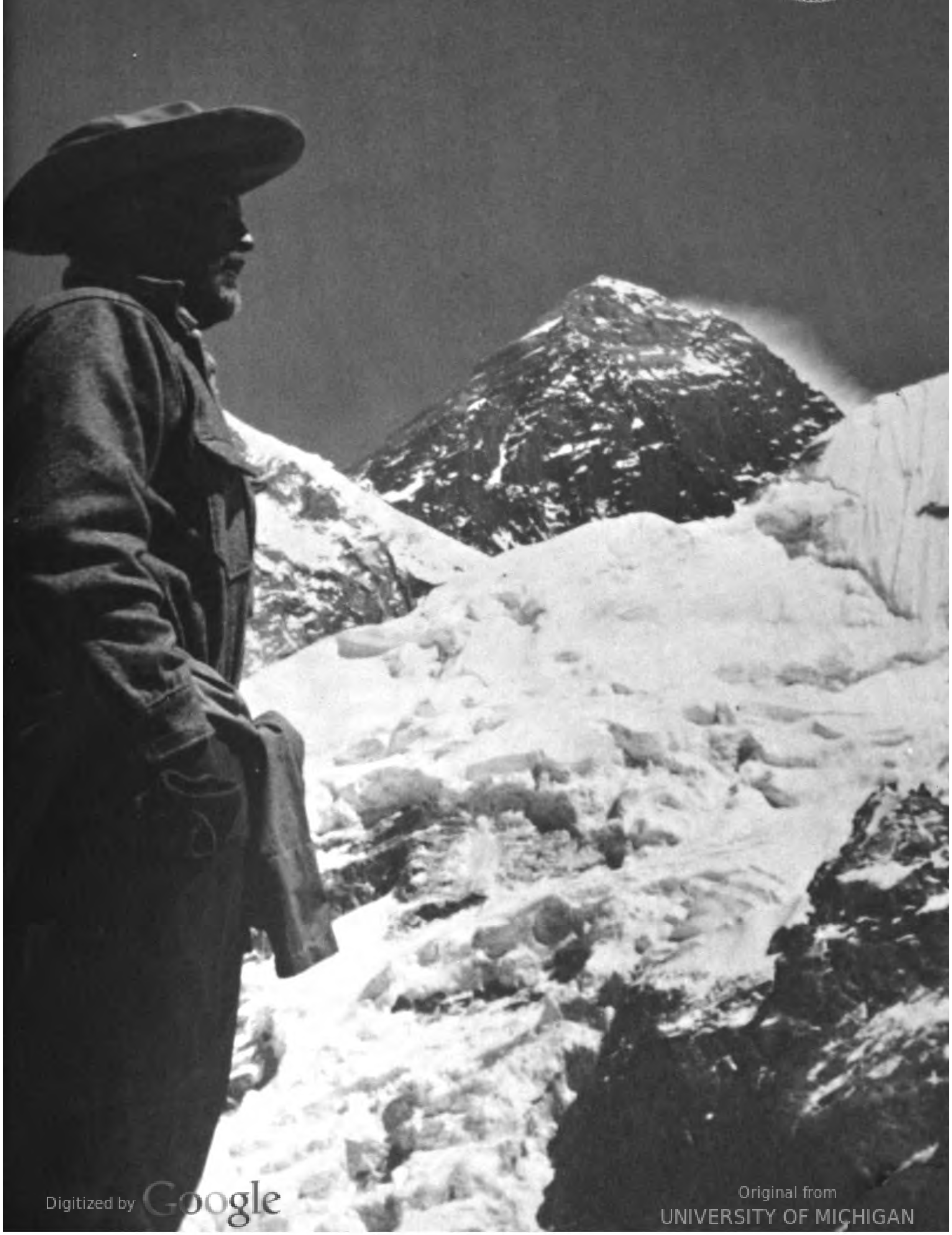
# NAVAL RESEARCH REVIEWS

DECEMBER 1964



# Sidewinder and Arcas Mated as Meteorological Probe

A low-cost, high-altitude meteorological probe rocket has been developed by the Naval Missile Center (NMC), Point Mugu, California, to acquire information about the density of the upper atmosphere during spacecraft launches. The rocket, which is capable of carrying a 12-pound payload to altitudes greater than 70 miles, is expected to be launched for the first time during a satellite operation when an unmanned Gemini capsule is put into orbit in the near future.

The meteorological rocket will be sent aloft carrying a deflated sphere of metalized plastic in the nose cone. The sphere will be ejected and inflated at peak altitude, then tracked by radars as it descends. From the radar data, technicians will determine the wind conditions and atmospheric density prevailing at the time of the spacecraft launching. This data will be correlated with information from other sources to evaluate the satellite operation.

The new vehicle consists of two standard rockets—the Sidewinder and the Arcas. The Sidewinder is used to boost the Arcas during the initial phase of its flight; and the Arcas, which on its own can reach altitudes of about 200,000 feet, will carry the payload to the 70-mile height.

NMC was assigned the task of developing the Sidewinder-Arcas probe in 1962. The first launching tests of the system were conducted at the White Sands Missile Range early in 1963, and the first sea level tests were conducted at Cape Kennedy last November.

*Combined Sidewinder and Arcas rockets stand on launching pad prior to test.*

# The Plasma Pinch Engine

## A New Source of Power for Space Missions

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*Air Programs*
*Office of Naval Research*

As a result of intensive research conducted by the military services and the National Aeronautics and Space Administration, an electric propulsion system has been designed and operated successfully in space. This milestone was passed on July 21, 1964, when an electron-bombardment ion engine was launched by NASA from Wallops Island, Virginia. Although the flight was suborbital, permitting the new engine to operate for only a few minutes above the earth's atmosphere, it served to verify the predicted efficiency of the new engine as well as to provide concrete evidence of the remarkable progress that has been made in ion-plasma physics.

Electric rocket engines are low-thrust devices that use electricity to heat or accelerate a propellant to develop thrust with very high specific impulses—in the order of 1000 seconds and more. They are expected to be of greatest value in space, since a small amount of thrust (in the order of millipounds) will move large payloads. Because their own mass is small and the specific impulse they provide is high, electric rocket engines will operate on relatively small amounts of propellant for long periods of time. However, since they will not produce enough thrust to lift themselves off the earth's surface, large chemical booster rockets will be required to put them into orbit.

### A Plasma Pinch Engine

One class of electric rocket engines under development by the Navy for space applications is the plasma pinch engine. Figure 1 is a schematic of a plasma pinch engine, called the "E-2," that has been developed under contract to the Power Branch of the Office of Naval Research by Republic Aviation Corporation's Power Conversion Laboratory. Essentially, this engine functions by the interaction of an electric current and a magnetic field in the presence of a propellant (hydrogen gas). Under these conditions, a force is produced that compresses, or "pinches," the gas, causing it to be exhausted very rapidly and thereby to exert a force that moves the vehicle in which the engine is mounted.

In the laboratory, power is supplied by a 24 volt dc battery. In a space environment, the primary energy source would normally be solar cells. This voltage is built up to 1700 volts dc, stored in a bank of capacitors,

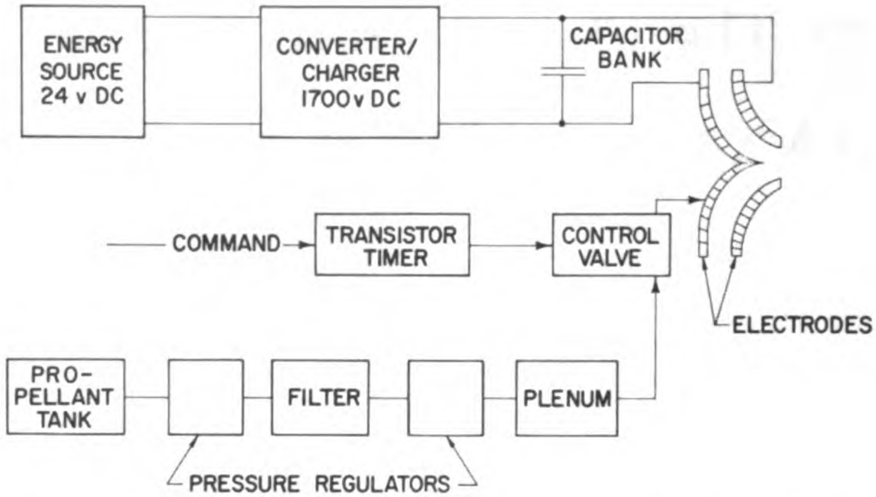


Figure 1 — Schematic of ONR's E-2 Plasma Pinch Engine. The propellant and electrical power systems are self-contained and mounted on the engine. The propellant is hydrogen gas stored at pressures in excess of 1000 psi. A solenoid control valve is pulsed at a rate determined by the transistorized timer. A plenum chamber maintains constant pressure during each pulse.

and applied to a pair of electrodes that make up the nozzle assembly of the vehicle and that act as the electric positive and negative load output terminals. At the same time, the propellant is pulsed, by means of a control valve, into the space between the electrodes. As the gas becomes ionized, current starts to flow, causing the capacitor to discharge. The current growth is extremely rapid and is accompanied by a growing, self-induced magnetic field. Currents of 70,000 amperes and magnetic fields of 2000 gauss have been measured. As mentioned in the preceding paragraph, the interaction of this current and magnetic field "pinches" the gas. There is no net force or thrust on the electrodes, which are shaped in the form of a nozzle so that the plasma formed is exhausted into the ambient atmosphere. As a result of the exhaustion of the gas, a force is applied to the vehicle in the direction opposite to that of the exhaust.

This operation takes place in a few microseconds. Then the capacitor is recharged, and the engine is ready for the next firing command, which is given at a rate which will provide the average thrust desired.

Compared with the weight of the engine, the amount of thrust that can be applied is very low; but because the exhaust velocity of the gas is very high, the specific impulse is correspondingly high. Advantageous also is the variability of the thrust level, which is controlled by changing the pulse rate. Furthermore, since each pinch is a separate operation, dependent only upon the charged condition of the capacitors, the engine may be started or stopped instantly, regardless of the time that elapses between successive pinches.

## The First Flight

In 1965, the Navy plans to flight-test, for the first time, a plasma pinch satellite in space. ONR, the Bureau of Naval Weapons, and the Naval Research Laboratory are cooperating in this effort. The objective will be to verify the performance of the E-2 engine in the space environment. Telemetered data on acceleration, propellant consumption and pressure, spin rate, and voltages will be recorded on the ground so that the thrust, specific impulse, and reliability of the engine can be determined. Space effects on the engine system and plasma effects on communications also will be observed.

The engine and the power, telemetry, and command systems that will make this first flight are being designed and integrated into the satellite by Republic Aviation Corporation. The engine will be mounted in the equatorial plane of the satellite, 8 inches off center, in a 24-inch diameter shell. The energy source will be solar cells. When the satellite has been placed in orbit, the plasma-pinch engine will be started and stopped on command from the ground station by means of a radio link. The engine firings will maintain the spin rate at a nominal one revolution per second to provide stabilization. Figure 2 is a view of the plasma pinch engine as it will be packaged in the satellite.

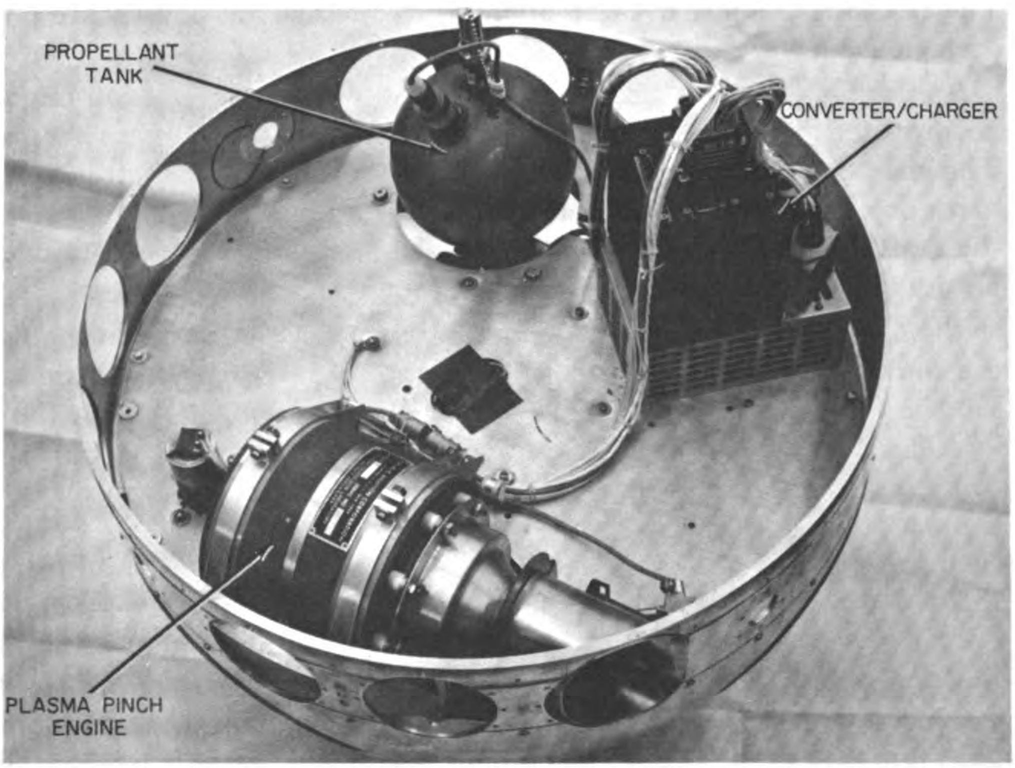


Figure 2 – The E-2 Plasma Pinch Engine as it will appear when packaged for its first test flight. The complete assembly weighs 22 pounds, of which the engine weighs 11 pounds. The vacant spaces are reserved for instrumentation.

## Applications

A number of potential applications exists for the plasma pinch engine in Naval satellites of the future. They are outlined below and discussed in succeeding paragraphs.

- CONTROL
  Attitude
  Stabilization
- PROPULSION
  Interplanetary missions
  Orbital corrections
- COMBINED PROPULSION AND CONTROL

*Attitude control and stabilization.* These applications present partner problems in satellite design. Attitude control refers to achieving a preferred position or orientation of axes about the satellite's center of gravity; such control is necessary to maintain the proper orientation of sensors and antennas. Stabilization means maintaining that preferred orientation in an environment of disturbances. Take as an example an earth satellite whose spin axis is oriented perpendicular to the earth-sun line. Because of solar pressure, magnetic field interaction, and meteorite impact, the stability of the satellite is constantly being upset. The resulting changes in orientation are very small, but if they are not corrected, they produce large angular drifts of the spin axis.

*Interplanetary missions.* Propulsion for an interplanetary mission might be provided by combined chemical and plasma pinch engine systems. The chemical system would be required to place the spacecraft into an earth orbit, while the plasma pinch engine would be operated to propel the craft from this orbit deeper into space, such as to a planet, to take advantage of low consumption of power and propellant.

*Orbital corrections.* Very small amounts of thrust are required to change the course of a satellite in space—for example, to change a navigational satellite's near-polar orbit to a polar orbit and to change a satellite's low-altitude orbit to a synchronous high-altitude orbit (such as from 200 to 22,300 miles). Low thrust pulses are required also to obtain proper inclination and circular orbital path and to offset degrading forces, such as drag and gravity. Still another way in which small amounts of thrust can be utilized is in keeping the proper spacing between satellites operating in a network. For example, it might be desirable for all of the satellites to have the same orbital inclination, but to be displaced at equal intervals in longitude, and for them to maintain those positions for a number of years. Our hypothetical problem, then, is to keep all orbit nodal lines equally spaced. Because of the oblateness of the earth, all orbits precess, the rate of precession being proportional to the inclination angle. Very small differences in the inclination of the orbits result

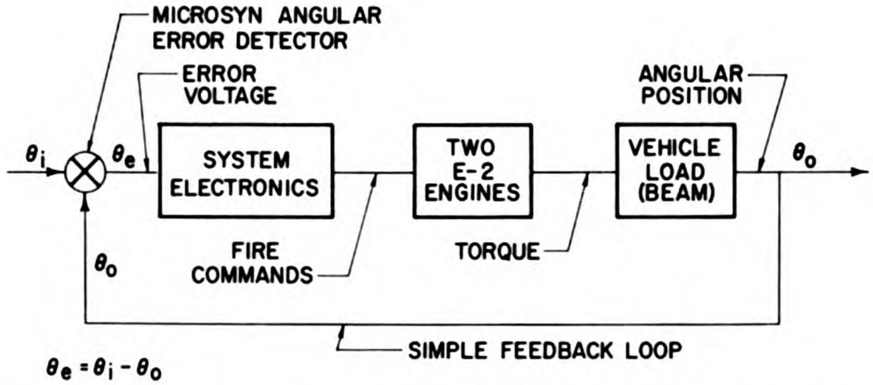


Figure 3 – Block diagram of a single-axis attitude-control system for which two plasma pinch engines serve as the torquing devices.

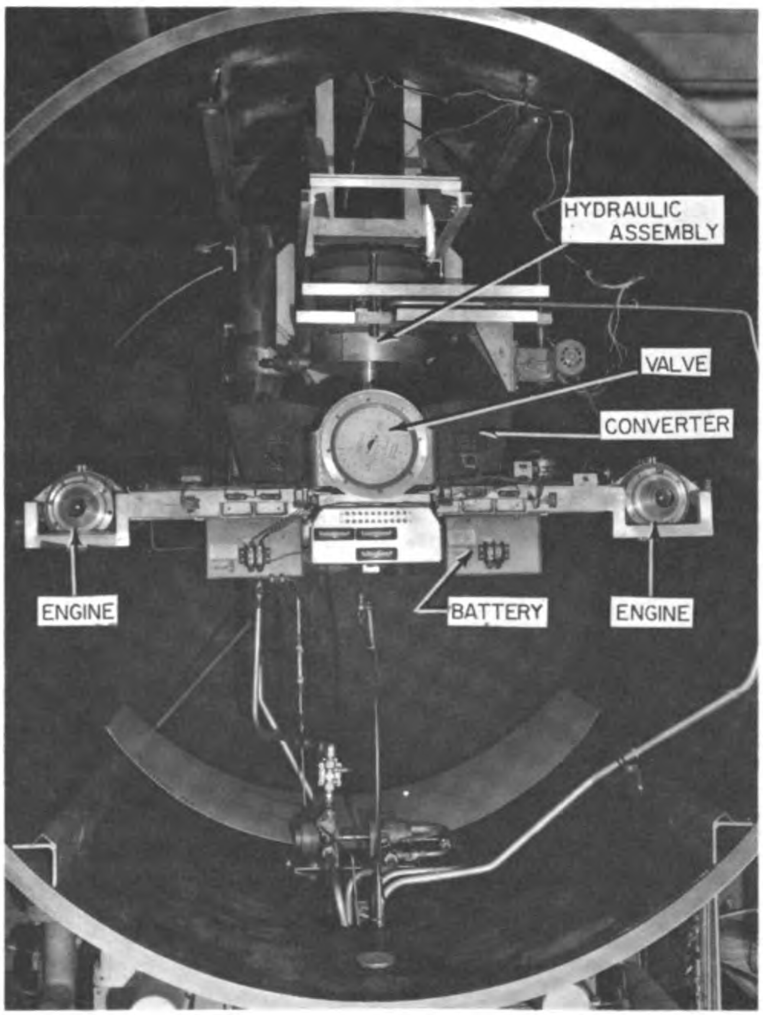


Figure 4 – The E-2 Plasma Pinch attitude-control system set up for testing in a vacuum chamber. Indicated are the batteries, converters, exhaust view of the two engines, the vacuum chamber pressure indicator, and the hydraulic assembly. The hydraulic bearing provides low static friction and low viscous friction torques.

in unequal precessional rates, which upset the equal spacing in longitude of the nodes. Since booster engines cannot be relied upon to provide this vernier control, on-board engines, such as the plasma pinch engine, could be relied on to make the necessary small changes required.

*Combined propulsion and control.* The most efficient utilization of a plasma pinch engine is expected to be made through the one-engine answer it offers for meeting both the propulsion and control requirements of satellites. Economy in weight and cost would result.

### Laboratory Model of Attitude Control System

The Air Programs office of ONR has worked since 1962 on the attitude-control and stabilization applications of the plasma pinch engine. Republic Aviation has built and tested, in the laboratory, a single-axis attitude-control system for which two plasma pinch engines serve as the torquing devices. Although control and stabilization about two or three axes will be required to meet the needs of a satellite in space, a single-axis study can provide information concerning the performance of the system that can be extrapolated to a two- or three-axis problem.

The laboratory system is described in Figure 3. It consists of an angular error detector that converts mechanical position to a proportional voltage; system electronics that sense magnitude and direction of error and generate a fixed pulse-rate command to the appropriate one of the two plasma pinch engines; and the vehicle load, which, for test purposes, is mounted on a pivoting beam that is supported hydraulically. If we assume that the vehicle is correctly oriented and that disturbance torques are not present (the angle of error being $\Theta_e = 0$; see Figure 3), the vehicle would maintain the desired attitude without a control system. However, periodic, intermittent, and constant disturbances do occur, causing the vehicle to veer from its preferred orientation. These disturbances could be caused by motions of equipment or personnel within the spacecraft and by the interaction of the vehicle with local gravity and magnetic fields, solar pressure, and meteorite impacts. The control system developed by ONR would maintain the desired orientation of the vehicle in spite of such disturbances. It would do so by means of an on-off control system, commonly referred to as "bang-bang"; that is, the corrective torque would be either zero or some discrete positive or negative value. This type of system causes small oscillations of the vehicle about its preferred axis. The peak-to-peak value or the root-mean-square value (rms) of this oscillation are measures of the angular accuracy.

Of importance to the designer is the fact that the system is not complex; it can be described mathematically by a differential equation of

*—Continued on back cover (inside)*

# Men to Match Mount Everest

*The Group Psychology Branch of the Office of Naval Research is supporting a number of programs of research designed to determine how groups of men react under unusual conditions. One of these is a program which was tied into the 1963 American Mount Everest Expedition. It was designed to investigate the various psychological factors associated with the climbers who made the successful assault under extreme environmental conditions. Information gained from this investigation is relevant to problems connected with the selection and training of Naval personnel for special types of assignments. "Men to Match Mount Everest" is an account written by a psychologist and mountain climber who was a member of the Mount Everest team. It describes the findings of the first phase of the research.*

A telephoto view of Mount Everest (the peak to the left, behind which clouds are forming) from Mamche Bazar, the chief Sherpa village, which is about 12,000 feet high. Everest is about 25 miles away. The peak to the right, obscured by clouds, is Lhotse, the fourth highest mountain in the world.

# Men to Match Mount Everest

**James T. Lester, Jr.**
*Director*
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Mountains, like the sea, seem always to have been powerful stimulators of the human imagination. When myths still held satisfaction for man and did not offend his image of himself as a rational being, there was practically no competitor of mountain peaks for the title "Home of the Gods." The feeling of awe and the sense of a power entirely apart from that over which man has any control—which may well be the inner source of all religious development—have been aroused almost universally by the viewing of a mountain range or peak. A British geographer, early in this century, argued that if Greek thought had not developed in a country of mountains, the particular form which human consciousness today takes in the Western world would almost surely be different; he was simply saying, in the terms of this century, what has been expressed one way or another since earliest antiquity; namely, that there is a power in mountains which cannot be denied. To understand this power one may turn to myths or to naturalism.

With the rise of naturalism and the decline of mythology, men began to seek a mastery over nature that was unthinkable formerly. In the middle 1800's in Europe and England mountain climbing began to become popular as a sport, rather than as an act with great personal and often religious significance (as when Empedocles climbed Mount Etna in order to commit suicide in solitary grandeur). As the drive for mastery became part and parcel of the Western mind, the power of mountains operated in many individuals as a tremendous personal challenge. It has driven men to perform barely credible feats of physical endurance and achievement—as indeed all forms of geographic exploration have. To the rest of mankind, this power and its effects have seemed uncanny. Yet, while most of us hardly dream of participating in the adventures of such men, their acts fascinate us, and though we ask monotonously, "Why do they do it?", we are excited by each new expedition and want to hear the story and see the pictures. Clearly, the mountains continue to arouse us, whatever attitude our times and habits of thought condition us to take toward this arousal.

Since its summit was established as the single highest point on the earth in 1852, Mount Everest has probably awakened more people to the drama of climbing than has any other mountain. Though it is by no means the most difficult peak in the world's highest range (from the point of view of technical climbing), its absolute uniqueness, which appeals even to limited imaginations, and its implied "superiority" as a mountain have given its challenge the widest appeal. Team after team of unusually capable men (mostly British) have attempted to reach the summit; only three teams have succeeded, all since 1950: a British group, including Sir Edmund Hillary, in 1953; a Swiss group in 1956; and most recently the American team, under the leadership of Norman Dyhrenfurth, in 1963 (see *Naval Research Reviews,* May 1963).

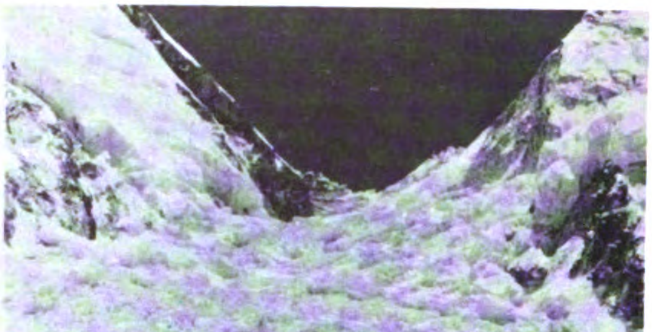
### A Psychologist on Everest

Under a contract with the Office of Naval Research, I went to Mount Everest as a scientific member of the American team. Four scientific programs were carried out during the trip: one in glaciology (Dr. Maynard Miller, Michigan State University), one in physiology (Dr. William Siri, University of California, Berkeley), one in sociology (Dr. Richard Emerson, University of Washington), and my own in psychology. Although prior to the expedition much concern was expressed about combining so much science with climbing, even among some of the team members, there now seems to be no question that the investigators or their work in any way interfered with the main task of the expedition, which was carried out with brilliant success.*

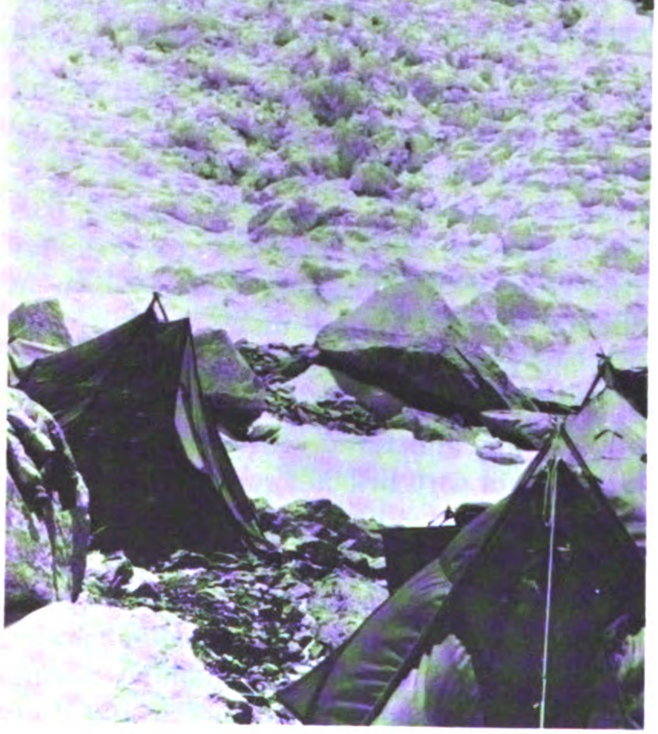
The opportunity given me to go on the expedition afforded a unique chance to study differences that might appear among men under severe and actual (as opposed to laboratory) stress. The men were to be assessed before the climb by a team of psychologists, in much the same manner as the Office of Strategic Services (OSS) assessed personalities during the war; information concerning individual performance would then be collected in the field and compared with the original assessment information. Some men might be more vulnerable to "stress" than others, individuals might differ in the kinds of stress to which they responded, and recovery rates might differ. All of these aspects of performance were to be studied by observation and interview, with an eye to improving the basis for selecting men for stressful assignments.

A major aspect of the performance of men in isolated, stressful environments is their handling of themselves—for example, their emotional control and expression, their reactions to prolonged frustration, and their manner of dealing with the behavior of others. Continual observations bearing on these matters were made. In addition, each team member made repeated ratings on a scale indicating his favorable or unfavorable feeling toward each of the other men. Four months after the end of the expedition, the team members were asked such questions as how much they would like to return on a similar expedition with

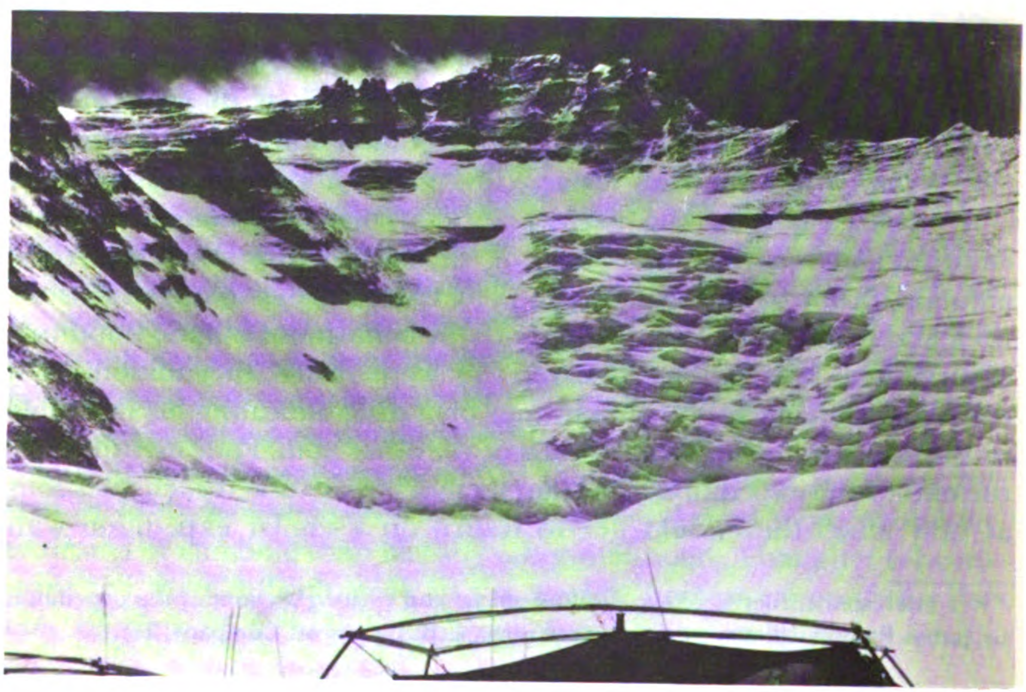
*The interested reader is referred to the official and exciting account of the expedition, by James Ramsey Ullman, *Americans on Everest,* J. B. Lippincott Company, 1964.



View of the icefall of the Khumbu Glacier, taken from base camp (about 18,000 feet in altitude). About two-thirds of the way up this icefall, which is on the route to the summit of Everest, Jake Breitenbach was killed by falling ice. The icefall is in constant slow motion.



Looking up from camp 2 (advance base camp) toward the face of Lhotse, where the Khumbu Glacier forms. The summit of Everest is up the slope which extends out of the picture to the left.



The first summit team leaving advance base camp. In the lead is Jim Whittaker, carrying the flag which he planted on the summit on May 1, 1963. The climb to the summit from this camp took five days; the return trip to the camp, only one day.

Base camp, the home of the expedition for more than two months.

each of the men, what kind of a person each man seemed to be, who seemed to have the most influence in the group, and if there was anyone who seemed more interested in his own personal goals than in the group's goals.

In addition to these applied aspects of the psychological research program (the prediction of stress reactions and of interpersonal behavior), data were collected bearing on an area of basic science, that is, an area in which the applications of the knowledge gained have not yet been foreseen. The social psychologist, Theodore Newcomb (formerly an ONR contractor), of the University of Michigan, has done much work to develop laws which describe the process by which stable interpersonal relationships develop among a group of initial strangers (see *The Acquaintance Process,* T. Newcomb; Holt, Rinehart, and Winston, 1961). An effort was made to collect similar kinds of data on Mount Everest in order to test his hypotheses under different conditions and on a different kind of group.

## Some Results of the Study

This project has been a one-man operation. A great deal of clerical and statistical work remains to be done, but some early results can be described.

With regard to the climbers' reactions to stress, matters have not worked out as expected. What happened is that all of the team members withstood the various stresses at a high level of effectiveness, and few, if any, of the expected differentiations among the men could be made; all were grouped together at the high end of the performance scale. In line with this finding, the men reported, following the expedition, that subjectively the average stress they experienced on the trip was somewhat below their expectations, and even the maximum stress on this trip was slightly below the highest stress they had experienced previously while mountaineering (naturally there were individual differences in these reports; team averages are being discussed here). Personality integration remained at a high level throughout the expedition, and individual behavior was highly consistent. There was a notable lack of those "personality changes" that often are said to occur on such ventures. I am inclined to believe that the unusually large size of the group (18) had a lot to do with this condition, providing more variety and more support for each individual.

The focus, then, shifts from stress to more general aspects of each man's behavior in the field. The most important use for this information is to clarify the basis on which team members made their post-expedition judgements concerning the persons with whom they would like to return on another such expedition. In other words, what features of another man stood out in a subject's mind when he made such a judgement? If it is shown, for example, that industriousness and emotional control are highly correlated with answers to the question about returning, that provides a different picture of the situation than would be the case if the correlates were consideration toward others and sensitivity to effects of one's own behavior. The analysis relating such post-expedition ratings to the criterion is in process, and the results are not yet available. However, one finding in this area can be mentioned.

### How Each Climber Was Perceived

When only three weeks out on the trail, and before we had reached the foot of Mount Everest, each member was asked to describe each of his teammates in terms of a list of 60 adjectives that had been given to him earlier, checking only those words that seemed to him to apply. A procedure for analysis was devised that may be described roughly as follows: the frequency of use of each of the 60 words by the group as a whole was determined. Then a tally was made for each individual, showing (a) how many of the frequently-used words were *not* applied to him by the group as a whole, and (b) how many of the infrequently-used words *were* applied to him by the group. The resulting selection of words, for each individual, gave an idea of what that person's most salient characteristics were as seen by his teammates.

The total number of words appearing on each subject's list served as an index of the overall saliency of that person in the group's eyes, indicating in what respects he blended into the general group norm—the behavior that was considered average in the group—or was seen as different in some striking way.

As the group norm was set at quite a high level (in the sense that each person expected himself and others to perform well, both physically and interpersonally), it was not surprising to find that those individuals with the longer lists were described predominantly by negative words. In other words, saliency was achieved far more by seeming a bad guy than by seeming a good guy.

What is somewhat surprising is that the number of salient adjectives describing a man as seen by the group, at this early stage, bore a close relationship to the frequency with which that man was chosen (some eight months later) as a hypothetical teammate for a return expedition. It looks as if impressions were formed relatively early and persisted. This finding raises such interesting questions as whether the persistence is due to a consistency in each man's behavior during the expedition, or whether he continued to be seen in one light in spite of subsequent changed behavior on his part which ought to have changed the impression others had of him but failed to do so. I think the consistency explanation is the more accurate. The next step along this route of analysis is to establish which individual words best describe the higher and lower scorers on the "return" question.

### Personality Similarities

Since a great deal of information about personalities of the Everest team was collected before the expedition, it may be of interest to indicate briefly some of the characteristics which the team members appear to share with one another.

Verbal intelligence in the group was at a level consistent with the relatively high educational attainment of its members. The ability of the members to think logically and critically was highly developed, more so than was their fund of general knowledge and their ability to sort out complex and emotionally charged interpersonal situations.

Test results showed that the team preferred careers that provided opportunity for personal development and fulfillment and that required a high level of learned skills. The interest patterns of the climbers are comparable to those of people in professional and technical occupations, and they are particularly similar to those of physicians, psychiatrists, and psychologists. Why the latter finding should be true is a matter for speculation; my own interpretation is that the teammembers share with those occupational groups a combination of two things: (a) an involvement with human concerns and with human beings as ends-in-themselves (rather than with people as objects to be manipulated), and (b) a desire to join this involvement with highly developed objective methods and skills, and to retain control over situations, as would be done in a psychological laboratory or clinic. In any case, I feel sure that this similarity provided a basis for rapport between the team and me which aided substantially in the data-collection program.

The men tended to describe themselves as having a disposition that is restless and dislikes routine, that is interested in self-development, that measures progress more by inner than by outer standards, and that is more concerned with theoretical and esthetic matters than with obtaining power or money. They appear to share a quality which might be labeled as "assertive individuality": a rejection of convention for its own sake, impulsiveness, strong self-will, and the conviction that one's own wishes are worth satisfying. They react negatively to signs of submissiveness or self-abasement, self-denial, indecision, and anxiety—either in themselves or in others.

On the whole they are an introverted group, more interested in possibilities and what *might be* done than in facts and what *has been* done. They are more inclined to base conclusions on logical thought

*—Continued on page 20*

# The Effects of Sensory Deprivation on Deaf Subjects*

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In introducing a series of reports on experimental studies of sensory deprivation, Professor D. O. Hebb of McGill University, a pioneer in this field, commented as follows:

> *The work that we have done at McGill University began, actually, with the problem of brainwashing. We were not permitted to say so in the first publishing. What we did say, however, was true—that we were interested in the problem of the effects of monotony on the man with a watch-keeping job or other task of that sort. The chief impetus, of course, was the dismay at the kind of "confessions" being produced at the Russian Communist trials. "Brainwashing" was a term that came a little later, applied to Chinese procedures. We did not know what the Russian procedures were, but it seemed that they were producing some peculiar changes of attitude. How?*
>
> *One possible factor was perceptual isolation, and we concentrated on that. I should say that the work was not done, or planned in detail, by me. Credit for the work belongs to Woodburn Heron, W. H. Bexton, T. H. Scott, and B. K. Doane, the men who planned the work, devised the tests, and analyzed the results.*

Although fewer than ten years have elapsed since the initial studies of sensory deprivation were carried out by Bexton, Heron, Scott, and Doane, a voluminous bibliography of research in this area is available currently. Much of this research has been concerned with the effects of sensory deprivation upon imagery. A number of investigators, utilizing a variety of techniques, have reported the occurrence of hallucinatory-like phenomena in many experimental subjects during varying periods of isolation. Clinical studies have shown that patients with a variety of

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*The research described in this article was supported, in part, by the Office of Naval Research.

†Associated with Dr. Mendelson in the studies described in this article, and in the preparation of the article, were the following investigators: P. E. Kubzansky, Ph.D.; R. Harrison, Ph.D.; L. Siger, Ph.D.; P. H. Leiderman, M.D.; F. R. Ervin, M.D.; D. Wexler, M.D.; and P. Solomon, M.D.—all affiliated with the Departments of Psychiatry, Massachusetts General Hospital, Boston City Hospital, and Harvard Medical School.

disorders requiring surgical and medical attention may experience imagery and disordered behavior when environmental stimuli are either drastically reduced or monotonously repetitive.

**The greatest proportion** of all experimental studies of sensory deprivation has been carried out with college-age subjects who have normal sensory and motor capacities. Nevertheless, there is a large population of individuals who have one or more sensory impediments which may be more severe and certainly more chronic than those induced in any experimental procedure. These individuals include the deaf and the blind as well as some rare persons with congenital insensitivity to pain. In view of the large amount of work that has been done in the area of experimental sensory deprivation, it is surprising to find that little attention has been given, within a sensory-deprivation paradigm, to individuals who have a major sensory deficit. For example, although a great deal of information has been gathered concerning the psychology of the deaf, a review of the literature reveals no previous attempts to utilize deaf subjects in sensory-deprivation experiments.

One of the major obstacles in working with the deaf is achieving adequate communication between the investigator and the subject. Communication processes among the deaf may include writing, speech, lip reading, the manual alphabet, and the language of signs. However, the majority of the American deaf population communicates by means of the conventional language of signs, which, during recent years, has undergone extensive study and linguistic analysis. Investigations carried out concerning the language of signs and symbolic behavior of the deaf have demonstrated that the representational quality of the language of signs is adequate not only for the communication of factual and referential material, but also for the expression of complicated conceptual meanings and nuances of thought. These background data provided a fund of information for the design of the communication techniques employed in the experiment described in this article.

**Twenty male students** at Gallaudet College, the national college for the deaf, served as subjects for the experiment. These students were between 18 and 22 years of age, the mean age being 20.5 years. The hearing loss of the students exceeded 80 decibels bilaterally, and the mean loss was 85.2 decibels. All I.Q. levels were within the normal range. The students were highly proficient in communication via the language of signs.

Ten of the students had congenital deafness—that is, their deafness was documented as having existed before the age of one year. Ten subjects had acquired deafness; in other words, they apparently were born with normal hearing but sustained a hearing loss between the ages of 18 months and 5 years. All subjects were in good health and, aside from hearing, showed no evidence of any major sensory deficit, including visual impairment.

Each subject was studied under two conditions—control and experimental. The two sessions for each subject were conducted exactly one week apart and at the same time of day.

The experiment was carried out in a sound-attenuated, uniformly illuminated room. Prior to the beginning of the experiment, the subject was instructed to urinate, if necessary, and to take a drink of water if he was thirsty. The subject's watch, pocket contents, and shoes were removed. He was seated in a Barcalounger-type chair, and the headrest was adjusted for his comfort.

During control sessions, the subject faced a 4- by 4-1/2-foot panel which contained five 9- by 12-inch photographs of familiar Gallaudet campus scenes. The experimental sessions were similar to the control sessions except that the picture panel was removed and translucent cups were placed over the subject's eyes, permitting transmission of light, but blocking any perception of patterned visual stimuli (see photograph). Each control or experimental session lasted one hour, but the subject was not informed of the exact time the session would actually take. The subject's sign-language communication during the sessions was observed through a one-way-mirror partition.

**All reports of imagery** by the subject were translated from the language of signs into English. Each image was recorded by the experimenters on the first page of a questionnaire designed to assess the

A deaf subject reports a visual image in the language of signs. The subject is wearing translucent eye occluders. This photograph was reproduced from a single frame of a motion picture record of the experiment.



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subject's reactions to imagery: affect, control, distance, and dreamlike quality. The qualities of the image described were assessed also in terms of color, dimension, realism, and spontaneity. The questionnaires were presented to the subject immediately following the end of the experimental and control sessions.

When the subject had completed his imagery-assessment questionnaires at the end of his second session, three additional questionnaires were administered. They were exactly the same as the visual-imagery questionnaire, but asked the subject to rate visual imagery which occurred in "a usual night dream," "a usual daydream," and "what you think we expected you to report."

The findings of this experiment were that subjects had more visual images during the experimental sessions than during the control sessions. Since each subject served as his own control, it appears that the frequency of visual imagery was related to the degree of visual deprivation. The quality of visual imagery reported during control and experimental sessions did not differ; it would be tempting, therefore, to postulate that all of the subjects' visual imagery was a form of daydream behavior. This postulate is not supported by comparisons made of visual daydreams and control imagery, which suggest that the quality of imagery experienced in the experiment was quite different from real-life fantasy behavior.

More visual imagery was experienced during the first session than during the second session, regardless of the type of session given first or second (experimental or control). It is reasonable to assume that subjects would be more anxious when, naively, they entered the first experimental session, and the higher incidence of imagery experienced during the first session may reflect this anxiety. Interestingly, a significant decrease in imagery during the second session was observed only for subjects with congenital deafness. No data were obtained in this experiment to assess the degree of anxiety associated with the inital session for the congenitally deaf; however, there is no *a priori* reason to assume that one type of deaf subject would experience more or less anxiety than the other type during the initial session.

**Data obtained for auditory imagery** showed that congenitally deaf subjects had fewer auditory images during their second session than during their first session, while subjects with acquired deafness had considerably more auditory images in the second session. Subjects with acquired deafness were more likely to have experienced sound some time during their lives than subjects with congenital deafness, and it is possible that the acquired deaf subject's expectancy for auditory imagery increased during the experiment. It is, of course, very difficult to delineate and describe adequately a deaf subject's perception of sound in an auditory image. A congenitally deaf individual may state that he "hears something," but his description is frequently limited to a variety of tactile and visual perceptions which he equates with sound. As might be expected, subjects with acquired deafness reported more auditory images than subjects with congenital deafness. Although the differences were not statistically significant, they do support the notion that stimuli occurring in the very early sensory history of the individual may influence imagery experienced later in life.

The results obtained in this experiment highlight the fact that imagery experienced by deaf subjects in deprivation experiments has a quality different from other forms of imagery. Perhaps the most important finding was that deaf subjects can be utilized for studies of imagery behavior in sensory-deprivation experiments when adequate provision is made for communication via the language of signs. Future studies of this type with deaf individuals may enrich our knowledge concerning the role of auditory stimuli in the development and control of imagery behavior. In addition, these studies add to our fund of information about the effects of greatly intensified forms of sensory deprivation, such as may be experienced by astronauts during long journeys into space.

**Research with deaf subjects** represents only one segment of the total research program in sensory deprivation carried out by psychologists, psychiatrists, physiologists, and biochemists. These investigators have assessed a large number of parameters associated with the effects of reduced sensory input on cognitive, perceptual, and physiological processes. As research has progressed, the multiple interacting variables associated with decreased sensory stimuli have been recognized and studied in detail. Such variables include personality factors of subjects who volunteer for sensory-deprivation experiments, effects of immobilization and restraint, and motivational aspects, such as the subject's desire to conform to or deviate from the conduct he believes to be expected of him in the experimental situation.

Although a number of investigators have not agreed on all findings, several important conclusions have emerged. First, changes in suggestibility and changes in perceptual and cognitive function may occur in sensory-deprivation experiments. Second, changes in biological correlates of neural function may occur, as exemplified by alterations of the electroencephalograms during long periods of sensory deprivation. Alterations in patterns of thinking and modifications of imagery behavior may also take place. Data obtained recently from sensory-deprivation studies with animals strongly support the notion that deprivation of sensory input during early growth and development may significantly affect morphologic development and metabolic functions of the central nervous system.

**Much work remains** to be done in this area. Many hypotheses remain to be tested with methodologies which are more sophisticated than those attempted to date. In conclusion, a quotation from a chapter of "Effects of Deafferentation on Brain Function and Behavior" (Progress in Neuro-biology: V, edited by R. G. Grenell; Harper & Row, New York, 1962) summarizes our current conceptualization of the effects of sensory deprivation.

*[Our knowledge of the] effects of sensory deprivation on the developing organism [has] been obtained from animal studies. The effects on the mature organism are illustrated by studies of man in whom behavioral changes are transitory but may be quite striking. If we consider the developing organism as a self-organizing system deprived of the sensory experience necessary to develop the equipment for continuing organization, then the mature organism might be described as a reasonably well organized information-processing system, which, deprived of new information, utilizes memory stores to complete perceptions and organize action. When the mature organism is deprived of the controls of environmental feedback, internal and external events are not differentiated, and cognitive processes may lose the organization necessary to deal with the physical universe effectively. If the animal raised in isolation doesn't know "which end is up," the isolated adult may be quite certain the wrong end is up. These changes are similar to those produced by other factors which disrupt information processing at some level of the neuraxis, such as sensory overload, amphetamine intoxication, and alcoholic delirium.*

*In summary, we would add our hypothesis to a long-standing conviction of many students of behavior that the brain as an organ of mind requires the input of information via sensory modalities for both its maturation and its normal function...For normal function, the brain must operate as part of a dynamic loop of information transfer of which the real world is an integral part.*

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*—Continued from page 14*

than on feelings. They are not highly gregarious, want to go their own way, and are more inclined to seek an understanding of others rather than closeness with them.

Although I would not have been able to draw up a set of psychological requirements for an Everest team before the fact, the characteristics that emerged from the assessment of this group of men seem to be neatly designed to equip them for such an expedition, and would seem to have had everything to do with the success, in every way, of the exercise.

The more detailed analysis of the data will continue well into 1965.

# On the Naval Research Reserve

## A New Feature

A new feature of "On the Naval Research Reserve" was initiated in the November issue of *Naval Research Reviews*. It consists of a series of articles prepared by members of Research Reserve companies in each Naval District—one District being highlighted each month. The first report of the series was submitted by Research Reserve members of the Eleventh Naval District. In the current issue, the feature is devoted to activities of companies of the Thirteenth Naval District. The articles were submitted through the ONR Branch Office, San Francisco, California.

It is hoped that each Naval District will be highlighted at least once annually. The following schedule has been established for the series:

| *Naval District* | *Month* |
|---|---|
| FIRST | January |
| THIRD | March |
| FOURTH | July |
| FIFTH | May |
| SIXTH | February |
| EIGHTH | August |
| NINTH | April |
| ELEVENTH | November |
| TWELFTH | June |
| THIRTEENTH | December |

In addition to the new series, "On the Naval Research Reserve" will include articles on the overall Research Reserve program, as it has in the past.

## The Research Reserve in the Thirteenth Naval District

The great Northwest is known for its green forests, towering peaks, and rushing rivers teeming with fish. These features, and many others characterized by beauty, splendor, and vastness are typical of the Thirteenth Naval District's four-state area: Washington, Oregon, Idaho, and Montana.

Operating the District's Naval Reserve Program is a primary responsibility of RADM William E. Ferrall, USN, District Commandant, whose headquarters are in Seattle. Although small in number, the members of the six Research Reserve units in the District are an important asset to the program. The units are located at Seattle, Richland, and Pullman, Washington; Portland and Corvallis, Oregon; and Idaho Falls, Idaho.

Today, membership in the Thirteenth Naval District's Research Reserve is made up of about 126 devoted and talented Naval Reservists, as compared with 138 a decade ago. In the face of the great reduction in overall Naval Reserve strength during recent years, the fact that only this slight decline has occurred in the membership of the Research Reserve is a tribute to the interest, enthusiasm, and loyalty of these participating officers.

Great appreciation for the strong support received from District headquarters—particularly from Admiral Ferrall and his officers—is often expressed by Research Reservists. CAPT R. E. Harmer, USN, Chief of Staff, showed outstanding leadership during recent months while he was Acting Commandant. He was a featured speaker at the Science and the Seas Seminar, held in Seattle, and at the Nuclear Sciences Seminar, conducted at Idaho Falls. Continuous, effective cooperation has been extended by CAPT F. P. Lyons, USNR, Deputy for Naval Reserve and Training; his associate, CAPT R. E. Sandvigen, USNR; and LCDR D. N. Thomas, USN, Research Program Officer. These men and many others in the District organization are giving invaluable service to the Research Reserve.

## New Horizons for Battelle

Naval Reserve Research Company 13-2 at Richland, Washington, hometown of the sprawling Hanford Atomic Plant in southeastern Washington, is on the threshold of change. Because General Electric Company has operated this entire facility as prime contractor for the U.S. Atomic Energy Commission since 1946, the members of NRRC 13-2 have, for the most part, been General Electric Company employees. Early this year, two announcements were made that portend a significant change in the Hanford scene and for the members of NRRC 13-2.

For 20 years, Hanford has been the chief producer of plutonium in the United States and in this capacity has made a major contribution to the military strength and security of the country. It has been increasingly apparent in recent years that stockpile requirements of this material were being filled and that shutdown of some of the plutonium-producing reactors and their supporting facilities was inevitable. On January 8, 1964, a decision to shut down three of the Hanford reactors, starting on January 1, 1965, was announced by President Johnson.

This news was followed closely by the announcement that General Electric would gradually withdraw from Hanford and be replaced by several different AEC contractors in the interest of more diversified operations and the stimulation of incremental commercial investments.

One member of the unit, CDR E. D. Sayre, USNR, a project manager in the Business Planning and Transfer Operation, is engaged in this transition.

Although members of the unit will become employees of different commercial concerns as the transition from single- to multi-contractor operation proceeds (four will become employees of Battelle Memorial Institute), the unit has high hopes that its role will continue to be much the same as it has in the past.

On or about January 1, 1965, Battelle Memorial Institute of Columbus, Ohio, will assume the responsibility for operating the Hanford Laboratories, which will then be known as the Pacific Northwest Laboratory. The $83 million facilities require an annual operating budget of about $25 million. Battelle plans to build an additional laboratory facility with $5 million of its own funds to conduct research in addition to that sponsored by the AEC for the Pacific Northwest.

The diversification of talent and the varied disciplines of work (operation and research) at the Hanford Plant have enabled NRRC 13-2 to present a wide spectrum of interesting and informative technical lectures. Although understandably weighted toward nuclear developments, the work engaged in at Hanford is of such broad scope that virtually all phases of activity in the field have been touched upon. Attention has been given also to other fields of general interest. Some of the most rewarding programs have been those involving youth in the area. For example, outstanding foreign-exchange students have been called upon to present background information on the social, economic, and political aspects of their homelands. Two recent drills of this nature (open to the public) were by Miss Vivian Gericke of the Union of South Africa and Miss Manika Voellmecke of West Germany. Consideration has been given also to youth interested in science. Each year many members of the company serve as judges at the local science fair. One member, CDR W. A. Burns, was a judge at the science exhibit at the World's Fair in Seattle, Washington.

NRRC 13-2 was first commissioned in 1948 as a composite unit and later became a Reserve Research company. Thus it has been in existence for almost the same length of time that General Electric Company has operated the Hanford Plant. Several of the members who were in the unit in 1948 are still active today. Although Hanford's profile will be changing, members of Reserve Research Company 13-2 are optimistic that the changing scene will result in new strength.

## New Aspects of Leadership

An outstanding talk by U.S. Senator Henry M. Jackson is the latest addition to Naval Reserve Research Company 13-1's new look in leadership training for Research Reservists.

NRRC 13-1 in Seattle, Washington, has been stressing a somewhat different approach in its leadership training program each quarter during the past couple of years. Under direction of the Leadership Officer, CDR A.S. Hanson, USNR, the program has included talks by a variety of community and national leaders. Each has given different slants on leadership by talking about his own experiences within his own particular field. For example, COL George Foster, of the Office of Civil Defense, Region 8, discussed "Leadership and Civil Defense," and Raymond B. Royal, Superior Court Judge, spoke on "International Law."

Recently, CDR Hanson took advantage of the election year by presenting two excellent discussions of leadership in public affairs. The unit was extremely fortunate in scheduling a talk on "Leadership at the State Level," by Dan Evans, the Washington State Republican Gubernatorial candidate, and on "Leadership at the National Level," by U.S. Senator Henry M. Jackson.

In his talk, Mr. Evans emphasized the part all citizens must play in politics if the success of our democratic system is to prevail. He discussed the two-party system, its importance to our governmental processes, and how individuals can get involved in political activities from the grass roots right up to the top job in the State in either political party.

Senator Jackson spoke intimately and authoritatively of the civilian/military relationship in affairs at the national government level. He provided a frank insight into some of the domestic and international problems faced by national leaders. He discussed and answered many questions relative to Department of Defense research and development activities as viewed by a member of the Armed Services Committee of the Senate.

Both Senator Jackson and Mr. Evans gave excellent non-partisan talks, and the opportunity to listen to such outstanding leaders was welcomed.

This type of leadership program is recommended highly to other Naval Reserve Research companies because it provides a broad concept of leadership, which is considered to be particularly desirable for the type of officers associated with the program.

## International Recognition

CAPT Donald S. Farner, USNR, Professor of Zoophysiology and former Dean of the Graduate School at Washington State University, was recently elected Secretary-General of the International Union of Biological Sciences at Prague, Czechoslovakia, where the fifteenth General Assembly was held. CAPT Farner, former commanding officer of Reserve Research Company 13-3 in Pullman, Washington, was one of five delegates representing the United States.

The International Union of Biological Sciences is one of the oldest official international scientific organizations, and 32 nations are now members.

## How It's Done in Seattle

At a time when many Research Reserve units are experiencing difficulty holding their own on membership—because many officers are "finishing up their twenty" and because of other factors—NRRC 13-1 in Seattle has brought in nine new members since the start of this fiscal year. This favorable recruiting experience has resulted from several varied activities.

Perhaps the most noteworthy effort was the highly successful "Science and the Seas" seminar sponsored by the company and held at the Naval Air Station in Seattle in June. The seminar, which was chaired by CAPT Fred Wiggin, USNR, then commanding officer of NRRC 13-1, provided a great deal of attention and favorable publicity for the Research Reserve Program.

Another factor in the recruiting success has been the high quality of regular programming offered by NRRC 13-1. Technical programs have been varied purposely in order to appeal to a broad segment of the scientific community, and they have been supplemented with an outstanding leadership program presented by community, State, and national leaders.

The company has been alert also to make contact with Naval Reservists who, for one reason or another, are no longer qualified for Selected Reserve programs, but are still interested in affiliating with an active program. Such officers who qualified under the ground rules of the Research Reserve were welcomed into NRRC 13-1.

The enthusiasm and interest of individual members of the company also has contributed greatly to the overall success of the recruiting program. With their continued support, the Seattle Research Reserve company should have a banner year.

## A Top Competitor

Naval Reserve Research Company 13-5, Corvallis, Oregon, under the command of LCDR Russell L. Lincoln, USNR, placed third in the annual competition for Naval Reserve Composite and Specialist units of the Thirteenth Naval District. Twenty-eight companies participated in the competition.

The third-place company receives a permanent engraved plaque, and LCDR Lincoln receives a letter of commendation from the Commandant, Thirteenth Naval District.

The previous year (fiscal year 1965), NRRC 13-5 was nominated for the General Excellence Award by the Commandant to represent the Thirteenth Naval District. LCDR Lincoln was the commanding officer that year, as well, and he received a letter of commendation from the Chief of Naval Research.

## Elephants Beware!

Big game hunting in Africa—in particular, the shooting of elephants—is not usually associated with scientific research beneficial to human health. Yet CDR Irven O. Buss, USNR, Professor of Wildlife Biology at Washington State University and former commanding officer of Naval Reserve Research Company 13-3 in Pullman, has recently returned from a year in Africa with findings about the reproductive process in elephants that could cast light on the mysteries of human embryo growth.

CDR Buss, on leave from Washington State during the 1963-1964 academic year, shot 146 elephants in open hunting areas near his headquarters at Fort Portal, Uganda, as part of his long-range study in ecology and reproduction of the African elephant. CDR Buss selected elephants for study because their great size makes easier the detection and tracing of glandular secretions found only in infinitesimal amounts during early fetal development in smaller mammalian species. After each elephant had been dissected and all desired data obtained, the animal's edible parts were distributed to the local inhabitants for food.

Approximately 84 females were shot; parts of the reproductive structures were then packed in dry ice and sent by air to laboratories at Cambridge University. Additional reproductive materials were preserved and shipped to Washington State University for study at the present time. In Cambridge, a specialist-collaborator, Dr. R. V. Short, discovered that progesterone, which is believed to exist in the ovaries of all other mammals, could not be detected in the ovary of the elephant, regardless of the stage of the reproductive cycle. A report by Buss and Short of this finding has been accepted for publication in the *Journal of Reproduction and Fertility* in 1965.

For a second, peripheral phase of his work, Buss was joined by Drs. J. Metcalfe and W. Parer of the University of Oregon Medical School; E. Kleihauer, H. Bartels, and K. Riegel of the University Medical School, Tubingen, Germany; and P. Wright of Makerere College University, Kampala, Uganda. During this study, in which blood of the mother elephant was compared with that of the fetus, it was discovered that in the early fetus an amino acid is present which is not present in later fetal life. Buss considers the implications to be profound and numerous; for example, it is entirely possible that if the mother, regardless of species, should fail to supply the early fetus with this acid, the development and chance for survival of the offspring would be seriously affected. Buss believes that the findings may be relevant to human embryo development as well. These results, prepared for publication by Kleihauer, Buss, and Wright, will be released in Germany.

## Oregon and the Deep Sea

One of the more important academic developments in the Northwest has been the expanding program of oceanography at Oregon State University, Corvallis, Oregon. This institution is rapidly gaining prestige and recognition throughout the world. Much of this development is due to the leadership and direction of a Research Reserve officer, CDR Wayne V. Burt, USNR, former commanding officer and now a member of Reserve Research Company 13-5 in Corvallis. In civilian life he is Chairman of the Department of Oceanography and Director of the Marine Science Laboratory.

CDR Burt joined the Naval Reserve as an ensign in 1943. He studied meteorology and later served in Navy Weather Centrals at Noumea, New Caledonia, and Pearl Harbor. After the war he enrolled at Scripps Institution of Oceanography in La Jolla, California, where he received his MS degree in physical oceanography in 1948 and his Ph.D. in the same field in 1952. After working as an oceanographer at The Johns Hopkins University and the University of Washington, he came to Oregon State University in 1954 to begin a program in oceanography under the sponsorship of the Geophysics Branch of the Office of Naval Research.

In 1958 the oceanography program at Oregon State University was selected by the Office of Naval Research as one of ten university programs to receive major support in the first TENOC plan. The Office of Naval Research provided funds for increasing the size and diversity of oceanographic research and instruction as well as funds to design and construct the 80-foot research vessel ACONA (See *Naval Research Reviews,* Oct. 1963).

Under the impetus of the TENOC plan, the oceanography program at Oregon State University became a graduate department of oceanography in 1959. The activities of the department have increased steadily, and it is now one of the larger oceanography departments in the country. Facilities include a new building on the campus in Corvallis, Oregon, the newly converted 180-foot research vessel YAQUINA, and a new Marine Science Laboratory on the Oregon coast at Newport. The faculty of 30 provides graduate programs for 75 full-time students and an equal number of graduate students who are minoring in oceanography. Students may major in physical, chemical, biological, geological, or geophysical oceanography or marine radioecology.

The full-time staff is engaged in research programs in all branches of oceanography. These programs are now supported by grants and contracts from the Office of Naval Research, the National Science Foundation, the U.S. Air Force, the Atomic Energy Commission, the National Aeronautics and Space Adminstration, and the Department of Health, Education and Welfare.

## Navy Day at Idaho Falls

Naval Reserve Research Company 13-6 at Idaho Falls has rightly won a nationwide reputation as one of the most aggressive units in the country. Over the years it has sponsored a series of highly important seminars on the general subject of nuclear sciences. In addition, its work in presenting the Navy and Naval Reserve to the public has been outstanding.

NRRC 13-6 also has the proud distinction of being the first winner of the nationwide competition for the coveted General Excellence award.

Governors, members of Congress, Navy League leaders, educators, and scientists have found their way in large numbers to this thriving city on the banks of the Snake River. This year's observance of Navy Day in Idaho Falls stands out as an example of the public-spirited attitude of this Naval Reserve Research Company. Under its leadership, the efforts of the Idaho Falls Council of the Navy League, the local NRA Chapter, the Naval Reserve Surface Division, and the Navy's famed Nuclear Power Training Unit at the National Reactor Testing Station were all coordinated. Mayor Eddie Pedersen came up with an official Navy Day proclamation and ordered a general display of flags. Radio and TV stations gave generously of their time and space. The day's activities were climaxed at a well-attended banquet at the local hotel, with the theme "Freedom of the Seas is vital to the peace and prosperity of the United States." Speakers included LCDR Dallas Pence, USNR, Commanding Officer of the Surface Division; LT T. R. Heath, USNR, President, Navy League, and member of Intelligence Division 13-1; LT T. J. Rodgers, USNR, civilian nuclear submarine scientist and member of NRRC 13-6; CDR Mark Baum, USNR, National Surgeon, NRA, and a member of NRRC 13-6; and CAPT Thomas J. Wadsworth, USNR, President of NRA, general chairman of Navy Day activities, and a member of NRRC 13-6.

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## Research Reserve Seminar at Boston Cancelled

The April-May 1964 issue of *Naval Research Reviews* listed the last Research Reserve seminar planned for fiscal year 1965 as one to convene at Boston, Massachusetts, on June 14, 1965. This seminar has been cancelled because a suitable meeting place was not available. It is expected that the seminar will be rescheduled, possibly in July 1965.

LCDR Inhorn, left, receives the Commandant's plaque from CAPT C. L. Dillard, USN, commanding officer of the ONR Branch Office, Chicago. Looking on at right is LCDR Matthias Stelly, USNR, present commanding officer of NRRC 9-14.

## NRRC 9-14 Top in Ninth Naval District

Naval Reserve Research Company 9-14, Madison, Wisconsin, has been designated the top Reserve Research company of the Ninth Naval District. LCDR Stanley L. Inhorn, USNR, served as commanding officer of the company for the year of competition.

The competition among the 26 Reserve Research companies in the District was decided on such criteria as participation in active duty for training, effective education programs in Naval research at the weekly drills, public relations, recruiting efforts, and administrative leadership.

The award to NRRC 9-14 was notable, also, in that this is the third time the Madison company has won the Commandant's plaque over the past 5 years.

## Next, a Phonon Maser

One of the winners of the 1964 Nobel Prize for Physics was Professor Charles Hard Townes of the Massachusetts Institute of Technology. Professor Townes was an investigator for the Office of Naval Research from 1947 to 1962. The award was made for "research in quantum electronics that led to the production of intricate oscillators and amplifiers behind the laser (optical maser) beam." The first maser was constructed at Columbia University in 1954, and one of the first applications made of it was at the Naval Research laboratory in a 50-foot radio telescope. Professor Townes is now at work on a phonon maser, a device which will amplify sound waves by principles similar to those underlying the radio and optical frequency masers and lasers.

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*Articles are arranged under the ONR division or Navy laboratory having cognizance of the research described.

†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

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†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

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†Written by the editorial staff of *Naval Research Reviews* or adapted from anonymous sources.

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the second order. Important also is the fact that test results indicate that the system is capable of high angular accuracy (8 minutes of arc, rms). With improvements in packaging and integrating the electronics with the engine (see Figure 4), an even higher accuracy appears attainable.

## Diving Saucer Returns to Pacific Coast

Captain Jacques-Yves Cousteau's Diving Saucer, a research vehicle designed to operate at depths as great as 1,000 feet, is taking part in undersea studies off the coast of California and Mexico this winter. The studies are being made by the Scripps Institution of Oceanography, the Navy Electronics Laboratory, the Naval Underwater Sound Laboratory, the Naval Ordnance Test Station, and the Pacific Missile Test Center. Funds to support the Saucer's operations are being provided by the Navy and the National Science Foundation.

The Saucer, which resembles the flying saucers of science fiction stories, was used by Scripps scientists for two weeks in February 1964 for research in the La Jolla and Scripps Canyons near San Diego. The Office of Naval Research supported the research. During this investigation, the vehicle proved particularly useful in exploring the middle depths of the coastal submarine canyons—between those that are within reach of divers wearing aqualungs and the much greater depths visited previously by the bathyscaphe TRIESTE.

The Diving Saucer weighs about 7,000 pounds, is approximately 10 feet in diameter and 6 feet high, and is propelled at a speed of about 1 knot by two water jets mounted on its sides. It holds two crew members—a pilot and an observer—who lie in a prone position and view their marine environment through two large windows. A hydraulically controlled arm and a specimen catch basket attached to the vehicle allow the crew to collect rock, vegetation, and some sea animals.

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Psychologist-mountaineer Dr. James T. Lester, Jr., a member of the 1963 American Mount Everest Expedition, pauses at the 17,000-foot-level during the Himalayan ascent. The nearly snow free summit pyramid of Everest, more than 29,000 feet high, is in the background. In an article beginning on page 7, Dr. Lester discusses his study of the effects of stress on the American climbers.