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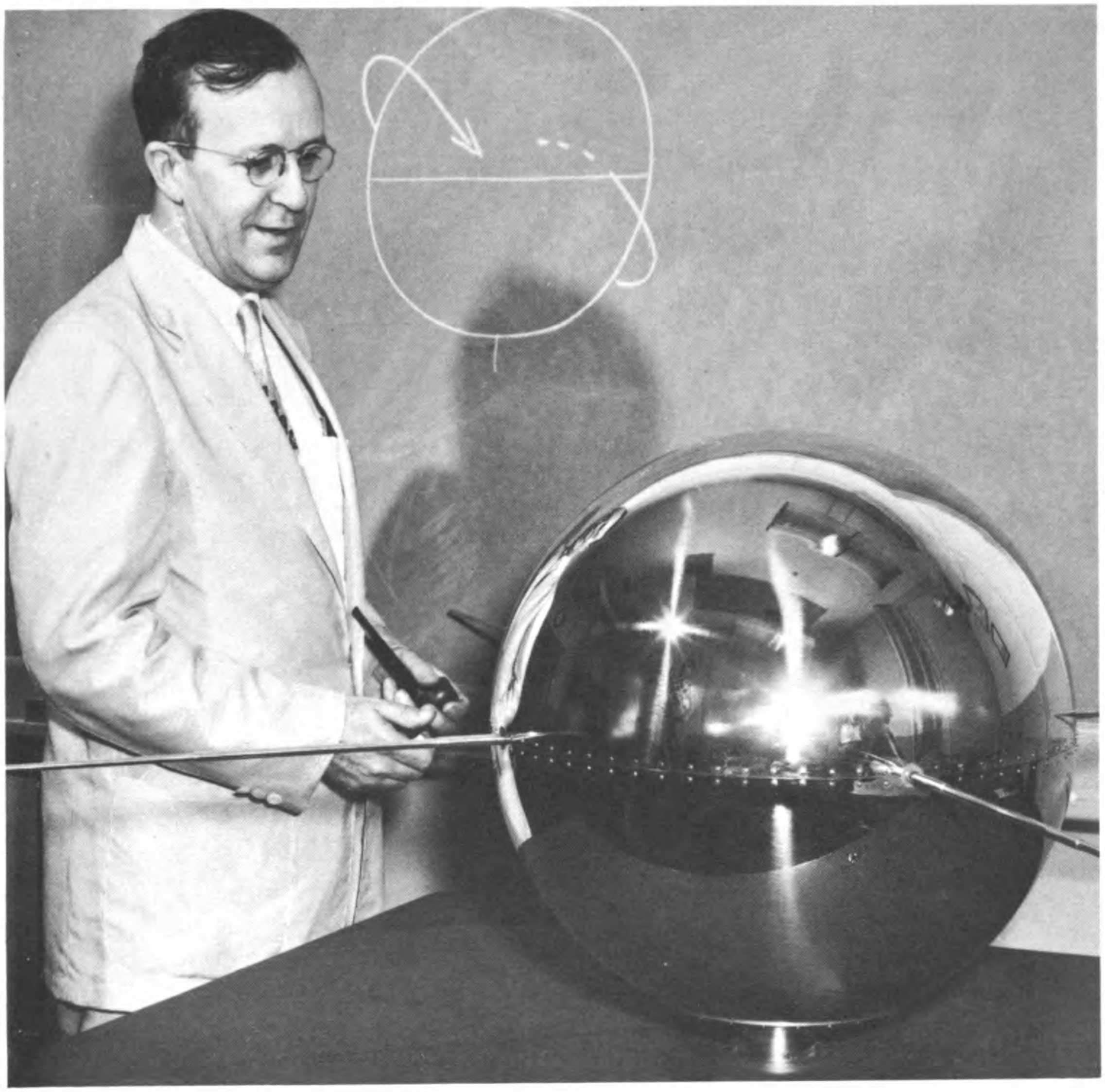
RESEARCH REVIEWS



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DEPARTMENT OF THE NAVY
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DECENNIAL YEAR
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The USS NAUTILUS. Equipment designed to measure the concentration of gases and radiation on this ship is described in articles beginning on p. 13 and p. 16.

What is Creep?

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When structural engineers talk about nuclear power plants and hypersonic missiles, the word "creep" is frequently mentioned. Just what do these experts mean when they refer to creep? It is the purpose of this short note to answer this question on the basis of research carried out at the Polytechnic Institute of Brooklyn under contracts sponsored by the Office of Naval Research, the U. S. Air Force, and the NACA.

Engineers are in the habit of calculating the structural behavior of their designs on the basis of highly simplified assumptions. This is, of course, necessary, because nature is so complicated that a consideration of all of its aspects would lead to unending research rather than to the design of practical structures or weapons. In 1678 Robert Hooke discovered one of the laws of nature which was to become extremely important in engineering stress analysis. He expressed this law by the latin sentence "ut tensio sic vis," which can be translated into our current language of engineering as "stress is proportional to strain." An overwhelming majority of all engineering stress analyses has been based on this law.

Today we know that Hooke's law is valid only for very small deformations. As the accuracy of measuring instruments improves, a small permanent set in the deformations can be discovered at lower and lower stresses. Consequently, elastic analysis can have only limited validity. Nevertheless, it is used almost invariably by engineers, because it is hard to break a habit 300 years old. As long as we can afford to use very high safety factors in architecture or structural engineering and can restrict the maximum stress to comparatively small values, the validity of Hooke's law is not impaired. But when the engineer wants to calculate the actual failing load of a structure, the simple law has to be abandoned. In the last twenty years or so progressive civil engineers have made a determined effort to introduce the concept of plastic deformations into civil engineering practice. On the basis of what is today known as "limit design" or "limit analysis," they were able to develop rules of calculation which in many cases are even simpler than those based upon Hooke's law and which at the same time give the actual failing load of the structure with a reasonable degree of accuracy.

At ordinary temperatures and very high stresses it seems, therefore, that we have to abandon Hooke's law in favor of a law describing plastic behavior. In a similar manner, whenever the temperature of the structure or machinery is raised to a high level, the concept of perfect elasticity has to be abandoned and that of creep deformations must be introduced.

What do we mean then by creep? When a weight is suspended from the lower end of a rod whose upper end is rigidly fixed, the rod elongates

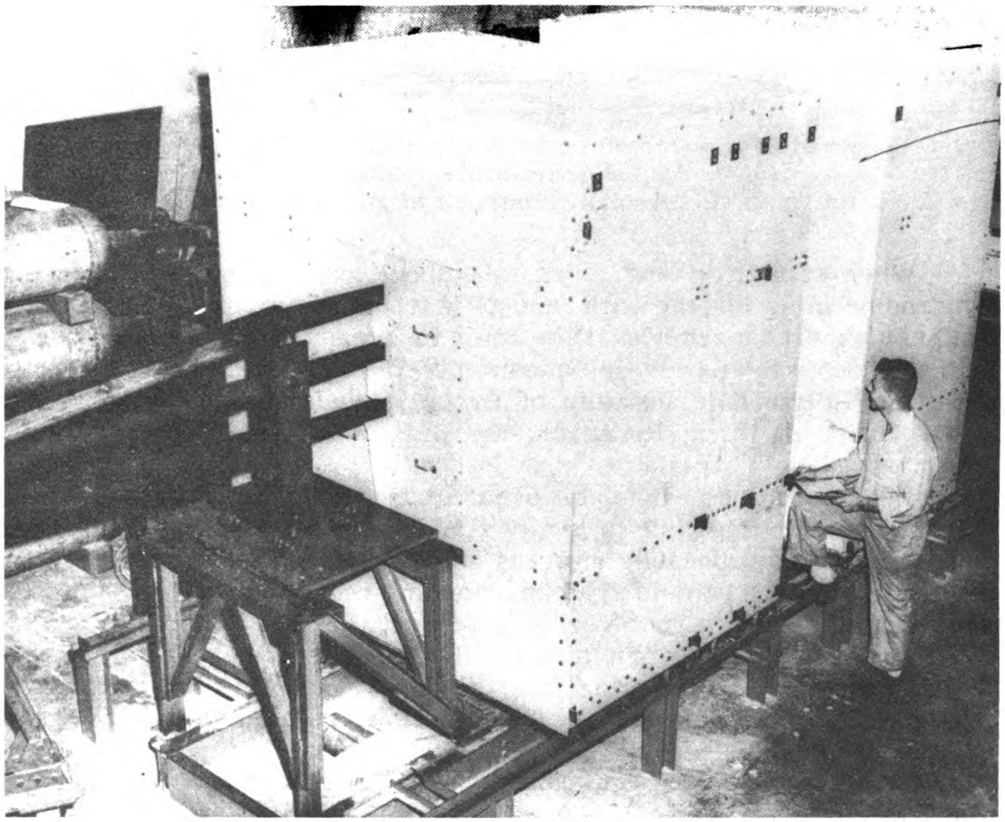

Figure 1 - The large creep oven at the Polytechnic Institute of Brooklyn, used to test cylindrical shells under constant bending moments.

immediately upon the application of the load. When the test is carried out with steel at room temperature and the maximum stress is of the order of 30,000 lb per sq in., accurate measuring instruments will indicate that the initial length of the bar is regained as soon as the load is removed. If the same experiment is repeated after the bar has been surrounded by an oven which maintains its temperature at a level of 1200°F, a permanent deformation can be measured after removal of the load. As a matter of fact, if the load remains suspended from the bar, repeated measurements of the length of the bar will show continuously increasing deformations. This phenomenon is known as creep.

In the last thirty years creep deformations have interested machine designers largely in connection with the development of steam and gas turbines operating at ever-increasing temperatures. These engineers have worried about maintaining the proper tolerances between the moving and the stationary parts of the machines in spite of creep. In a similar manner, structural elements of nuclear power plants can deform to such an extent that they are unable to perform their functions, and the wings and control surfaces of hypersonic airplanes and missiles can distort sufficiently to alter substantially the aerodynamic forces and to render inoperative the moving parts of the structure. This is reason enough for the engineer interested in problems of machinery and structures operating at high temperatures to explore the problems arising from creep deformations.

Metallurgists and metal physicists have not yet agreed upon a final explanation of the atomic mechanism of creep deformations. It appears likely that plastic slip and viscous flow are equally responsible for the phenomenon. In plastic slip, neighboring layers of the material slide over one another like playing cards in a pack. Pure viscous flow, on the other hand, is something resembling the deformations of hot asphalt or glass. In polycrystalline aggregates, which make up most of the structural metals in use, free sliding and free viscous flow are complicated by the geometric restraint existing among the crystals and the intercrystalline layers. During the creep process the crystals not only slide over the intercrystalline layers, but they also roll, deform, and often even recrystallize. The physical phenomenon is complex, and this complexity is reflected by the variety of mathematical formulas that have been proposed to describe creep.

An overwhelming majority of all creep tests has been carried out on rods in tension. This uniaxial state of stress is the simplest one that can be observed experimentally. When the stress is maintained constant, the elongation is only a function of time. The application of the load is followed by an instantaneous deformation which in most creep tests is perfectly elastic and linear as a function of the stress. Immediately afterwards, high creep rates can be observed which diminish with time until a uniform rate of creep is reached. The initial stage of changing creep velocities is usually designated as the transient or primary phase of creep, while the phase in which the creep rate is constant is referred to as steady or secondary creep. In constant-load tests this second phase is followed by a third one in which the creep rates again increase, first slowly and then rapidly, until finally the rod fractures. This last period of the experiment is referred to as the tertiary phase of creep.

In structures designed for a comparatively long lifetime, the secondary phase of creep is usually the most important one. This is the reason why secondary creep has been explored more than any of the other phases. If the experimenter plots the minimum creep rates against stress on semilog or log paper, he usually obtains reasonably straight lines connecting the experimental points. In the first case the creep rate is an exponential function of the stress, and in the second one it is a power function. These laws have been used extensively in the literature of creep behavior. In addition, other laws, such as the hyperbolic sine law, also have been proposed. For the person who does not want to specialize in creep-stress analysis, the important thing to remember is that with our structural metals the creep rate increases very much faster than the stress. It is a linear function of the stress only with a few materials of limited usefulness in structures, such as glass-like materials and high polymers.

Fortunately, research has already yielded a considerable amount of information on how to introduce the concept of creep into practical stress analysis. In particular, it has been shown that at the moment of load application the distribution of the stresses is exactly the same as it would be without creep. This initial distribution begins to change as soon as creep sets in, and after a certain amount of time a rather different stress distribution is approached. This second, and more or less final, stress distribution is approximately reached after a period of time that depends upon the temperature, the stress, and the material properties. It may be a few seconds, a few minutes, or possibly even a few months or years. It can also be calculated on the basis of information available today. The analysis is best carried out with the aid of the elastic analogue. According to this analogue, the distribution of the stresses in a body whose deformations are caused exclusively by the steady creep phenomenon is exactly the same as that in a perfectly elastic structure of similar shape subjected to the same loads. But this perfectly elastic structure is not a linearly elastic one, and for it Hooke's law is not valid. Consequently, the calculation of the stresses in this body must be based on nonlinear laws of perfect elasticity. These laws are simple to write down, but their solution very often involves a great effort and time-consuming computations.

This is the reason why a second analogue, called the plastic analogue, can be of help. It has been shown that the stress distribution in a body subject to creep approaches asymptotically the stress distribution governed by the laws of perfect plasticity if the value of the exponent in the power law of the creep phenomenon increases and approaches infinity. This means that in the limiting case the stressman interested in creep behavior can use the large body of information already developed for analyzing the ultimate loads carried by such structural elements as mild steel beams. The results obtained by the expert in limit analysis are therefore available to the analyst of creep deformations.

The first problem of interest to the stressman dealing with machinery or structures subjected to very high temperatures is the determination of the maximum deformations and the time necessary to develop them. A second problem of interest is the danger and the mode of failure. Here again a number of interesting new phenomena arise.

The first experimental observation in this connection is that a bar at high temperature can perfectly well support a given load in tension for hours but nevertheless, after a day or two, break. This is essentially

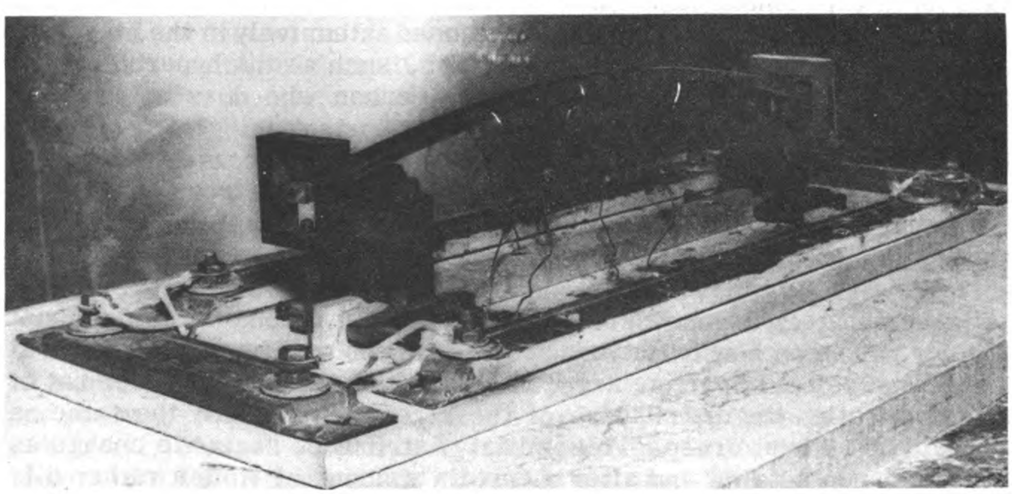

Figure 2 - Creep bending test on solid rectangular bar.

an instability phenomenon. As the bar elongates because of creep, its cross-sectional area decreases, since creep takes place substantially without a change in volume. A consequence of the smaller cross-sectional area subjected to the unchanged load is, of course, an increase in the stress. But increasing stresses cause very much more rapidly increasing strain rates, and this vicious circle can end only by fracture. Fracture takes place after an indefinitely long period of time if the stress-strain rate law is a linear one, as it is, for instance, for some kinds of glass. But with the metals of our structures the law is always a highly nonlinear one, and fracture occurs after a finite time that can sometimes be quite short. It is therefore proper to talk about a critical time of creep tensile-fracture.

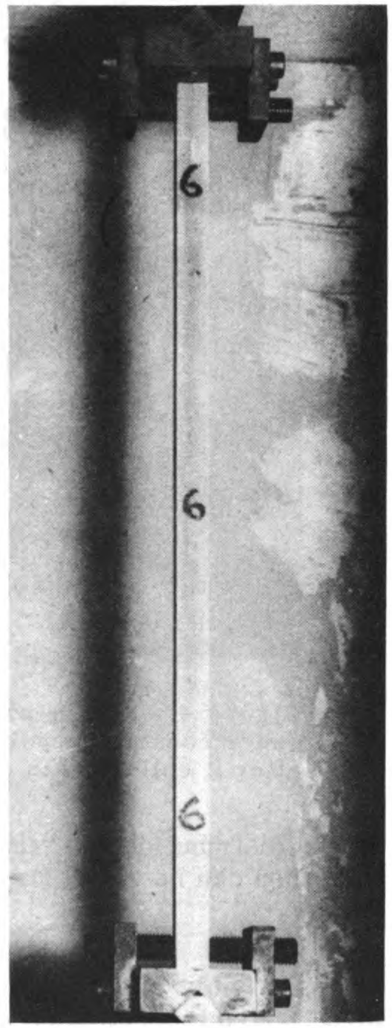

Figure 3 - A column and its adjustable knife-edge supports, photographed inside the oven.

A similar instability occurs with columns. A column is defined as a straight bar subjected to compressive forces acting in its longitudinal direction. Since perfect machine tools and perfect machinists do not exist in our imperfect world, the axis of a column always deviates slightly from the straight line. But the load applied to the ends of the column through knife edges must act along a straight line. The deviation between this straight line and the axis of the column acts as a lever arm whose product, along with the compressive force, is the bending moment to which the section of the column is subjected. Under this bending moment the curvature of the column increases, first slowly and then more and more rapidly. Increasing curvature corresponds to increasing lateral deflections which give rise to larger and larger bending moments; these in turn cause higher and higher rates of creep deformation in bending. Again the vicious circle can end only in total collapse. When the creep law is a nonlinear one, this collapse takes place after a finite period of time. This period can be properly designated as the critical time of the column.

The analyst of structures which operate at very high temperatures is therefore faced with entirely new problems. In addition to the old concepts of stress and strain, he has to take into account the new parameters, temperature, and time. No structure or machinery is safe in the established sense; it can be considered useful for only a finite length of time. In order to produce the proper design, the analyst must be conversant with these facts, as well as with the methods of analysis of

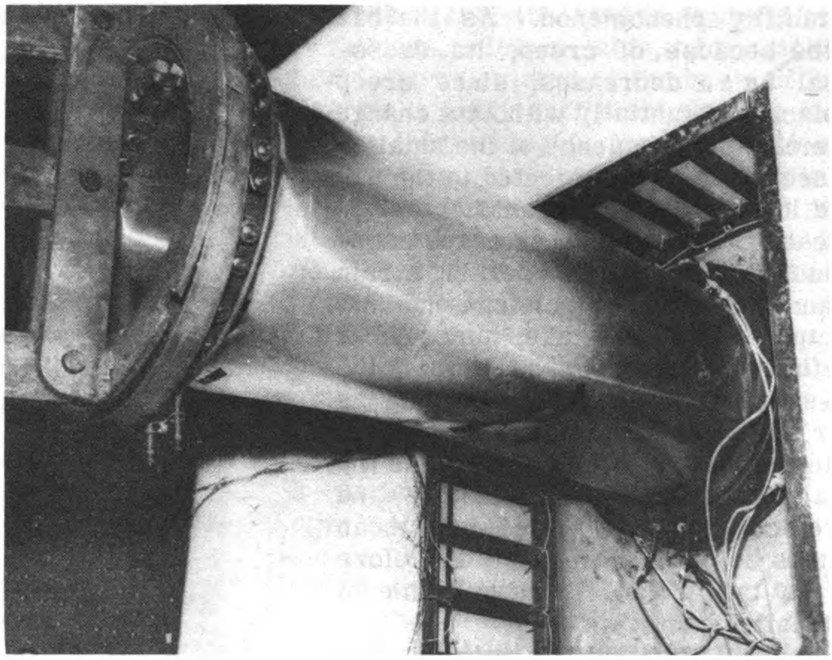

Figure 4 - A thin-walled circular cylindrical shell tested under constant bending-moments is visible inside the oven after it collapsed in consequence of creep.

stress distribution and structural instability in the presence of creep. Only then can he vouch for the integrity of his design for a limited period of time.

Probably the most complex creep phenomenon that has yet been investigated theoretically and experimentally is the collapse of a thin cylindrical shell under a constant moment. A series of tests has been carried out at the Polytechnic Institute of Brooklyn under a contract sponsored by NACA. In these tests, cylinders of 16-in. diameter and 40-in. length were attached to a strongback and subjected to the action of a constant bending-moment. The cylinders were surrounded by an oven which maintained the temperature of the cylinder constant at 500°F for the duration of the test. As the bending moment was applied, the cylinders flattened almost imperceptibly because of elastic deformations. This flattening in consequence of creep increased as time went on, until it became so large that the cylinder suddenly collapsed. The time between the application of the bending moment and collapse was again designated as the critical time. In the tests performed, this critical time varied from a few minutes to a few hours.

Rather to the surprise of the investigators, a creep buckling theory based on highly simplified assumptions gave critical times in good agreement with the results of the experiments. It seems, therefore, that the foundations of our creep analysis are sound and that we may also expect other satisfactory results from the theory in the future.

The Application of Research to Management Problems

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The old attitude toward management research is giving way to a new and healthy one. The previous position was essentially that of the old Greek Sophists, who had a negative sort of philosophy. Gorgias, one of the leading Sophists, used to argue that: (1) nothing exists, (2) if something did exist, you couldn't know about it, (3) if you did know what it was, you couldn't communicate it. This argument could be paraphrased to apply to management problems in the following manner:

- We don't need any research on management problems, because we already know enough.
- Even if we did need some research, the people who do it are too academic and not practical enough.
- When they're not too academic, they come out with results which we already know.

There may be a great deal of merit in this point of view, as there also was in Gorgias'. But there is another one which is gaining more and more acceptance and which assumes that: (1) management problems are on the increase, (2) trial-and-error methods are costly and clumsy, and (3) systematic observation, measurement, and control are necessary adjuncts of the management process. Associated with the development of a new attitude toward research is the realization that the conduct of research and the application of research are two different processes. In other words, a person who is both a good research man and a good human relations engineer is a rarity.

For a great many reasons, some of them good and some not so good, research on management problems has had a slow start. But to say that there has been little systematic research on management problems is not to imply that there is no knowledge on how to handle such problems. There is a great deal, much of which has arisen from many years of solid experience. But organizations have complicated themselves at an accelerating pace, and trial-and-error experience is too slow and costly. Because we are eager to increase the speed at which new concepts are discovered, it is necessary to resort to the more systematic and, generally, less costly methods of research for solution to problems of the day.

While struggling to apply to current problems the latest research findings, we must keep an eye on the changing industrial picture and be ready to face the future with something more than just hope. It is part of the job of the research man to keep abreast of events as they concern him and initiate plans and research for use when the event occurs. For instance, it is now the policy of the U. S. Air Force to develop a proficiency test for personnel to operate a new weapon while it is still in the design stage. This is a far cry from the day when, less than 10 years after inception, a set of trade questions constructed in Cincinnati for a number of occupations were found to be 50% obsolete. In the field of management it is equally disastrous to apply outmoded ways—and it is necessary, in this field, to be alert to future changes.

Two processes appear to me to have utmost importance in the application of research results:

- The synthesis and coordination of research results and concepts.
- The development and application of theory to assist in the solution of difficult problems.

As an example of the need for coordinating research results and concepts, I would like to discuss briefly some aspects of supervisory problems that have appeared in the literature under such headings as "The Employee-Centered Supervisor vs. the Task-Centered Supervisor." In some of these articles it has been loosely stated that the group led by the employee-center supervisor tends to be more productive than the work group of the task-centered supervisor. Actually, before such a concept can be applied to a particular situation, we need to know exactly how precise the statement is, where and under what conditions it applies, and what other related concepts would be useful to help solve a particular supervisory problem. Fortunately, there is a growing body of research on this subject, and reference to it is extremely helpful.

In one study, for example, it was found that increased pressure toward productivity had different effects, according to whether initial pressure had been low or high. At low initial pressure, increased task-centeredness of the supervisor raised both productivity and morale. At higher initial pressure, increased production-emphasis failed to increase production and significantly reduced morale. Another study showed that group cohesiveness in small work groups lowered or raised production, according to whether the members perceived the organization as a threatening or as a friendly and secure place to work.

To aid in explaining these results, projects sponsored by the Office of Naval Research have developed such concepts as the "social distance" between a supervisor and his subordinates. Social distance has been found to be measurable through a leader's perception of his subordinates. The more differences he perceives between them, the greater his distance from them. Perhaps, surprisingly, a supervisor well accepted by his subordinates has been found to operate more effectively if he maintains some social distance between himself and his men.

There is also the concept of "initiating structure," indicating the process by which the leader communicates what is expected of each of his subordinates, and the concept of "consideration," the morale-supporting function of the leader. These dimensions appear to be uncorrelated. To do a good job, we should know and bring together these ideas, as well as concepts of followership, interaction, situational variables, and much more. Just the bringing of these together helps to develop a better program than does the use of a set of unrelated assumptions.

The coordination of research results is important; if it is done properly it may lead to the creation of new concepts and new theories. The development of such concepts and theories—provided they are sound and backed by research findings—is the highest and most profitable step in the research and application ladder. The advantages of good concepts and theories over poor ones are that more facts can be fitted into the good ones, analysis is made easier, and solutions to new problems come at a rapid rate.

One common factor coming out of all research on the behavior of groups and of man-machine systems is the importance of the perceptual process—in motivation, in interpersonal relations, in productivity, in accidents, etc. Those concerned with management problems can obtain more insight into the science of human relations by an understanding of this complex process and its relation to management problems than by studying any other psychological concept. For instance, there is an "hypothesis" theory of perception, developed by Professor Jerome Bruner of Harvard University, which can be very useful when applied to problems of interpersonal relations.

The "hypothesis" theory of perception, as applicable to the present discussion, may be stated in three parts. First, each individual is not the passive recipient of all the events that are going on around him. He, at every moment, has certain attitudes, a "set" of expectations or, as Bruner says, certain "hypotheses"; he "tunes in." To take a somewhat facetious example, if one strikes a person, he immediately sets up certain hypotheses as to what events will probably occur within him and in his immediate vicinity.

The second step in the perceiving process is the receipt and impact of information—the events generated lead to activity in and around the person, which may be thought of as information feeding into the person. In the illustration given above, this information may derive from hard looks, running away, retaliation of some sort, etc.

The third phase is the checking phase—confirmation or lack of confirmation of the original hypotheses takes place. If the original hypotheses are confirmed, they are reinforced; if they are not confirmed, they are weakened, and changing forces are set up. In the striking incident, if the abused person runs away when expected to do so, then the hypotheses are confirmed, and that is that. If, however, the blow is returned, then the original hypotheses have not been confirmed, and a new set of hypotheses has to take the place of the old. Needless to say, the behavior of the recipient of the blow also may be described in terms of hypothesis theory, just as well.

Now if you substitute for the blow some other interaction among people, it is possible to use hypothesis theory to analyze, explain, and eventually develop remedial action, if required, on any problem of an interpersonal nature. This theory may have operational application to such problems as absences, turnover, accidents, individual or group productivity, morale, training, and supervisory problems. For instance, an explanation of those behaviors which prevent solution of a problem may help pave the way for the development of more positive action. Let's say that the problem is how to carry on effective supervisory training. There are a number of individuals involved:

- The supervisor.
- Members of the group he supervises.
- His supervisor.
- The training officer.
- Others (e.g., policy-makers).

An understanding of the perceptions of each one of these people is very helpful in dealing with the problem.

Let's start with the supervisor. He has certain hypotheses concerning himself, his work group, the training officer, and management; and concerning his skills, abilities, interests, desires, need for training, etc. These may or may not be different from those of the training officer, the employees, and management. In this case, we will assume they are not. Now suppose that a training program for supervisors is started. Lectures, demonstrations, visual aids, participative sessions—all the information that a good training program possesses—is passed on through use of the best methods to the supervisor.

The process of absorbing this information is determined to a large extent by the number, kind, and strength of the hypotheses the trainee holds. If he has a strong and determined hypothesis that no training person can show him how to do his job, it takes a good deal of information and training skill to get him to change his hypotheses. He will not change his attitude toward the training until there is a change <u>in his perception</u> of the entire situation. Nevertheless, in spite of himself, he <u>may learn</u> and remember something.

The third stage is the feedback or confirmation-nonconfirmation stage. If he goes back to his job and fails in those instances where he tries to apply some principle he has learned, his original hypothesis is strengthened, and the training has had no effect on him. If, however, he tries out some new thing that he has learned and it does work, then his original hypothesis loses a little strength. Each successful repetition weakens the hypothesis even more until he finds that he has to substitute a new hypothesis for the old one. At that stage, he has learned.

Consider the training officer. He starts a training program with the expectation, or hypothesis, that such a training program is a good thing. This hypothesis may be subjected to attack by individuals who apparently have different hypotheses or who may not want to be trained because of poor motivation, pig-headedness, ignorance, or some other reason. If the feedback he gets indicates that no value is being received from the training, he should then either change his hypothesis about the excellence of the course (if the student hasn't learned, the teacher hasn't taught) or, if his own hypothesis is strong, try to change the attitudes or motivation, i.e., the hypotheses, of the trainees.

Much could be said about some important research in other areas, such as individual needs. Needs are intimately tied in with perceptions and rather basic to an analysis of why people act the way they do. Intuitively or through experience, the good commanding officer, as well as the good training officer, learns how to recognize the needs of the individuals and how to use this knowledge to motivate individuals and groups to achieve greater productivity and satisfaction. It is possible, for instance, that a good leader is one who perceives differences and similarities among his followers, meets certain basic needs of his followers, and perhaps satisfies some of his own needs as well.

What has been said about the application of research to management problems is not meant as a comprehensive program of action. We have merely presented an illustration of what might be done and perhaps offered a challenge to some intelligent manager.

Shipboard Ice Remover Made from Pulse-Jet Engines

Serendipity—the chance discovery of things not sought for—is a wonderful thing. About 18 months ago, NRL investigators working on the pulse-jet engine research project at Chesapeake Bay Annex discovered that a small, valveless pulse-jet engine made an excellent hole-digger for setting posts in frozen ground (Research Reviews, May 1955). Now, at the request of the Bureau of Ships, NRL has turned the versatile pulse-jet into a de-icer for removing the ice that accumulates on rigging, winches, and other topside equipment of ships in very cold weather.

The de-icer burner, shown in the photograph, consists of a pair of 2.5-inch O.D. valveless pulse-jet engines operating 180 degrees out of phase. Products of combustion from each engine are collected in a common pressure chamber and then passed through the exhaust nozzle. A penetrator spacer tip located at the end of the exhaust nozzle maintains the correct distance between the surface of the ice to be melted and the nozzle.

For starting, the de-icer is placed on a stand and coupled to a forced-feed fuel supply and a compressed air line, and connections are made to a 110-volt power supply to fire the ignition plugs. Once the engines are running all umbilical lines are disconnected, except for one lightweight hose for fuel. The burner weighs less than 12 pounds, and its exhaust flames will penetrate about 7.5 inches of hard ice in one minute.

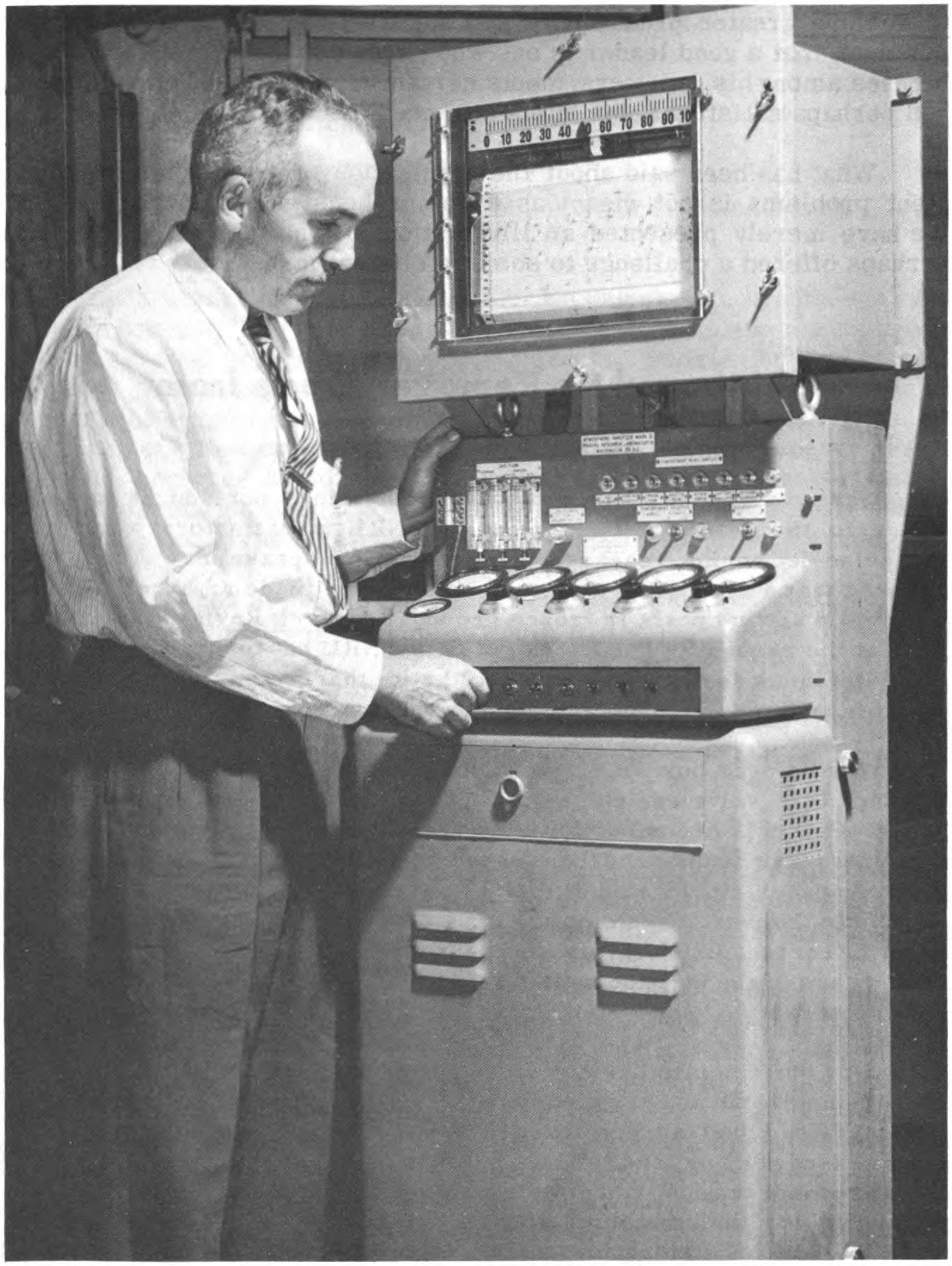


Figure 1 - Dr. F. S. Thomas inspects controls of the Atmosphere Analyzer, which he helped develop.

Atmosphere Analyzer for Atomic-Powered Submarines

F. S. Thomas
Chemistry Division
Naval Research Laboratory

The Navy's two atomic-powered submarines, the USS NAUTILUS and the USS SEA WOLF, are now equipped with the Atmosphere Analyzer (Figure 1), an apparatus that quickly determines and records the concentrations of the major components of the atmosphere in the ships' compartments. The analyzer is an outgrowth of the Naval Research Laboratory's long-standing program of basic and applied research in personnel protection.

The need for a device that determines the concentrations of the major components of a submarine's atmosphere—oxygen (O_2), hydrogen (H_2), carbon monoxide (CO), carbon dioxide (CO_2), and hydrocarbon vapors ("HC")—is readily apparent when one considers the effects of variation of the concentrations of these gases. Through respiration, oxygen is constantly being removed from the atmosphere, and carbon dioxide is constantly being added to it; as the concentration of oxygen progressively decreases, or that of carbon dioxide increases, personnel suffer progressively increasing physical distress, leading to complete disablement. Carbon monoxide results from incomplete organic combustion and, in even very small amounts, produces an oxygen insufficiency in personnel due to reduction of the oxygen-carrying ability of the blood. Hydrocarbon vapors are also toxic, particularly if personnel are exposed to them for long periods of time. Hydrogen is produced in the ship by the batteries, and even low concentrations in air present an explosion hazard.

Although studies of the atmosphere of submarines have been carried on for many years, it was not until 1948 that a program was initiated at NRL to develop a gas-analysis system. This program was sponsored cooperatively by the Chief of Naval Operations, the Office of Naval Research, and the Bureau of Ships. As an approach, investigators studied many physical, chemical, and electrical methods of gas analysis, including thermal conductivity, infrared absorption, and mass spectrometry.

As the NAUTILUS developed, such an urgency was put on the work of producing a gas analyzer for it that it became necessary for the Laboratory itself to undertake production of the first unit. Commercial analysis elements that had been modified and improved as a result of the previous studies were utilized. Many of the established practices in naval equipment development were either cut short or bypassed altogether because of the shortage of time.

The first completed model of the composite analyzer was installed on the NAUTILUS early in 1954. A second and much improved model, which was later constructed to replace the first model, was installed on both the NAUTILUS and the SEA WOLF. (See Figure 2.)

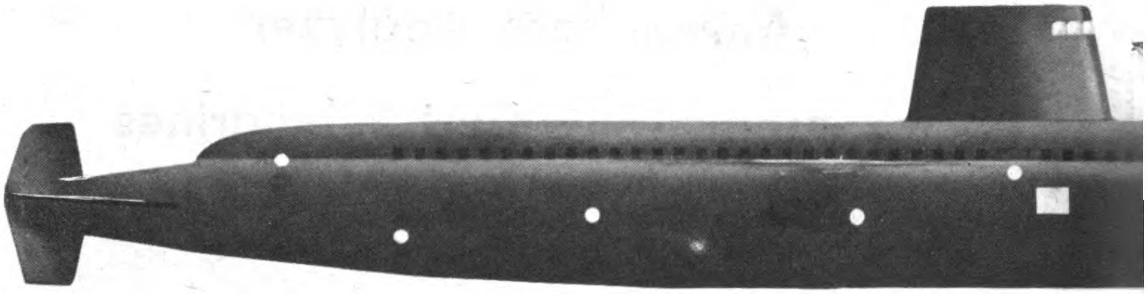


Figure 2 - The USS NAUTILUS, showing location of compartmer
from which gas samples are obtained and of Atmosphere Analyzer

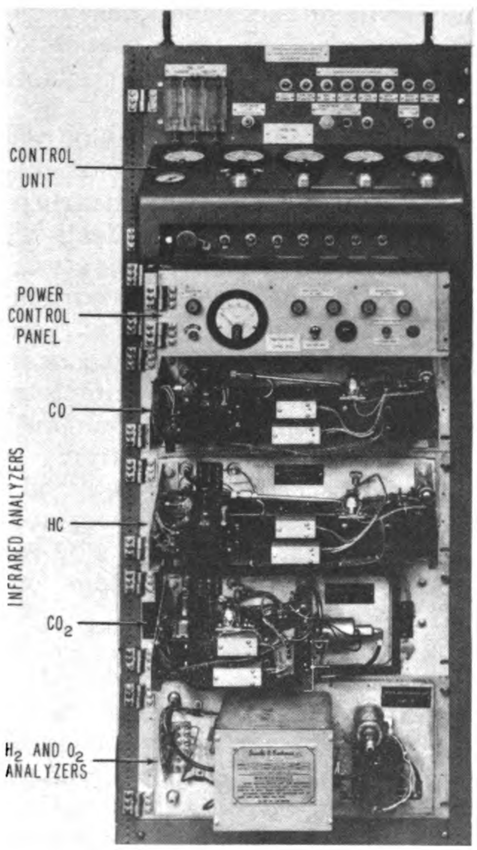


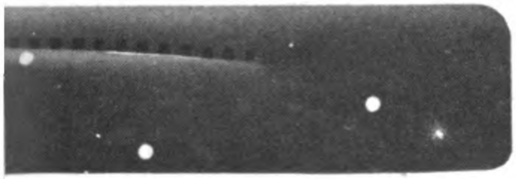
Figure 3 - Control panels and testing units of the Atmosphere Analyzer.

The relationship of the units of the Atmosphere Analyzer is shown in Figure 3. The control unit at the top of the console contains most of the operation and test-function controls as well as the meters that indicate the concentration of gases. Other indicators on this panel show the compartment from which the atmosphere sample is being drawn, the sample flow rate, and the instrument operation time.

The unit below the control panel is made up of two panels. The front panel contains the power controls and indicators, main fuses, and a voltmeter. The back panel (hidden by the front panel in Figure 3) contains a commercially built, specially packaged electronic voltage regulator, which supplies 115-volt AC power to the critical portions of all the analyzer elements. The regulator can be bypassed if necessary, but with reduced accuracy of analysis.

The panels below the power unit contain, in order downward, the analyzer elements for CO, "HC," CO_2, and O_2 and H_2, both on the bottom panel.

The analyzers for CO, "HC," and CO_2 are basically identical nondisperse infrared spectrographs, one for each component. Each spectrograph is composed of two major assemblies—the radiation unit, which is on the front of the panel, and the electronic amplifier, which is on the back. The radiation receiver for each analyzer is a pure, sealed sample of the atmosphere component whose concentration is determined in that



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element; thus the receiver can respond only to those portions of the infrared spectrum corresponding to the component's molecular structure. Synchronous interruption of the infrared beam and amplifier output annuls spurious signals due to ambient variations, vibration, and electronic noise.

The analyzer for oxygen makes use of the unique paramagnetic property of oxygen. Thus a nonmagnetic test body placed in a magnetic field tends to be forced out of that field only by the oxygen in the atmosphere sample. The amount of this force is determined by balancing an electrostatically produced force against it. The variable potential of the electrostatic field is used to produce a meter indication of oxygen concentration.

The hydrogen concentration in the sample is determined by comparing the rate of heat transfer through the gas sample with that through a sealed dry-air reference. This method can be used because hydrogen is the only major constituent of the submarine atmosphere whose thermal conductivity is greatly different from that of air.

The use of these physical methods provides highly selective, rapid, continuous analysis without the use of liquids, chemicals, or manual operation.

Samples of submarine atmosphere are drawn into the analyzer by means of eight small pumps mounted in the back of the console. Each pump pulls air through one of the eight installed tubes that extend from the console to the sampling locations in the ship's compartments. The pump outputs combine into a single tube, which carries the sample to the five analyzer elements. If the operator wishes to sample the atmosphere in a particular compartment, he simply activates the pump leading to that compartment.

Ready, periodic determination of the proper operation and calibration of the analysis units has been provided for by including on the control panel (1) control switches that introduce simulated gas signals into the analysis elements, (2) a hand-pump system that produces a zero signal by removing the atmosphere sample from the analysis elements, and (3) an intake fitting by means of which standard gas samples can be introduced into the analysis elements.

The equipment has demonstrated an indication error within 2 percent of full scale under laboratory conditions, and it should function within the 5 percent error permitted for operational submarine use.

A more detailed description of the Atmosphere Analyzer appears in Report of NRL Progress for May 1956, which is obtainable from the Office of Technical Services, Department of Commerce, Washington, D. C.

How Radioactivity is Measured on the NAUTILUS

R. C. Waddel
Nucleonics Division
Naval Research Laboratory

Navy spokesmen have often declared that the USS NAUTILUS (Figure 1) represents a milestone in naval progress approached in importance only by the transition from sail to steam. This progress is taking place at such a rapid pace that designers and engineers have been hard put to solve the many complex problems encountered in constructing and equipping the atomic-powered submarines. One such problem has been that of providing radiological safety for crewmen. Not only was it necessary to develop a piece of equipment which would measure radiation at critical locations aboard the ships, but also to develop one that would operate reliably over the long periods of time during which the ships cruise submerged, often at high speeds.

In the early phases of design and construction of the NAUTILUS, attention was directed to the development of a device which would measure

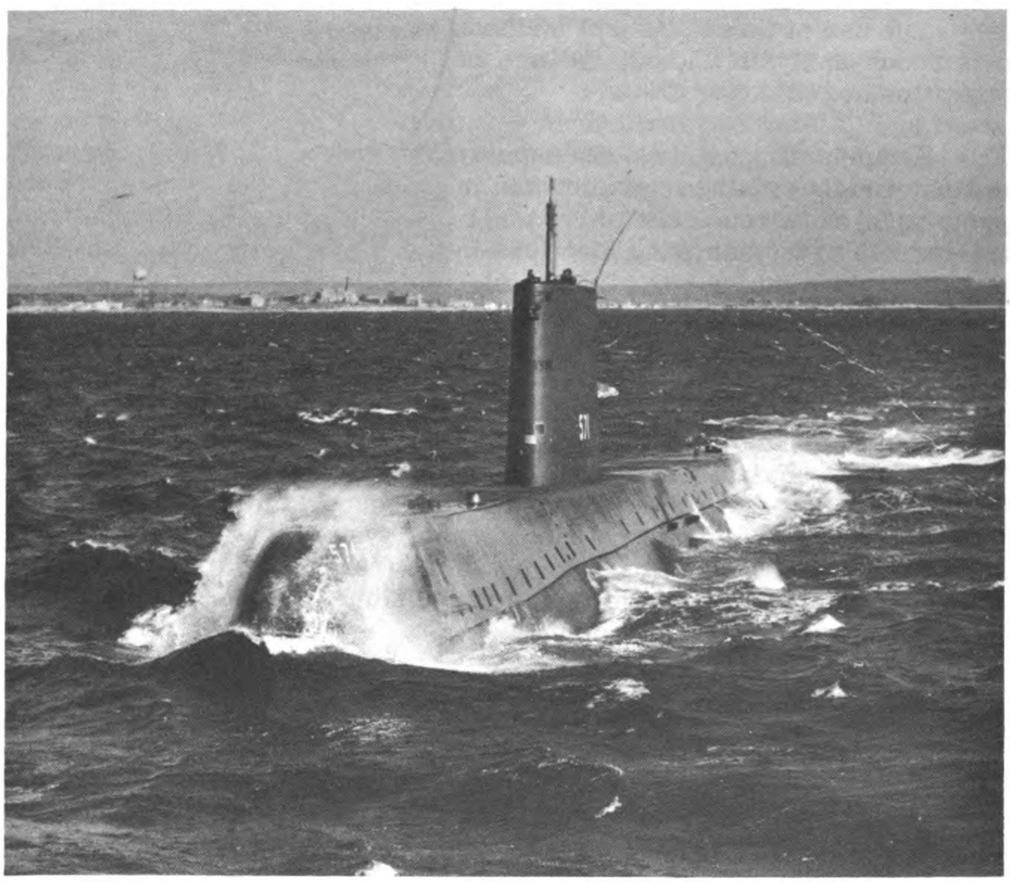


Figure 1 - The USS NAUTILUS underway.

reliably the radioactivity of airborne particles within the submarine. The first attempts to build acceptable equipment failed. As a result, the Naval Research Laboratory was called upon to develop, on a "crash" basis, a computer-detector that would work. The equipment was built, and eventually three identical models were installed in the NAUTILUS. They are located at widely separated places and as close as possible to optimum spots for detecting radiation. One is located forward near the officers' quarters, another is in a compartment directly over the reactor, and a third is near the control center.

The equipment, called the Computer-Detector Radiac CP-275/BEQ-1A is made up of three units. The largest unit (Figure 2) houses the filter-tape, detector, and computer mechanisms. The center unit contains the air pump and its driving motor. And the smallest unit contains a remote meter and light display.

Tests have revealed that the device possesses the required reliability and sensitivity. Also, it operates without difficulty in a gamma-ray field of 10 milliroentgens per hour. Performance is good in spite of ship noise, shock, and vibration. The equipment gives readings on radioactivity in a range between 8×10^{-10} and 8×10^{-7} microcuries per cubic centimeter, and, in so doing, reassures the crew that the atmosphere is well within tolerance limits on radioactivity. The sampling rate of 2.5 cubic feet per minute is regarded as sufficient to give a satisfactory reading on the condition of the atmosphere.

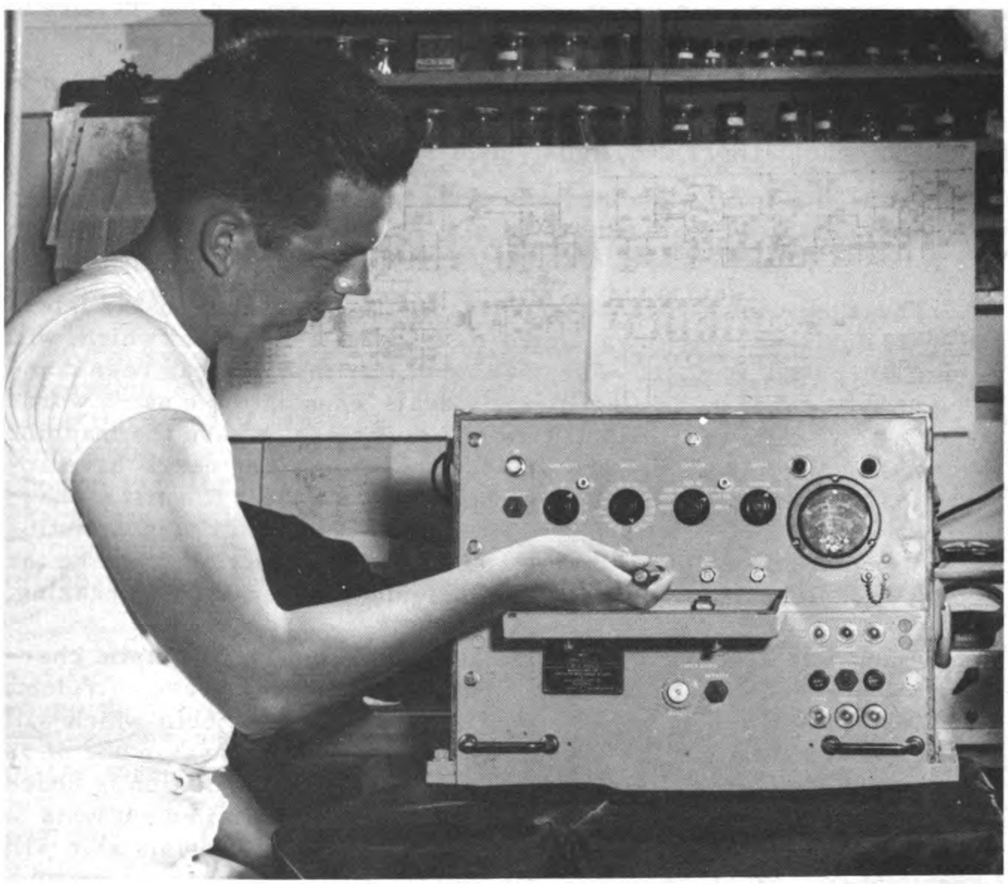


Figure 2 - Laboratory check-out of Computer-Detector Radiac.

The standard handbook in use at NRL on radiological safety lists 78 airborne isotopes which might occur in an atmosphere under test. The new device is able to detect the maximum permissible exposure levels of 68 of these isotopes and shows a significant deflection for an activity of 10^{-9} microcuries per cubic centimeter.

The atmosphere is sampled at the rate of 2.5 cubic feet per minute by pumping the air through a slowly moving filter tape. Emanations from any radioactive deposit collected on the tape strike a scintillating crystal whose light flashes are detected and amplified by a photomultiplier. Suitable electronics provides a meter deflection and alarm signals at several locations if the activity level is too high. In order to achieve the reliability required of the equipment, scientists at NRL gave careful attention to the selection and lubrication of the air pump, the tape drive, and chassis construction, to the choice and mounting of electrical components, and to circuit details.

The equipment was designed so as to be easy to maintain. Its drawer-type construction permits easy access to all parts of the main instruments, warning lights automatically indicate certain instrument malfunctions, and calibration and voltage checking systems are built in. In all, the equipment weighs 543 pounds and occupies 13.29 cubic feet.

The protection provided by the Computer-Detector has been of great importance to the successful operation of the NAUTILUS. As the Navy's transition to nuclear power continues, the equipment is sure to be given much broader application.

A more detailed description of the Computer-Detector is given in Report of NRL Progress for June 1956, which is obtainable from the Office of Technical Services, Department of Commerce, Washington, D. C.

Analyzer for Speaking Voice

The Electronics Branch at ONR has a contract with the International Business Machines Corp. to develop a machine which will recognize spoken English. The making of this machine has been complicated by the fact that different individuals enunciate the same words in quite different ways. Thus it is not sufficient to have the machine recognize a particular pattern of sound. Project engineers have approached the problem by analyzing phonemes into their linguistic characteristics and then following through to find a system of characteristics for the sounds or combination of sounds. The object is to make the system hold true regardless of the individual who may be speaking.

Phonemes have been classified into the following linguistic characteristics: Vocalic, consonantal, compact, diffuse, grave, strident, nasal, continuant, tense, voiced. An analyzer has been built which will separate a phoneme into its frequency components and assign one of 32 fixed levels of amplitude to each component. This information is coded on a tape and fed into a Type 704 computer in which detailed analysis is performed. In addition to spectral analysis, temporal analysis also will be performed to measure short-time average power of sound components and the density of axis crossings per unit time.

Seasonal Changes in Sea Level

June G. Pattullo
Scripps Institution of Oceanography

For pure lazy fun, try lying on a sandy beach in the sunshine watching the waves wash in and out. Just the sight of all that motion has a relaxing effect. This hardly seems to be a scientific activity, but it was surely in some such way, thousands of years ago, that men discovered the rythmic rise and fall of the sea we know as tides.

There are limits, though, to human patience (or even laziness). It eventually becomes necessary to let a measuring stick of some kind do your watching for you. You get unbiased, untiring observations—and frequently your measuring stick gives you answers to questions you hadn't thought to ask! This is what happened with the tide gauge.

As early as 1828 an engineer named Palmer had an automatic gauge recording water levels in the port of London. Slowly this practice spread to other European ports, and by 1900 more than 100 gauges were rolling out records. It was soon noticed that sea level not only changes throughout the day but that the level is different from month to month. At almost all European ports it is higher in the second half of the year than in the first. Why?

Right after the turn of the century several papers appeared offering explanations. Geelmuyden suggested that changes in atmospheric pressure and winds were the causes. A man named Van Der Stok disagreed volubly. Petterson said there was a "general pulsation of the ocean from the tropics to the Polar Sea" and concluded that local effects could not be very important. Gallé argued that European sea levels were changing in response to changing flow of ocean currents in the Gulf Stream system.

Thirty years later other kinds of data were introduced into the discussion. Nomitsu and Okamoto showed that changes in sea level along the coast of Japan were accompanied by changes in temperature (and hence in volume) of the water. LaFond, of the Scripps Institution, showed that the same thing happens on this side of the Pacific—the changes in sea level observed at Scripps pier corresponded to changes he could compute by using temperature and salinity measurements taken offshore.

Then came a breakthrough. The International Union of Geodesy and Geophysics (UGGI) decided to organize the sprawling body of tide-gauge data that was accumulating all over the world. The first two publications, which appeared in 1940 and 1950, contained 100,000 values of the mean monthly height of sea level. Here was a rich source of material. No longer was an oceanographer tied to the data from his own gauge or from a few neighboring stations. Now he could compare his observations with what had been going on at Oslo, or Buenos Aires, or Bombay.

This was immediately attractive to two globe-minded workers at Scripps, Walter Munk and Roger Revelle. Here were tens of years of records on the behavior of the sea surface. Surely these records could tell us much that would improve our knowledge of the motion of the sea surface.

The sea surface undergoes oscillations and changes in shape of many different time scales. The yachtsman recognizes a quick gust of wind by the dark patch of tiny ripples it makes as soon as it touches the sea surface. On the other hand, the slow loss of water from oceans to icecaps is revealed by benches the water has cut into the edges of the continents—benches that took thousands of years to carve. The whole range of such variations we call the "spectrum" of sea-surface changes. Until quite recently oceanographers were familiar with only parts of this spectrum.

We recognize ripples, with fractions of a second between crests; chop, that is several seconds long; and swell, perhaps 20 seconds long. Then there is more or less of a gap until we get to periods around 12 and 24 hours, when we find tides. But practically nothing is known about changes with longer periods than the tides but shorter than the slow changes in level that take many years. Are there no waves in between, in the "holes" in the spectrum? Within the past few years much work has been done at Scripps, and at other oceanographic institutions, in an effort to learn more about the gaps. The UGGI averages provide a source for work of this type. With them one can study changes with long periods as compared with a month but not long when compared with the number of months of record.

The period with which we chose to start seemed to us the obvious one—waves of annual period. The earlier papers had shown that an annual period is usually observed—we thought we'd like to know something about how it looks on a global scale.

This problem is not just an isolated curiosity. If the sea surface changes its level or its shape, there must be some physical reason. Perhaps the ocean currents change from one season to the next. Perhaps the changes are a reflection of wide-spread atmospheric effects. Our tide gauges may be more versatile tools than we had thought—and relatively inexpensive and reliable tools they are. It would be good luck, indeed, if it turned out that the tide records could serve as land-based observation posts of such oceanic phenomena as currents.

The possibility was interesting enough to make us sit down with the Union's publications and go through the long task of reducing their tabulations to the point where a summary could be given. We finally emerged with a new set of numbers, only 5000 this time, and all in comparable units. We proceeded to plot and combine these in an effort to get a general description of world sea-level variations throughout the year. The tabulated values and the derived charts were published recently by the Journal of Marine Research. *

*June Pattullo, Walter Munk, Roger Revelle, and Elizabeth Strong, "The Seasonal Oscillation in Sea Level," Journ. Mar. Res., Vol. 14, No. 1, 1955.

There is one most striking result. The seasonal variations in sea level are about the same over very long distances, even across oceans. Most of the gauges at the European coast show cycles similar to one another. Furthermore, these are also similar to the cycles observed on the American coast across the Atlantic. This is exciting; it means we are dealing with a large-scale phenomenon, perhaps an ocean-wide one.

Over all of the Northern oceans there is a gentle rise in sea level, starting in spring or summer and reaching a maximum in fall or winter. Figure 1(c) shows a typical case. The amount of rise from lowest to highest mean-level averages about 8 inches, although it varies greatly from place to place.

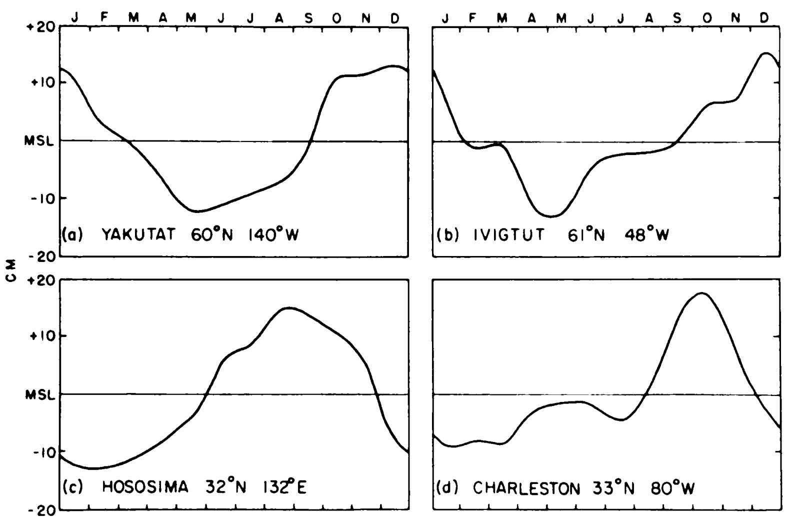


Figure 1 - Seasonal variation in sea level at selected gauges. (Left) North Pacific Ocean; (Right) North Atlantic Ocean.

The cycle in the Southern Hemisphere is more or less a mirror image of what we observe in the north—when sea level is high north of the equator it is low in the south. We can visualize the sea surface tilting back and forth throughout the year, with the equator as a sort of fulcrum, but the data are not completely conclusive on this point.

Closer inspection of the data in the Northern Hemisphere reveals that the oceans here are not behaving quite as units. Tide gauges between the equator and about 45°N show a maximum height in September; gauges north of 45° have a maximum 3 months later, in December. (See figures.)

Is this also true in the Southern Hemisphere? Unfortunately, we at Scripps were unable to tell from our data. But another worker in this field, Dr. Eugenie Lisitzin of the Finnish Oceanographic Institution, believes there is evidence for a breakdown of the Southern gauges into two sets or zones, also. This means we have three, possibly four, great oceanic areas, each going through an annual oscillation more or less as a unit. One is north of 45°N, another between 45°N and the equator, a third south of the equator, and a fourth, possibly, in some deep southerly latitudes.

Let us suppose that the Northern Hemisphere "humps up" in winter and spring, so that the water stands high in the center and low at the edges. If the Southern Hemisphere behaved in the same fashion, then the coastal gauges would show high levels while the Northern Hemisphere coastal gauges were low. But the average difference across the equator could be zero!

A test for this humping possibility is provided by gauges on islands in the middle of the oceans. In the past there have been too few island gauges to ensure an answer. At those islands that do have records, such as Hawaii and Bermuda, the level is high at the islands at the same time it is high on the mainland; thus the humping hypothesis does not seem to be the correct one. There may be some humping—the island gauges generally show reduced oscillations as compared with the coastal ones—but the seasonal change is primarily a north-south tilt, not a hump, apparently.

This is really a fairly simple picture. Is there a simple explanation for it? Four possibilities seem likely:

- There is an annual tide caused by astronomic bodies.
- The ocean is acting like an inverted barometer under changes in atmospheric pressure.
- There is a net seasonal transport of mass from one part of the ocean to another (blown there by winds, perhaps).
- The water is expanding because of local heating in the summer.

Let us look at each of these in turn.

Tides. The oscillation cannot be a tide, in the usual sense of the word. The amplitude of the annual astronomic tide can be computed to within a fair degree of approximation. It is only an inch or so at most, and has a maximum at the poles and a minimum near 30° latitude. This just does not agree with the observations. (See Figure 2.)

Atmospheric pressure does have an annual cycle, but only part of this will have an effect on a tide gauge. If the average pressure over all the oceans goes down 1 millibar, nothing may show up on the gauge. (Because water is relatively incompressible, average changes have negligible effects.) But if the average pressure goes down 1 millibar and the local pressure goes down 2 millibars, then the sea level at the point of observations will rise about 1 cm, or 2/5 of an inch.

It turns out that this effect is observable, but is not generally large. It is most important around Japan, China, and Greenland, but even then atmospheric pressure plays a secondary role. Around Japan, for example, the atmospheric pressure decreases 5 to 10 millibars from winter to summer. But the observed rise in sea level is almost a foot—4 or 5 times as large as could be caused by barometric changes alone.

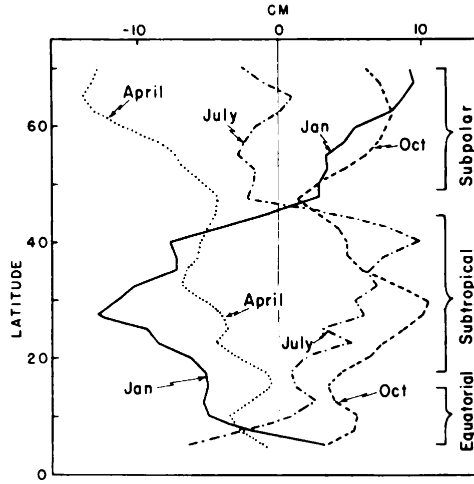


Figure 2 - Recorded departures from mean sea level as a function of latitude for each of four months (Northern Hemisphere).

Net mass transport. From the tide-gauge data alone we cannot be sure whether the sea level rises because there is more water under the gauge or simply because the water under the gauge has a larger volume in summer than in winter. We recall that Nomitsu and Okamoto, and later LaFond, found the second case to be true off Japan and California. In other words, summer water just takes up more space.

The direct way to decide between these alternatives would be to use two recorders. A pressure gauge at the bottom would tell the total weight or mass of water above the bottom. A surface float would tell the height of the water column.

Unfortunately, we do not have many pressure gauges sitting on the bottom; at least we have no year-long records. So we resorted to the method Nomitsu, Okamoto, and LaFond used: we computed the volume of the water near the tide gauges from temperature and salinity observations. Many of these new computations were made possible by the large number of bathythermograms taken by Navy and Coast Guard ships during and since World War II.

The results are curious. The northern oceans again split into two zones. In the area south of 45°N there is almost no change of mass during the year; the changes are in the volume of the water and are caused largely by changes in temperature. Salinity effects are small but not negligible. North of 45°N, temperature changes are not large enough to explain the observed variations in height. The salinity observations are too scarce for us to draw conclusions from them. And we do not know whether or not there are mass and volume changes in this zone. South of the equator, in the Southern Hemisphere, data are few, but the indications are that the changes are volume changes, not net-mass changes.

Local heating. We would think now that we have found little evidence for any of the other three possibilities and that local heating must be the cause of observed changes—at least for 0-45°N. But is it? Let us look at the temperature data more closely.

The observations tell us only how much heat is in a water column, not how it got there. Some preliminary computations suggest that advection as well as local heating may be important. That is, it seems as if, during summer and fall, warm water must be flowing into the Northern Hemisphere from somewhere—presumably from the Southern Hemisphere. To settle this question we need to make many more observations south of the equator.

We hope to see a lot of progress in the Southern Hemisphere during the forthcoming International Geophysical Year. At that time a great and international increase in effort will be made all over the world. Dozens of new installations will be made on islands, by more than 15 countries. For example, the South American nations, Australia, New Zealand, France, and the United States all have major programs in the South Pacific.

The expanse of area covered, especially that away from the edges of continents, will be increased many fold. For the first time we will have widespread temperature and salinity observations that are synchronous in time and are near the tide gauges.

Perhaps we will be able to track the water from one hemisphere to another. Probably we will get some surprises. Almost certainly we will find better ways of asking the questions that now perplex us. As a case in point, suppose that the water <u>is</u> tilting up in the north and down in the south during September. What in the world is keeping it from simply running down hill?

Symposium on Naval Hydrodynamics

The Office of Naval Research (Mechanics Branch) with the National Academy of Sciences - National Research Council sponsored an unclassified symposium on naval hydrodynamics which was held in Washington, D. C., from 24-28 September 1956. This symposium—the first of a series now planned to be held on a yearly basis--was an outgrowth of a continually growing need for meetings devoted exclusively to developments in the rapidly advancing field of hydrodynamics, particularly in the areas basic to naval and marine applications. Emphasis was placed on critical surveys of those areas, including identification of requirements for further research; these surveys were presented by recognized authorities.

The program, which was presented to 430 participants, included the following speakers and subjects: C. C. Lin on boundary layer stability, S. Corrsin on turbulence in shear flows, G. K. Batchelor on wave scattering due to turbulence, M.J. Lighthill on river waves, W.H. Munk and M. Tucker on the ocean wave spectrum, D. Gilbarg on free streamline theory and steady state cavitation, M.S. Plesset on physical effects in cavitation and boiling, H. Snay on hydrodynamics of underwater explosions, G. P. Weinblum on seaworthiness, H. Lerbs on hydrodynamics of marine propulsion, J. V. Wehausen on ship wave phenomena, M. Strasberg and H.M. Fitzpatrick on hydrodynamic noise, J.B. Parkinson on hydrodynamics of water-based aircraft, J.W. MacColl and R.N. Cox on basic hydroballistic phenomena, J. C. Niedermair on hydrodynamic barriers in ship design, and L.M. Milne-Thomson on some problems and methods in hydrodynamics.

Research Notes

Marine Biology Studies at University of Rhode Island

Very little is known of the beginning stages of algae and seaweed, and still less about the interrelation of the plant and animal life at various levels of the ocean and the biology of the plant and animal communities there. Consequently, ONR is sponsoring two projects in marine biology at the Narragansett Laboratory of the University of Rhode Island.

Dr. David M. Pratt is undertaking a "study of the dynamics of biological productivity of the benthos." (Benthos is a general term for anything that grows on the sea bottom.) Dr. Charles J. Fish has undertaken a project entitled "The biology of marine fouling growth on and adjacent to the bottom." The projects embrace two different approaches to the same goal—to lay the groundwork for further steps to prevent fouling of objects such as anchors, ship bottoms, mines, and cables submerged in the sea.

Cathodic Protection, 1956

Since shipbuilders first began constructing ships of iron they have been pestered by electrolytic corrosion. This occurs when two different metals—say a steel hull and bronze propellors—find themselves near each other in sea water. There are now in use two standard methods for combatting this insidious corrosion. The first involves the use of "sacrificial anodes," blocks of zinc or a similar metal bolted to the ship's underbody near the propellors, which cause current to flow to the hull, thus protecting it. The other method is to coat the bottom of the ship with nonconducting paint. Neither of these methods has prevented corrosion; they only extend by a few months the time between drydockings.

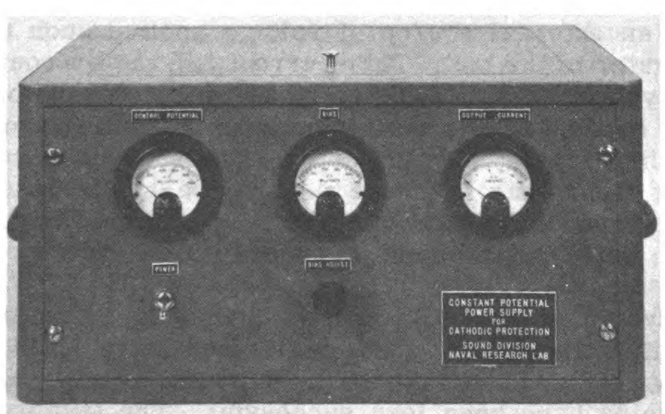
For the past five years the Bureau of Ships and NRL have been working cooperatively on more effective protection by utilizing impressed currents. Various types of anodes are placed in the water at critical locations and an external source of voltage applied such that current flows in the water to the hull. This current offsets or counteracts the flow caused by the difference in potential between steel and bronze. Like many another concept that is theoretically excellent, this one has been difficult to achieve in actual practice. Designing the best type of anode and insulating mount has been one problem; a more serious one has been to impress exactly the right amount of current under conditions that vary with water environment or speed of the ship.

These systems of cathodic protection by impressed current have worked out quite well for ships of the mothballed Reserve Fleet (Research Reviews, May 1952 and January 1955). But similar systems applied to operational ships have been less successful. The twin requirements that the electrical potential at various locations around the hull be accurately and frequently measured and that the flow of impressed current be altered accordingly, have demanded almost continuous monitoring by a trained observer, thus increasing maintenance costs and defeating the main purpose of cathodic protection.

In 1952, NRL installed on the submarine AMBERJACK an automatic controller consisting of a standard electronic amplifier which operated a servo-motor mechanism. This device had been used extensively in the laboratory and was able to maintain the potential of steel plates at any desired value when they were immersed in a tank of salt water. But when it was installed on the submarine, difficulties were experienced in operation. Furthermore, since the power supply which furnished the cathodic-protection current was undersize and had to be operated at maximum capacity, with no latitude in its control, this particular device could not be evaluated.

The next attempt resulted in a magnetic-amplifier type of controlled power supply designed to furnish a constant source of current for cathodic protection under all operating conditions of hull polarization and water resistivity. This instrument was installed on a Coast Guard cutter, the CUYAHOGA, and operated over approximately a two-year period. While it performed well for its intended purpose, the use of constant current was found to be inadequate for control in cathodic protection. But a second magnetic-amplifier type of controller, which operates on the potential difference between a zinc electrode and the steel hull of the ship, proved to be successful. By this method the amount of current to the hull can be automatically regulated, and thus any desired potential difference between the two metals can be maintained.

It was installed on the PC-776 at the Norfolk Group, Atlantic Reserve Fleet, in June 1956 and has performed exceptionally well in the maintenance of cathodic protection on this vessel for the last three months. The fact that no moving parts or electronic devices are used in the controller makes it suited for naval use, since maintenance of the equipment can thus be reduced to a minimum. At the present time its high cost prohibits its widespread use, but it is expected that further developments and production economies may effect its practical application in the Fleet.



On the Naval Research Reserve

New Companies Activated

The March issue of Research Reviews reported activation meetings of two new Naval Reserve Research Companies, NRRC 6-17, Huntsville, Alabama, and NRRC 6-18, Nashville, Tennessee. Naval Reserve Research Company 6-17, with LT H. F. Thames, USNR, as Commanding Officer, held its activation meeting on 20 March 1956 at which LCDR J. T. Bedsole, USNR, then Naval Reserve Research Program Officer, Southeastern Area, was present. The present Commanding Officer of NRRC 6-17 is LCDR Curtis B. Williams. Naval Reserve Research Company 6-18, Nashville, Tennessee, commanded by CDR G. B. Suddeth, USNR, held its activation meeting on 4 May 1956, with CDR H. F. Burr, USNR, Special Assistant to the Chief of Naval Research (Research Reserve), attending.

California has four new companies. Naval Reserve Research Company 11-8, at the Naval Air Missile Test Center, Point Mugu, California, is commanded by CDR Mark S. Jones, USNR. Naval Reserve Research Company 11-9, at Aerojet-General Corporation, Azusa, California, has LCDR James C. McConahay as the Commanding Officer. Both of these companies were established 1 April 1956. Naval Reserve Research Company 11-10, Ventura, California, with CDR Omar B. Richardson, USNR, as Commanding Officer, and Naval Reserve Research Company 11-11, Santa Monica, California, with CDR Carl H. Young, USNR, as Commanding Officer, were both established 1 July 1956.

Naval Reserve Research Company 9-4, Peru, Indiana, was officially activated on 18 June 1956. LCDR George R. Wagner, USNR, is Commanding Officer of the new company.

Research Reservists at Brookings, South Dakota, who have previously operated as a Panel under Naval Reserve Research Company 9-6, Minneapolis, Minnesota, were formally activated as a company on 1 July 1956. LCDR Gerald B. Spawn, USNR, is Commanding Officer of this company, designated NRRC 9-11.

Two Panels of Research Companies have recently been formed. A Panel of Research Company 6-2, Auburn, Alabama, has been formed at West Point, Georgia, with LT Carl Summers, USNR, as the Officer-in-Charge. A Panel of Research Company 3-5, New Haven, Connecticut, was formed at Hartford, Connecticut, with CDR Kenneth I. Boone, USNR, as Officer-in-Charge.

New designations have been assigned the Washington area Companies. Companies formerly designated as W-1, Washington, D. C.; W-2, Washington, D. C. (NRL); W-5, Bethesda, Md. (NMRI); and W-7, Annapolis, Md., have been redesignated as Naval Reserve Research Companies 5-8, 5-9, 5-10, and 5-11, respectively. This was occasioned by the transfer of Naval Reserve activities in the Washington area from the Potomac River Naval Command to Commandant, Fifth Naval District, on 1 July 1956.

New Training Specialist Joins Research Reserve Staff

LCDR Kehoe

Miss Eleanor Kehoe joined the staff of the Research Reserve at the Office of Naval Research as Training Specialist on 24 September 1956. A member of the Naval Reserve, she served on active duty from February 1943 to August 1955. Upon release from active duty she attended The George Washington University from which she received a Master of Arts degree in Personnel Administration.

Miss Kehoe attended the U. S. Naval Midshipmen's School at Northhampton, Massachusetts, and was commissioned an Ensign on 4 May 1943. She has held the rank of Lieutenant Commander in the Naval Reserve since 1 April 1952. From 1943 to 1951 she served in communication and administrative duties on the staff of Commander, Western Sea Frontier; Commandant, Twelfth Naval District; Commander, Naval Station, Treasure Island; and Commanding Officer, Naval Supply Center, Oakland, California. In 1951 she reported to her active duty assignment at the Bureau of Naval Personnel as the Military Personnel Officer. Miss Kehoe has been awarded the Naval Reserve Medal, American Area Campaign Medal, Victory Medal World War II, National Defense Service Medal, and Navy Expert Pistol Medal.

A native of Alexandria, Minnesota, Miss Kehoe attended St. Cloud Teachers College, the University of Minnesota, and the University of Wisconsin. She received a Bachelor of Science degree in Education from the University of Maryland.

NAVY SPOKESMEN ARE SAYING ---

Part of the Navy's shipbuilding program for fiscal year 1957 calls for a nuclear-powered light cruiser. In regard to the use of nuclear power to propel surface ships, RADM H. C. Bruton, USN, Director of Naval Communications, says:

"While nuclear power has unharnassed the submarine from many operational restrictions, and has provided it with a capability not dreamed of 20 years ago, it also offers many advantages for surface ship propulsion. The powerful naval surface ship task force of today is utterly dependent on its mobile logistics replenishment group. Necessary high-speed operations burn up fuel fast. For example, a typical destroyer burns fuel almost six times as fast at 30 knots as it does at 15 knots. Therefore, present surface ships, especially destroyer types operating at high speed, must refuel frequently, sometimes as often as every few days in order to provide a safety factor. The employment of nuclear power will completely eliminate the requirement for refueling at sea."

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LAST MONTH WITH "VANGUARD"

As the earth-satellite program moves into high gear, in preparation for IGY next summer, important disclosures are being made more and more frequently. The following are quotations from addresses by NRL personnel associated with Vanguard, or from Department of Defense releases.

• Dr. J. P. Hagen, Project Director of Vanguard, said in Chicago, Oct. 1, "We are now moving into the Air Force Missile Test Center at Patrick AFB, Florida. The launch pads, gantry crane, and blockhouse are being readied . . . testing of parts will commence in a few weeks. Within a few months the first of a series of test vehicles will be fired . . ."

• The first radio tracking station for detecting and measuring the path of, and obtaining other information from the satellite has been established at Blossom Point, Md., about 40 miles south of Washington, D. C. This station will be used initially to evaluate all components of the Minitrack radio tracking system and to train the operating crews for the other tracking stations. Initial tests indicate a high degree of efficiency and reliability for the little satellite transmitter, which weighs only 13 ounces and has a potential broadcast range of more than 4,000 miles using Minitrack receiving stations.

• Eight stations are to be provided in the basic north-south fence (roughly along the 75th meridian), ranging from a latitude of 32° S, in Chile, to 38° N, at Blossom Point, providing a probability of intercept within this region of over 95%. Two additional stations will provide initial acquisition and orbital determination during the first orbit, one on the island of Antigua within the AFMTC test range, 1500 miles down range from the launcher, and the other at Navy Electronics Laboratory, San Diego, Calif., to provide pickup data approximately 85 minutes after launch.

• On 23 Sept., Dr. John P. Hagen, Director of Project VANGUARD announced the appointment of J. Paul Walsh as Deputy Director of the project.

• Over the past ten years, rocket experiments have given the first direct view of the solar spectrum beyond the ground level cut-off at 2856 A. From spectrographic and photon counter measurements we now know the general shape of the sun spectrum all the way down to x-ray wavelengths of a few angstroms. But the sum total of all rocket measurements add up to less than an hour of useful observations. To catch the spectrum of such short-lived phenomena as solar flares is a tremendously difficult task with conventional rocketry. A satellite offers the nearest approach to a continuous observing station above the atmosphere.

The hydrogen-Lyman-alpha line at 1215.7A is the most prominent feature of the far-ultraviolet solar spectrum. It is absorbed in the earth's atmosphere between 90 and 70 kilometers, the D-region ionosphere. A satellite experiment can monitor the sun in Lyman alpha almost continuously for many days and would be worth hundreds of randomly fired rockets for the same purpose.

In This Issue

The great heat generated by some machinery and by hypersonic airplanes and missiles causes component metal parts to deform. Scientists are now producing detailed explanations of this phenomenon.

There is much more to management research than the trial-and-error methods of the efficiency expert; it involves observation, measurement, and close study of interpersonal relationships.

These two articles describe equipment designed to measure the concentration of radiation and gases in the compartments of atomic-powered submarines.

Much is known about the changes in sea level that occur daily, but relatively little about those that occur seasonally. This article considers explanations that have been given for the seasonal changes.

COVER PHOTO: Dr. John P. Hagan, Director of Project VANGUARD, inspects the first full-scale model of the scientific Earth satellite. The figure on the blackboard shows the orbit IGY scientists hope the satellite will follow.

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