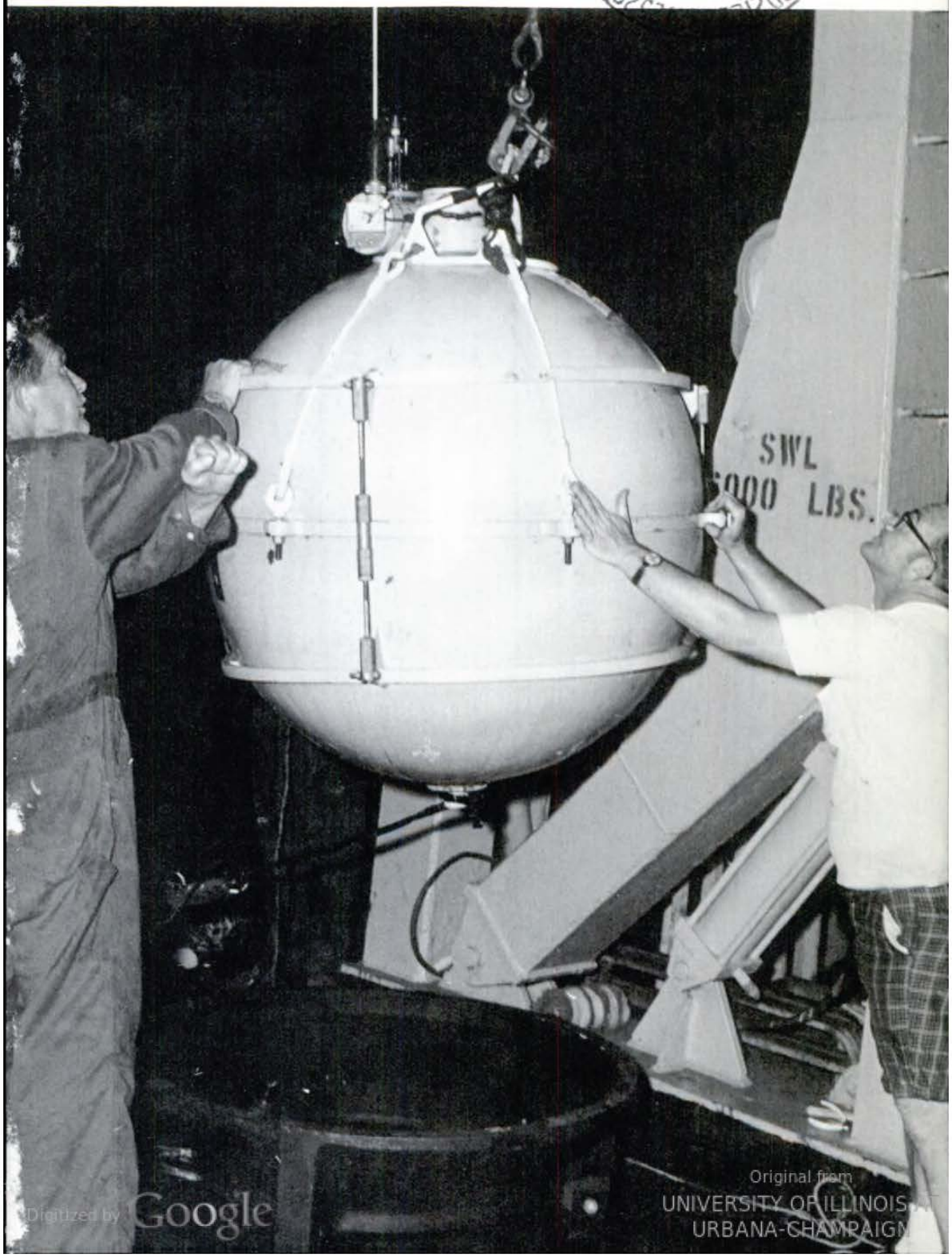
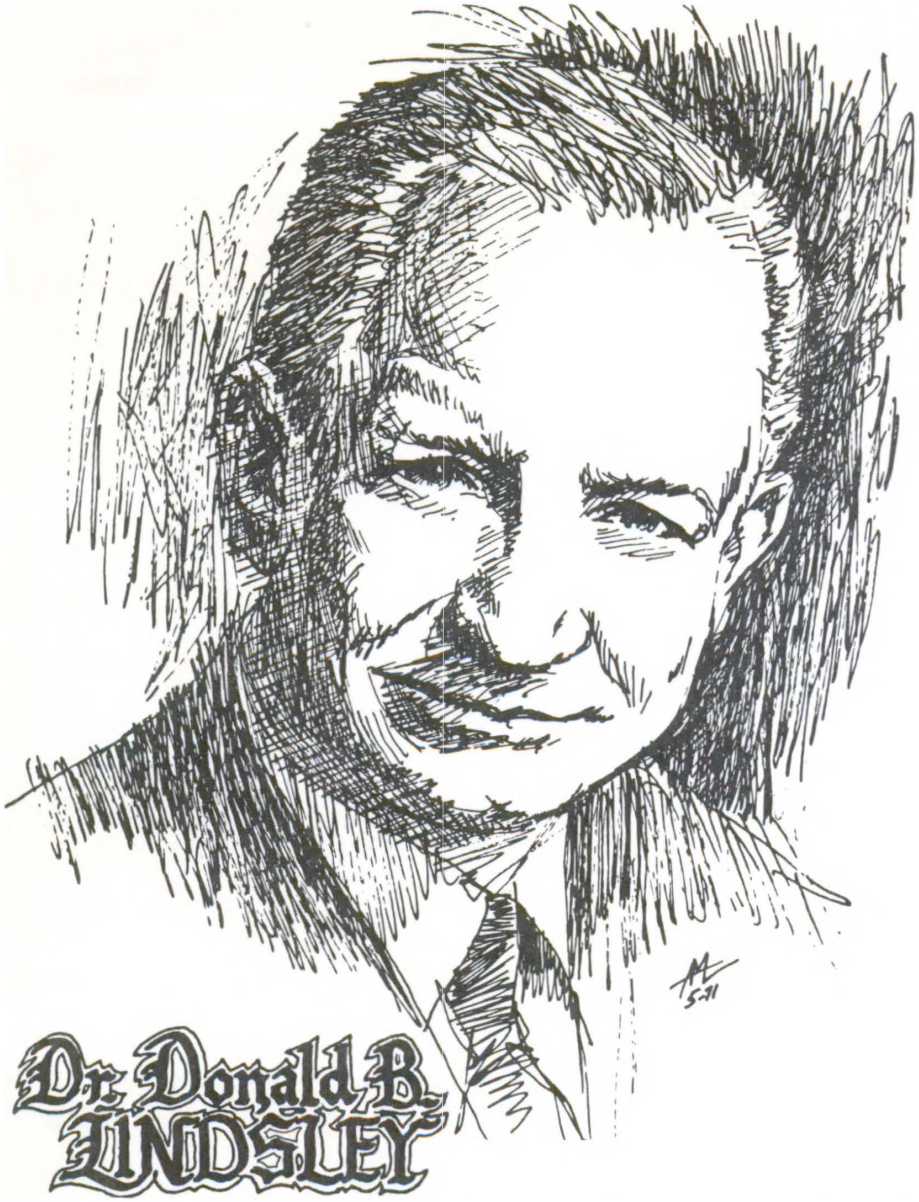
NAVAL RESEARCH REVIEWS

MAY 1971



PROFILES IN SCIENCE



Dr. Donald B. LINDSLEY

Dr. Donald B. Lindsley was a pioneer in the United States in the use of electromyography and electroencephalography as they related to behavior. He has made notable contributions to the understanding of spinal and brainstem reflexes, neuromuscular disorders, the growth and functional organization of the brain and its relation to behavior, especially mechanisms of sleep-wakefullness, emotion, attention, perception, and learning. Lindsley's research on brain organization and behavior was supported from 1956 to 1970 under an Office of Naval Research contract.

During World War II he directed a research group on radar operation and training under the Office of Scientific Research and Development, for which he was awarded the Certificate of Merit by President Truman. He is a member of the National Academy of Sciences. Dr. Lindsley has served on many military and government committees including the Undersea Warfare Committee of the National Research Council in liaison with the Office of Naval Research. As a Professor in the Departments of Psychology, Physiology and Psychiatry at the University of California at Los Angeles, he has been responsible for the training and motivation of numerous graduate and post-doctoral students, many of them have become outstanding scientists and were supported wholly or in part by contract funds.

Personnel and Training Research Programs

Dr. Victor Fields*
Office of Naval Research

Introduction

The Personnel and Training Research Programs are directed to problems of man's preparation for and performance in his world of work—especially work in the Navy and Marine Corps. More precisely, our mission is to support fundamental research in those specialties of behavioral science which we see as likely to contribute to better management of human resources in the Navy through better personnel measurement and evaluation; through better assignment, rotation, and retention; through better training; through better advancement; and, in general, through better utilization of personnel. These aims are subsumed under five task areas.

Within these five task areas we are currently funding 29 work units or contracts. Twenty-two, or 76 percent, of these work units are less than three years old, which in part reflects our recent efforts toward program changes and new directions. Twenty-two of these contracts are solely ONR funded, five are funded by other offices, and two are jointly funded by ONR with the Bureau of Naval Personnel and by ONR with the Marine Corps. With respect to the types of contractors in our program, about 53 percent of them are universities; 44 percent are business firms; and one is an in-house laboratory.

Description of the Research Program

As we indicated earlier, there are five task areas under which our research is conducted. The first area is concerned with research in psychological measurement, personnel selection, and personnel assignment. The effort under this task area constitutes about 10 percent of our total funding commitments in FY 1971. Much of the work in this area has dealt with problems in factor analysis. This is one of the essential statistical techniques in determining the underlying dimensions of human characteristics and capabilities which can be assessed by a myriad of psychological tests. Notable is the work of Tucker at the University of Illinois whose significant contribution of three-mode factor analysis to

Dr. Fields is a Research Psychologist specializing in industrial and educational psychology. He is presently Director of the Personnel and Training Research Programs in the Psychological Sciences Division of ONR. He was formerly Head of the Psychological Research Branch in the Bureau of Naval Personnel.

psychological measurement is well documented in the psychometric literature. Hymphreys, prior to his appointment as an assistant director of the National Science Foundation, worked on computational problems in factor analysis. In the psychometric world, Lord is well known as the author, with Novick and Birnbaum, of a recent book entitled, "Statistical Theories of Mental Tests Scores," which was produced in connection with a contract funded by this program and the Mathematical and Information Sciences Division of ONR. Lord's interest in test item parameters has led him to consider problems of individualized or tailored testing, with or without computers. But to assure future implementation of these concepts, if feasible, we have funded the Navy Personnel and Training Research Laboratory at San Diego to investigate the application of computer techniques to individualized testing.

In this area of selection and psychological measurement, we anticipated some time ago that questions of cultural bias, in mental tests used with disadvantaged members of our society, would become a serious issue in the military services. Therefore we contracted with American Institutes for Research to analyze this problem and find means for correcting test bias if any should exist. They have collected data in industrial and military settings. At this stage of the research the industrial data cast some doubt on the fairness of nonverbal aptitude tests as well as verbal tests. They suggest the use of race or ethnic grouping as a moderator variable, especially in heterogeneous populations. Dunnette at Minnesota is concerned with larger issues involved in psychological testing and equal employment. Because there is much work yet to be done on this problem, we plan to continue the support of research that will investigate the conditions under which bias occurs not only in mental tests but also in interviewing and in performance assessment, especially in connection with minority groups.

The second task area, which constitutes about 40 percent of our current effort, is concerned with the problems of retaining people in the Navy. While the history of the personnel retention problem in the military services is a long one, throughout this long history neither basic nor applied research results have shed much light on the central behavioral or sociological problems. It seems, at least to me, that one essential ingredient for scientific progress on this problem is still missing, *i.e.*, a theory or a model of the process that we are trying to understand and control when we talk about retention. We have therefore emphasized research which we consider important to an understanding of the psychological processes underlying the career motivations and decisions of sailors. Central to this program is the work of Dubin, a sociologist, and Porter, an industrial psychologist, at the University of California (Irvine). Their work is aimed at defining the sources of attachment to work. One of their approaches is presently in the context of incentive systems. They believe that the quality of one's attachment to work and

to the work environment varies with the extent to which the source of attachment is also a source of reward to the working individual. This has important implications for the design of career incentive systems in the Navy and therefore for retention. Concurrently with this work we are supporting research by Beach at the University of Washington on decision-making because of its potential relation to underlying processes of career decisions; by Bass at the University of Rochester on techniques for arousing and directing motivation for self-development in anticipation of future changes in the world of work; and by Nealey at Colorado State University on measuring the relative importance of job factors that affect reenlistment and performance.

Included in this task area is rather large contract with the University of Minnesota under the overall management of Dunnette. While this contract covers a rather diverse program of research, much of it has relevance for the personnel retention question. For example, one of the investigators, England, has formulated a theory of the structure of values which may contribute to our understanding of differential career motivation. In the past his subjects have been executives and managers in industry. More recently he has collected data on Navy officers' values for the purpose of describing, measuring, and understanding their personal value systems and the relevance of those values to behavior, including career attitudes and motivation. Also included in this project are studies on the occupational consequences of differences in personal preferences, studies on impression formation and behavior prediction in employment interviewing, studies on work motivation and other consequences of incentive systems, studies on optimal strategies or multivariate prediction, studies on personnel utilization models, and studies on a system for evaluating the three personnel functions of an organization: staffing, development, and motivation.

Research related to personnel retention is highly relevant to plans for a volunteer force. The absence of a draft will radically change the Navy world of work and the motivational variables of its members. There will be a greater need to understand how systems of incentives operate among volunteers in the Navy. Under these conditions, opportunities will develop for application and testing of research findings including Dubin's model of incentives. This model posits a structure of satisfied, indifferent, and dissatisfied workers for whom differential incentives may be needed.

The third task area is aimed at developing reliable and objective methods of job analysis, evaluation, classification, and design. The funding of this task area was reduced to zero in FY 1971 because of the priority of research in the personnel retention task area. However, we intend to budget for this area in FY 1972 and subsequent years because requirements for job evaluation methodologies, especially in respect to officer billet structures, have already become evident. Furthermore, we may anticipate that the advent of a volunteer force and a Navy

of considerably reduced size will bring problems of job structuring and redesign.

Currently there are two contracts in this task area that were carried over from earlier years. The contract with Performance Research, Inc. provided for a number of meetings of a World of Work panel. The panel was composed of an interdisciplinary mixture of people representing social psychology, industrial psychology, industrial engineering, psychiatry, anthropology, and sociology. This group met from time to time to define the problems in the world of work. Their discussions served to give direction to our plans for research on the interactions between man and his job. In addition, a book has been prepared and is being edited which will not only reflect the discussions of the group but will undoubtedly provoke needed thinking about the way the world of work will evolve in the next few decades.

In another contract, Crossman at the University of California (Berkeley) has been investigating the Jaques concept of time-span-of-discretion as a means of assessing the value of a supervisory job and the level at which it should be placed in the supervisory hierarchy of an organization. The time-span-of-discretion indicates how much time elapses between a person's decision and his superior's review of it. Since time-span is related to degree of responsibility, it should serve as an index of job complexity. While the collection of the data needed to arrive at a determination of time-span has proved to be cumbersome, and shorter methods have proved to be less reliable, the method has promise for the evaluation of very complex jobs that defy other objective means of mensuration.

The fourth task area is aimed at research on proficiency, performance effectiveness, and criterion performance. Only 13 percent of the FY 1971 effort was allocated to this area. A contract recently completed with Siegel at Applied Psychological Services demonstrated the feasibility combining individual performance measures in a unit or ship to estimate the overall effectiveness of the unit. Such global personnel measures may prove to be necessary to meet the future demand for ship-readiness indexes. Mackie at Human Factors Research has been investigating the auditory performance of submarine sonarmen and the kinds of training and job aids that might improve their target classification performance. One such aid under active consideration is a random-access 20-channel tape recorder. This permits playback, on demand, of typical passive sonar sounds. The sonarmen would use the recorded sounds as standards against which to compare the sounds he hears in the water. This should facilitate his task of target classification.

The fifth and final task area is concerned with the effectiveness of learning and training. Of principal concern are the conditions of the learning situation, the individual differences of the learner situation, the individual differences of the learner, and the instructional strategies that

facilitate or inhibit learning and remembering. The funds allocated to this program are about 40 percent of our budget in FY 1971.

This is an area of research that needs emphasis because of its obvious relevance to the immense training establishment of the Navy. Training costs per man are so high that even a slight gain in training efficiency or individual proficiency can be translated into enormous savings in human resources and dollars.

With this in mind, ONR was one of the first to promote individualized instruction by programmed means. This later evolved into computer-assisted instruction (or CAI) which stimulated many innovative undertakings in individualized education and training technology. However, although CAI in the Navy is being studied in operational settings under the specifications of Advanced Development Objective 43-03, there is still much to be learned about the many ways to use the computer as an effective aid to learning and teaching. Therefore we are supporting six tasks which are directly aimed at improving the methods of CAI or which are investigating learning and teaching strategies in the setting of a CAI laboratory. Thus, for example, Rigney at the University of Southern California is attempting to develop methods of student-computer interaction which will be free from the limitations of frame-by-frame presentation. In applying computer-assisted instructional techniques to electronics maintenance training, Rigney has developed a computer program which generates material to be presented to the student on the basis of only a symptom–malfunction matrix. This means that many author hours can be saved when a curriculum must be changed to incorporate a new electronic circuit or a new weapon system. Feurzeig at Bolt, Beranek and Newman is experimenting with CAI programs which monitor a student's performance on line and diagnose his learning difficulties. This work is being done with relative motion and maneuver board problems, a not insignificant component of the junior line officers' curriculum.

Another group of contractors is more concerned with instructional strategies in CAI than with computer software technology. For example, Glaser is attempting to develop techniques which will permit the assessment of the individual learner's relevant characteristics in order to prescribe the learning conditions which will optimize the individual's learning. Hansen at Florida State University performs studies on learning in a CAI laboratory. Hansen's principal concern is with teaching strategies and learning conditions which optimize individualized training, but has also conducted an extensive study of the effectiveness of computer-managed instruction of an entire semester of a college level course of programmed instruction. This contract has also lent considerable support to the Naval Reserve's Project Enrich, a study of the feasibility of CAI in Naval Reserve cadre training. Project Enrich is a significant CAI milestone in the light of the importance being attached by DOD to the

existence of a strong ready reserve backing up a reduced regular force. At Stanford University, Atkinson is studying individual learning styles and instructional strategies by collecting student response data on line in a CAI-administered course on computer programming regularly offered by the university.

Not all of the research in this task area is concerned with computer-assisted instruction. Underwood at Northwestern University is engaged in studies of verbal learning and memory. His chief interest at the present stage of his research is in the mechanisms by which newly acquired information is stored in one's memory. He envisages dimensions of memory and a kind of memory aptitude with possibilities of measuring such an aptitude for personnel selection and assignment purposes. Similarly, Di Vesta at Pennsylvania State University is interested in determining how memory is related to the way the learner organizes the material and the relative effects of visual or auditory modes of learning on acquisition and retention.

While it is expected that reduced turnover will characterize a volunteer force, it is likely that there will be a heavy initial influx of men with marginal aptitude and abilities. Learning and teaching problems will multiply and training facilities, content, and methods may have to be altered. In that event, CAI systems which are highly adaptive to individual differences would be the method of choice. Therefore, research on generative and adaptive systems will be supported at a higher rate than heretofore.

Dynamic Scheduling for Aviation Training

Approached by the Aviation Training Division of DCNO (Air) with the problem of providing effective scheduling of flight training activities, the ONR-supported George Washington University Program in Logistics is conducting research on applying Dynamic Scheduling Systems to problems in resource allocation and utilization in an aviation training context. The major goal is to develop a computer-based dynamic model of the entire aviation training process from the time candidates enter the primary phase and terminate either by designation as Naval Aviators or wash out. The objective is to determine the most efficient scheduling of activities that will minimize the time students must mark time while waiting for the availability of an aircraft. This same model will also highlight such problems as training bottlenecks, holdover pools of students, and the location of inadequate or excessive allocation of resources wherever they exist in the system. Another goal of the research is to design a mathematical model that will make it possible to calculate how many flying hours can be expected from training aircraft when only a certain amount of time is arbitrarily allowed for maintenance. The model is planned to take into account the variability of such factors as weather, runway configurations, number of aircraft on the field, sortie length, syllabus and non-syllabus flights and all other factors which have an influence on the number of hours per year an aircraft can be utilized in flight training activities. Since the cost of aviation training accounts for some 28 percent of the naval aviation budget, it is hoped that this research project will build scheduling tools that will insure maximum pilot training efficiency under budgetary constraints.

Human Processing of Conflicting Information

Robert A. Fleming*
Naval Electronics Laboratory Center
San Diego, California

Two of the most important changes which have occurred in command control systems have been (1) the tremendous increase in the sophistication and accuracy of electronic sensing and identification devices and (2) the vast elaboration of both inter- and ultra-unit communication networks. The result has been that the command control decision maker now has available much more information than he ever had before. Unfortunately, the incoming information is rarely in complete agreement. Often the information is conflicting, such as evaluating one aspect of the tactical situation may suggest one particular course of action while evaluating another aspect of the situation may suggest a completely different course of action. It is the task of the command control decision maker to combine and evaluate this conflicting information in an optimal manner and, on the basis of his evaluation, decide upon his response to the situation.

The present research was concerned with how well humans can combine and evaluate conflicting information. Consider the hypothetical situation of a task unit commander in charge of three ships, which we shall label as A, B, and C. As the task unit steams along, the approach of an enemy plane is detected. The immediate task of the unit commander is to determine which of his three ships is in the greatest danger of attack and then defend that ship. Let us further assume that different characteristics of the plane are associated with differing probabilities of attacking one of the three ships. For example, the altitude of the plane may suggest that it is most likely to attack ship B; its present course, however, may be directly toward ship A indicating that this ship is in the greatest danger of being attacked; and finally, this type of enemy plane may have armament which is best suited for attacking ship C.

	Ships		
	A	B	C
Altitude	.20	.50	.30
Course	.60	.30	.10
Type	.10	.20	.70

*Dr. *Fleming* is an Engineering Psychologist specializing in basic and applied research, computer simulations, programs, and development of computer aided human engineering techniques.

That is, the altitude of the plane indicates it has a 20% chance of attacking ship A, a 50% chance of attacking ship B, and a 30% chance of attacking ship C. The probabilities associated with the course and type of aircraft are interpreted in a similar manner.

On the basis of this information, the commander must decide which ship is in the greatest danger of attack. Which ship do you think it is, assuming that the three characteristics of the plane are equally important and independent of one another?

Given these assumptions, the proper inferential procedure for determining the correct ship is to multiply the column probabilities and then normalize. That is:

$$\begin{aligned} \text{Ship A:} \quad & .2 \times .6 \times .1 = .012 \\ \text{Ship B:} \quad & .5 \times .3 \times .2 = .030 \\ \text{Ship C:} \quad & .3 \times .1 \times .7 = .021 \\ & \qquad\qquad\qquad\quad .063 \end{aligned}$$

Normalize:

$$\begin{aligned} \text{Ship A} &= .012/.063 = .19 \\ \text{Ship B} &= .030/.063 = .48 \\ \text{Ship C} &= .021/.063 = .33 \end{aligned}$$

Thus, the proper evaluation of this conflicting information indicates that the overall probability of attack (OPA) on ship A is .19, while ship B has a .48 OPA and ship C has a .33 OPA. Other things equal, the mathematically correct decision then would be to defend ship B since it is in the greatest danger of attack.

In the experiment, 40 electronic technician trainees at the Naval Training Center, San Diego, were required to complete 200 problems similar to the example just given. They had to state which ship they felt was in the greatest danger of attack as well as estimating the OPA on that ship. Thus, a fully correct response for the sample problem would would have been "B, 48." They had 10 seconds to solve each problem.

With regard to ship selection, the results showed that *none* of the subjects used the correct strategy of multiplying the column probabilities. By far the most common strategy was to *add* these probabilities. This strategy often failed to indicate the correct ship, as is indeed the case in the sample problem where adding probabilities would suggest that ship C is most likely to be attacked.

The use of an adding strategy is particularly ineffective, for it is most likely to fail the decision maker when he is in the greatest need of help, such as on the low OPA problems. The mathematics of the situation is such that with OPAs above .60 adding invariably gives the correct ship. It is only at the lower OPAs (.34-.60) where adding will not automatically

point out the correct ship. But it is precisely at these lower OPAs where one finds the most conflicting information and it is on these problems, not the high OPA problems, that the subjects need the most help. Yet, as just noted, this is where their adding strategy is most likely to fail.

The situation is compounded even further when we examine the results of OPA estimation. The general trend was to overestimate the low OPAs (.34-.50) and underestimate the high OPAs (.50-.99). That is, the subject tends to overestimate the probability of attack on the problems he is most likely to miss and underestimate the threat on the problems he is most likely to correctly solve.

These same results were also found for subjects who were given the complete correct answer (*e.g.*, "B, 48") after each problem.

The results of these experiments strongly indicate that humans adopt a suboptimal strategy when attempting to combine and evaluate conflicting information. Since the mathematics involved are quite simple, the processing of this type of information would seem to be an ideal candidate for automation. The "raw" probabilities could be automatically processed with only the final OPAs presented to the command control decision maker. However, since automation is not always available, it would certainly seem advantageous to instruct any personnel who may have to process conflicting probabilistic information on the basic multiplicative relationship between independent probabilities as well as in general probability theory, Bayes' Theorem, and other related topics.

Scientists Achieve Breakthrough in Laser Research

Naval Research Laboratory scientists have achieved continuous laser oscillation from a free-burning, low pressure flame for the first time.

This significant achievement, which is expected to advance the research of the laser for a variety of uses, was a combined effort of Drs. H. S. Pilloff, S. K. Searles and N. Djeu. This accomplishment was a direct result of experiments begun by the scientists last September.

The scientists reported the free-burning flame laser differs from other chemical laser systems because it does not depend on external power sources (by flash lamps or electrical discharges) or special gas flow techniques.

In explaining their results the scientists stated that once the flame laser has been ignited, it is totally self-sustaining as long as the supply of reagents is maintained. Continuous-wave oscillations were observed in a low pressure CS_2-O_2 flame at three infrared wavelengths with a total power output of about one milliwatt.

In the NRL-developed procedure for measuring optical gain in a flame, these scientists used a mode-controlled laser as an active probe. This method depends on measuring a change in the single mode laser oscillation range when the intra-cavity flame is ignited.

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The ONR Program in Engineering Psychology

Martin A. Tolcott and Gerald S. Malecki*
Office of Naval Research

The Engineering Psychology Programs of the Office of Naval Research are concerned generally with problems relating to the interface between Navy and Marine Corps personnel and the equipment with which they work. The overall program objectives are to generate new knowledge about human performance in the kinds of systems typical of current and future naval operations, and to develop improved ways of organizing, processing and presenting this information so that it may contribute to the design of more effective naval systems. The usual type of scientific relationships dealt with are human performance capabilities on realistic tasks, as they are affected by variations in the design of the equipment being used.

The entire program is included in one budget item, called Human Engineering, but for discussion purposes it is convenient to divide the program into five categories, as follows:

- Information inputs and display concepts
- Motor outputs and control concepts
- Information processing and decision making
- Models, methods and data organization
- Man's performance in the sea

The first three categories—input, output and processing—encompass the three functions normally performed in all systems. Research in these areas seeks answers to one of the major concerns of the system designer—namely, how best to combine man and machine to accomplish these functions. The fourth category deals with the continual problem of translating scientific data into terms usable by design engineers, and developing models and methods to help make use of the data. The fifth category is really a composite because it includes the same types of research as found in the first four categories, except that it applies to the underwater environment. However, underwater performance research has been treated as a separate category for several years, and for those

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**Dr. Tolcott* is Director of the Engineering Psychology Programs at the Office of Naval Research. From 1948 to 1966 he was with Dunlap and Associates, Inc., where he directed a variety of research and consulting projects concerned with design of man-machine systems. He has also served as Director of the Behavioral Analysis Division at the Center for Naval Analyses.

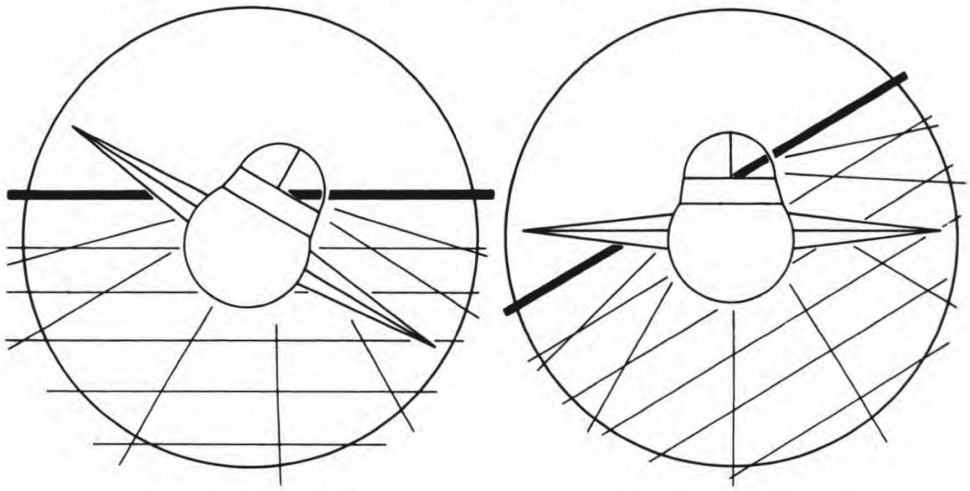
Mr. Malecki is Assistant Director of the Engineering Psychology Program at ONR. His areas of responsibility include research programs related to human engineering design criteria and operator performance in man-machine systems. Prior to his current assignment, he worked at the Naval Personnel Research Laboratory and in the aerospace and metallurgical industries.

interested in examining year-to-year trends, it is treated separately here again.

Information Input and Display Concepts

This portion of the program deals with two types of displays: (1) those designed specifically for use in aircraft, either as flight instrumentation or as part of an airborne weapon system, and (2) those designed for more general use in detecting and classifying weak signals such as might appear on radar or sonar scopes, either airborne or shipborne. Research on aviation displays is represented by two work units. One, being conducted by Roscoe at the University of Illinois, is motivated by the fact that many laboratory studies have demonstrated the superiority of an aircraft attitude indicator in which the moving element is the *aircraft* symbol, rather than the *horizon*. Figure 1 illustrates the difference between these two types of displays. The one on the left shows what a moving aircraft type of indicator would look like when an airplane is in a roll condition; the display on the right shows the traditional moving horizon indicator under the same conditions. Despite previous experimental findings, designers have been reluctant to incorporate the moving aircraft feature into aircraft flight instrumentation, partly because the results have not been fully validated in flight, and partly because of the ingrained experience of pilots. The current research is an *in-flight* experimental comparison between the conventional flight indicator (moving horizon) and a new display concept known as the frequency-separated display.* On the new display, the two extreme concepts are combined

Figure 1 — Illustration of the basic figure-ground controversy in the presentation of aircraft attitude



*See the article *Symbolic Flight Displays* in the February 1971 issue of Naval Research Reviews, page 1.

in a single indicator, on which the moving aircraft symbol responds only to rapid, high-frequency changes in roll or pitch, such as those which are caused by wind buffeting or by initial movement of the control stick, while the horizon moves in response to slower, low-frequency changes (such as might occur during a gradual change of heading or altitude). Flight tests will begin shortly; if flight control accuracy improves, and control reversal errors are reduced, the results could have a significant effect on design of future aircraft flight instrumentation.

The second study is concerned with measuring target acquisition performance by an airborne observer using a television display, as a function of target characteristics and field-of-view of the display. The task simulates part of the process required in operation of airborne missile guidance systems. The work is being performed by D. Jones at Martin-Marietta, in a highly instrumented guidance development center, in which a terrain model moves forward to simulate range closure while a gimbaled flight head provides three rotational degrees of freedom plus lateral and vertical motion. Some of the results suggest that a wide field of view (14.5°) allows smaller targets to be detected and recognized than does a narrow field of view (7.3°), but it also increases the chance of missing a target completely. Also, with a wider field of view, target acquisition time is longer, requiring as much as 42 seconds under low contrast conditions. These results are typical of the kind of performance data useful in conducting system design tradeoffs.

The research efforts dealing with radar and sonar type displays have explored various design techniques for improving detection and identification of targets with low signal-to-noise ratios. For example, work at Human Factors Research, Inc. has shown that photographing a display surface on a pre-stretched film and then shrinking the film, produces an image with greater clarity. Other work has involved modifying the design of displays to be compatible with more effective patterns of eye movement. For example, a rotating radar scope which permits the operator to maintain his visual search along a stationary strobe has been found to improve detection performance. Similarly, experiments have been performed with simulated sonar displays (as shown in Figure 2) which avoid the usual requirements for a spiral search pattern by the operator, as shown on the left. Several types of wedge-shaped displays have been tried, in which the eye movement pattern during search is along the horizontal and from bottom to top, as shown on the scopes on the right. Figure 3 presents experimental results which indicate consistently superior detection performance with one of the wedge displays. The average improvement is equal to about 0.5 decibel of target intensity.

Plans for future research in the area of displays include two major thrusts:

1. Work on aircraft displays will be expanded. One such effort, recently initiated by Gilmour at Boeing with support from ONR's Air

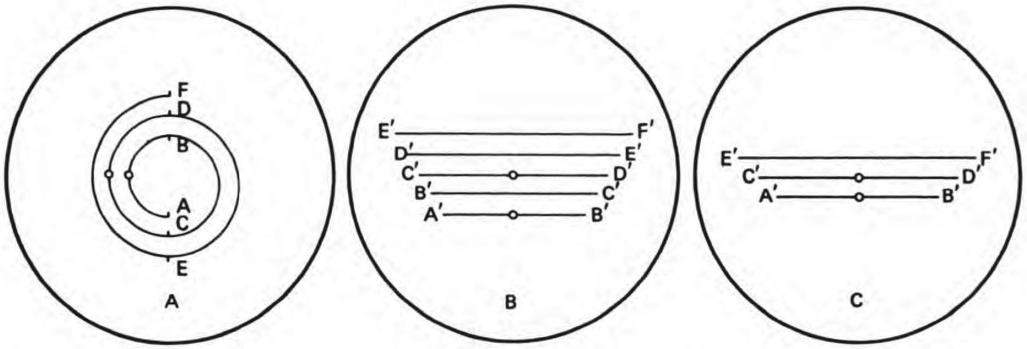


Figure 2 — (A) A portion of an exaggerated spiral display. (B) A portion of a wedge display with a target represented on alternate lines. (C) A portion of a wedge display with a target represented on successive lines.

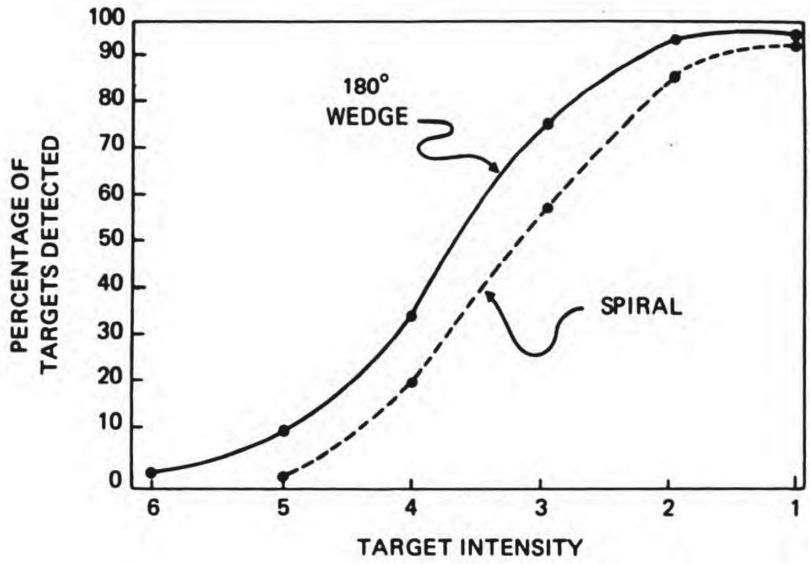


Figure 3 — Showing percentage of targets detected as a function of target intensity (in decibels attenuation of a reference signal) for two displays

Programs Office, is an attempt to develop a quantitative scale to express the overall complexity of a target/background scene as viewed by an airborne observer, and to measure the effect of this complexity on target acquisition. Results could lead to better mission planning and improved pre-flight briefing materials and in-flight aids.

2. Work will be increased on ASW displays, both airborne and ship-borne, especially on computer-assisted methods of enhancing operator performance. The intent here is to take advantage of future trends in automation to enhance human perceptual performance in critical military operations.

Motor Output and Control Concepts

Only one effort is currently underway in this area, namely the final phase of research and development on *Hardiman*. As many people are aware, *Hardiman* is a powered, load-bearing exoskeleton designed by Mosher at GE to be worn by a man to augment his physical strength and endurance. It is powered electrohydraulically, and will provide the user with a capability to lift over 1000 pounds. Its movements are congruent with those of its operator, and a force feedback feature provides the operator with cues necessary for manipulation of objects, such as loading ordnance on aircraft. Successful performance has been demonstrated with one arm assembly, and a complete functioning prototype should be ready for testing in 1971.

Future plans in the category of control concepts are limited to the possible extension of work on adaptive control techniques. The general concept here is that of continually modifying the task difficulty so as to maintain performance proficiency within specified limits. The technique has proven useful in certain training situations, and the thrust of any extended effort would be to apply the principles to an existing Navy simulator to evaluate its utility as a research tool. Studies of carrier landing systems represent a class of research efforts to which this technique could be fruitfully applied.

Information Processing and Decision Making

One effort, recently initiated by Peterson at the University of Michigan, is examining various modes of expressing human judgments about probabilities events, such as predicting a ship's destination on the basis of certain known data about the ship. The focus of interest here is the ultimate development of effective man-computer interactive systems to enhance human decision behavior. Neither the problem area nor the approach are novel; what is new is our attempt to study this behavior in a context which will lead, hopefully, to improved Navy man-machine systems.

Probabilistic judgments are essential in a wide variety of Navy operational situations, including intelligence analysis, target classification, selection of tactics, diagnosis of equipment malfunctions, and many others. The trends toward reduction of military manpower will require that we utilize the potential of computers to the fullest to assist men in these intellectual activities, while making sure that we do not ignore the judgments of experienced military personnel. This means that rather than trying to replace man completely, we must try to combine man and machine wisely. In this research program, hypotheses developed in real operational systems will be tested and refined under controlled conditions in the laboratory, then validated back in the real systems. The

first system being used in this fashion is the Ocean Surveillance Intelligence System.

Plans are to expand this part of the program significantly. Planning is already underway for a conference of decision researchers who are approaching the problem from different points of view, together with Navy operations people who stand to benefit from the application of the new concepts. The intent is to identify concepts which are functionally the same, although they may be expressed in different terms—such as objectives, priorities and utilities, or posterior probabilities and correlations—and to determine the degree of relevance of the various approaches to operational Navy problems. Related research is also being planned to study the problem of how to design computer software so that a man-computer interactive system best serves the needs of the user. Looking at its deeper significance, we anticipate that this part of the program will address the emerging issue of how to avoid the feeling by Navy personnel that they are being overwhelmed by rapid technological changes. For people to operate systems effectively, they must be made to feel that they are still in control. Computers must be able to communicate with people, as well as the other way around. Our job is to learn how to provide guidance to computer system designers.

Models, Methods and Data Organization

This particular portion of the program deals with efforts to furnish engineers and psychologists who are designing systems with the data and methods they need to do their jobs effectively. The translation of human performance research data into design handbook form represents one of the approaches, perhaps the one with the longest history. The most recent effort of this type—the up-dating and expansion of the Joint Services Human Engineering Guide to Equipment Design by American Institute of Research—is now scheduled for completion in 1971. A related effort is one by Teichner at New Mexico State in which research in the literature is being organized into categories concerned with five broad types of performance, and the data being reanalyzed and replotted in an attempt to develop models of the effects of factors influencing human performance over a broad range of conditions.

Others efforts in this area are concerned with developing improved methods for evaluating the human engineering adequacy of equipment and systems during various phases of design and development. Finally, several related efforts are concerned with developing digital simulation models representing systems of varying degrees of complexity. Such models make it possible to evaluate alternative system design concepts rapidly, provided that one can identify, in advance, the relevant human performance variables. Much of the basic work in this field was originally sponsored jointly by several of the programs in ONR's Psychological

Sciences Division, and is now being carried forward and applied to systems in development by Naval Ships Systems Command and the Bureau of Naval Personnel Labs.

Work on the modeling of human behavior will continue to be supported, with future emphasis on design guidelines for computer software designers, as suggested earlier.

Man's Performance in the Sea

The research programs on *Man's Performance in the Sea* encompass the following categories of effort: development of underwater work measurement techniques and instrumentation; measurement of cognitive, perceptual and motor capabilities of divers; determining the effects of thermal stress on human performance; and development of human engineering principles for the design of underwater hand tools and manipulator devices.

These programs span a rather wide range in their goals and context; some are fundamental experiments being conducted in the laboratory and diving tanks, while others are more applied, related to on-going naval operations, and conducted in the open sea. The overall objective is to generate a systematic body of knowledge about man's performance in the sea over a wide range of tasks, tools, and environmental conditions.

One of the newer programs initiated about a year and a half ago by Pesch at Electric Boat is concerned with a comparison of diver performance and remote manipulator operator performance in accomplishing applied undersea tasks. The major variables center about the complexity of the tasks and the design of the manipulator system. Examples of applied tasks which are being investigated are: drilling, pipe joining, cable cutting and valve manipulation.

A diving tank has been equipped with a simulated submersible control station and actual manipulator arm, and shallow water experiments are being conducted in this facility with both divers and manipulator operators.

At sea tests have been conducted in connection with the sea trials of the Autec submersibles, such as the Sea Cliff with its dual manipulator arms.

The results of this research generally indicate that a diver is able to perform all the selected tasks faster and with greater precision than manipulator operators. However, superiority of the diver is highly task dependent; divers are very much faster than manipulator operators for connect/disconnect tasks, but not much better in drilling and tapping tasks. Ultimately, we hope to learn how to combine divers and manipulators most effectively.

In view of the Navy's long range program to exploit the undersea environment, our research on man's performance in the sea will be continued. Immediate plans call for the integration of available data into a systematic format approaching that of a handbook in terms of its usefulness to designers, but also highlighting the research gaps so as to guide our own future efforts. In connection with our Man-in-the-Sea program, we work closely with other Psychological Science programs, other ONR Divisions such as the Biological and the Ocean Sciences, as well as BuMed and NavShips.

Conclusion

In conclusion, the Engineering Psychology Programs will increase its concern with computer-aided human information processing, maintain a strong program in operator performance as related to aviation and undersea systems, and generally place growing emphasis on humanizing an increasingly technological Navy.

Erratum for Note About Polymer Materials for Fuel Tank Sealant

In the March issue of *Naval Research Reviews* a brief article on page 26 described new polymer materials for fuel tank sealants. The second and third sentences of the first paragraph were worded incorrectly resulting in a misleading impression. These sentences should read: "It is believed that present material may not withstand the heat stresses expected at sustained supersonic speeds to be attained in the future by the new naval aircraft. If this should occur and, as a result, fuel vapor should leak into the wing interior, it could impair the performance of the aircraft." We regret any misunderstanding that might have resulted from the original version.

Hydrocarbon Oxidizing Bacteria as Anti-Oil Pollutant

Dr. G. Soli, Naval Weapons Center, China Lake, under an ONR contract, is isolating and characterizing microorganisms capable of degrading hydrocarbons in the marine environment. One of the purposes of this effort is to develop methods for treating bilge and ballast residues aboard naval vessels and oil slicks at sea. Dr. Soli has collected hydrocarbonoclastic microorganisms from various locations along the California coast. The species so far isolated seem to be effective in emulsifying and digesting approximately 75% of the crude oil used in the tests. This digestion takes place within a 48 hour period. Gas chromatography of the small undigested part showed it to consist of high boiling and tar fractions present in crude oil while all the normal paraffins had been biologically utilized. The metabolic products (most of which behave like lipids) of this biological activity are being analyzed. New isolations are planned in the Santa Barbara, California, area where a natural seepage exists.

1700-Foot Helium-Oxygen Chamber Dive by Comex at Marseilles

Dr. Xavier Fructus, Medical Director of COMEX, the very able and energetic French diving company in Marseilles, reported recently on the successful chamber exposure of two young divers, Patrick Chemin aged 22 and Bernard Reuillier aged 25, to a pressure of helium-oxygen equivalent to 1706 ft of seawater. The experiment was carried out in COMEX's Experimental Hyperbaric Center and commenced at 3:00 p.m. on 16 November 1970. The divers were compressed to 1150 ft in 24 hours (1 meter per minute to 355 ft) and then remained there for 16 hours. They descended an additional 160 ft in only 50 minutes the next morning, and then at a slower rate travelled to 1510 ft over the next 10 hours. They rested again for 16 hours over the third night at this depth. On the morning of 19 November they made a fast initial drop to 1610 ft and then traveled more slowly to 1700 ft, which depth was reached at 5:23 p.m. They remained at 1700 ft for 77 minutes, made a short excursion to 1706 ft, and then ascended to 1627 ft in the first 22 minutes of decompression. Final decompression from this depth to the surface extended over the next nine days. The divers emerged in fine condition at 12:10 p.m. on 28 November. They had spent five days at depths greater than 1000 ft and 38 hours at depths greater than 1500 ft.

Oxygen partial pressure was 0.42 atm at 1700 ft and during decompression it was controlled at 0.5 atm. The Scientific Director further commented that, although there were symptoms of static and kinetic tremor with dysmetria and a drop in awareness by each subject during moments of relaxation or when he was not stimulated by a task which interested him, the changes would appear to have only a moderate influence on the behavior and working possibilities of divers at 1700 ft. Observers noted that Reuillier at 1700 ft inserted a wire into a socket and screwed it up with a small screw driver almost as easily as he would have done on the surface, in spite of the tremor and the impression of making an increased effort. In Fructus' opinion the so-named High Pressure Nervous Syndrome does not seem to represent an insurmountable obstacle at depths between 1600 and 2000 ft.

Information about the experiment was received with great interest at the Royal Naval Physiological Laboratory (RNPL) in Alverstoke, Hants., where the former world-record chamber dive to 1500 ft was made only last March. The technique of fast compression followed by long stages with no change in depth was originated by RNPL for that experiment. The fast compression was used to deliberately evoke similar neuro-muscular tremors and EEG changes for study and the long pause was added to permit the divers to return to a baseline condition before proceeding to the next depth level. It was discovered at that time that this effect increases with depth and that a return to baseline was not completed within 24 hours in the deepest range of experiment. If, as has been postulated, the changes described result from a ventilatory acidosis, then the speed of compression and the ambient temperature are two factors which could easily be regulated to limit the disturbance. The U.S. Navy method of slower overall compression without large stages might well prove to be more kindly to the operational divers. The question is not likely to remain much longer in doubt. The number of chambers in the world in which 2000-ft dives

are possible is rapidly increasing, and several laboratories including RNPL have been discussing chamber dives in the range from 1500 to 2000 ft.

The COMEX experiment also underlines the effectiveness of the French Centre National pour l'Exploitation des Oceans (CNEXO) in coordinating national efforts to further man's penetration under the sea. The dive was conducted under CNEXO sponsorship. The depth achieved correlates well with the design depth of the ARGYRONETE, the large research submarine being built for CNEXO and its petroleum institute IFP. The ARGYRONETE is an 82-ft submersible with a diving displacement of 300 tons and a design depth of 1970 ft. Battery capacity of 1200 kWh will give her a diving speed of 4 knots. The ship contains two pressure hulls of which the dry one is 12 ft OD and 40 ft long. The diving chamber is 7 ft OD and 16 ft long. An air lock will give access from one hull to the other or from the diving chamber to the sea. The crew is planned for four divers in the pressure compartment and six operators (including a doctor) in the dry compartment. The divers will have 20 kW available for 6 hours per day for underwater work outside. The submarine is designed to travel 400 miles on the surface at an average speed of 6 knots and then to spend three days on the bottom (eight days with an auxiliary power source). Useful load will be three tons.

Study on Merchant Marine Safety Regulations Completed

The Maritime Transportation Research Board of the National Research Council under an ONR contract has completed and issued a report, "Merchant Marine Safety: A Study of the U.S. Merchant Marine Safety Regulatory System" (December 1970). The report is one result of a joint Department of Commerce-Department of Defense program studying Merchant Marine transportation, for which ONR is the contracting agency. DOD is an active participant since over 90 percent of military supplies and equipment are transported overseas by ship. The Navy supplements its own fleet of transports with ships chartered from the Merchant Marine, and in wartime would depend heavily on an expanded Merchant Marine. This particular study focused on how safety regulations, particularly safety inspection procedures, affected the cost of building ships in this country and operating them under the U.S. flag. The report concludes that there are at least five separate agencies—Coast Guard, Maritime Administration, Public Health Service, American Bureau of Shipping, and the Department of Labor—involved in regulating the safe design, construction and operation of the U.S. merchant fleet. It further points out that unnecessary duplication in the regulation and enforcement procedures of these agencies adds to the cost of construction and operating the ships and recommends that the responsibility should be limited to the Coast Guard and American Bureau of Shipping. The report also noted that the stringency of U.S. safety regulations is not reflected in lower ship loss statistics or in reduced maritime insurance premiums as compared to the merchant fleets of other countries which have lower safety standards. The study proposed a total of nine recommendations for improving the Merchant Marine Safety Regulation System.

Research Notes

Ambient Noise Buoy

Naval Research Laboratory (NRL) engineers have developed a bottom-anchored, unattended ambient noise buoy with no surface floats for monitoring acoustic signals in remote areas of the ocean. This buoy can be left in place for a period up to forty days. It can be acoustically recalled or can surface on a clock timer as desired. The advantages of this system are threefold. First, there is no question as to the contamination of data. Secondly, there are no surface floats or ships involved, eliminating the influence of wave action on the measurement string which might affect the data. And thirdly, an extended period of data taking can be accomplished without the need of extensive and difficult to obtain ship time.

The buoy utilizes the frame work and housing of a special buoy developed for seismic research. The ambient noise buoy includes instrumentation for recording the acoustic signals from one to four hydrophones in the frequency band of 20 to 600 Hz. These signals are recorded analog on a four channel magnetic tape recorder. An automatic reversing and switching system makes is possible to record 18 days of data from one hydrophone, 9 days from two, or 4.5 days from four. The precision clock, clocked functions, sonar recall system and batteries are all contained within the buoy instrumentation capsule.

The buoy and line of hydrophones are suspended above a 300 pound anchor by a 3/8 inch polypropelene line with the recall anchor release located immediately below the instrumentation capsule. Each hydrophone with preamplifier is connected to the instrumentation by RG-58 A/U cable. The cable and hydrophones are secured to the 3/8 inch line and sufficient glass spheres attached to provide positive buoyancy to the line. The instrumentation capsule is capable of being moored in depths to 25,000 feet with the hydrophones placed above as desired in the water column.

This system was developed by the Systems Engineering Staff, Acoustics Division for research programs in ambient noise and acoustic propagation. Plans for the immediate future are to include provisions for data sampling, broader frequency band, improved recall system, a new recorder for longer record length and increased number of hydrophones. This work is sponsored by the Office of Naval Research.

Discovery of an X-ray Source in Perseus

A new source of x-rays has been discovered in the constellation Perseus by scientists at the Naval Research Laboratory. The origin of the x-ray emission, which has been designated Perseus XR-1, is probably associated with the Seyfert galaxy NGC 1275, which is also identified with the strong radio source Perseus A. The distance to this galaxy is about 200 million light-years. Its energy output in the form of x-rays is equivalent to the total output at all wavelengths of 10^{13} (ten trillion) stars like the sun. NGC 1275 is the fourth extra-galactic object from which x-rays have been detected, and is exceeded in its energy output only by the quasar 3C 273.

An Aerobee rocket, carrying instrumentation designed to measure the diffuse x-ray background radiation and to search the sky for new discrete sources of x-rays, was launched from White Sands Missile Range on February 28, 1970. Because the instruments were substantially more sensitive to low energy x-rays than those which had previously been flown, it could be expected that objects would be detected which had been missed in earlier observations of the same region. Analysis of the data from this flight revealed the existence of an x-ray source in the constellation Perseus. The object most likely to be

emitting x-rays is the Seyfert galaxy NGC 1275. From the observed intensity and spectrum of the x-ray source, its intrinsic x-ray brightness can be computed, since the distance to NGC 1275 is known from its optical red shift. This distance is about 200-million light-years, which, together with our observations, implies an x-ray output of 2×10^{46} ergs per second in the wavelength band from 1.0 to 100 Angstroms. This is equivalent to the total radiation at all wavelengths of 10^{13} stars like the sun. For comparison, the Milky Way galaxy contains about 10^{11} stars.

The present observation brings the total number of extra-galactic x-ray sources to four. (There are about 50 known x-ray sources within our galaxy. Although they appear very intense because they are relatively nearby, their intrinsic x-ray power does not approach the enormous power associated with the extra-galactic sources.) The others are the giant elliptical galaxy M 87, which is also a strong radio source known as Virgo A, the quasi-stellar radio source (quasar) 3C 273, and another radio galaxy known as Centaurus A or NGC 5128. X-ray emission from M 87 and 3C 273 was also first observed by scientists at the Naval Research Laboratory. The most powerful of these x-ray sources is 3C 273 at a distance of nearly 2-billion light-years. The present observation places NGC 1275 second on the list, and M 87 and Centaurus A are now third and fourth, respectively.

Seyfert galaxies are named for Carl Seyfert, who first defined their properties as a group and made optical observations of a number of them (including NGC 1275) in 1943. The principal identifying characteristics of these galaxies are a small, extremely bright nucleus and a spectrum containing strong, broad emission lines. The great width of these lines is generally thought to indicate very high velocity motions of the gas in these galaxies. In short exposure photographs, only the bright cores show up, so that they resemble ordinary stars. This compact characteristic has led astrophysicists to speculate about the possibility that Seyferts may be a link between ordinary galaxies and quasars, even though optically they are only one-thousandth as luminous as quasars.

Radio astronomers have been studying Perseus A (3C, 84, NGC 1275) for the past ten years. It belongs to a class of variable radio galaxies which can change their radiated power as much as 10^{41}-10^{43} erg/sec in one year. (The entire energy output of the Milky Way is 10^{43} erg/sec.) With long baseline interferometry it has been shown that NGC 1275 and the quasar 3C 273 have core-halo radio structures and that the core component is about one light-year in diameter in the former and less than three light-years in the latter. Repeated outbursts occur in the cores on time scales of months to years. Clouds of relativistic particles (cosmic rays) are ejected and expand into the halo, which contains the cumulative debris of millions of core explosions over millions of years.

In the past few years, infrared astronomy has revealed that Seyfert galaxies can be tens of thousands of times brighter in the invisible infrared than in the visible light. It would, therefore, be justified to call Seyfert galaxies "invisible quasars." The discovery of x-rays from NGC 1275 shows that the radiated power in x-rays exceeds the infrared power, so that the "invisible quasar" characteristic is even more enhanced in high energy radiation.

Quasars and radio galaxies have strained our conventional concepts of the generation of power by nuclear fusion and the discovery of even greater galactic power radiated in x-rays has deepened the mystery of the basic energy source. Energy from gravitational collapse can exceed the nuclear energy content of all the mass of a galaxy, and compact spinning objects like pulsars have a greater store of rotational kinetic energy after collapse than was originally available from thermonuclear conversion of all the stellar mass. Current theories of explosive galaxies speculate on compact nuclear regions containing hundreds of millions of pulsar-like objects or a giant "spinar" containing the mass equivalent of a hundred million stars and spinning with a period as short as days to months (the Milky Way makes one revolution in 200-million years).

It is estimated that one or two percent of all spiral galaxies may display Seyfert characteristics. If most Seyfert galaxies emit x-rays at the rate determined for NGC 1275, they could possibly account for the diffuse x-ray background radiation, whose origin is still

undetermined. However, NGC 1275 is a particularly remarkable Seyfert galaxy and is a much more powerful radio source than most. It is very likely to be well above average in its x-ray output as well. Hence, it would be premature to assume that Seyfert galaxies are, in general, very powerful x-ray sources. Because Seyfert galaxies are not nearly as distant as the quasars and may be displaying essentially similar phenomena on a smaller scale, they are likely to provide important clues in our effort to unravel the enigma of the quasars.

Promising Solution of Aircraft Tip Vortex Problem

Under an ONR contract, Rochester Applied Science Associates, Rochester, N.Y. is pursuing the further development of a promising new approach to solving the tip vortex or wake turbulence problem that seriously affects both fixed-wing aircraft and helicopters.

The tip vortex is a funnel-like swirl of air turbulence deposited in the wake of wing tips of large aircraft or rotor blade tips. Its danger is that it can cause a closely following smaller aircraft to roll suddenly or even invert, particularly during take-offs and landings. In addition, there have been cases of damage to Navy aircraft due to wake turbulence while maneuvering between aircraft in the same flight. In the case of a helicopter rotor blade, it causes the familiar noisy blade slap or rotor bang and imposes unusual stresses on the rotor blade.

Under an earlier ONR contract RASA explored a theory that injecting a relatively small jet of air into the tip vortex as it forms could accelerate the breakup of the vortex. The concept has the advantage of not requiring a separately powered system to supply air.

Tests of the RASA air injection technique were first conducted last November in the eight by ten-foot low-speed wind tunnel at the Naval Ship Research and Development Center, Carderock, Md., using a fixed wing as the test model. These tests made use of a new experimental bubble visualization device under development by Sage Action, Inc., Ithaca, N.Y., under another ONR contract. The device, which generates tiny helium-filled bubbles that are fed into the wind tunnel airflow at the rate of 15,000 per minute, made it possible to observe the forming structure of the tip vortex for the first time. Observers saw the vortex core form rapidly downstream, where it appeared to remain at about the same size and strength. With the bubbles filling it in and light provided by a high-intensity, narrow-beam lamp, the core was seen as a solid, brilliant tube. When the jet of air was injected, the rapid dissipation of the concentrated core was clearly demonstrated. Although test results are in the process of being fully reduced and analyzed, measurements made during the test have shown that the core was broken up without affecting the lift of the airfoil or causing a measurable increase in drag.

The goal of the new ONR-supported RASA study is to discover the flow mechanism by which the concentrated tip vortex flow seems to be virtually eliminated. This includes an investigation of the basic nature of the initial mixing of linear and swirling flow. In this way it is hoped to learn the most efficient means of eliminating the effects of the tip vortex under all flight conditions. Exploration of the feasibility of incorporating the air injection concept ultimately in aircraft design is expected to follow later.

Chemistry Symposium

Inorganic Chemistry, 2-6 August 1971, at New Hampton, N. H. Gordon Research Conference. Sponsored by the Air Force Office of Scientific Research and the Gordon Research Conference. For information contact Dr. Anthony J. Matuszko, Air Force Office of Scientific Research (NC), 1400 Wilson Blvd., Arlington, Va. 22209. Telephone Area Code 202, OX 4-5337.

Self-Generated Magnetic Fields in Plasmas Produced by Lasers

Magnetic fields, thousands of times larger than the earth's magnetic field, have been produced in the laboratory by focusing the light of a high-power laser into a small solid target.

When the laser light is focused, by means of a lens, onto a solid target, the target vaporizes and a dense plasma or fully ionized gas is produced. This laser-plasma consists of rapidly moving electrons and ions whose motion is strongly affected by electric and magnetic forces. The pressure (a hundred thousand atmospheres) and temperature (a few million degrees) in a laser-plasma approximate the conditions existing in the interior of some stars. In fact, fusion reactions, which are responsible for the energy of stars (including our sun), have been reported in a few laser-plasma experiments.

Recent work at the Naval Research Laboratory in Washington, D.C., by John A. Stamper, Stephen O. Dean and Edgar A. McLean, has shown that laser-plasmas can exhibit another of the phenomena associated with stars. This is the generation of magnetic fields. These magnetic fields result from electric currents originating in the laser-plasma itself, and are thus called self-generated fields.

The target and a low-pressure background gas were initially contained in a vacuum-tight chamber. A .01-inch-diameter plastic fiber (lucite) was used as a target in most of the studies, and both nitrogen and helium were used as background gases. A two-billion-watt laser was used to produce the plasma. The laser plasma expanded with high velocity (a million feet per second) into the background gas, producing a thin shell or interaction region. Magnetic fields generated near the focus of the laser beam (at the target) were observed to be carried outward with the expanding laser-plasma. The fields were very intense (thousands of times the strength of the earth's field) within a half-inch of the target, but the strength was much smaller farther away from the target. The field at 1-1/2 inch from the target was comparable to the earth's magnetic field (1/3 Gauss).

Electron thermal energy is primarily responsible for the magnetic field in the NRL experiment. Thermal energy or heat is kinetic energy associated with the chaotic or disorderly motion of many particles. The phenomenon which allows this thermal energy to produce electric currents (and thus a magnetic field) is related to the thermoelectric effect in solids. In plasmas, however, the situation is more complex with thermoelectric effects, pressure gradients and laser radiation playing a role. Large gradients in the pressure and temperature exist near the laser focus and these can act as a "battery" to drive electric currents associated with the magnetic field.

Remote Electromagnetic Detection of Metals and Minerals

A new discovery has been made by Prof. George W. Pratt of the Massachusetts Institute of Technology under an ONR contract concerning the remote electromagnetic detection of metals and minerals. The discovery is that a pulsed magnetic field moves domain walls in metallic or mineral samples. When the pulse is over, the walls relax back to their original position, emitting approximately one kilocycle electromagnetic wave which will propagate to a degree through sea water. In view of the large pulse fields which can be attained together with the new sensitive superconducting magnetometers, this may lead to a significant advance in remote detection technique.

Progress in Prevention of Decompression Sickness

A Navy research program has produced new information on how divers contract decompression sickness or the bends, and this has led to experiments with a drug that has successfully prevented the bends in animals.

The study is under the direction of Dr. C. Chryssanthou of the Beth Israel Medical Center, New York City, under contract to the Office of Naval Research. The findings raise for the first time the possibility of a preventive drug that would sharply reduce the incidence of the disease. In particular, it might solve the problem of the diver who gets the bends when decompressed by a time schedule established as safe for the average person. It also might save the life of a diver who must be brought up quickly in an emergency.

Dr. Chryssanthou based his investigation on his earlier finding that part of the mechanism of the disease may be the action of substances in the body that stimulate the smooth muscles, such as blood vessels. One such substance is bradykinin, which tends to contract these muscles.

In trying to learn more about this process, Dr. Chryssanthou discovered a previously undetected substance contained in the lung tissues of mice, rabbits, and humans that appears to be activated or released during the compression-decompression period. He found that this substance, which he has named Smooth Muscle Acting Factor or SMAF, sensitizes or "primes" the smooth muscles so that they are ready to contract in response to the stimulus of bradykinin and also histamine. He also learned that SMAF itself directly causes contraction of smooth muscles.

The constriction of the blood vessels slows down the circulation of the blood, thereby inhibiting the gradual escape of gas from the tissues of the diver during decompression and making it more likely that gas bubbles will form in his blood stream. It is the formation of these bubbles that causes the bends, which can be fatal.

Dr. Chryssanthou decided to experiment with an anti-bradykinin, anti-histaminic drug in the hope that it would counteract the effects of SMAF. Selecting the drug 2-4 phenylpiperazinylmethyl cyclohexanone or PPCH, he injected it into a strain of obese mice especially susceptible to decompression sickness. The mice were given the drug before exposure to high atmospheric pressure and were then subjected to fast decompression.

In spite of the rapid return to normal pressure, the mice did not develop the disease. In contrast, a control group which did not receive the drug developed all the symptoms of decompression sickness. Later examination showed that the injected mice had gas-free tissues while the control group had tissues bloated with gas.

It is not yet known whether the drug interacts chemically with SMAF or somehow conditions the body tissues to resist its action. Also little is known about any possible side effects. Research is continuing with the objective of determining its possible use of human divers, including how far in advance of a dive the drug should be administered. In addition to the possibility of preventing the bends, the work is expected to develop a much better understanding of the mechanism of the disease.

Naval Research Laboratory Scientists Improve In-Water Photographic Techniques

Ocean scientists at the Naval Research Laboratory have developed a new lighting technique that promises to be a "breakthrough" in the use of optical sensors to study the earth's last frontier, the deep ocean floor.

Chester L. Buchanan, Associate Superintendent of NRL's Ocean Technology Division, which conceived and developed the technique, said that it was of vital importance to the future employment of both manned and unmanned vehicles in the studies of the deep ocean.

The technique, called LIBEC for Light Behind Camera, consists of mounting a powerful light source 10 to 30 feet behind the camera in order to reduce the light backscattered into the lens by the intervening water and particles suspended in it. This backscattered light normally reduces contrast and limits the effective range of any optical system.

Both the light placement behind the camera and the increased ranges produced by the LIBEC technique make it necessary to provide a more powerful light source. The NRL team used six 8,700 Joule pulsed Xenon lights in testing the technique. The total of over 50,000 Joules is two orders of magnitude greater than the lights used in NRL's present search system.

During recent tests at depths ranging to 5,000 feet, these lights were mounted 30 feet above a camera and used to photograph both the deep ocean floor and a two foot diameter white disc target at distances up to 120 feet. Using the LIBEC technique, the white disc was clearly observed at a range of 120 feet and usable bottom photographs were obtained at all ranges up to 70 feet. With standard lightning techniques comparable photographs could be taken up to about one half of this distance.

The exposures of the white discs were used to determine the contrast produced by the LIBEC and standard lighting systems for comparison. The results show that in this experiment the LIBEC technique increased the contrast by a factor of five.

According to Robert Patterson, the NRL photographer in charge of this development, this increased contrast can be used to more than double the useable range and quadruple the area coverage of in-water optical sensors.

The Ocean Instrumentation Branch of NRL's Ocean Technology Division is currently engaged in developing operational instruments which will make it possible for the NRL search system to use the LIBEC technique.

The primary requirement is the development of a new large format camera, since current underwater cameras used small films which cannot adequately resolve the large area which can be photographed by this technique.

Device Detects Lightning 100 Miles Away

Navy research on thunderstorm processes has led to the development of an optical device capable of detecting lightning as far as 100 miles away. The ultrasensitive device registers the occurrence of lightning by sensing the minute short-lived changes in light intensity caused by lightning.

Operation of the detector is based on optical sensors consisting of silicon solar cells sensitive enough to register lightning in distant clouds even in bright daytime when not visible to the human eye. The detector can be fitted with a special filter which allows it to respond only to lightning and not be confused by the random changes in the intensity of sunlight.

The new instrument was developed by scientists at the New Mexico Institute of Mining and Technology as a research tool for the study of processes of cloud electrification. The research, supported by the Office of Naval Research, is part of a broader program of investigations into thunderstorms, storm electrification processes, lightning dynamics and other atmospheric phenomena that present a hazard to naval operations.

Atmospheric electricity can affect missile launchings, aircraft operations, communications, refueling operations and weather forecasting and modification. A lightning stroke, for instance, striking a missile in flight, or even occurring in its vicinity, could seriously damage the missile's guidance system or its firing mechanism.

The lightning detector was developed mainly to investigate why lightning occurs in "warm clouds." Such clouds are found in tropical and subtropical climates usually at altitudes below 15,000 feet, the approximate freezing level.

At present there is some theoretical understanding of the occurrence of lightning in clouds above the freezing level. Two opposite electrical charges must form and be separated in a cloud for lightning to occur. One theory is that this phenomenon, known as

charge separation, is initiated by ice forming in a cloud since ice crystals are positively charged and water droplets are negative. This theory, however, does not satisfactorily explain the apparent occurrence of lightning in clouds below the freezing level.

Besides its usefulness as a research tool, the new instrument may find other practical applications around ships and naval stations. As a scanning device, it can detect the presence of dangerously electrified clouds and pinpoint distant areas of lightning, thereby contributing greatly to the safety of naval operations.

Simulation Explored for Use as a Ship Project Scheduling System

The use of an ONR-funded Transportation Simulator (TRANSIM) as a means of scheduling and controlling new ship construction projects is being explored by the Naval Ship Systems Command. TRANSIM, a computer-based general purpose transportation simulator which was developed by Mr. A. M. Feiler of UCLA under an ONR contract, has the capability for application to a wide range of scheduling and resource allocation problems. The procedure holds promise as an improved PERT/CPM technique in its ease of use and greater flexibility in the type of information that can be presented to the project manager. A recent demonstration for Ship Acquisition Project Managers showed among other things how the technique would operate on such problems as availability of repairs parts, technical resources available and time to complete repairs. One advantage of the TRANSIM technique is that it provides all of the critical paths of the project on the basis of probability, allowing the project managers to take account of the effects of changes in such critical areas as design, yard production schedules, work force availability, equipment deliveries and funding. The technique is under consideration for use in the ULMS project.

Frozen Blood Moves Toward Wider Use

The long-term preservation of red blood cells by freezing and their use of transfusions after thawing, a technique developed by Dr. Charles Huggins of the Massachusetts General Hospital with partial support of an Office of Naval Research contract, has moved toward wider use. The first license for the general use of frozen blood has been issued to Massachusetts General by the National Institutes of Health. The licensing facilitates interstate transportation and international shipment of frozen red blood cells to help victims of disaster. The technique has already been successfully used in Vietnam on an experimental basis. At the present time, it has been established that the freezing method developed by Dr. Huggins preserves red blood cells for as long as two years. In addition to permitting a greater stockpiling of blood, including supplies of rare types of blood, the technique has been found recently to reduce the incidence of hepatitis. The washing procedure used in the thawing process is credited with removal of a hepatitis factor in donated blood. The process also seems to remove other substances from the blood that causes some persons to become sensitized to further transfusions. Although presently the technique for freezing blood is more expensive that the refrigeration of whole blood, it is more economical since refrigerated whole blood can only be kept for 21 days. Generally one-eighth of refrigerated whole blood must be discarded for that reason.

Propeller Shroud Capable of Steering Ship Under Study

A new concept for a propeller shroud that would be capable of steering a ship like a rudder while utilizing the advantage of the shroud in increasing the thrust of the propeller and protecting it from obstacles is being evaluated by the Navy. Evaluation is taking place at the Massachusetts Institute of Technology under a contract funded by the Office of Naval Research. The concept for the shroud was advanced by LCDR Samuel J. Gordon of the Office of Naval Research. The new concept, for which LCDR Gordon has been awarded a patent, embodies a departure from conventional shrouds now in existence, including those which swing the shroud and propeller together from side to side to serve as a rudder.

Propeller shrouds work on the principle of the airfoil or airplane wing. On the airplane wing, air flows faster on the top, or convex surface, than along the bottom, resulting in lower pressure on the top surface as compared with the underside. This pressure difference creates a lifting force on the wing. In propeller shrouds, this principle is utilized to accelerate or decelerate the rate of water flow around the propeller depending on whether the convex surface of the shroud is on the inside or the outside. This velocity—and hence pressure—difference creates a radial force directed inward in the accelerating type of shroud and outward in the decelerating one.

In conventional (Symmetric) shrouds, because of their uniform cross section around their entire circumference, the forces counteract one another and no net radial force results. If, however, the shroud is designed so that the forces do not concel out, a large radial thrust can be developed. If in addition the shroud is rotatable around the propeller, the direction of the thrust can be controlled and used to steer the ship.

Working on this theory, LCDR Gordon conceived a non-axisymmetric shroud capable of producing a lateral force and designed to rotate around the propeller for steering purposes. Based on preliminary analysis and tests, it appears that this propeller shroud concept would provide several advantages over the rudder. Besides protecting the propeller blades from obstacles, the device would eliminate the drag associated with the rudder. The radial thrust could also be applied to provide a lifting or depressing force. In calm seas the shroud could be positioned so as to provide an upward push in a way similar to the hydrofoil, thus decreasing the effective displacement of the ship and increasing its speed. In stormy weather, particularly with a following sea, a downward force would be useful to keep the aft part of the ship down and the propeller in the water. If this lifting and depressing could be oscillated to coincide with the ship's nautral roll and pitch, the shroud might be helpful in freeing a stranded vessel.

The work underway at MIT is concerned with testing models of several configurations to determine experimentally how closely the predicted capabilities of the device can be realized.

Liquid Metal MHD Power System Studied

The first phase of a Navy analytical study to assess the feasibility of a liquid metal magnetohydrodynamic (MHD) power system has been completed. The encouraging result of the analysis has led to the initiation of an experimental research effort with a liquid metal MHD system.

The Argonne National Laboratory, Argonne, Ill., supported by the Office of Naval Research, performed the feasibility analysis and is conducting the experimental work.

An MHD system is based on the principle that an electrically conducting fluid passing through a magentic field produced a voltage. The faster the flow and the higher the temperature of the fluid, the greater the power output and the efficiency of the overall system.

In the past MHD systems have been studied using plasma—gas heated to a temperature of more than 4000 degrees F—as the working fluid.

The Argonne study is based on a two-phase system. The liquid metal used as the main working fluid is sodium which is heated to 1200°F. This is combined with helium to speed the flow, thereby producing a two-phase working fluid. Studies indicate that the cycle is capable of achieving an efficiency of about 22 percent. Further studies using lithium and helium predict an overall cycle efficiency of 36 percent or higher.

The study shows that liquid metal MHD systems compare favorably with conventional steam turbine power systems. By eliminating the need of a steam turbine with its attendant reduction gearing, a liquid MHD system would be more compact, simpler and more reliable to maintain, and would operate much more quietly. This makes it promising as a stationary or mobile power source. The use of a liquid metal compressor instead of a mechanical compressor would increase quiet operation. The availability of superconducing magnets to provide the magnetic field would add to the compactness and reliability of the system.

Liquid metal MHD systems are being studied in France, West Germany, and the Soviet Union. The latter country is known to have mounted an extensive effort in this field. Considerable research on a liquid metal MHD system for space applications is also underway in this country at the Jet Propulsion Laboratory.

One long-range prediction of the Argonne study, based on the data and theory developed so far, is that there is a clear indication that a MHD generator with significantly higher efficiencies can be achieved. Further studies and experiments with model generators will be conducted under ONR sponsorship to establish the performance parameters and the potential benefits to the Navy of liquid metal MHD generators.

Aircraft Cockpit Evaluation Program

As part of the Joint Army-Navy Aircraft Instrumentation Research (JANAIR) program, for which ONR serves as the chairman, ONR is supporting an exploratory development program aimed at providing improved techniques for evaluating the physical compatibility of an aircraft pilot or crewman with the cockpit or crew station he occupies. The program, conducted by Boeing, has developed both computer techniques and a man-model that will enable an aircraft designer to plan cockpit arrangements to fit any size individual in the entire crew population early in the design process. The program is concerned with cockpit geometry, which includes not only the seats but also the placement of the displays, controls, personal equipment, windshield, canopy, windows, interior surface shape, and openings for ingress and egress. Standard methods presently used for cockpit geometry evaluation (CGE) are difficult and time-consuming and are unable to cover the entire range of sizes and shapes of crewman who will operate the aircraft. As a result, there are naval aircraft which are hazardous to operate by individuals of certain sizes. Using a computer and the three-dimensional man-model, the CGE program provides data on three basic parameters—physical interference, visual interference, and reach limitations. The new technique would replace drawing reviews, mockups, mathematical models, flight simulators, and prototype flight test techniques presently used. Eventually the CGE program will make it possible to design any aircraft from the inside out—in other words, the cockpit first rather than starting with the airframe and engine and finishing up with the cockpit.

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Ambient noise buoy developed by the Naval Research Laboratory will monitor acoustic signals in remote areas of the ocean. *See page 20.*

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Promotion Selections

There were one thousand six hundred and sixteen officers selected for promotion to Lieutenant Commander by the Fiscal Year 1971 Reserve Selection Board. Congratulations go to twenty-two members of the Research Reserve Program.

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