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20th Year on the Frontier of Science

A Successful Experiment

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Vicennial Article

Among the luckiest research workers in American universities today are those who are fortunate enough to conduct their investigations in one of the ten Three-Services laboratories sponsored by the Department of Defense. These centers for fundamental research, like the excellent Atomic Energy Commission's nuclear-physics establishments, have resulted in outstanding programs in the universities where they are located.* For example, the world-famous activities in the communication sciences at M.I.T. would never have developed had the Joint Services Electronics Program (JSEP) not provided so favorable an environment.

The original triad of Three-Services laboratories was the postwar survivor of the enormous research and engineering facilities on the campuses of Harvard, M.I.T., and Columbia during World War II, which were born of the military need to develop and exploit sophisticated electronic devices. Of the three, the M.I.T. Radiation Laboratory was the largest, and its staff of distinguished scientists, which included, among others, I. I. Rabi, E. M. Purcell, Julian Schwinger, Louis Alvarez, Robert Bacher, Lee DuBridge, Jerrold Zacharias, Norman Ramsey, and Hans Bethe, devoted its talents to a broad range of interests. Primary was the development of microwave radar, but the gamut spanned from the most highly theoretical aspects of electrical noise, electromagnetic propagation, and solid state physics to the tough job of making reliable connectors for use in the tropics.

The smaller and more specialized Columbia Radiation Laboratory concentrated on the development of microwave generators, particularly magnetrons for the very highest frequencies of one centimeter and below, and the Harvard Radio Research Laboratory centered its research in the field of communications and electronic measures. The staffs of these laboratories constituted a unique assembly of scientific talents. Never before had such large numbers of outstanding scientists and engineers been brought together to work on technical developments for a single objective. Clearly, these centers represented a national asset from the point of view of national security which was sufficient to warrant continuing them at least in part.

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*Stanford University, Massachusetts Institute of Technology, Harvard University, Columbia University, Polytechnic Institute of Brooklyn, University of Illinois, University of California, University of Southern California, and University of Texas.

When the war ended, there was great danger that these facilities would be completely dissipated. The directors of the National Defense Research Committee (NDRC), which had sponsored these activities, decided to disband operations on the grounds that to perpetuate emergency wartime management structures in a peacetime economy would be wrong. The NDRC was directed by an illustrious board of scientists, including Karl Compton, Vannevar Bush, and James Conant, who believed that a rapid return to peacetime modes of operation was vital. They thought that members of academic faculties from around the country who had been attracted to the study of military problems should be encouraged to resume their prewar academic pursuits as quickly as possible in order to vitalize the neglected graduate education of scientists and engineers. Considering the small number of Ph.D.'s who had been trained during the wartime era, their view was valid and was indeed so proven by the vast explosion of graduate schools in the years that followed.

However, to disband so precipitously would have left a void. First, the potential for rapid mobilization in the event of another national emergency would have been lost. An effective research capability had been established, and special competences, particularly in the fields of microwave electronics and solid state physics, promised to contribute much to basic research of the future. Second, well equipped laboratories, service facilities, and administrative organizations had emerged. Machine shops, electronics laboratories, tube shops, stockrooms, casting rooms, publication facilities, as well as purchasing staffs and contracting management were all there to provide first-class service and to relieve research workers of administrative responsibility. To dismantle such installations would have resulted in tremendous loss of scientific and financial capital. But the die was cast, and the management of these wartime laboratories made plans for an orderly termination of their activities and for the postwar careers of their faculties and staffs.

While, in 1945, a war-weary world had hopes that a lasting peace might be possible, many Americans believed that it was necessary to preserve some share of the scientific and military competence we had forged during the war as insurance against less pleasant eventualities. Many of us were particularly concerned with finding a way to continue the discovery of new fundamental knowledge of the kind that had played a decisive role in the late war years by its exploitation. It was at this stage that three unusual and visionary individuals discovered that they shared the same concern for preserving the core of the existing R & D capabilities and merged their efforts, setting out to retain a nucleus of research and development capability in each of the three universities that had been responsible for the wartime effort previously mentioned. Dr. Emmanual Piore representing the Navy; Dr. Harold Zahl, the Army Signal Corps; and Dr. John Marchetti, the Air Force, entered into considerable consultation and discussion with the academic institutions involved. Eventually, a major mutual advantage of continued government sponsorship of basic research in the electronic sciences was realized. Early in the discussions, an attempt was made to assign a given postwar research responsibility to each one of the three services and to rationalize the assignment of one institution to one of the services, but obviously, this was not a particularly easy thing to do, at least on the basis of any logic. Each of the continuing efforts was of interest to all branches of the military, and each of the academic institutions had developed working relationships and friendships with scientists and the military officers of the three services. As a result, the services decided to join together as sponsors of all of the laboratories. The programs would be directed by a Technical Advisory Committee, comprised of representatives of the three services, who would serve as liaison with the various institutions. And so it was that the wartime laboratories evolved from vast organizations whose attention had been directed toward immediate military problems to relatively modest basic-research centers under three-services sponsorship.

The programs were known as the Joint Services Electronics Program. The charter for those university efforts was extremely broad, providing only very general guidelines and leaving project selection and direction to the laboratory directors. For example, the contract for the Research Laboratory of Electronics said only "to carry out basic research in the field of electronics." The flexibility has been evidenced by the broad range of activities housed in RLE. These have included research in solid state physics, communication theory, computer sciences, neurophysiology, group dynamics, linguistics, low-temperature physics, low-energy nuclear physics, as well as plasma physics, psychology, acoustics, and the engineering development of a variety of devices, such as the electronic correlator and the Collins liquid-helium cryostat. The other Three-Services laboratories also have grown broadly and lustily over the boundaries where the field of electronics interacts with other disciplines.

The military services and the universities involved had different, but overlapping, objectives which still remain a primary basis for collaboration and continued support of university electronics research programs. Military sponsors were interested in preventing the complete collapse of the extensive basic and applied research effort developed during the war and a mobilization upon which to build in an emergency. On the other side of the fence, universities were anxious to have a rapid transition back to an educational program that included very substantial graduate programs, involving not only teaching but also research for faculty and graduate students. Military sponsorship of basic-research laboratories was an avenue by which this could be accomplished. Means were provided whereby the most modern electronic equipment, supportive facilities and personnel, plus trained staffs of academic and professional personnel could be retained and associated with a teaching program. In addition, the three-services sponsorship removed the necessity of seeking individual project support by giving large-block grants with which to operate the laboratories and, when needed, to help pay for that portion of faculty members' time which was devoted to research efforts. In fact, during the immediate postwar period, there were no agencies from which to seek project support. It is probably not an overstatement to say that there would have been little university research at the time had these laboratories not been created. The Three-Services laboratories represented the first experiment in large-scale government financing of university research, a pattern which was adopted quickly by the Atomic Energy Commission in establishing laboratories for nuclear-physics research.

As the original three laboratories thrived and the advantages of local decision-making on the details of the scientific program made possible by consolidated support became increasingly obvious, new Three-Services centers were established—the Stanford Electronics Laboratory in 1947, the Stanford Microwave Laboratory in 1951, the Laboratory of the Polytechnic Institute of Brooklyn in 1955, the Control Systems Laboratory at the University of Illinois in 1959, the University of California Electronics Research Laboratory in 1961, the Electronics Sciences Laboratories at the University of Southern California in 1963, and the Laboratories for Electronics and Related Science Research at the University of Texas in 1964.

Each of these centers was created by bringing together programs and faculty that already existed at the sponsoring university. Nearly all of the existing research programs that served as the nuclei for the JSEP stemmed from wartime military-technical interests and were already being funded in a piecemeal and less satisfactory way by one or another branches of the Department of Defense. It is interesting to note in passing that there was surprisingly little duplication among the major fields of interest in the laboratories. This undoubtedly stemmed from the fact that the earlier militarily sponsored activities had a considerable degree of coherence based on specific, though broad, problem areas that originated, in large measure, from wartime research assignments in which duplication had been deliberately avoided. In some cases the research efforts reflected the wartime activities of the principal scientists at other places rather than any local history. As an example, the extensive program of work on microwave circuits and microwave ferrites at the Polytechnic Institute of Brooklyn grew largely from the Radiation Laboratory activities of Dr. Nathan Marcuvitz. In any event, this fortunate diversity of interests has provided the military establishment of the Nation with an extremely comprehensive basic-research activity to support its applied research and development activities.

How well have these laboratories functioned? From the military standpoint, they appear to have been a good investment. The fact that several more were created is certainly evidence of satisfaction with the first of them. The value of the standby research capability thus provided was demonstrated during the Korean War when the RLE provided a nucleus of scientific and administrative skills for setting up applied divisions which rapidly grew into the Lincoln Laboratory. A similar development at Columbia provided the staff support for the Hudson Laboratory.

Each one of the laboratories has made major scientific and technical contributions to the continuing and growing military technology of the United States. Some of the more significant of the many innovations, both large and small, which have come from these laboratories are the development of the maser and laser at the Columbia laboratory by Dr. Charles Townes; scatter communications, atomic clocks, and communication signal techniques from M.I.T.; tactical control systems and precision gyroscopes for the Navy from the University of Illinois; superpower microwave tubes and improved high-frequency communications from Stanford University; as well as contributions to very low noise receivers from several of these institutions, to mention just a few.

The fundamental discoveries that supported a very substantial number of the important innovations in military electronics have flowed from these centers. Possibly even more important, the JSEP centers have, at the same time, provided the resources for a truly professional graduate education in a variety of physical science and engineering disciplines related to electronics for literally thousands of graduate students. And finally, the laboratory faculties have insured the existence of a number of professional groups of scientists and engineers that serve as impartial advisors and consultants on technical problems of military interest.

Significant also is the fine spirit of cooperation among the three services while working together to supervise and support the Three-Services laboratories through a JSEP Technical Advisory Committee, consisting of representatives of each service, which provides technical orientation and program guidance and recommends funding levels.

From the point of view of the universities, the single-contract method of support employed in the JSEP is particularly valuable because it is so flexible, permiting quick exploration of new ideas and providing funds for research facilities and instrumentation to support a number of projects. Also, a stable level of financing over a period of years has allowed the buildup of faculty, research staff, and a graduate student body beyond that which the institutions' own resources could possibly have permitted even though individual, federally financed research

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White Mountain Research Station: Institution of "Highest" Learning

Between altitudes of 4100 and 14,246 feet in the White Mountains of east-central California, a wide variety of scientific research is being conducted around the calendar in and near a $2 million complex of four laboratories, collectively designated the "White Mountain Research Station," that claim the distinction of being the highest of their kind in the United States. Like the scientist-astronauts, -aquanauts, and -ice islanders, the high-altitude scientists are carrying their research as near as they can to the sites of the phenomena of interest to them, rather than confining their studies to conventional laboratories in which the experimental conditions often must be simulated. Although the high levels of the mountains have proved most attractive to physiologists (with respect to the effects of the oxygen-depleted atmosphere on man), they have attracted botanists, meteorologists, geologists, nuclear physicists, astronomers, psychologists, and representatives of other disciplines as well, because of their rich offering of scientific "unknowns."

From the Owens Valley—a deep trough that parallels the range on the west and separates it from the Sierra Nevada—the White Mountains rise steeply, from 4100 feet at the town of Bishop to 14,246 feet at the summit of White Mountain Peak. They consist primarily of rocks which formed from layer upon layer of sediments, some of which probably were deposited during Precambrian time, the earliest chapter of geologic history. During the hundreds of millions of years that have passed since then, great pressures were exerted by the surrounding earth, folding and deforming the beds of rock severely and finally pushing them upward along a great north-south trending fault line. The interminable processes of erosion set in, disintegrating the surface rock, spreading new sediment over the range, and providing footholds for life.

From the valley, the range appears dry and barren—and, indeed, by Sierra Nevada standards it is, because those mountains block off and receive most of the flow of moisture from the Pacific Ocean. But from the high shoulders of the White Mountains, the view is strikingly different. At those altitudes, the equivalent of about 10 inches of water is received annually, mostly as snow—enough to sustain a profuse variety, if not a large quantity, of plants and animals. There, the parched and twisted trunks of bristlecone pines stand in ghostly groves; wide green meadows lie in the shallow hollows between red-brown, cream-colored, and coal-black mountains; and, through the summer, snow patches glisten on shady slopes. More than 800 species of plants make these high regions their home, many of them growing above timberline. One hundred and sixty families of insects are represented, and there are 45 native mammals, including bighorn sheep, mountain lion, and wild horses.

Although it was not anticipated at the time, concerted scientific "exploitation" of the White Mountains really began in 1948, when the Navy erected an observing station at an altitude of 10,000 feet on Crooked Creek and constructed a 20-mile access road from the State highway at Westgard Pass. The station was used in support of guided-missile research and development then underway at the Naval Ordnance Test Station, China Lake, on the Mohave Desert about 100 miles to the south. In 1950, when the original purposes of the station had been fulfilled, Dr. Nello Pace, of the University of California, who had been searching for a site for a high-altitude physiological research laboratory, and the Office of Naval Research, which recognized the importance of high-altitude research to Navy interests, arranged for the transfer of the station to the University and for its support by ONR. It was the first step of several that were taken in subsequent years to utilize the higher portions of the range as a permanent reserve for research.

The Navy responded enthusiastically to Dr. Pace's research interests because they focused on a problem which, if not solved, could have serious repercussions in Naval operations. If, for example, the Marines had to be transported suddenly to a high-mountain battlefield, they would be a weak, sick, and ineffectual fighting force unless a means were found to adapt them quickly to the low-oxygen atmosphere. The experience of Indian troops who were called upon suddenly a few years ago to occupy mountain passes 19,000 feet high in the Himalayas, in response to border crossings by the Communist Chinese, is a case in point. Because of the degrading effects of the reduced oxygen content of the air, the Indians performed very poorly, and the Chinese, who, presumably, were acclimatized, swarmed over the border. For the human body to adjust fully to atmospheric conditions prevailing at an altitude of 18,000 feet (the highest level at which full acclimatization can occur), several months are required. It is hoped that through research such as that undertaken on the White Mountains, a thorough understanding will be achieved of the effects of the altitude and the adjustments which the heart, lungs, blood, and other tissues must make to perform at their maximum capacity. As a consequence, ways may be found to induce these adjustments by artificial means. The accompanying article, "Physiology at a 'Higher' Level," reviews this problem and discusses some of the approaches taken to solve it.

Work was begun on a second, larger research installation—a 40- by 100-foot quonset hut and accessory buildings—in the spring of 1951 at an altitude of 12,470 feet on Mt. Barcroft (named in honor of Sir Joseph Barcroft, the British scientist who pioneered in high-altitude physiology). The construction involved, among other tasks, the conversion of a poor jeep trail into a good truck road, the drilling of a water well (probably the highest in the United States), and the pouring of 100 cubic yards of cement. Accommodations, including a large kitchen and dining room, now are provided for 24 male and 4 female scientists. There are eight laboratory rooms designed for multipurpose research, and there are offices and a workshop. An extensive library of scientific and historical literature relating to high-altitude physiology has been collected. A small weather station is in operation. Facilities are provided also for keeping experimental animals ranging in size from tiny mice to large monkeys. Here, as at Crooked Creek, a two-man maintenance crew is on duty throughout the year.

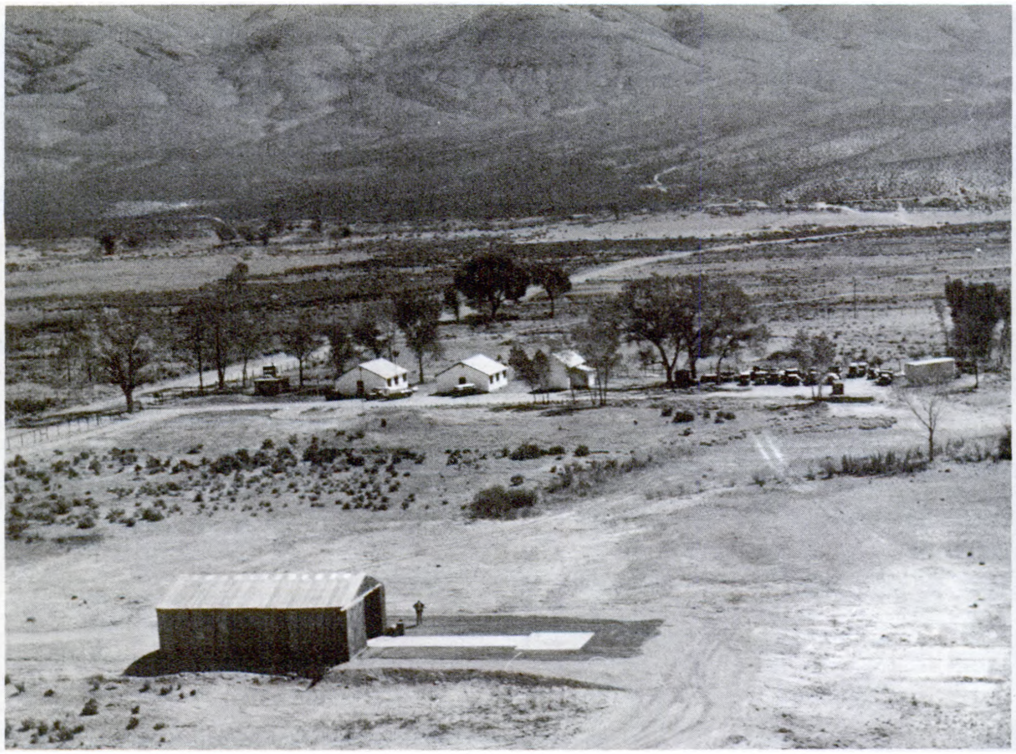
The establishment of the Barcroft laboratory was followed, in 1952, by arrangements made with the Forest Service to set aside 20 square miles of the highest portion of the range—all above an altitude of 11,000 feet—for high-altitude research.

A two-room stone hut was erected on the summit of White Mountain Peak, six miles north of the Barcroft laboratory, in 1955. A road that is negotiable by four-wheel-drive vehicles, during summer months only, connects the two installations. The summit laboratory accommodates four persons and provides cooking and sleeping facilities and power.

Under a National Science Foundation grant, a 12,000-volt power line was strung between Bishop and Barcroft in 1957, bringing to the high laboratories all of the electricity required for their operations. Earlier, a telephone line was established between the Bishop telephone exchange and Crooked Creek. In addition, both the Crooked Creek and Barcroft laboratories were equipped with shortwave radio transmitters and receivers, which permit daily radio communication with the Berkeley campus.

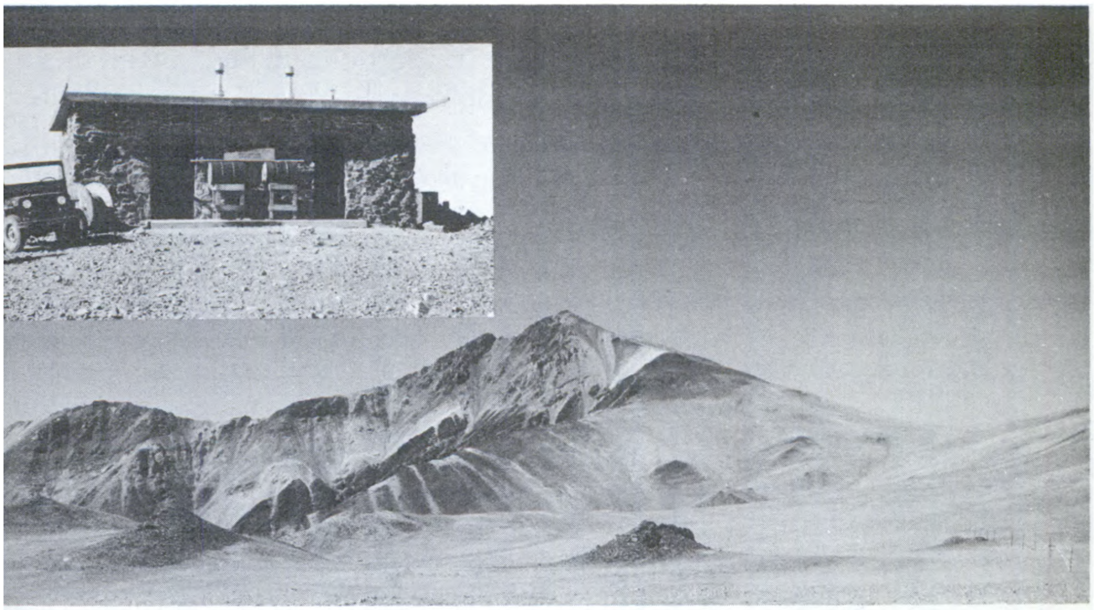
In 1964, new laboratory and office buildings were erected in the Owens Valley near Bishop. In addition to serving as the headquarters for the resident scientists and the station manager, this installation provides shortwave radio communication, animal-keeping and -experimentation facilities, and warehouse space for equipment earmarked for delivery to higher elevations.

With the four laboratories and the extensive life-science laboratories of the University of California at Berkeley, investigators are provided with the means for conducting comparative research at five levels between sea level and 14,246 feet. Although Bishop is 300 miles by road from Berkeley, and Barcroft is 57 miles by road from Bishop, the travel times between the various laboratories usually are not great because reliance is being placed increasingly on air transportation. A three-place, 800-pound-payload helicopter, whose operating ceiling is 20,000 feet, was made available to the Station by the National



The Owens Valley laboratory, altitude 4100 feet.

The Crooked Creek laboratory, altitude 10,000 feet.



White Mountain Peak and the summit laboratory, altitude 14,246 feet.

The Barcroft laboratory, altitude 12,470 feet.

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Aeronautics and Space Administration. In it, one can reach Crooked Creek, Barcroft, or the summit from Bishop in a matter of ten or 15 minutes. An excellent airport in Bishop provides facilities for operation of conventional aircraft.

Because of the universality of appeal of the setting to scientific interests, many investigators in addition to physiologists have availed themselves of the station accommodations. As an indication of the range of subjects they have explored, the following brief accounting of representative research other than animal physiology is presented (physiological research is discussed in the following article).

- The late Dr. Edmund Schulman of the University of Arizona, who visited here frequently during the early 1950's, made what is undoubtedly the most famous of White Mountain discoveries—namely, that some of the bristlecone pines growing near timberline are more than 4600 years old and thus the most aged living entities now known to exist.
- Drs. Bruce Murray, James Westphall, and Robert Wildey of the California Institute of Technology set up an infrared telescope and observatory at 13,000 feet (highest in the U.S.) with which they determined the temperature of the shadowed area of the moon (−270°F), the mean temperature of Jupiter for 12 nights (−229°F), and for the first time detected heat radiation from a single source beyond the solar system (Betelgeuse).
- Dr. Emil Mrak of the University of California at Davis compared food storage at sea level with that in the relatively low-oxygen air of the Barcroft laboratory and showed that a significant improvement in keeping qualities of food stored over a period of several years was experienced on the mountain.
- Dr. Laura Phillips of the University of California, in a study conducted for the National Institutes of Health, compared behavior and learning of humans at sea level and high altitude. She found that at high altitude, short-term memory was imparied in coping with difficult problems, but improved with respect to easy ones, indicating that marked motivational changes had occurred.
- Dr. Vern O. Knudsen of the University of California at Los Angeles made very exact measurements of the velocity of sound at various altitudes in the range, by means of which he was able to determine the Mach numbers associated with those altitudes.
- Professors William Fretter from Berkeley and Harold Ticho from UCLA and other nuclear physicists, utilizing bubble and cloud chambers and other instruments, took advantage of the five- to ten-fold increase in cosmic ray activity on the mountain over that at sea level to define more clearly some of the characteristics of forces existing between nuclear particles.
- Dr. V. C. Lamarche, Jr., of Harvard University, studied erosion processes in the White Mountains in terms of the exposure of bristlecone

pine roots. Using the aged roots as measuring sticks, he discovered that erosion has occurred quite uniformly over the past 3000 years.

- Drs. Gilbert Levin and Norman Horowitz of the Jet Propulsion Laboratory tested for NASA a prototype of the Gulliver life-detection apparatus that may be landed on Mars at the culmination of one of the first flights to that planet.
- Dr. Robert E. Holzer of the University of California at Los Angeles, in a study of atmospheric electricity conducted high in the range, linked ionization in the air to the genesis of thunderstorms.
- Drs. Harold Mooney and Robert White, UCLA botanists, carried portable laboratory equipment to numerous sites on the mountain and measured the rates of photosynthesis of a variety of high-altitude plants under natural conditions.

At the Owens Valley laboratory and at the Crooked Creek and Barcroft laboratories is provided the shell of support which a scientist requires to seek understanding in virtually any discipline to which the high levels of a semi-arid, alpine environment have meaning. Visiting scientists are asked to bring along only the research tools of their specialty and to pay a small fee toward their lodging and the upkeep of the laboratory spaces and equipment they may use. The latter is barely measurable against the magnitude of the research opportunities presented.

Sixteen years now have passed since ONR began supporting the White Mountain research station. During that period, the Navy has provided funds for Station construction, maintenance, and the salaries of employees, and it has made available much of the equipment and facilities upon which Station operations depend, such as radio transmitters, trucks, jeeps, road graders, and "weasels." In recent years, NASA has joined in the support of the laboratories, and funds for specific facilities or investigations have been provided by NSF, the Rockefeller Foundation, the Army, the Air Force, NIH, and AEC. With this strong backing and the continuing interest in the Station shown by the University of California, the uninterrupted pursuit of knowledge in an environment that once was considered too hostile to admit of more than "hit and run" research tactics appears to be assured. *—R. D. O.*

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grants were available and could have been obtained to support faculty research. Furthermore, the consolidated support made it possible for the faculty to concentrate on research rather than be bothered by proposal writing, contract negotiating, and dealing with the federal and university bureaucracy on the myriad of details that modern research-grant management involves.

Physiology at a "Higher" Level

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White Mountain Research Station

Although oxygen comprises only 20 percent of the air we breathe, it is singularly the most vital constituent for man's survival. To appreciate fully its unique necessity, we need only observe the great number of medical problems in which the primary concern is the supply of oxygen to the tissues. For example, diseases of the circulatory and respiratory systems may have diverse origins, but the basic physiological distress is an inadequate tissue oxygen level.

Natural limitations of oxygen supply are imposed in ascents to the higher altitude regions of the atmosphere. In the past, only a few resident high-altitude natives and an occasional explorer needed to be aware of the impaired body function associated with the rarified air. With the advent of modern aviation and more recently with the access improvements to high mountains for pleasure, these impairments were experienced more universally. Thus, a better understanding of the medical problems associated with low-oxygen levels (hypoxia) has become imperative.

Since the first report of mountain sickness was published in 1590 by the Jesuit naturalist, Acosta, the names of scientists such as Bert, Mosso, Zuntz, Barcroft, Haldane, Monge, and Dill have been synonymous with the early physiological evaluation of hypoxia. During the last decade of the nineteenth century, the first high-altitude laboratory was established on the Jungfrau in the Swiss Alps. At the present time, a number of such laboratories are in existence throughout the world. The White Mountain Research Station in California is one of a few that are in operation on a year-round basis. This article will attempt to describe in cross-section some of the many and varied physiological research projects being conducted at the Station.

The projects have been of two basic designs—first, the evaluation of the acclimatization process in men and animals native to the sea-level environment when taken to higher altitude; and second, the investigation of adaptive (genetic) variations in animals native to the various altitude regions. The greater part of the research to date has been of the first type, but this should not be taken as indicative of the total potential of the Station.

It should also be pointed out that for the purpose of this article only a few of a much greater number of equally good projects were singled out for discussion. The choice was determined largely by the author's own personal knowledge of, and association with, those selected.

Respiration

One of the earliest physiological observations made in regard to high-altitude exposure was the immediate increase in ventilation rate of the lungs. Breathing is ordinarily regulated in response to changes in the carbon dioxide and oxygen partial pressures and the hydrogen ion concentration (pH) of the blood. During the early period of altitude exposure, the levels at which these variables are regulated, especially the carbon dioxide, change markedly. Ralph H. Kellogg (University of California, San Francisco) has visualized these changes as being analogous to the resetting of a thermostat. In his years of investigations at the Station, Kellogg has attempted to determine the mechanism of this "chemostat" with the hope of understanding better the regulation of breathing at both sea level and altitude. Studies have indicated that the increased breathing at altitude could be accounted for by a readjustment of the carbon dioxide "chemostat" to lower levels.

Donal Reed, working with Kellogg, observed that the increased severity of mountain-sickness symptoms following sleep was due to a depression of the respiratory center to carbon dioxide stimulation, which results in decreased ventilation. As a consequence, the lungs are underventilated during sleep, and the arterial blood has a lower oxygen content. These findings indicated that during sleep at an altitude of about 14,250 feet, the physiological elevation was raised to 16,000 feet.

Robert A. Mitchell (University of California, San Francisco) has demonstrated the presence of chemical receptors (chemoreceptors) on the surface of the medulla which are sensitive to changes in the pH of the cerebrospinal fluid. These receptors play a very important role in the regulation of breathing. John W. Severinghaus (University of California, San Francisco) and coworkers have studied changes in the amount of carbon dioxide present as bicarbonate ion in the cerebrospinal fluid in an attempt to clarify the mechanism of the respiratory adjustment at altitude. Their findings indicate that the "resetting" of the "chemostat" is accounted for by the rapid decrease in cerebrospinal fluid bicarbonate ion levels upon ascent to high altitude. This change was observed to occur before similar changes were noted in the blood. The adjustment allowed for lower levels of carbon dioxide to produce as much respiratory stimulation at high altitude as higher levels had done before ascent.

Physical exercise at sea level has a marked effect on the respiratory response, resulting in rapid and deep breathing. This response has been shown to have a fast and slow component, evidenced by immediate increases in depth and rate followed by a more gradual increase as exercise continues. The fast component is considered to be a result of nervous control, while the slower portion is due to progressive changes in blood chemistry. Pierre Dejours, Ralph H. Kellogg, and Nello Pace (University of California, Berkeley) studied the effects of altitude on the respiratory response to exercise and found that the same components were present, but with increased activity.

At the present time, plans are being made to extend some of these observations. Kellogg has scheduled a study which will correlate the altitude ventilatory responses with changes in arterial and cerebral venous blood and in the spinal fluid. Severinghaus is interested in the long-term effects of hypoxia on the sensitivity of the chemoreceptors.

Circulation

As stated previously, the primary physiological concern at altitude is the maintenance of an adequate supply of oxygen to the tissues. Among the many adjustments which occur to assist in this effort, some of the most dramatic changes are observed in the circulatory system. Increases in the heart rate, the number of circulating red blood cells, and the size of the vascular bed are all of significant value. Research in this area has been centered around an attempt to understand the underlying mechanisms that initiate these changes and the resulting effects on other organs and systems.

The chemical detection of oxygen in the blood is carried out by chemoreceptors located on the arch of the aorta and the carotid artery. R. S. Gilfillan (University of California, Berkeley) has developed a surgical technique, called glomectomy, by which these receptors can be removed. Donald W. Badger (University of California, Berkeley), working with Pace, compared the effects of altitude on the blood of the glomectomized animals to that found in intact animals. He observed a much greater increase in the volume of red cells in the animals operated upon than in normal animals at high altitude. The plasma volume decreased slightly in intact animals, whereas the decrease was nearly 50 percent after glomectomy. This study gave some indication of the role of oxygen in initiating the altitude response. The results lead one to conclude that the oxygen chemoreceptors mediate the degree of hematological adjustment to hypoxia.

The development of a sea-level monkey colony in Berkeley under the direction of Pace has made possible the use of these subhuman primates in high-altitude research. One development that has been of significant value is the surgical implantation of catheters in the major blood vessels of the body for long periods of time. W. H. Inge and W. G. Wisecup of the U.S. Air Force studied blood-pressure changes in two of these animals during a 30-day exposure to an altitude of 12,470 feet. Their results show that the blood pressure in both the aorta and pulmonary artery rise sharply during the first days of exposure. The aortic pressure started to fall after seven days and reached sea-level values during the fourth week of exposure. On the other hand, the pulmonary pressure remained elevated for the entire period. These findings reflect another part of the picture of bodily adjustment to hypoxia through an increased circulation in the lungs as denoted by the sustained pulmonary pressure.

Growth and Development

For some time it has been thought that one of the major causes of birth defects is a reduction in the amount of oxygen available to the developing fetus. The high-altitude environment offers the opportunity to study this possibility in a large population of otherwise healthy animals. Bernard Baird has found that there is a significant increase in the number of cardiovascular anomalies among new-born deer mice native to an altitude of 12,470 feet as compared to natives of lower elevations. The most common prenatal defect is the failure of the wall between the ventricles of the heart to close properly during development. In humans, this condition gives rise to the "blue baby."

This finding may account, in part, for the increased mortality among young rats and mice at high altitude as reported by several investigators. Fenton C. Kelley (University of California, Berkeley) reports a 16 percent depletion in rat litter size during the first five days after birth. In fact, he was able to detect as early as the fifteenth day of pregnancy that 17 percent of the developing fetuses were abnormal. It appears that the first five days after birth constitute the critical period for survival in these animals, as evidenced by a mortality of only three percent thereafter.

One of the most imaginative studies of growth and development at high altitude is headed by Arthur H. Smith (University of California, Davis).* The basic aim is to determine the physiological changes during growth and development in the hypoxic environment. With a clear insight of the limitations imposed in this type of study, Smith chose the chicken as the experimental animal. Several physiological characteristics which are distinctive for fowl were the basis for the choice. First, because of their ovipary, it is possible to keep mature parent animals at one elevation and the developing embryo at another. With this capability, one is able to distinguish between hereditary and environmental influences. Another benefit is that the egg form allows for more convenient observation of the developing fetus. Finally, egg laying is a complicated metabolic process; therefore, the egg-laying rate can be

*Other research conducted by Dr. Smith on chickens—the effects of acceleration—is discussed in *Naval Research Reviews,* November 1965.

used as an index of the metabolic function in the mature animal during acclimatization.

The results of this work, to date, show that chickens can be raised successfully at the Barcroft laboratory (12,470 feet). The current colony includes animals of the eleventh selected generation. An interesting fact is that the growth rate and maximum size are not appreciably altered at high altitude. The egg-laying rate and male fertility are also comparable to those at sea-level. The principal reproductive defect is a decrease in hatchability of fertile eggs. In the Crooked Creek colony (10,000 feet), sea-level strains have a 30 percent hatchability, while the Barcroft high-altitude strain has a 60 percent value—both of which are considerably below the 80 percent value observed at sea level. In addition, the mortality is substantially greater at high altitude for all age groups.

Emerson L. Besch (University of California, Davis) has used the chicken to study the rate of transfer of oxygen from the lung to the blood at high altitude. The results indicate that the rate is diminished, but that the degree of removal is more efficient.

Pathological studies of these animals have been conducted by H. Olander (Cornell) and R. R. Burton (University of California, Davis). Distinct changes have been observed in the respiratory and circulatory systems. The most striking change is the increase in the size of the endocardium, leading to 'warty growths' (mucoid degeneration) primarily in the region of the valves. Interestingly, these growths do not regress upon return to sea level. In the lungs, the paribronchii are enlarged and diffuse, which is in accord with the observations of Besch that the efficiency of oxygen exchange is enhanced.

Central Nervous System

The central nervous system (CNS) is known to be particularly susceptible to hypoxia. The classical descriptions of mountain sickness include several neurological symptoms; *e.g.*, insomnia, headache, anorexia, increased irritability, and both sensory and motor alterations. A detailed investigation of the effects of acclimatization and deacclimatization on the function of the CNS has been undertaken by Paola S. Timiras (University of California, Berkeley) and co-workers. An attempt is being made to determine which portions of the CNS are most sensitive to hypoxia and to what degree the duration of exposure influences these areas.

By means of the techniques that have been developed to measure spontaneous and evoked activity of specific brain areas, it will be possible to compare the growth and development of the CNS in sea-level and high-altitude rats. The present rat colony at the Barcroft laboratory consists of two successive generations of rats born at high altitude.

Timiras hopes to compare these animals with sea-level native animals brought to high altitude in order to assess any differences in the role of the CNS in regulating the responses of other systems to hypoxia.

Louise M. Heim (New York Medical College) has reported on the first findings of this group. It has been determined that the development of the CNS, as measured by brain electrical stimulation, is delayed at high altitude, but that once maturation has been achieved, increased excitability is found.

Metabolism

In order to survive, animals must maintain an adequate supply of energy for the many body processes. This energy is derived from a complex series of chemical reactions which are referred to collectively as "metabolism" and in which oxygen plays an obvious essential role. If a deficiency of oxygen exists, the resulting loss of available energy has limiting effects on many active tissues.

The utilization of carbohydrate provides the bulk of the energy transformation under normal conditions. With this in mind, Timiras and others found that at high altitude there was a marked depression in the ability of liver and muscle to store sugars as glycogen. Subsequent studies by the author revealed that a decrease was evident in the amount of circulating blood glucose as well as in the liver stores through at least eight months of exposure. By using glucose that had been tagged with radioactive carbon-14, it was possible to demonstrate a significant decrease in the oxidation of this compound to carbon dioxide. As yet, the specific defect has not been elucidated; however, it is apparent that the problem concerns the manner in which the six-carbon molecule is treated prior to degradation to smaller units. One can only speculate at this point that the hypoxic condition in some way alters the mechanism of glucose utilization.

An interesting series of experiments has been conducted on a particular subspecies of deer mouse (*Peromyscus maniculatus sonoriensis*) native to the White Mountain region. During six and one-half years spent as the resident physiologist at the Station, Raymond J. Hock studied metabolic responses of this animal to changes in altitude and temperature. This subspecies is distributed from the floor of Death Valley below sea level to the 14,246 foot summit of White Mountain Peak. The climatic variation in this span is from the arid desert of the lower elevations to the arctic-alpine conditions near the summit. Of particular interest to Hock were the changes through genetic alteration of these animals at various elevations and the degree to which such adaptive alterations might influence the responses to other environmental extremes.

The first comparative study to be completed was the measurement of body and organ weights of mice trapped at the different altitudes. The heart weight was found to be greater at higher altitudes, which is similar to the findings in acclimated animals. Unlike the changes observed in acclimatization, an increase in body weight and a decrease in adrenal weight were observed as the altitude increased. The body-weight increase might reflect added insulative changes in fur and fat, whereas the adrenal-weight reduction may be a true adaptive change to the specific environmental condition.

A series of experiments were conducted in which mice were translocated from their native environment to another environment. Using exercise endurance as a reference, Hock observed that low-altitude natives did improve their initially poor performance at high altitude after acclimatization. The high-altitude native upon translocation showed a progressive deterioration in performance in the lower altitude location. This might reflect the presence of cardiac and respiratory anomalies which have been shown to occur in greater numbers at high altitude.

Both Hock and Robert E. Smith (University of California, Los Angeles) have been interested for many years in the effect of temperature on metabolism. The presence of two species of hibernating mammals (marmots and ground squirrels) on White Mountain has provided them with convenient subjects for such studies. Recent discussions of long-term space travel have focused much attention on this unique physiological process. Quite apart from this consideration, the physiologist finds the ability to establish a steady state at such low temperature (6°C) of the greatest interest. Smith has studied extensively the role of brown fat in thermoregulation of both hibernators and nonhibernators. Together with Hock, he has shown that the brown fat is selectively activated when hibernating animals are placed in even more severe temperature conditions (—12°C). The arousal process, which is initiated at these temperatures, derives thermal support from the metabolic heat produced in these tissues. The heat transfer has been shown to affect the lower brain centers and the organs of the thoracic cavity (heart and lungs). More detailed studies are under way to determine the unique metabolic conditions that exist during hibernation and during the period of arousal.

It is readily apparent that the scope of physiological research conducted at the White Mountain Research Station is very large. Furthermore, the future research program at the Station certainly will become more diversified as the interest in environmental factors grows. Plans are being discussed already to establish a monkey colony at the Barcroft laboratory for further investigation of the hemodynamic and metabolic changes associated with high-altitude exposure. The use of the facilities

—*Continued on page 22*

Research Notes

Deep Scattering Layer Detected in Arctic Ocean

Underwater acoustics research conducted at the drifting-ice station T-3 (known also as "Fletcher's Ice Island") in the Arctic Ocean has revealed for the first time the presence of the so-called "deep scattering layer," which is known to exist in other oceans, but which was thought to be absent in the arctic. The arctic scattering layer was identified by the study of precision depth recorder (PDR) records taken over a period of several years from T-3. In the Atlantic, Pacific, and Indian Oceans, the deep scattering layer occurs throughout the year at depths between 200 and 600 meters during daytime and at higher levels at night.

Further investigation of the phenomenon is planned for this summer. In order to define variations in the layer, two sounders in addition to the 12 kcps sounder employed in the past, will be operated—these in the frequency range between 12 and 200 kcps. A nephelometer, an adaptation of the Thorndike bottom camera, which is used to measure light scattering, will be employed also, as will tapes of the scattering of sonar signals.

These investigations will be made in close cooperation with a team of marine biologists under the direction of Dr. M. J. Dunbar of McGill University (under ONR contract). If the arctic scattering layer is the counterpart of the deep scattering layer of other oceans, it should be associated with a concentration of organic life. Identification of the key species may provide the information required to establish the nature, extent, and migration of the layer as well as further our knowledge of the biological resources of the Arctic Ocean.

The drifting station, which is maintained by the Arctic Research Laboratory at Barrow, Alaska, now is located about 250 nautical miles north of Barrow—the most favorable position it has been in during the past four years from the standpoint of supply. The Laboratory's R4D and Cessna-180 aircraft took care of most of the spring airlift, although assistance in freighting heavy supplies, such as fuel oil, was given by the Alaska Air National Guard in conjunction with several training flights it made to the island.

A College Education for Fishermen

A two-year curriculum designed to provide an excellent background for students wishing to enter the fishing industry will be initiated at the University of Rhode Island in September 1967.

Commenting on the need for the new course of study, Dr. James W. Cobble, Dean of the URI College of Agriculture, said "A young man who wants to go into farming can enter institutions in every state in the Nation where he can obtain a good education. If the same young man wants to enter the fishing industry, however, he cannot obtain an education in this field at any university in the United States, and very few community colleges or technical-vocational institutes offer a program which would be of much help to a commercial fisherman."

The curriculum calls for a combination of morning classroom lectures and afternoon experience in shops and on leased fishing vessels. However, to earn their associate-in-science degrees, students will be required to learn more than just how to catch fish. Areas of study will include English, economics of food production, algebra and trigonometry, first aid, seamanship and fishing gear, accounting, physics, marine engineering, navigation, biology and conservation, vessel construction and appraisal, business management, fishery technology, speech, personnel and industrial relations, marketing of food products, and fishery hydrography.

New Topside Paint for Submarines

A combination of special paints that can be applied to the topsides of submarines at bases in cold, damp regions and still provide adequate protection for those surfaces for six months or longer has been developed by a Naval Research Laboratory chemist. One of the submarine bases at which trouble has been experienced in the application of standard paints is Holy Loch, Scotland. There, the temperature is near freezing most of the year, rain falls an average of 16 days per month, and most of the time the relative humidity is above 70 percent. Shortly after the application of standard paints under such conditions, the coatings deteriorate and separate from hull surfaces, thus failing to do their job.

The NRL chemist, D. E. Field, developed a moisture-cured urethane topside paint. When applied in cold, damp weather, this paint is dry to touch in 30 minutes and hard enough for minor traffic in less than eight hours. Three patrols, each lasting more than six months, made by submarines coated with the paint, have shown that the coatings remain hard, tenacious, and durable.

The paint is supplied in two packages, which must be mixed at least an hour before use. Since the paints react with moisture, they should be applied within eight hours in damp climates. If the container is kept sealed, by pouring off only the amount needed for immediate application, the application life can be extended to 30 hours.

Although research in this area was directed originally toward the development of a flat black topcoat, it became necessary to develop a primer because those already available lacked adequate adhesion when applied under adverse weather conditions. A flat white paint that can be tinted to various shades of gray by addition of the black topcoat also has been developed.

The new paint serves only the specific purpose discussed above; it does not replace standard topside paints for application during fair weather.

Where the Honor Belongs

The following communication received by the editor from CAPT R. T. Miller, Commanding Officer and Director, Navy Mine Defense Laboratory, Panama City, Florida, sets the record straight as to which was the first large U.S. ship built from the keel up for ocean research. In a picture caption in the May 1966 issue of *Naval Research Reviews* (page 5), the editor stated that this ship was the ATLANTIS II of the Woods Hole Oceanographic Institution.

...This honor, I believe, belongs to the ROBERT D. CONRAD, AGOR-3, which was laid down in January 1961 and went in service in late 1962. ATLANTIS II went in service in 1963. The two designs are very close in size. They can be classed as "large vessels," although they are not the largest vessels to have been designed for ocean research purposes. The AGOR-3 class is 209 × 40 × 15-feet by 1380 tons full-load displacement, and the ATLANTIS II is 210 × 44 × 17-feet by 2300 tons full-load displacement.

The preliminary, or conceptual, design of the AGOR-3 class actually dates back to 1954. It began with an October 1953 conference on Oceanographic Research Vessels, which was sponsored by the Office of Naval Research and which is described in the December 1956 issue of (Naval) Research Reviews. *Representatives of the Scripps Institution of Oceanography, as well as of Woods Hole, served on the Steering Committee which reviewed the characteristics of the design at that time. The design of ATLANTIS II did not commence until several years later.*

The ROBERT D. CONRAD was built by the Navy for the oceanographic program and assigned to the Lamont Geological Observatory for operation.

Women Scientists at Sea

When two women scientists spent three weeks on a cruise aboard the Naval Oceanographic Office's research ship USNS LYNCH last January, they broke a 135-year precedent of that Office, whose crews and scientific parties previously had consisted entirely of men (see *Naval Research Reviews,* Feb.-Mar. 1966). Since that report was printed, word has come from the National Science Foundation regarding participation by women in its cruises, which has occurred regularly since 1962, primarily in Antarctic waters aboard the Foundation's research vessel USNS ELTANIN. The cruises average about 60 days in length. This year, for example, Dr. Nancy W. Walls and Mrs. Dorothy E. DeFoor (assistant) took part in Cruise 23 of the ELTANIN, which terminated in Auckland, New Zealand, on May 30. The two women, who are from the Georgia Institute of Technology, conducted a study of microbiological features of marine sediments.

Gulf Stream Changes Recorded in Bulletin

A monthly bulletin entitled "The Gulf Stream" has been instituted for release by the Naval Oceanographic Office. The new technical summary will present Gulf Stream positions at the beginning and end of each month and positions that are normal at those times. Associated mean sea-surface temperature patterns and variations of the temperatures from normal for the western North Atlantic will be shown also.

Data and analysis used in preparation of the new publication will be based on current Naval Oceanographic Office experimental programs being conducted with the assistance of the Office's Air Survey Unit. The Unit's aircraft, which are equipped with meterological and oceanographic sensors, including an airborne radiation thermometer for recording sea-surface temperatures, make regular flights in the western North Atlantic. The primary purpose of the flights is the evaluation of airborne oceanographic instrumentation.

Hydrographic Boat Engaged by Viet Cong

A hydrographic-survey boat—soundboat-7 of the USS MAURY (AGS-16)—was hit by enemy gunfire in Viet Nam waters recently while running sounding lines near Chu Lai. The 52-foot-long round-bottom boat was taken under fire by automatic weapons from a beach about 150 yards away. Crew members of soundboat-7, which normally carries ten men, were quick to return the fire with small arms.

Immediately after the attack, the coxswain swung the heavy, double-planked boat to make a withdrawal. As he did so, a second burst cut across the bow at deckhouse level. Several bullets struck the craft, one of which passed through a window, narrowly missing a fathometer operator. The boat's crew then silenced the enemy with fire from her 50-caliber machine gun.

Ensign Donald Puccini, of Oakland, California, officer in charge of the soundboat, credited his crew's quick reactions in manning their stations and returning the fire for holding damage to a minimum and averting personnel casualties.

The USS MAURY and her sister ship, the USS TANNER (AGS-15), two of the oldest and staunchest hydrographic survey ships in the world, have been sharing duty in South Viet Nam waters. They are 6800-ton converted World War II attack cargo ships that have been specially configured for hydrographic surveying. They have an overall length of 426 feet and a complement of about 350 officers and men. Each carries four soundboats, which are capable of operating on independent missions for periods of a week or 10 days.

"Splat Cooling"

A process which creates new metallic alloys and holds possible broad implications in electronics and other fields has been developed under the part-sponsorship of the Metallurgy Branch of the Office of Naval Research.

The procedure (informally called "splat cooling") involves blasting a molten droplet of a pure metal or an alloy against the rim of a refrigerated metal wheel spinning at high speed. The droplet is then cooled, in the form of a small piece of thin foil, at the rate of 2,000,000°F per second—before the atoms have time to realign themselves in their traditional patterns.

When liquid alloys are cooled faster than a certain critical rate, metastable phases can be obtained. In many cases, crystalline phases, not found under equilibrium condition, have been synthesized. Some of these phases have very simple crystal structures (such as a simple cubic structure, with one atom per unit cell, in tellurium-gold and tellurium-silver alloys) and others have rather complex, still not identified structures. A typical example in the latter class is a new metastable phase in gold-germanium alloys, which has been found to be superconducting below about 1.6°K. In a relatively small number of binary alloys, rapid cooling from the liquid state has produced amorphous phases. Such phases were found in tellurium-base alloys with germanium, silicon, and gallium and also in alloys of palladium with silicon (within the range of from 14 to 22 percent Si). The tellurium-base alloys have very high electrical resistivity (practically insulators), but the palladium-base alloys are metallic in character. Between room temperature and 2°K, the temperature coefficient of these alloys is only 0.00017/°C. The structure of these alloys has been studied by electron-microscopy, and preliminary results on the kinetics of amorphous to crystalline transition now are becoming available for several alloy systems.

Production of these "abnormal" alloys is currently limited to small bits of thin foil having structures that never existed before. Such foil could be utilized in fields where only small quantities of materials are required. Although future applications are still speculative, several possible implications have been suggested. New electrical and magnetic properties may be discovered. This process now leads to the synthesis of new superconductive alloys, which are useful as components of computers and other devices that require very small amounts of energy.

More than 3000 small craft of fiberglass construction have been built for Navy service. Fiberglass has completely replaced wood as a hull material in new construction of craft up to 60 feet in length. Current studies show a potential for fiberglass as a hull material for much larger craft.

Physiology—Continued from page 18

by graduate students involved in doctoral research projects is increasing each year. Since 1950, a total of 154 scientific articles have been published which relate to work conducted at the Station, and each year the average number of publications has increased. With the continuing expansion of the facilities, the utility of the White Mountain Research Station is improving, making the mountain increasingly attractive to those segments of the scientific community interested in high-altitude research.

On the Naval Research Reserve

Midwest Research Seminar in Meteorology and Oceanography

The Midwest Research Seminar in Meteorology and Oceanography was held on the campus of The University of Michigan, May 2-13, 1966, with 64 Naval Reserve officers in attendance. The seminar was sponsored jointly by the Office of Naval Research and The University of Michigan and was administered by Naval Reserve Research Company 9-3, Ann Arbor. LCDR Dale E. Briggs, USNR, served as seminar chairman, and LCDR Jopeph J. Keeley, USNR, and LCDR Robert C. Fitzpatrick, USNR, served as assistant chairmen.

During the opening morning session, Dr. Gordon J. Van Wylen, Dean of the College of Engineering and a former Navy submarine officer, welcomed the group and told of the current status and the future plans of the Engineering College. Dr. Geoffrey A. Norman, Vice President for Research and a colonel in the Air Force Reserve (retired), warmly welcomed the Reservists, saying that it gave him a wonderful feeling to have the men in uniform on campus, then described the University's $51 million research program. CAPT Thomas J. LaForrest, Commanding Officer, NROTC Unit, University of Michigan, welcomed the Naval officers to the Ann Arbor area. The opening session concluded after brief messages from CAPT George A. Belleau, USNR, Commanding Officer, Naval and Marine Corps Reserve Training Center, Detroit, and representative of the Commandant, Ninth Naval District, and CDR Orval D. Hughes, USNR, Commanding Officer, Office of Naval Research Branch Office, Chicago.

A luncheon was held the first day, at which the opening-session speakers were guests. CAPT L. B. Melson, USN, Assistant Chief for Research, ONR, Washington, D.C., the featured speaker, gave an exciting account of the role ONR and its research submersible ALVIN played in the location and recovery of the hydrogen bomb off the coast of Spain in March 1966.

The technical portion of the seminar was divided into three phases. The first two phases consisted of five half-day symposia in meteorology and six half-day symposia in oceanography. Field trips made during the last two days of both weeks comprised the third phase. The seminar program was organized to provide the equivalent of a one-semester survey course in modern meteorology and oceanography. It was planned to enhance the individual officers' potential value to the Navy, in the event of mobilization, by presenting information on current trends of research in meteorology and oceanography of importance to today's modern Navy. University professors, researchers, and research administrators from universities, industries, and Federal and State agencies were speakers. Each one was considered to be nationally renown for his work.

The meteorology sessions had two general themes. One had to do with current data-collection and -assimilation systems, and the other had to do with the mathematical modeling of the atmosphere to predict weather conditions from the data collected. Papers were presented on the "Naval Weather Service Computer Network," a sea- and ground-level data-collection system; "The Global Horizontal Sounding Technique (GHOST)," an upper level data-collection system; and "TOS, The Operational Meteorological Satellite System," and the "Meteorological Rocket Network," both of which are applied to outer space data collection. Papers entitled "Dish Pan Simulation of Large Scale Atmospheric Circulations" and "Numerical Simulation of the General Circulation of the Atmosphere" were typical of those describing mathematical modeling procedures. Approximately 30 people from the U.S. Weather Bureau attended the meteorology sessions, raising the total attendance of a number of these sessions to more than 120.

"Physical," "Geological," and "Biological Oceanography" were topics for the first three half-day oceanography sessions. These were followed by an extremely interesting session on "Polar Research," which was chaired by CAPT Maynard M. Miller, NRRC 9-16, East Lansing, Michigan. ONR programs concerning the Arctic were discussed in detail. Professor Mary Alice McWhinnie ended the session with an outstanding talk on "Interdisciplinary Oceanography in Antarctica." "Water Supply and Pollution" and "Ocean Engineering" were the titles of the last two sessions.

Field trips made to The University of Michigan's North Campus during the first week included briefings and tours of the Cyclotron, Swimming Pool Nuclear Reactor, and the High Altitude Research and Space Physics Laboratories. Three talks on remote sensing were given by Institute of Science and Technology personnel. "Air Infrared Scanners," "Multispectral Sensing," and "High Resolution Radar" were the topics discussed. Local military-orientated research companies were visited during the second week. Optical-computing and data-analysis systems were examined at the Conductron Corporation, and space-simulation equipment was seen at the Bendix System Division. The University of Michigan's 85-foot radio telescope at Peach Mountain, which has been supported since its inception in 1956 by the Electronics Branch of ONR, was visited on the last day of the seminar.

A formal banquet was held for the seminar officers and the symposia chairmen on Tuesday evening, May 10. RADM John K. Leydon, USN, Chief of Naval Research, was the banquet speaker. Admiral Leydon discussed the philosophy and the role of ONR in carrying out the mission of the Navy as a component of the Department of Defense, speaking in detail of the Navy's interest and need for oceanographic research. While on campus, the admiral toured the facilities of several ONR-sponsored projects and spoke with the project supervisors. His visit was concluded on Thursday morning, May 12, with a press conference in Detroit.

CAPT D. J. Marker, USNR, Special Assistant to the Chief of Naval Research for Research Reserve, spoke to the group on the last afternoon of the seminar. CAPT Marker discussed the current status of the Naval Reserve Research Program, giving particular emphasis to recruitment and promotions.

Thirteenth Annual Naval Reserve Research Seminar

The 13th Annual Naval Reserve Research Seminar was conducted at the Naval Research Laboratory, Washington, D.C., from June 6-17, 1966. Sixty-four Reserve officers on active duty for training were welcomed by CAPT T. B. Owen, USN, Director of the Laboratory. CAPT Owen reviewed the mission of the Laboratory and highlights of research programs currently in progress.

A luncheon sponsored by Naval Reserve Research Company 5-9, located at NRL, was arranged for the opening day. LCDR G. Abraham, USNR, Commanding Officer of NRRC 5-9, introduced the guest speaker, CAPT D. J. Marker, USNR, Special Assistant, Research Reserve, Office of Naval Research, who discussed the future of the Research Reserve and the need for an emphasis on recruiting to bolster the membership being depleted by retirements of World War II members.

The two-week period was occupied by tours of the scientific divisions of the laboratory in which the fields of applications research, electronics, radar, radio, sound, chemistry, mechanics, metallurgy, solid state, atmosphere and astrophysics, optical physics, nuclear physics, plasma physics, and ocean sciences and engineering were covered by lectures and examinations of experimental areas. Demonstrations were conducted of the Rainbow optical aircraft landing aid; tracking of satellites with the 150-foot diameter steerable dish at the Chesapeake Bay Division, located 40 miles from NRL; and the operation of

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a lightweight, unfolding radar antenna for satellites. In addition, the Engineering Services Division presented a review of machine, electronic, foundry, sheet metal, and plating shops which support the instrumentation requirements of NRL's research programs. An opportunity was provided for Reservists to examine their service records at the Bureau of Naval Personnel.

On the closing afternoon, RADM J. K. Leydon, USN, Chief of Naval Research, made a surprise visit to the seminar. In his remarks, he emphasized the needs of the Service for the Research Reserve and encouraged that Reservists take an optimistic view and have full faith in the future with respect to their role in the ever-changing scientific and technical areas.

Naval Districts were represented by the following numbers of Research Reserve companies: 1ND-3, 3ND-4, 4ND-7, 5ND-7, 6ND-6, 8ND-4, and 9ND-12. Participants also represented the NROS, Construction Battalion, and Coast Guard Reserve programs.

Seminar on Missile and Space Research

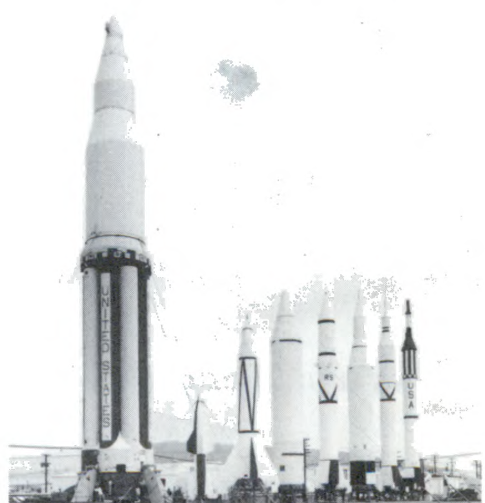
Naval Reserve Research Company 6-17, Huntsville, Alabama, conducted a weekend seminar at Redstone Arsenal on May 13-15, 1966. The theme for the seminar, which attracted Reservists from nine states, was "Missile and Space Research." A total of 141 Reserve officers having research interests gathered for the event (88 Navy, 2 Coast Guard, 8 Air Force, and 43 Army). All Southeastern states were represented, from Kentucky to Florida and from South Carolina to Texas.

The technical sessions, some of which were classified, covered the following subjects: research aims, propulsion, electronics and electro-mechanics, materials and methods, mathematics, and education and training. A tour of facilities of the Marshall Space Flight Center was conducted on the afternoon of May 14, and a banquet was held at the Redstone Arsenal Officers Open Mess that evening.

The welcoming address for the seminar was delivered by COL Thomas W. Cooke, USA, Commander of the Army Missile Support Command at Redstone Arsenal. CAPT Bart J. Slattery, USN (Ret), Chief of the Marshall Space Flight Center's Public Affairs Office, was the banquet speaker.

Facilities for the seminar were provided by the Army Missile Support Command at Redstone. Technical Speakers included employees of the Army Missile Command, Marshall Space Flight Center, Huntsville Campus of the University of Alabama, Thiokol Chemical Corporation, and Rohn & Haas Corporation.

LT Alvin Steinberg, USNR, of NRRC 6-17, acted as seminar chairman; he was assisted by LCDR James H. Hoyle, USNR, unit Commanding Officer, and by other unit members.



These missiles appeared to be lined up at attention when viewed by Reservists during the weekend seminar at Huntsville, Alabama. They are, left to right, Saturn 1, Hermes, German V-2, Jupiter, Redstone, Juno, Jupiter C (Redstone with Spin Bucket), and Mercury (carried first astronaut in suborbital flight).

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Editor: RICHARD D. OLSON

NAVSO P-510

White Mountain Peak, 14,246 feet high, in east-central California. Situated on its summit is the highest research laboratory in North America. The photograph was taken from a point near a second research laboratory, located at an altitude of 12,470 feet. A third laboratory is in operation in these mountains at an altitude of 10,000 feet, and a fourth is located in the valley at the foot of the range (altitude, 4100 feet). The facilities, which are collectively designated "The White Mountain Research Station," are operated by the University of California and supported in large part by the Office of Naval Research. They are described in the article beginning on page 5. Physiological research conducted at the Station is discussed in the article beginning on page 12.