 – Hierarchical network of aircraft assemblies

RETLO is the inverse operation. To illustrate, the query "RETHI/FSN_K/APPLICATION" would retrieve all the records referenced by the application keys in the record having the specified FSN_K that are *higher* in the hierarchy. Similarly, the query "RETLO/FSN_K/APPLICATION" would retrieve all records referenced in the application keys in the FSN_K record that are *lower* in the hierarchy.

This retrieval by hierarchy can be shown as output on a graphic display console. Also a RETHI function, by specifying records of bits and pieces items as the operand, can be used by an inventory manager to find all the intermediate and largest assemblies that would be affected if shortages of bits and pieces items occurred. Inversely, the RETLO function, by specifying a record of one of the largest assemblies as the operand, can be used to determine which intermediate assemblies and bits and pieces are necessary to support this major system.

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Time and Cost Reduction

The introduction of an information system into a management organization generally causes a radical transition, particularly when the information within that system (including data and programs) is extensive, reliable, and easily accessible.

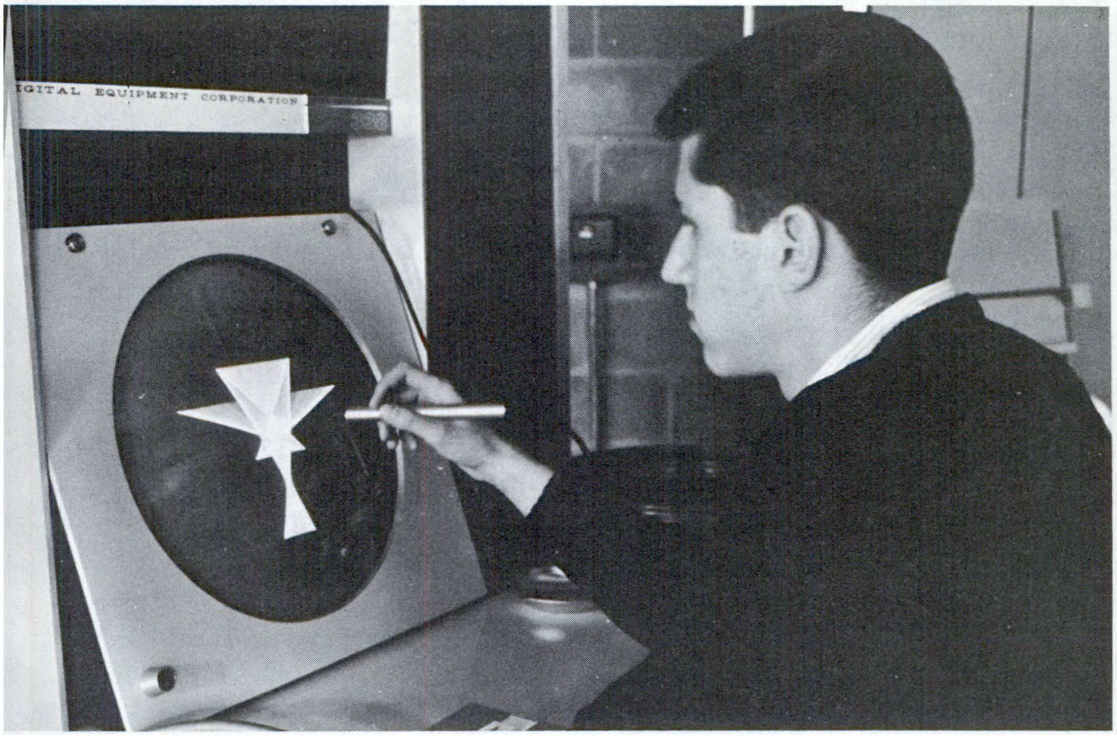
A primary reason for this transition is the great time reduction usually achieved in decision cycles. For instance, at ASO the shipping instructions in response to a requisition can now be issued within an hour after receiving a request. Before the system was installed, a tedious manual process involving bulky printouts and card files was required which took as long as three weeks. Another reason for the transition is the staff's recognition of the real value of the freshly updated information provided by the system. This strongly contrasts with the low value of bulky inventory reports, sometimes three months out-of-date, which previously served as the main source of inventory management information. For instance, the staff at supply depots now has available the up-to-date state of inventory at each activity, number of items of each kind there were at the last inventory taking, how many have been issued since, and how many have been received. This information is invaluable in expediting material shipment.

In view of the current emphasis on cost-effectiveness in system selection, it is pertinent to discuss the savings inherent in introducing on-line information systems. For example, the transaction-by-transaction processing makes better use of the computing equipment, thus offsetting the higher cost of random-access mass storage required for on-line operation. In addition, the shortening of the decision process in responding to material requisitions is reflected by reduced cost of necessary inventories; at ASO, savings from reduced inventories alone (three weeks less supply) paid for implementing the on-line services.

Although some savings such as the above can be predicted before actual system implementation, others can be determined only through experience. For instance, at ASO it was found that there was a decrease in the number of erroneous shipments. Since the cost of each shipment is relatively high (approximately $100), even a small reduction in such errors results in significant savings. Reduction in procurement actions, based on actual up-to-date usage statistics that became available, produced further savings.

Development of Experimental Facility

The experience gained at ASO clearly indicated that close man-machine cooperation is essential in effective problem solving. This led to the development of specifications for a prototype man-machine general problem-solving system which could be applied to practically



Graphic console at the problem-solving facility

all fields of intellectual endeavor. Typical examples are library service, law, medicine, engineering, and management. These specifications in turn led to the design of an automated, memory-oriented, problem-solving facility at the University of Pennsylvania which combines on-line information storage and retrieval capability with on-line programming. The user may prepare programs for new system functions at a remote terminal and transmit them into the mass memory.

The total problem-solving capability of the facility is growing with usage. All kinds of information, *e.g.*, resources, problem-solution structures, methods, and algorithms, are being stored for further use, thus allowing the system to accumulate knowledge and capability. The incoming information, whether programs or data, is being organized in records and indexed with association words so that it can be retrieved in response to descriptions of new problems. The system is being enhanced continuously through reindexing and reclassifying the changing organization of the total information.

The experimental facility at the University of Pennsylvania has already been utilized in attacking various problems in the fields of library service, sea traffic control, competitive games, legal research, and medical information. The system that has evolved during the last seven years is applicable to a great variety of naval organizations, and should have a major impact on future naval tactical, strategic, and logistic environments.

New Polymers – New Uses

Herman F. Mark
Department of Chemistry
Polytechnic Institute of Brooklyn

The conventional, classical fields for the application of organic polymers are the industries of textiles, packaging and printing materials, rubbers, plastics, coatings, and adhesives. These fields represent a very large volume of synthetic and natural polymer consumption—more than 60 million tons in 1966 in the United States alone. However, they are gradually being saturated with numerous materials which compete with each other; the future does not offer a very promising outlook for substantial further expansion. Thus, it is essential to determine whether other areas of industrial activity could absorb substantial quantities of organic polymers if properties and costs of these polymers were so adjusted that their application would prove advantageous—both technically and economically—to these industries. Such application should also prove advantageous to the nation as a whole, including both military and civilian activities.

It appears that the construction industry could consume considerable quantities of all kinds of organic polymers *if* certain properties or, even better, certain combinations of properties could be built into these materials. This would include the construction of boats, airplanes, and buildings. To get a rough estimate of the dimensions involved, it should be mentioned that such building activities in the US in 1966 amounted to about 150 billion dollars. Twenty percent of this amount was spent for construction materials such as metals, concrete, brick, glass, and wood.

Polymers, if used in the construction industry, could serve either as *structural* (load-bearing) units or as *finishing* materials. The latter category could either service the system being constructed with water, air, gas, fuel, and/or electricity or provide for the finishing of its surface, floors, ceilings, and walls. Until now, polymers have been mainly used in the finishing sector as floor tiles, coatings, covers, electrical and thermal insulating materials, *etc.*

It is obvious that the successful expansion of polymer application in this field cannot be brought about by the development of one single property, *e.g.*, tensile strength, to an extravagantly high value. Rather, it will take a combination of several properties to make a polymeric material particularly valuable and attractive for a special use. A rubber tube, for example, must be soft, flexible, elastic, abrasion resistant, impermeable to air, and resistant to temperatures up to 150°C.

For polymeric materials to be used as structural units, the following characteristics must be present:

- High rigidity modulus—if possible, higher than 700,000 psi;
- High softening or melting point—if possible, higher than 500°C;
- High tensile strength—if possible, higher than 100,000 psi;
- High elongation to break—if possible, above ten percent;

(Note: Favorable values of high tensile strength and high elongation to break result in a large area being under the stress-strain curve, *i.e.,* a large amount of energy will be required to break or tear the material. This, in turn, manifests itself as high impact strength and high abrasion resistance.)

- High resistance to the action of solvents and swelling agents even at elevated temperatures; and
- High resistance against deterioration by heat, radiation, and aggressive chemical reagents.

Materials having a somewhat favorable combination of the above properties will find numerous profitable applications.

Crystallization and Crosslinking

Three different principles—crystallization, crosslinking, and the use of inflexible chain molecules—have already proved useful in achieving reasonably well balanced compromises of the above properties. Further, these principles should be good working hypotheses for future efforts in achieving still better combinations.

It has long been known that the crystallization capacity is a very valuable property of linear, flexible macromolecules when a good combination of thermal and mechanical properties is desired. Even linear polyethylene, which is a completely nonpolar material with weak interchain bonding, is rigid, relatively high melting (130°C), strong, tough, abrasion resistant and insoluble in anything at room temperature *only* because it possesses a strong tendency to crystallize, *i.e.,* to form lamellae, bundles, or domains of high lateral order. The same thing is true for isotactic polypropylene, which melts at 170°C, and for isotactic polystyrene, which melts at 230°C. If the macromolecules contain polar groups and are of regular architecture, even better combinations of mechanical and thermal properties can be obtained. Examples are polyvinyl alcohol, polyvinylidene chloride, polyoxymethylene, and many aliphatic polyesters and polyamides, *e.g.,* polycaprolactam or 66 and 610 nylon. All of these materials have intrinsically flexible chain molecules of regular architecture which have a distinct tendency to form crystalline domains. A systematic accumulation of the interchain forces inside these domains rigidifies and reinforces the entire structure to such an extent that the system becomes hard, high softening, and insoluble.

It has also long been known that a combination of favorable properties can be obtained by the chemical crosslinking of long, flexible chain molecules. Rubber is a typical example. As the original segmental mobility of the individual chains is reduced by establishing localized but strong carbon-sulfur and sulfur-sulfur crosslinks, the material becomes more rigid, higher softening, and less soluble. As more and more crosslinks are introduced, their average distance along flexible chains decreases, and the system is progressively stiffened. Finally, hard rubber or Ebonite, a material which is rigid, high softening, and completely insoluble and unswellable, is materialized.

The effect of crosslinking depends on certain factors:

- *The length of the crosslinking element* is important because very short crosslinks such as direct bonds between the carbon atoms of two chains, methylene bridges or sulfide, disulfide, and thiosulfoxide bonds, create stiffness and high softening sooner than longer crosslinks such as those provided by the use of diamines, diepoxides, diolefins, dialdehydes, and diisocyanates. Apparently, the original segmental mobility is maintained when the relatively flexible chains of longer crosslinks are used, even if the tiepoints are relatively close together.

- *The chemical nature of the crosslinks* is important for resistance to elevated temperatures and to chemical reagents. To illustrate, carbon crosslinks are very resistant to both influences; sulfide, disulfide, and ester crosslinks are sensitive against heat and alkali; acetalic tiepoints are sensitive to acids; and urethane-type bonds are cleaved by elevated temperature. Thus, depending on the nature of the base polymer, a rather wide choice of crosslinking agents is available which will produce three-dimensional networks with desired properties.

The incorporation of a reinforcing filler into a polymer causes an effect similar to that caused by crosslinking. The term "reinforcing" refers to the very intimate contact that exists between the filler and the polymer chains in molecular dimensions, and to the strong adsorption forces which fix and immobilize the polymer chains at the surface of the filler particles.

Although the effects caused by crosslinking and crystallization appear to be very similar, there are important differences:

- The rigidity in a crystalline system is the result of many, regularly spaced lateral bonds between the oriented chains. Each of these bonds is weak; the ultimate effect comes from their large number and their regularity. In a crosslinked system, the bonds between the long flexible chains are strictly localized, strong, and randomly arranged in the system. As a result, crystallization is a *reversible* phenomenon, whereas crosslinking is *irreversible*. Thus, crosslinking is the preferred technique for producing thermoset resins.

• Crystallization is a *physical* effect which takes place at all temperatures and which is strongly influenced by mechanical processes such as orientation and relaxation. Crosslinking, on the other hand, is a *chemical* phenomenon which needs the presence of certain special reagents, is strongly accelerated by elevated temperatures, and is only slightly influenced by mechanical processes.

Many hard, infusible, and insoluble products are made with the aid of crosslinking. These products include (1) all hard rubbers; (2) urea-, melamine-, and phenol formaldehyde condensation products; (3) polyesters which use glycerol, trimethylol propane or pentaerythritol as components; and (4) resins which are hardened by grafting styrene on a polyester backbone containing aliphatic double bonds. Although there are obvious and significant differences between the effects of crystallization and crosslinking, it is encouraging that *two* different principles can be used to attain a desirable combination of valuable properties. The use of stiff linear chain molecules presents a *third* independent principle that can be used to arrive at the same result.

Inflexible Chain Molecules

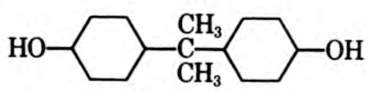
Crystallization and crosslinking produce stiffness, high softening, and difficult solubility by establishing firm lateral connections between intrinsically flexible chains. The same result can be obtained by incorporating the stiffness in the *individual* chains and constructing them so that their segmental motion is intrinsically restricted. One step in this direction is introducing bulky substituents into chains with flexible backbones. For instance, polystyrene, although it has no crystallinity or crosslinking, is still a hard, relatively high softening (90°C) polymer. The absence of crystallinity results in complete transparency; the absence of crosslinking results in reversible moldability and easy-flow characteristics.

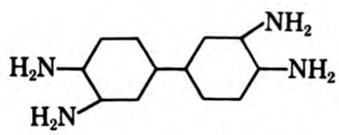
Similar conditions prevail in polymethylmethacrylate, a material which is linear, noncrystalline, and which has intrinsically flexible backbone chains. However, these backbone chains are stiffened by the two substituents, CH_3 and $COOCH_3$, at every other carbon atom. As a result, polymethylmethacrylate is a hard, brilliantly transparent, relatively high softening (95°C) thermoplastic polymer with many useful and valuable applications.

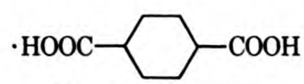
The only weakness of both materials is their low resistance against swelling and dissolution. It seems that, although the bulky and eventually polar substituents are capable of producing favorable mechanical and thermal effects connected with the overall mobility and flexibility of the chain segments, they cannot offer sufficient resistance to the penetration of the system by solvents or swelling agents. This latter process is a strictly localized phenomenon and depends on the affinity of the substituents for the particular solvent molecules.

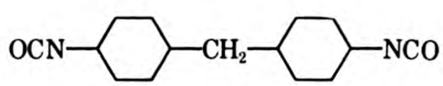
Similar effects are produced in cases where the backbone chains themselves are rigid and their substituents are so arranged that crystallization is prevented. Classical examples of such polymers are cellulose acetate and cellulose nitrate. The glucosidic backbone chains in these materials possess a considerable intrinsic stiffness, and the irregularly arranged acetyl and nitrate groups of incompletely substituted specimens do not permit crystallization. In any case, both materials are hard, transparent, high melting, and noncrystalline thermoplastic resins which have been widely and successfully applied for many years. Cellulose acetate, like polystyrene and polymethylmethacrylate, is still rather sensitive to the action of solvents and swelling agents; cellulose nitrate only dissolves in a few selected systems.

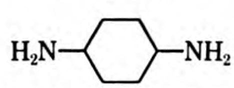
The principle of using intrinsically rigid chains has recently been studied in more detail, and several new and interesting embodiments have been found. Some of these structures are shown below:

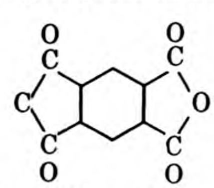

Bisphenol


Tetraminodiphenyl


Terephthalic acid

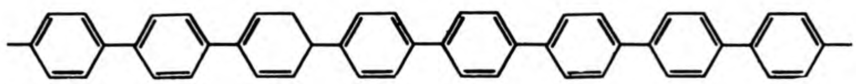

Methylene bis phenyl-
isocyanate


Paraphenylene diamine


Pyromellitic anhydride

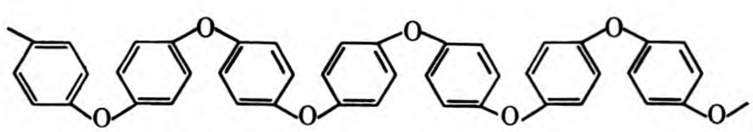
Based on rigid monomeric units, such as those shown above, polymers have been synthesized which are substantially uncrystalline and uncross-linked; but which represent very hard, high softening, and solvent resistant materials. Early examples of this type are the polycarbonates and the linear epoxy resins which are based on bisphenol. More recent representatives are polyphenylene oxides, polyphenylene sulfides, polyxylylenes, polybenzimidazoles, polyimides, and polyphenyloxazoles, all of which exhibit unusually high resistance to softening, swelling, and decomposition. In fact, some of these materials can stand temperatures up to 500°C for long periods without softening or deteriorating, and are completely insoluble in all organic solvents up to 300°C.

Other rigid molecules currently being studied for possible application in the field of high temperature resistant materials are based on aromatic chains such as polyphenylene which cannot fold even at rather high temperatures. This is due to the fact that, although rotation



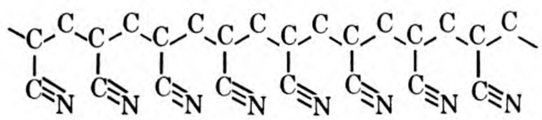
about the carbon-carbon single bond between the *para*-combined phenylene rings can lead to different angles between the planes of consecutive rings, this rotation *cannot* lead to a kink or bend in the main chain. Thus, representatives of this species are rigid, high melting, have high crystallization tendencies, and are highly insoluble. This combination of valuable properties of poly-*para*-phenylenes has been investigated intensely, and several types with relatively high molecular weight have been synthesized.

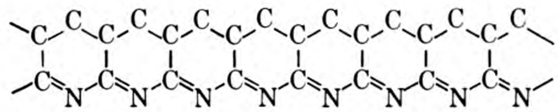
Para-polyphenylene oxide and polyphenylene sulfide are other examples which show the chain stiffening action of a *para*-phenylene unit. Rotation about the bonds between an ether oxygen atom and the adjacent carbon atoms of the ring does change the plane of the angle



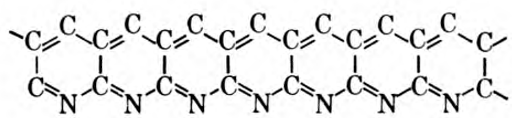
between two units, thus leading to bends and kinks in the chain. However, the rotational freedom is noticeably inhibited by the presence of the aromatic rings on either side of the oxygen or sulfur atom. Consequently, chains of this type represent high melting, rigid, and relatively insoluble materials.

Another interesting way to arrive at chains made up of condensed rings is the synthesis of so-called ladder polymers. The first example of such a structure was prepared by exposing polyacrylonitrile to elevated temperatures. The resultant electron pair displacement caused rows of fused six-membered rings to form. (Note: This is accomplished by electron moving from lower left corner of chain to lower right corner, thus completing the ring.)





This displacement caused the polyacrylonitrile to stiffen, discolor, and become highly insoluble. Further heating leads to evolution of H_2 and aromatization. Thus, a black, completely infusible, and insoluble



material is obtained whose structure corresponds to a linear graphite in which one carbon atom of every ring has been replaced by nitrogen.

These examples show that there are many possibilities for the formation of long, stiff chains. In all cases, the properties of the resulting materials have been more than satisfactory.

Combined Use of All Three Principles

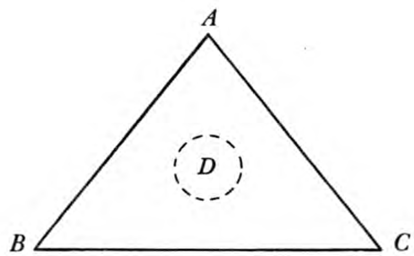
The existance of three different and independent ways to establish favorable compromises of valuable properties stimulates the attempt to explore combinations of these principles to see whether such combinations might lead to even better results. To get a convenient survey of such combinations, let us consider a triangle in which the three principles of crystallization, crosslinking, and chain stiffening are represented by the three corners or points, A, B, and C, respectively.

The corner A is populated by a large number of crystallizable, thermoplastic polymers with flexible chains which have proved to be particularly successful as fiber and film formers. Representative materials are polyethylene, polypropylene, polyoxymethylene, polyvinyl alcohol, polyvinylchloride, polyvinylidenechloride, and such polyamides as six and 66 nylon.

Corner B contains the typical thermoset, highly crosslinked systems such as hard rubbers; urea-, melamine-, and phenol formaldehyde condensates; highly reticulated polyesters; polyepoxides; and polyurethanes.

Finally, corner C is representative for the amorphous, thermoplastic resins with relatively high rigidity and high softening range. This includes polystyrene, polymethylmethacrylate, ABS resins, polystyrene derivatives, polycarbonates, linear polyepoxides, polyethers, and polycondensation products with inflexible chains.

To determine whether a combination of two of these principles has helped in forming products with more attractive and valuable properties, let us explore the sides of the triangle.



The line A-C accommodates several interesting fiber and film formers, one of which is polyethyleneglycol terephthalate (Terylene or Dacron). Even though polyesters have no lateral hydrogen bonding available to stiffen their solid crystalline phases, the *para*-phenylenic units of the acid introduce enough chain stiffening to bring the melting point of this polymer up to about 260°C—as high as the melting point of 66 nylon. Thus, chain stiffening cooperates with crystallization to produce attractive properties without bringing either of the two principles to an extremely high value.

Cellulose is another case in which excellent fiber and film-forming properties are built up by a combination of chain stiffening and crystallinity. These two effects together produce a polymer which is extremely rigid, does not melt at all, and is soluble only in a very small number of particularly potent liquid systems. Because of the presence of substantially rigid chains, high tensile strength and high softening characteristics become apparent at relatively low degrees of crystallinity. Thus, cellulose lies somewhere in the middle of the line connecting A and C.

Many of the recent spectacular improvements in cellulosic filaments were made by capitalizing on the dual origin of their fiber-forming potential. Cellulose triacetate is another example of the benefits resulting by combining A and C. In this case, the capacity to crystallize superimposes several favorable properties on the normal cellulose acetate, particularly insolubility in many organic liquids and heat settibility.

The line A-B contains all those rubbers which are slightly or moderately crosslinked and which crystallize when progressively stretched. Examples are natural rubber, high *cis* polybutadiene and polyisoprene, butyl rubber, and neoprene. They lie more or less close to point B, depending upon the degree of crosslinking.

Up to this point, only systems of one component, *i.e.*, a specific polymer or copolymer, have been considered. However, in the technology of elastomers, it is customary to produce stiffening and temperature resistance by adding a hard, finely divided solid filler, *e.g.*, carbon black, silica, or alumina. The small, hard particles of the crystalline or pseudocrystalline reinforcing filler restrict the original segmental mobility in the polymer chains, thus causing a kind of crystallization of the system. In this manner, the presence of a filler simulates and replaces crystallization, bringing the system closer to point A.

The line C-B has been populated with certain useful polymers in an attempt to increase rigidity, high softening, and insolubility of stiff chain systems by additional crosslinking. In one instance, the combination of these two principles resulted in raising the heat distortion point of acrylic- and methacrylic polymers. This was done by incorporating allylmethacrylate or ethyleneglycol dimethacrylate. A second example is the "curing" of epoxy polymers, materials which are based on such stiff chain elements as bisphenol and cyclic acetals of pentaerythritol. Attempts are now being made to improve the properties of the more recent amorphous systems which have intrinsically stiff chains by cautious crosslinking, thus moving these materials from point C towards point B. The principal reason for this approach is to improve the resistance against dissolution and swelling at elevated temperatures.

The advantageous combination of two principles poses the question of whether or not a proper combination of all three could lead to still further improvements in property compromises. Much exploratory work is currently being done in this field, and certain interesting results have been obtained. One successful application of all three principles is aftertreating cotton with certain crosslinking agents or spinning rayon in the presence of such agents. By swelling cotton or appropriately spinning rayon, the rigid chains found in cellulose can be brought to a more moderate degree. The resultant fibers, although they possess satisfactory strength, elongation, hand and dyeing characteristics, have insufficient recovery power. However, by introducing a cautiously controlled system of crosslinks with the aid of bifunctional reagents, the recovery power and wrinkle resistance properties can be improved substantially. Further, this action does not affect the desirable properties which are present. Similarly, promising results have been obtained with mildly reticulated amorphous stiff-chain systems of the epoxy and urethane type where a reinforcing filler has replaced crystallization.

The combinations of all three principles are situated somewhere in the center of the triangle—point D. A thorough, systematic exploration of this area should lead to many new and interesting polymeric systems.

Marine Mammals to Join Sealab III Experiment

During training session in lagoon at Point Mugu, trainer works with Moki, the sea lion (right) and Gordo, a young harbor seal. Tuffy, the porpoise, looks on from the water.

Two porpoises, two sea lions, and a harbor seal will join 40 U.S. Navy aquanauts during Sealab III. It is expected that one of the porpoises will be Tuffy, the animal which won world-wide popularity during the Navy's Sealab II experiment in 1965.

The animals will be used for search and rescue, delivery of small items, propulsion aid, and assistance in underwater photography.

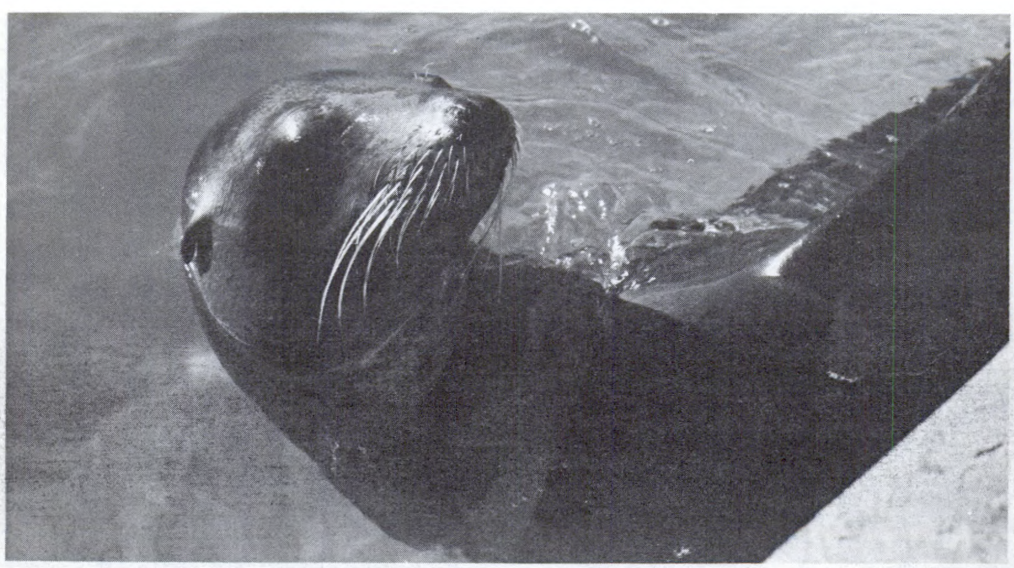
In delivering materials from the surface to the aquanauts, the animal would carry the item on his harness to the aquanauts on the bottom. Plans also provide for the animals to carry items between divers on the bottom and up to the surface. Materials carried by the animals could include tools, emergency medical supplies, specimens for laboratory analysis, and miscellaneous support items.

Using one of the marine mammals to assist a lost diver is also being studied. The animal will be trained to respond to an acoustic emergency signal by diving to the habitat, picking up a line, and carrying it to the diver who sounded the signal. The diver could then follow the line back to the Sealab habitat. The animal may also be trained to tow the diver to the habitat.

General training of two Atlantic bottlenose porpoises, two California sea lions, and one harbor seal to be used in Sealab III is underway at the Marine Bioscience Facility, located at the Naval Missile Center, Point Mugu, California. The mammals are being taught to "home" on an acoustic signal (even while untethered in the open ocean), to wear a harness, to carry a package on the harness, and to wait near a diver while the package is removed. By the summer of 1967 personnel of Sealab III will have defined the tasks the animals are to perform and their advanced training will begin.

As a secondary benefit from their support of the Sealab III operations, the Navy expects to obtain valuable research information not only on the adaptability, capabilities, and reliability of the animals, but also on the effectiveness of the methods of training and selecting animals for various types of work. It may also indicate new ways the animals can assist man in his exploration of the sea.

Left: Gordo, the young harbor seal, investigates activity outside his tank.
Below: Moki, the sea lion, takes a breather between training classes.



Research Notes

Fifty Research Programs Selected Under Project Themis

Secretary of Defense Robert S. McNamara has announced the selection of 50 research programs at universities located in 30 states and the District of Columbia under Project THEMIS during the academic year beginning this fall. Funding for the individual programs will be negotiated with the institutions.

Project THEMIS was initiated in January 1967 by Secretary McNamara in response to President Lyndon B. Johnson's request to all federal agencies engaged in research and development to examine their existing practices and policies and to explore the possibility of creating new opportunities for additional centers of research excellence within the nation's institutions of higher learning.

Project THEMIS has two complementary objectives: (1) the development of new centers of excellence capable of solving important defense problems in the years ahead, and (2) a wider geographical distribution of defense research funds, favoring institutions which have not heretofore received substantial opportunity and financial support in the field of defense research.

All research programs under Project THEMIS, which has an initial funding authorization of about $20 million from the Congress, will be unclassified. Funds for continuation of Project THEMIS support of the 50 pioneer programs and for an additional 50 programs in institutions of higher learning have been requested by the Department of Defense for FY 1968.

A total of 480 defense research proposals were submitted for the initiation of Project THEMIS by universities throughout the country. Screening reduced this number to 107 and further consideration resulted in the selection of the 50 programs listed below:

Project Themis Proposals Accepted

Institution	*Title*	*Service*
Alaska, Univ. of	Human Ecology	Army
Arizona State Univ.	Human Performance in Isolation	Navy
Auburn Univ.	Information Processing	Army
California, Univ. of; San Diego	Transport Phenomena in Flow Systems	Air Force
Case Institute of Technology	Research in R&D Management	Joint
Dartmouth College	Time-Shared Computing Systems	ARPA/Air Force
Delaware, Univ. of	Fluid Mechanics and Heat Transfer	Army
Florida State Univ.	Geophysical Fluid Dynamics	Navy
Florida, Univ. of	Solid State Materials	ARPA/Air Force
Florida, Univ. of	Logistics and Information Processing	Army
Georgetown Univ.	Laser Technology	Air Force
Georgia Inst. of Technology	Low Speed Aerodynamics	Army
Georgia Inst. of Technology	Interface Phenomena	Air Force
Hawaii, Univ. of	Astronomy Research	Navy
Houston Univ.	Information Processing System	Navy
Indiana Univ.	Environmental Hazards	Air Force
Iowa State Univ.	Auto. Navigation and Control	Navy
Iowa State Univ.	Ceramic and Composite Materials	Air Force
John Carroll Univ.	Laser and Ultrasonic Radiation	Air Force
Kansas State Univ.	Performance in Altered Environ	Air Force
Kansas, Univ. of	Remote Sensing Instrumentation	ARPA/Army
Kansas, Univ. of	Social and Behavioral Science	ARPA/Air Force
Louisiana State Univ.	Infectious Communicable Disease	Army

Louisiana State Univ.	Digital Automata	Air Force
Massachusetts, Univ. of	Deep Sea Submersibles	Navy
Minnesota, Univ. of	IR Detector and Laser Technology	Navy
Minnesota, Univ. of	Gas Turbine Technology	Navy
Mississippi State Univ.	Rotor and Prop Aerodynamics	Army
Missouri, Univ. of	Fluid Transport Properties	Army
Nevada, Univ. of	Cloud Physics	Air Force
New Mexico Inst. of M&T	Environmental Sciences	Navy
New Mexico Univ.	Radiation Effects	Navy
New York, State Univ. of; Albany	Modification of Environment	Air Force
New York, State Univ. of; Buffalo	Environmental Physiology	Navy
North Carolina State Univ.	Materials Response Phenomena	ARPA/Navy
Notre Dame, Univ. of	Deep Sea Eng. and Aerodynamics	Navy
Ohio Univ.	Low Level Navigation	Army
Oklahoma State Univ.	Electronic Description of Environ	Army
Oregon State Univ.	On-Line Computer Environ Research	Navy
Rutgers Univ.	Separated Flow	Air Force
Stevens Inst. of Technology	Nonlinear Physics of Polymers	Navy
Stevens Inst. of Technology	Cryogenic Science and Eng.	Army
South Dakota School of Mines	Modification of Convective Clouds	Navy
Southern Methodist	Automatic Navigation	Air Force
Tennessee, Univ. of	Dynamic Sealing	Navy
Texas A&M	Optimization Research	Navy
Texas A&M	Meteorology Research	Army
Texas Christian Univ.	Human Pattern Perception	Army
Utah, Univ. of	Chemistry of Combustion	Air Force
Virginia, Univ. of	Learning Control Systems	Army

Navy Tests Equipment For Use In Sealab III

Equipment and procedures which will be used in the U.S. Navy's forthcoming Sealab III experiment are now being tested in a unique underwater engineering program known as STEP.

STEP—an acronym for Submerged Test Engineering Platform—is providing the Navy with an opportunity to conduct experiments in an underwater environment similar to that which will be encountered in Sealab III. This phase of the advance preparation for Sealab III is being conducted by the Navy Mine Defense Laboratory in Panama City, Florida.

The STEP program involves the following areas:

- Mental alertness tests,
- Heat-loss studies,
- Evaluation of carbon monoxide filtration equipment, and
- Evaluation of an infra-red oven and a washer-dryer unit.

The tests for mental alertness and mental measurements will be made with volunteer subjects to further study diver efficiency in an underwater working and living situation, and to assist in establishing aquanaut "comfort levels" for the Sealab III habitat.

The heat-loss studies are being undertaken because helium is the principal gas used in the sea-floor habitat's artificial helium-oxygen atmosphere. Helium is a very efficient conductor of heat; however, this results in a high body heat loss by the aquanauts. This problem is to be resolved through the use of new insulation and heating equipment in the habitat. The latter will consist of heating coils embedded in the concrete floor of the habitat, thirteen overhead radiant heaters, and two vent-duct heaters. In addition, each of the aquanauts will be provided with an electric blanket.

The heat-loss studies will also investigate the heat-transfer possibilities involved in removing carbon monoxide from the habitat. A nonburning device using hydrogen gas as a fuel will be evaluated as a means of changing carbon monoxide to carbon dioxide which can be easily filtered. Heat is generated as a byproduct of this action.

An infra-red oven will be added to the electric stove used in the Sealab II experiment. This oven will speed the preparation of meals in the habitat; pre-packaged meals will be cooked, ready-to-serve, in 10 to 12 minutes. The frozen pre-packaged meals must fit into an oven $4 \times 21 \times 16$ in.

The washer-dryer unit being tested for use in Sealab III will process hundreds of towels to be used by the 40 aquanauts during the 60-day experiment. After each excursion into the water, the aquanauts will require a hot water shower to remove the salt water from the body. The shower also aids in restoring normal body temperature. It is estimated that each aquanaut uses approximately four fresh towels per day during his 12-day stay on the bottom, thus requiring a total of 2000 towels for the entire experiment.

The "platform" being used in these experiments is the cylindrical Sealab I chamber. The chamber—40 ft long and 10 ft in diam—was converted from surplus equipment floats to serve as the habitat during the Navy's first underwater living experiment, conducted at a depth of 193 feet in 1964. The chamber is submerged at a depth of 60 feet for the STEP program.

During Sealab III the depth capability of the Man-in-the-Sea program will be extended to the 425-450 feet level in the waters off San Clemente Island, California.

Use of Two-Dimensional Media for Real-World 3-D Visual Displays Evaluated

The Naval Training Device Center, Orlando, Florida, as an in-house project, has evaluated two-dimensional media for storing and reading out three-dimensional images of real-world terrain and displaying it on a television screen. The first phase evaluated a special set of factored transparencies, one containing the elevation information; the other, the ground texture information. These, in turn, were read out with a flying spot type of scanner. The latter, as the daylight source, generated a raster type of presentation that was projected through both transparencies *via* a lens system. The variations in the transmission of light, because of the transparency, were picked up and amplified by the respective photomultiplier tubes located at the end of each light path. Thus, two video signals were produced. This information, including any shadow characteristics in the stored scene, was combined in a video processor and displayed on a standard TV monitor.

In the next phase, the use of closed-circuit TV for viewing a hologram transparency was demonstrated. This phase of the task investigated the real and virtual images generated by a hologram transparency. The holograms were of various objects, such as aircraft carriers, trucks, and tanks. The size of the recorded image was approximately equal to the actual model in size, *i.e.*, no magnification or demagnification was intended. A laser beam or mercury light source with appropriate filter was used to illuminate the transparency. The hologram plate was mounted on a serve-operated turntable for rotation relative to the TV camera.

A visual display using a hologram plate is not only physically compact, but is also capable of supplying all the necessary three-dimensional information of real models. However, the state-of-the-art has not progressed to the degree where large areas of scene or terrain information can be stored on a small plate because of inability to illuminate the entire area. Another advantage of the hologram which was demonstrated is the ease of changing the scene by simply inserting a different transparency for another training situation.

NASL Develops New Firefighting System

Forces afloat and Navy firefighting schools will shortly receive a unique portable high expansion foam generating system developed by the Naval Applied Science Laboratory.

Within the past few years liquid fuel fires have been reported in engine, boiler and machinery spaces on a number of naval and merchant marine vessels. To meet this situation NASL designed and developed a portable high expansion foam system consisting of foam generating equipment and a sea water foaming agent for putting out liquid fuel fires.

High expansion foam, unlike conventional firefighting agents used aboard ship, will fill a compartment in a few minutes, flowing over and around obstructions, engulfing fires without reflash. High expansion foam can be applied from outside a compartment through a hatch opening, as compared to conventional agents which must be applied directly on, or in the immediate vicinity of, a fire. A swivel-mounted door can be positioned to direct the foam emission horizontally or vertically.

With this system the firefighting personnel need not remain in the vicinity of the foam generator during a fire since the foam agent can be introduced into the system at distances up to 250 feet from the foam generator.

New Navy Satellite, Designed to Study Auroras, Launched

A new Navy satellite, Aurora I, was launched in tandem with the Army's SECOR satellite from Vandenberg Air Force Base, California, June 29. The launching vehicle, the newly developed Thor/Burner II combination, placed both satellites in a circular polar orbit 2000 miles above the earth.

The Aurora satellite, built by Rice University for the Office of Naval Research, is designed to collect information on how auroras are formed. Specifically, it will measure the number and intensity of electrons and protons which enter the upper atmosphere from outer space. The satellite's instruments will also measure the emissions produced, principally aurora formations, when they collide with oxygen and nitrogen in the atmosphere.

Auroras are believed to be closely associated with magnetic storms and ionospheric disturbances which frequently degrade or disrupt radio communications. These disturbances also affect the performance of over-the-horizon radar systems, navigation systems and satellite-borne instrumentation. A better understanding of the sources and causes of these magnetic storms would lead to improved and more reliable systems.

The Aurora satellite, which weighs about 48 pounds and measures 24 in. × 14 in. × 10 in., will operate three detectors. One of these instruments, known as SPECS (Switched Proton Electron Channeltron Spectrometer), will make 36 separate measurements of the energy particles, ranging from very low to very high energy ranges. There is also a photometer designed to measure the intensities of red, blue and green light in auroral displays. Another photometer designed to measure ultraviolet light will permit the study of daytime auroras which cannot be detected from the ground. The satellite will transmit continuously at a frequency of 137.140 megacycles per second with a power of almost 700 milliwatts. Power will be supplied by nickel-cadmium batteries trickle-charged by solar cells.

The Aurora satellite is being monitored by tracking stations throughout the world, including Rice University's own receiving station on the Houston campus. Other auroral observatories located in Canada, Norway, Denmark, England, Sweden, New Zealand, and Alaska are participating in monitoring and evaluating the scientific data received from the satellite.

Fluidic Flight Control System for Helicopter

The development of a fluidic flight control system for a helicopter is being sponsored by the Naval Air Development Center, Johnsville, Pa. An all-fluid flight control system is described as one that uses moving streams of air or liquid instead of moving parts to sense and control a vehicle's motion. The NADC system, which is being developed by Honeywell, will be powered by bleed air from the helicopter's jet engine compressor.

The program, which has been underway since January, is aimed at demonstrating that such a system can reduce a helicopter's basic instability in flight. Plans are being made to flight test the system aboard a Navy CH-46A tandem-rotor helicopter, probably at the Patuxent River Naval Air Station next November.

NRL Scientists Measure the Moon

Radar Astronomers at the Naval Research Laboratory recently made the first accurate measurement of the moon, and found it isn't quite as big as they thought it was.

The NRL scientists, using a highly sensitive, special purpose radar system, determined that the average lunar radius is about 1.2 miles less than the presently accepted value of 1080 miles. This determination is based on radar-obtained data which shows an error of 6,652 ft in the accepted distance from the moon's center to its surface on the side facing earth.

When available radar data is combined with information provided by Lunar Orbiter I and Ranger VIII, a central lunar bulge ranging from 5,000 feet in the flatlands to 15,000 feet in the mountains becomes apparent. The bulge's existence and actual size have been a matter of controversy among astronomers for many years.

Allan Shapiro of the NRL Atmosphere and Astrophysics Division revealed the findings on July 26 at a meeting of the Committee of Space Research (COSPAR) being held in London. He presented a paper which he coauthored with E. A. Uliana, B. S. Yaplee, and S. H. Knowles, all of whom are on the staff of the E. O. Hulburt Center for Space Research at NRL.

Between August 11 and December 22, 1966, the four scientists used radar pulses to determine the lunar radius of the side facing the earth in about 230 different lunar areas with an accuracy of 500 feet. Currently accepted lunar radius values are based on optical measurements which are far less accurate than radar data.

Although NRL scientists have been attempting to determine the lunar radius with radar since 1957, a high degree of accuracy was not possible until last year when Lunar Orbiters I and II pinpointed the center of mass for the moon. This information completed an equation with which an accurate determination of lunar radii can be made using radar data.

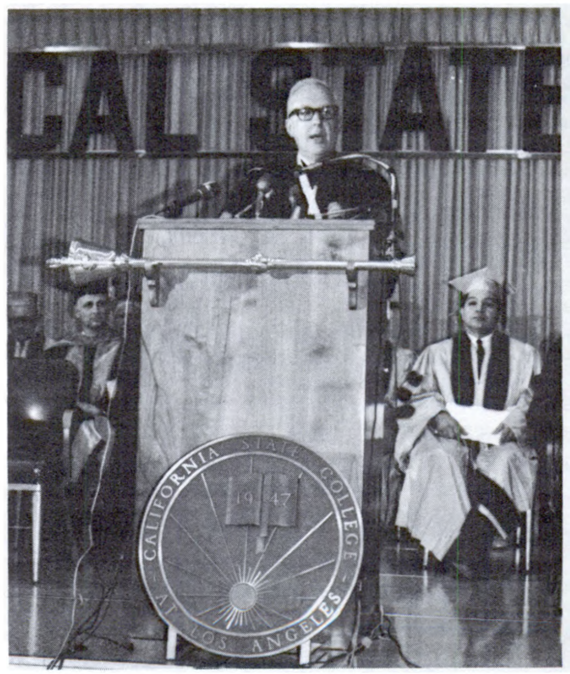
Radar data confirmed optical observations concerning variations in topography of the lunar surface. In addition, it was able to supply absolute values to the variation which could not be attained with optical instruments.

The Seventh Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems will be held at the Nassau Inn, Princeton, N.J., September 25-27. Additional information on this conference, which is sponsored by the Naval Air Turbine Test Station, may be obtained from Mr. R. A. Reale, NATTS.

An Active Sonar Classification Symposium will be held at the Navy Postgraduate School, Monterey, Cal., October 3-5. Additional information on this symposium, which is sponsored by the Sonar Systems Office, Naval Ship Systems Command, may be obtained from Code 1622, NAVSHIPS.

On the Naval Research Reserve

CDR J. A. Greenlee, USNR, Appointed College President



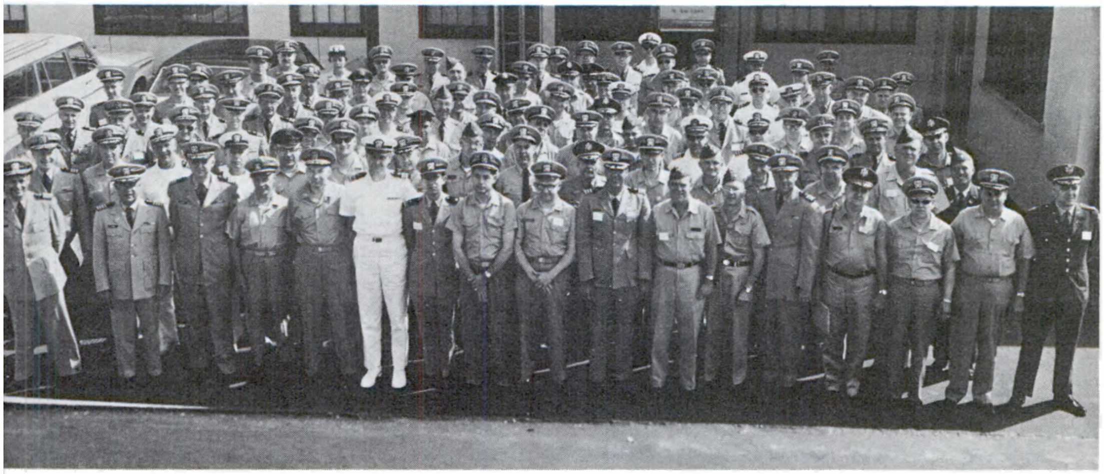
CDR John A. Greenlee, USNR, a member of NRRC 11-2, Pasadena, was recently inaugurated as President of California State College, Los Angeles, California. He joined the faculty of the college, the fifth largest in western United States, in 1965 as Vice President for Academic Affairs, and was appointed Acting President in 1966.

CDR Greenlee, who assumed his present rank in July 1955, was the founding officer for the Research Reserve company at Iowa State University. He has been associated with Research Reserve companies at the University of Iowa as well as at Pasadena, California.

Annual ONR Research Reserve Seminar

The 18th Annual ONR Research Reserve Seminar was conducted during the period June 5-16, 1967 in Washington, D. C. It was attended by 88 Navy, 14 Army, and seven Air Force reserve officers. The theme of the seminar, which was sponsored by NRRC 5-8, was "Today's Research and the Navy's Long-Range Objectives." CAPT Ernest J. Zellmer, USNR, Commanding Officer of NRRC 5-8, and CAPT J. R. Patton, Jr., USNR, a past Commanding Officer, served as co-chairmen for the seminar.

To carry out its theme and to bring the research reservists up-to-date, the seminar was organized into three parts: (a) presentations on the status of various naval weapons systems, their problems, and long-range objectives, (b) two field trips to naval research facilities (one day at the Naval Medical Research Institute at Bethesda, Maryland, and one half day at the Annapolis Division of the Naval Ship Research and Development Center), and (c) presentations on research in the fields of materials, human factors, energy, and electronics. As an added feature, the



seminar members spent one half day at the Naval Academy where they were briefed on the curriculum and viewed the facilities. Later, they enjoyed a crab feast hosted by NRRC 5-11 which meets in Annapolis.

The seminar was privileged to have its session opened by RADM John K. Leydon, USN, the then Chief of Naval Research, and to have its keynote presentation made by the Honorable Robert A. Frosch, Assistant Secretary of the Navy (Research and Development). The new Chief of Naval Research, RADM T. B. Owen, USN, briefed the seminar on the activities of the Naval Research Laboratory, which command he was relinquishing at that time.

Among the speakers on the naval weapons systems, problems and objectives were: ADM I. J. Galantin, USN, Chief of Naval Material; RADM R. S. Benson, USN, Commandant, First Naval District; RADM W. D. Houser, USN, Office of the Joint Chiefs of Staff; and officers from the Office of Naval Operations. These officers were: VADM C. B. Martell, USN, Director, Office of Anti-Submarine Warfare Programs; RADM P. A. Beshany, USN, Director, Submarine Warfare Division; RADM R. M. Isaman, USN, Director, Strike Warfare; and RADM F. H. Michaelis, USN, Director, Air Surface and Electronic Warfare Division.

The four days spent on research topics were chaired by members of the Office of Naval Research: Dr. J. H. Shenk, Director, Material Sciences Division; Dr. G. C. Tolhurst, Head, Physiological Psychology Branch; Dr. R. Roberts, Head, Power Branch; and Dr. A. A. Shostak, Electronics Advisor to the Chief of Naval Research.

Although the seminar had scheduled presentations on Vietnam in order to review that current problem, it had not anticipated the Mid-East crisis which erupted during its sessions. Dr. Fred Harrigan, a member of the National War College faculty, stepped into the breach and presented a background briefing on the situation there.

The second week of the seminar was spent at the National War College. The excellent facilities there permitted the seminar to break into small discussion groups at the end of each day's research presentations to review the topics and to correlate them with the long-range naval objectives presented during the first week. By this means, the officers were drawn into an "active loop" rather than remaining "passive receptors" throughout the session. Four members summarized the group discussions at the closing session of the full assembly.

During the seminar, a joint evening session was held with five research companies and a political military affairs company of the Washington area. The guest speaker for this meeting was VADM Fitzhugh Lee, USN, Commandant of the National War College, who presented a broad survey of the strategic factors affecting the several world power groups. A lively question period moderated by RADM Leydon climaxed this session.

The seminar proved to be an exceptional opportunity for Research Reserve officers to get "the word" on a number of fronts.

Mr. Pryce Receives Navy Superior Civilian Service Award

Mr. George W. Pryce, Associate Director (Management and Support), Naval Training Device Center, Orlando, Florida, recently received the Navy Superior Civilian Service Award. Presentation of the award, the highest that a bureau or office chief can bestow upon a member of his staff, was made by RADM J. K. Leydon, the then Chief of Naval Research, during a ceremony held June 29, 1967.

As a result of the Naval Training Device Center being moved from Port Washington, New York to Orlando, a number of complex management and personnel problems had to be analyzed and resolved in a relatively short period of time. The problem was further complicated because the relocation program had to be phased in three increments over two fiscal years.

To help resolve these problems, Mr. George Pryce, then Deputy Director of the ONR Civilian Personnel and Services Division, was detailed to Orlando in May 1965. He served as special management assistant to investigate all problems in the critical areas and to provide the detailed planning necessary to rebuild good personnel and management engineering offices. Upon completion of this task, in September 1965, Mr. Pryce joined the staff at Orlando at the senior management level. Since that time, he has continuously demonstrated his superior ability and devotion to the Center's problems.

Dr. Pappert Receives Award

Dr. Richard A. Pappert, a physicist at the Naval Command Control Communications Laboratory Center, San Diego recently received the Center's 1967 Honorary Scientific Award. Dr. Pappert, who has specialized in the modal propagation of vlf and elf radio waves, was the first to provide a theoretical interpretation of modal line splitting in the earth's cavity resonance lines which occur at extremely low radio frequencies.

Selected Contract Research Reports

The contract research reports listed below have been extracted from the Technical Abstract Bulletins 67-13 and 14 of July 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 67-13 and 14.

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

ASTRONOMY AND ASTROPHYSICS

Reports of Observatories, 1965-1966. University of Florida Observatory, University of Florida; Fla. U., Gainesville; Smith; AD-651 446

Morphology of Jupiter's Decametric Radio Sources; Fla. U.; Smith; AD-651 274

Gravitational Red-Shifts in Quasi-Stellar Objects; CalTech; Fowler and Hoyle; AD-652 191

Spectra, Masses and Rotation of Southern Galaxies; Wesleyan U., Middleton, Conn.; Page; AD-652 018

On the Synthesis of Elements at Very High Temperatures; CalTech; Wagoner *et al;* AD-652 178

Investigation of a New State in O15 Near the N14 + p Threshold; CalTech; Hensley; AD-652 225

A Quasar Model Based on Relaxation Oscillations in Supermassive Stars; CalTech; Fowler; AD-652 228

Radiative Corrections to the Neutrino-Electron Interaction; CalTech; Hebb; AD-652 229

ATMOSPHERIC SCIENCES

Response of the Geomagnetic Activity Index Kp to the Interplanetary Magnetic Field; Calif. U., Berkeley; Schatten and Wilcox; AD-652 380

Absorption and Emission in the 8-MM Region by Ozone in the Upper Atmosphere; Calif. U., Berkeley; Caton *et al;* AD-652 575

Simultaneous Observations of Solar Protons Inside and Outside the Magnetosphere; Iowa U.; Krimigis *et al;* AD-651 480

Ionospheric Motion and Internal Gravity Waves; Columbia U.; Bugnolo; AD-651 937

A Computer Program for VLF Ray Tracing in a Model Ionosphere; Iowa U.; Shawhan; AD-651 942

Microbarographs for Measurements of Atmospheric Waves; Columbia U.; Clay and Kraft; AD-651 820

BEHAVIORAL AND SOCIAL SCIENCES

On Some Efficiency Properties of the Two-Sector Production Model; Yale U.; Drandakis; AD-651 325

Stylistic Analysis; System Development Corp., Santa Monica, Calif.; Sedelow; AD-651 591

Note on Revising Instructional Programs; American Institutes for Research in the Behavioral Sciences, Palo Alto, Calif.; Brooks; AD-651 490

Intellectual Abilities of Symbolic and Semantic Judgment; Univ. of S. Calif., Los Angeles; Hoepfner *et al;* AD-651 222

Outline of an Information Processing Model for Simulating one Kind of Problem Solving; Yale U.; Johnson; AD-651 230

An IBM 1620 Program for Administering a Problem Solving Task to Individual Subjects; Yale U.; Johnson; AD-651 231

The Trans-Cultural Research and Training Institute (TCI); Human Sciences Research, Inc., McLean, Va.; Loubert; AD-651 312

Response Time as a Function of Response Mode and Item Difficulty; American Institutes for Research in the Behavioral Sciences; Brooks *et al;* AD-651 359

Communication, Cooperation, and Negotiation in Culturally Heterogeneous Groups; Ill. U.; Fiedler; AD-651 411

Some Necessary Steps Toward an Effective Theory of Organizational Behavior; Rutgers—The State U.; Indik; AD-651 633

The Evolution of Perceptual Frames of Reference; Amphenol Corp, Broadview, Ill.; Bevan *et al;* AD-651 872

Generation Difference in Values: American, Japanese-Americans and Japanese; Hawaii U., Honolulu; Arkoff *et al;* AD-651 874

On Methods and Purposes in Econometric Model Building; Princeton; Dagum; AD-652 572

Personnel Psychophysics: The Functional Relationship Between Job Complexity and a Number of Electronic Maintenance Training Variables; Applied Psychological Services, Wayne, Pa.; Pfeiffer and Siegel; AD-652 391

Prolonged Stress in Sealab II: A Field Study of Individual and Group Reactions; Yale U.; Helmreich; AD-651 974

Research Involving Communication Processes in Task Oriented Groups; Tufts U., Medford, Mass.; AD-652 390

Uncertainity as a Motivating Variable; Dartmouth Coll.; Lanzetta; AD-652 413

Experimental Interference With Primary Associates and Their Subsequent Recovery With Rest; Tulane U.; Bilodeau; AD-652 538

BIOLOGICAL AND MEDICAL SCIENCES

Effect of Prednisolone on Synthesis of DNA and RNA by Human Lymphocytes in Vitro; Calif. U., San Fran; Tormey *et al;* AD-652 513

Studies of Heme-Proteins. Dissociation Equilibria of Horse Hemoglobin; Minnesota U.; Mizukami and Lumry; AD-652 523

Hydrogen Bonding Specificity of Nucleic Acid Purines and Pyrimidines in Solution; M.I.T.; Kyogoku *et al;* AD-652 639

Feeding and Attack Patterns of Sharks; Cornell; Gilbert; AD-651 997

Placentation and Associated Aspects of Gestation in the Bonnethead Shark, Sphyrna Tiburo; Cornell; Schlernitzauer and Gilbert; AD-652 009

Electrocardiographic Studies of Free-Swimming Sharks; Cornell; Gilbert and Douglas; AD-652 011

The Visual Apparatus of Sharks; Cornell; Gilbert; AD-652 012

The AIBS Shark Research Panel; Cornell; Gilbert; AD-652 015

Plasma Infusions in Immunologic Deficiency States: Metabolic and Therapeutic Studies; Calif. U., San Fran; Stiehm *et al;* AD-652 521

Moniliasis, "Autoimmune" Polyendocrinopathy, and Immunologic Family Study; Calif. U., Los Angeles; Wuepper and Fudenberg; AD-652 522

Duration of Chronic Electroshock Treatment in Relation to Brain Weight, Brain Chemistry, and Behavior; Stanford; Pryor *et al;* AD-652 529

DNA Base Composition of Cytophaga Marinoflava n. sp. Determined by Buoyant Density Measurements in Cesium Chloride; Georgetown U.; Colwell *et al;* AD-652 540

Adansonian and Molecular Studies of Marine Bacteria; Georgetown U.; Colwell; AD-652 543

Effect of High Pressure Oxygen on the Uptake of DL-lysine-H3 by Brain and Other Tissues of the Rat; State U. of N.Y., Brooklyn; Ford *et al;* AD-652 296

Proceedings of the Symposium on Underwater Physiology (3rd), March 1966, Washington, D.C.; N.A.S.-N.R.C.; Lambertsen; AD-652 315

Stress Reviews. Thermal Stress—Heat; Texas Christian U., Fort Worth; Duke *et al;* AD-652 580

DNA During the Development of the American Sea Urchin; Columbia U.; Rosenkranz and Carden; AD-651 485

A Safranin-Fast Green Stain for the Differentiation of the Nuclei of Rumen Protozoa; Iowa State Univ., Ames; Schiff *et al;* AD-651 632

Ice Formation in Aqueous Media of Biological Interest; American Foundation for Biological Research, Madison, Wis.; Luyet *et al;* AD-651 765

Contributions to the Knowledge of Flora and Vegetation of the Southwestern Alaskan Mainland; Arctic Inst. of North America, Washington, D.C.; Hulten; AD-651 884

Electroencephalograms of Sharks; Cornell; Gilbert *et al;* AD-651 896

Dendrocoelopsis Periformis (Turbellaria Tricladida) and its Parasites From Northern Alaska; Arctic Inst. of North America; Holmquist; AD-651 921

The Selachian Nictitans and Subocular Fold; Cornell U.; Gilbert and Oren; AD-651 932

Screening of Flame-Resistant Materials and Comparison of Helium With Nitrogen for use in Diving Atmospheres; Union Carbide Corp., Tonawanda, N.Y.; Cook *et al;* AD-651 583

CHEMISTRY

Fluorocarbonyl Hypofluorite; Wash. U.; Cauble and Cady; AD-651 618

Direct Mass Spectrometric Sampling of High Pressure Systems; Midwest Research Inst., Kansas City, Mo.; Milne and Greene; AD-651 458

Spin-Echo NMR Studies of Internal Rotation in 1,1-Difluoro-1,2-Dibromodichloroethane; Ill. U.; Vold and Gutowsky; AD-651 476

Molecular g-value, Magnetic Properties, and the Ground State Electronic Structure of Fluoracetylene; Ill. U.; Weiss *et al;* AD-651 500

Rare Earths. Dissociation Energies of the Gaseous Monoxides of the Rare Earths; Pa. U.; Ames *et al;* AD-651 562

Molten Carbonate Electrolytes as Acid-Base Solvent Systems; Rensselaer; Janz; AD-651 604

Emission Microwave Spectroscopy: OCS; Lockheed Missiles and Space Co., Palo Alto, Calif.; Hill *et al;* AD-651 870

Sign and Magnitude of the Rotational Moment of 12C160; Harvard U.; Ozier *et al;* AD-651 898

Magnetic Resonance Molecular-Beam Spectra of Methane; Harvard U.; Anderson and Ramsey; AD-651 943

Kinetics of the Reaction of Fluorine With Difluoramino Radicals and the Dissociation of Fluorine; Dow Chemical Co., Midland, Mich.; Diesen; AD-651 951

The Dielectric Relaxation Spectra of Water, Ice, and Aqueous Solutions and Their Interpretation. Critical Survey of the Status Quo For Water: Tentative Interpretation of the Relaxation Spectrum of Water in the Time and Frequency Domain; M.I.T.; von Hippel; AD-651 964

Inorganic Coordination Polymers. Titanium (IV) Phosphinate Polymers; Pennsalt Chemicals Corp., King of Prussia, Pa.; Dahl and Block; AD-651 975

Icosahedral Carboranes. Carborane-Bis (Sulfenylchlorides) as Polymer Intermediates; Olin Mathieson Chemical Corp, New Haven, Conn.; Semenuk *et al;* AD-652 378

Excess Free Energies of Binary Molten Salt Mixtures From emf Data; Rensselaer; Dijkhuis and Janz; AD-651 968

Rotational Magnetic Moments of Alkali-Halide Molecules; Harvard; Mehran *et al;* AD-652 127

The Bound-Free Absorption Coefficient of the Negative Hydrogen Ion; Queen's U., Belfast (Northern Ireland); Bell and Kingston; AD-652 156

Long-Range Interactions Between Atoms and Molecules; Queen's U.; Dalgarno *et al;* AD-652 157

Some Properties of Atomic Helium; Queen's U.; Bell and Kingston; AD-652 158

On the Classical Theory of Electron Capture; Queen's U.; Bates and Mapleton; AD-652 159

Sorption of Gases by Solids; Rutgers—The State U.; Low; AD-652 528

Analysis of NMR Spectra by Means of Double-Resonance Data; Ill. U.; Friedman and Gutowsky; AD-652 640

Dynamic Mechanical Properties of a gel of Cellulose Nitrate in Diethyl Phthalate: Reduced Variable Analysis in Terms of Amorphous and Crystalline Phases; Wisconsin U.; Ferry and Ninomiya; AD-652 567

Indirect Determination of J and T1 by an NMR Spin-Echo Method; Ill. U.; Boden *et al;* AD-652 642

Carbon-13 Magnetic Resonance of Diene-Iron Tricarbonyl Complexes; Ill. U.; Retcofsky *et al;* AD-652 645

Laser Damage Study of Thin Films; Bausch and Lomb, Inc., Rochester, N.Y.; Turner and Refermat; AD-651 988

EARTH SCIENCES AND OCEANOGRAPHY

Biological Stations Occupied From Fletcher's Ice Island T-3 June 13, 1965—May 24, 1966; Univ. of S. Calif., Los Angeles; King; AD-651 393

The Columbia Effluent and its Distribution at Sea, 1961-1963; Wash. U.; Duxbury *et al;* AD-651 580

Research Ships of Opportunity Program, Project Neptune Limnos; Mich. U.; Robertson; AD-651 751

Investigation of Errors in the Measurement of Radiant Energy for Correlation With Primary Productivity; Scripps; Tyler; AD-651 922

Underwater Communication Sounds of the Sperm Whale, Physeter Catodon: Communication Sounds of Finback Whales; R. I. U., Kingston; Perkins *et al;* AD-651 939

Geographic Orientation in Aircraft Pilots: A Post-Flight Method of Reporting Navigation Performance; Human Factors Research, Inc., Goleta, Calif.; Borden; AD-651 324

Precipitates From Hydrothermal Exhalations on the East Pacific Rise; Scripps; Bostrom and Peterson; AD-651 290

Detailed Crustal Investigation Along a North-South Section Through the Central Part of West Germany; Southwest Center for Advanced Studies, Dallas, Texas; Landisman and Fuchs; AD-651 718

Physical, Chemical, and Biological Data From the Northeast Pacific Ocean: Columbia River Effluent Area, Jan-June 1963, Vols. I-VI; Washington U.; Love; AD-651 335, AD-651 336, AD-651 337, AD-651 338, AD-651 344, AD-651 345

Manganese Nodules, Topography, and Thickness of Quaternary Sediments in the Central Pacific; Scripps; Moore, Jr. and Ross Heath; AD-651 713

Sediments and Geomorphology of the Continental Shelf off Southern New England; R.I.U., Kingston; Garrison and McMaster; AD-651 941

Anti-Shark Measures; Cornell; Springer and Gilbert; AD-652 003

Advice to Those Who Frequent, or Find Themselves in, Shark-Infested Waters; Cornell; Gilbert; AD-652 004

Facilities for the Experimental Investigation of Sharks; Cornell; Davies *et al;* AD-652 008

Shark Chaser; Cornell; Gilbert; AD-652 010

Testing Shark Repellents; Cornell; Gilbert and Springer; AD-652 014

Researches on Bottom Organisms, Ecology and Environmental Biology of Adriatic Coast; Bari U., (Italy); Sara; AD-652 020

Physical, Chemical, and Biological Data From the Northeast Pacific Ocean: Columbia River Effluent Area, July-December 1963; Wash. U.; Beck; AD-652 353-356

The Tahiti-Tikehau Expedition; Cornell; Gilbert; AD-652 404

Current Measurements at the Mouth of the Gulf of Thailand, November 1964; Scripps; Faughn and Taft; AD-652 525

Description of Oceanographic Observations at Drift Station Arlis II in 1964-1965; Arctic Inst. of North America, Wash., D.C.; Kusunoki *et al;* AD-652 616

Magnetic Anomalies and Crustal Structure in Eastern Gulf of Mexico; Southwest Center for Advanced Studies, Dallas; Gough; AD-652 024

Aeromagnetic Gravity, and Sub-Bottom Profiling Studies in Western Lake Superior; Wisc. U.; Wold and Ostenso; AD-652 297

On the Possibility of a Helium Flux Through the Ocean Floor; Calif. U., San Diego; Suess and Wanke; AD-652 569

Narrative of Chain Cruise No. 46; Woods Hole; Bowin; AD-652 595

Organic Carbon in Surface Sediment From the Northeast Pacific Ocean; Wash. U.; Gross; AD-652 643

Reflections at the M Discontinuity and the Origin of Microseisms; Southwest Center for Advanced Studies; Hales and Nation; AD-651 966

Simultaneous Measurements on an Ice Island Surface and 1000 Feet Below; Lamont Geological Observatory, Palisades, N.Y.; Heirtzler; AD-652 407

An Average Geomagnetic Power Spectrum for the Period Range 4.5 to 12,900 Seconds; Lamont; Herron; AD-652 585

ELECTRONICS AND ELECTRICAL ENGINEERING

Language Facilities for a Man, a Machine, and Relational Data; Computer Command and Control Co., Wash., D.C.; Mann; AD-651 973

Spatial Data Systems: Organization of Spatial Data; Northwestern; Dueker; AD-652 005

Spatial Data Systems: Systems Considerations; Northwestern; Dueker; AD-652 006

Spatial Data Systems: Special Topics; Northwestern; Dueker; AD-652 007

Graph Theoretic Error-Correcting Codes; Northwestern; Hakimi and Bredeson; AD-652 604

Parametric Upconverter Study; American Electronic Labs., Inc., Colmar, Pa.; AD-651 808

MATERIALS

Stored Energy in Oxide Dispersion Strengthened Copper Alloys; M.I.T.; Chin and Grant; AD-651 358

The Microstrain Region in High-Purity Refractory Metals; Franklin Inst. Research Labs., Phila.; Prekel *et al;* AD-651 761

Strength and Stiffness of Hardwood Fibers; Yale U.; Tamolang *et al;* AD-651 331

Preferential Attack on Coupling Agent Treated Glasses; State U. of N.Y., Stony Brook; Levine and LaCourse; AD-652 408

Instability of Titanium and Ti/6Al/4V Alloy at Room Temperature; Columbia U.; Wood; AD-652 574

Damping Peaks in Deformed Nickel; Columbia; Sommer and Beshers; AD-652 531

Morphology and Mechanics of Wood Fracture; State U. of N.Y., Syracuse; Debaise *et al;* AD-652 055

MATHEMATICAL SCIENCES

Distribution-Free Statistics Based on Normal Deviates in Analysis of Variance; Calif. U., Berkeley; Doksum; AD-652 211

Some Concepts of Dependence; Calif. U., Berkeley; Lehmann; AD-652 216

The Asymptotic Theory of Galton's Test and a Related Simple Estimate of Location; Calif. U., Berkeley; Bickel and Hodges, Jr.; AD-652 290

On the Distributions of the Times Between Events in a Stationary Stream of Events; North Carolina U., Chapel Hill; Leadbetter; AD-652 364

Remarks on Higher Order Spectra; Calif. U., San Diego; Rosenblatt; AD-652 515

Remarks on Ergodicity of Stationary Irreducible Transient Markov Chains; Calif. U., San Diego; Rosenblatt; AD-652 517

Asymptotic Theory of Estimates of kth-Order Spectra; Calif. U., San Diego; Brillinger and Rosenblatt; AD-652 518

The Equilibrium and the Stability of the Riemann Ellipsoids; Chicago; Chandrasekhar; AD-652 520

Total Positivity and First Passage Probability Distributions; Mich. State U., East Lansing; Wang; AD-652 589

Numerical Studies of Strong Shock Waves. Properties of a Shock Wave for a Mach Number of 2.5; Ill. U., Urbana; Hicks and Smith; AD-652 591

Numerical Studies of Strong Shock Waves. Error Analysis for a Mach Number of 2.5; Ill U.; Hicks and Smith; AD-652 592

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Negative Dynamic Programming; Calif. U., Berkeley; Strauch; AD-652 213

Phase Type Service With Different Service Rates; Cornell; Lalchandani; AD-652 396

A Game Theoretical Approach to Some Situations in Opinion Making; Princeton; Marchi; AD-652 573

The Operational Calculus of Jan Mikusinski; Stanford; Newcomb; AD-651 387

Some Rectangular Games With a Two-Man Team; Calif. U., Los Angeles; Jackson; AD-651 525

The Measure Algebra as an Operator Algebra; Wash. U.; Rameriz; AD-651 890

Uniform Approximation by Fourier-Stieltjes Coefficients; Wash. U.; Rameriz; AD-651 891

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

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Random Noise

CDR Harris E. Steinke, inventor of the Steinke hood for submarine escape, has recently been assigned to the Navy's Deep Submergence Systems Project. He will head the Requirements Branch which is responsible for DSSP personnel planning, training requirements, and assisting in defining project goals.

Dr. Richard J. Russell, ONR contractor and formerly Director of the Coastal Studies Institute of the Louisiana State University, has been awarded the Navy Distinguished Public Service Award. The award, the highest honor the Navy can grant a civilian, was presented by RADM P. N. Charbonnet, COM8.

Dr. J. J. Gibson, ONR contractor, was recently elected a member of the National Academy of Science. His research on vision, perception, and spatial orientation has received wide application in various contact analog type displays.

Dr. Thomas S. Austin, formerly Head of Oceanographic Development, Naval Oceanographic Office, has been made Director, National Oceanographic Data Center. NODC acquires, processes, preserves and disseminates unclassified oceanographic data.

Dr. Harold L. Saxton, Superintendent of the Sound Division at the Naval Research Laboratory since 1948, recently retired after 27 years of federal service.

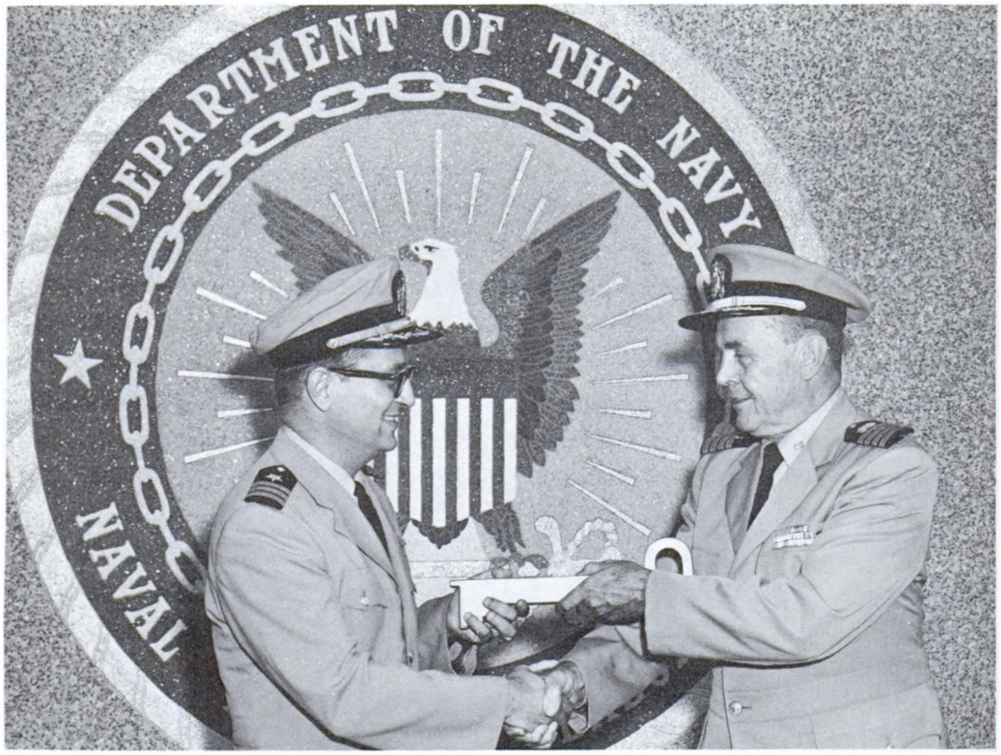
Dr. Paul M. Fye, Director of the Woods Hole Oceanographic Institution, has recently been elected President-Elect of the Marine Technology Society. He will assume the office on July 1, 1968.

Dr. Libber Assigned to ONR London

Dr. Leonard M. Libber, Head, Physiology Branch, Office of Naval Research, has been assigned to a two-year tour of duty at the ONR Branch Office, London. He will serve as a liaison scientist with the primary duty of becoming personally acquainted with the latest research progress in physiology. Also, he will summarize and report these findings to the Navy and the scientific community as a whole.

During Dr. Libber's absence, his associate, Miss Suzanne Kronheim, will serve as the Acting Head of the Physiology Branch.

New NRL Operations and Technical Services Building



CDR George Maragos, USN (left), Director of Support Services at NRL, accepts a symbolic key to the new Operations and Technical Services Building from CAPT Howard F. Curren, USN, Commanding Officer, Chesapeake Division of the Naval Facilities Engineering Command. The ceremony marked turnover of the building to the Laboratory.

The Naval Research Laboratory received the key to its new $3,000,000 Operations and Technical Services Building on July 28.

In a symbolic ceremony marking official turnover of the building, CDR George Maragos, USN, Director of Support Services at NRL, accepted the key from CAPT Howard F. Curren, USN, Commanding Officer, Chesapeake Division of the Naval Facilities Engineering Command.

The two-story structure was designed to provide improved support for the 1100 scientists and engineers engaged in naval research at NRL. Major support elements in the building are the Office of the Comptroller, Technical Information Division and Public Works Division. In addition, the building contains a 150-seat briefing room, a research exhibit hall, and a snack bar.

The construction of the Operations and Technical Services Building is one step in a multi-million dollar long-range development plan designed to continue modernization of the Navy's Corporate Laboratory.

Naval Air Propulsion Test Center Established

The Naval Air Propulsion Test Center, Trenton, New Jersey has been established, effective July 1, 1967. The Center has been created from the old Naval Air Turbine Test Station, Trenton and the Aeronautical Engine Laboratory, Naval Air Engineering Center, Philadelphia.

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Noted Astronomer Receives Navy's Conrad Award

Dr. William Markowitz, currently professor of physics at Marquette University, Milwaukee, Wisconsin, recently received the Navy's 1967 Captain Robert Dexter Conrad Award for Scientific Achievement. Dr. Markowitz retired several months ago from federal service, after a distinguished 30-year career as an astronomer at the Naval Observatory, Washington, D.C. Presentation of the award was made by RADM Edward A. Ruckner, USN, Deputy Chief of Naval Operations (Development) at the 1967 meeting of the American Astronomical Society on June 14.

This is the eleventh annual presentation of the Conrad Award, which was established by the Secretary of the Navy in 1957 as the Navy's highest scientific award recognizing an outstanding Navy scientist or scientific administrator, either civilian or military. Seven of the previous winners have been civilian scientists; three, naval officers. The late Captain Robert Dexter Conrad served in the Office of Naval Research when it was established in 1946 and was the primary architect of the Navy's basic research program.

Dr. Markowitz was recognized for his pioneering research in the field of time and frequency during his service at the Naval Observatory. He developed a system permitting world-wide distribution of precise frequency, which now provides the only method of maintaining the synchronization of clocks located at widely separated sites over the entire world. His precision control technique of high frequency time signals has made possible world-wide synchronization of ship and shore clocks to one microsecond. This increased precision has improved the accuracy of ship and aircraft navigation significantly and led to the development of more precise timing for missiles and satellites.

Dr. Markowitz was also a major contributor to the development of the atomic clock based on the cesium atom. His determination of the fundamental frequency of cesium has been adopted internationally as the definition of the atomic second. Another of his achievements occurred in 1964 when his preeminence in his field enabled him to obtain agreement on the coordination of time signals among the various countries belonging to the International Astronomical Union.

His citation reads as follows:

> "For his negotiations with other countries for synchronization of time and frequency, contributing significantly to increased reliability of techniques used in naval communications; and his extensive research on clock synchronization across the oceans with the aid of artificial satellites, demonstrating the feasibility of effecting synchronization with microsecond accuracy. His distinguished career as an administrator and as an individual researcher has enhanced the position of the United States and the Navy in the fields of astronomy, chronometry, geodesy, communications and navigations."

Dr. Markowitz was born in 1907 in Poland. He received his Ph.D. from the University of Chicago in 1931.

He is married and has one son. The family presently resides at 1626 North Prospect Avenue, Milwaukee.

The 25th Navy Symposium on Underwater Acoustics will be held at the Robert Meyer Motor Inn, Orlando, Florida, November 7-9. Additional information on this symposium may be obtained from Mr. John B. Hough, ONR Code 466.

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The problem-solving experimental facility developed under ONR contract at the University of Pennsylvania has been utilized in attacking various problems in the fields of sea traffic control, competitive games, legal research, etc. See article beginning on page 9.