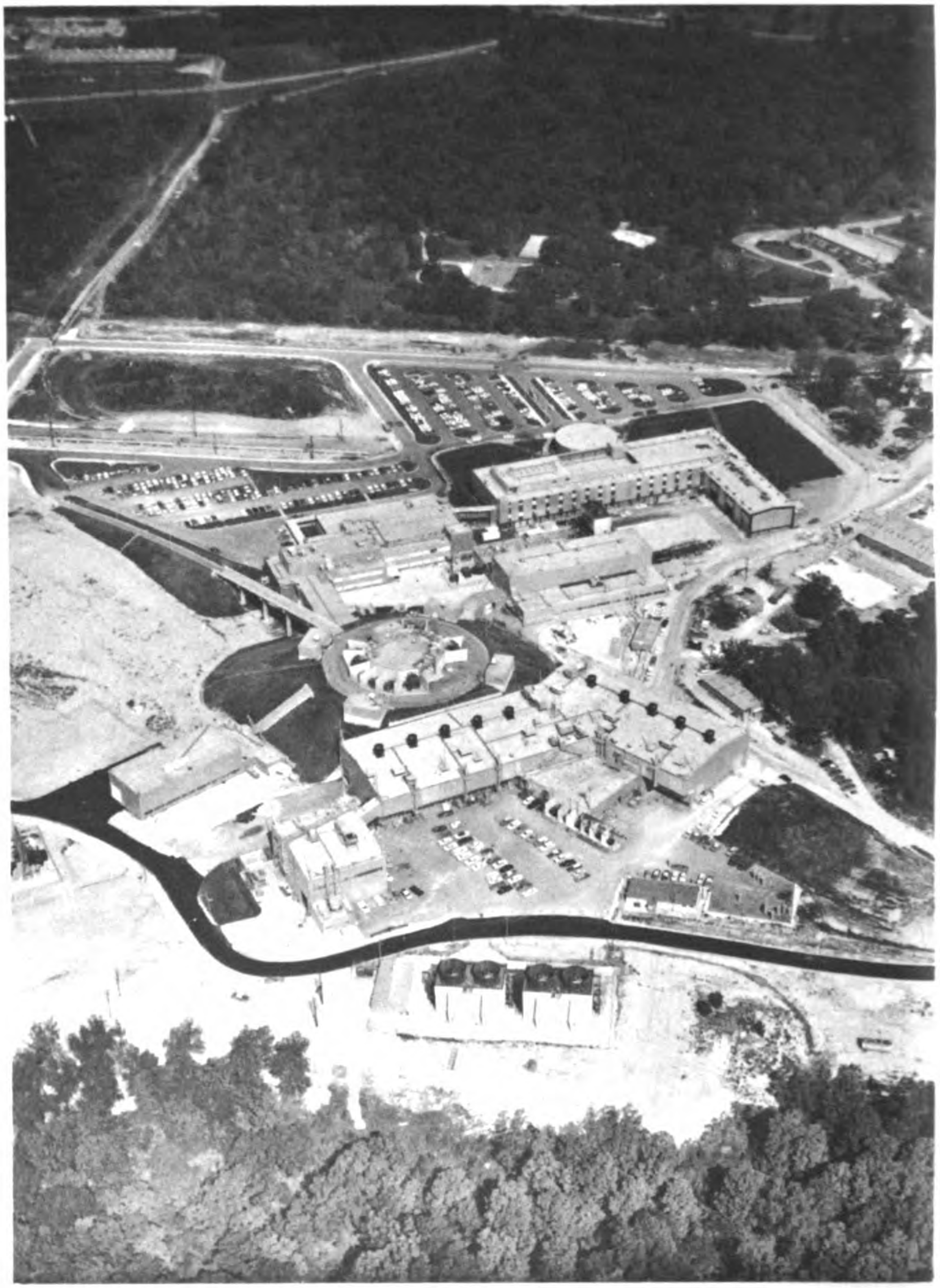
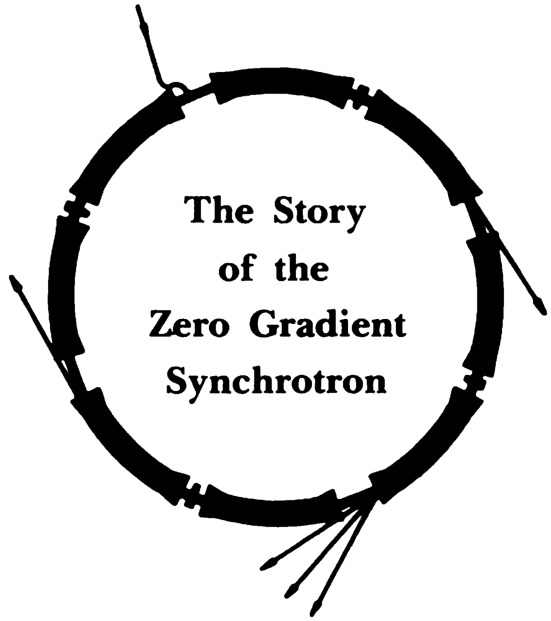
NAVAL RESEARCH REVIEWS

MARCH 1964



Aerial view of the Zero Gradient Synchrotron complex. The synchrotron is beneath the circular mound of earth at the center of the photograph.

The Most Intense Beam



The principal tool of the nuclear and "elementary" particle physicist is the particle accelerator—a device which accelerates atomic fragments (usually electrons or protons) to high energy and emits them in a collimated beam. By observing the distributions in angle and energy of the particles scattered by a particular nucleus—most often the proton—the physicist can infer some of the characteristics of the forces existing between nuclear particles. Furthermore, the projectiles sometimes knock particles out of the nucleus, thus initiating nuclear reactions. Study of these reactions and of the interactions of the secondary particles with nuclear matter provides valuable clues regarding the structure of nuclei.

In general, the higher the enrgy imparted to a beam of projectile particles, the higher the resolution with which the features of the nucleus can be examined. In addition, the creation of many of the so-called "strange particles" (particles which are unstable and not found in nature, but which are important to the understanding of nuclear forces) requires incident energies of billions of electron volts. Thus the history of particle-accelerator development is characterized by the invention of ingenious schemes for imparting higher and higher energies to the projectiles. All of the accelerators of the early forties were small by present-day standards, imparting less than 20 million electron volts to the electrons or protons which circulated in them. (An electron volt is the amount of energy imparted to an electron by the electrical field produced by a one-volt battery). Today, however, machines operating at 30 billion electron volts (Bev) are in use, and a 70 Bev machine is now being built by the Soviet Union.

But the amount of energy given to the atomic projectile is not the only important criterion of an accelerator's usefulness. The intensity of the beam (that is, the number of particles passing through a given area per second) is also important, and, for some experiments, even more important. Thus, when last August 1 the first pulse of protons was sent through the large new 12.5 Bev, $50 million ZGS (Zero Gradient Synchrotron) at Argonne National

Laboratory, an important event, indeed, had occurred.* True, as has already been pointed out, a few other machines impart more energy to each particle, but the ZGS can accommodate many more particles than these other machines.

Obtaining such an intense beam has required a very high level of design ingenuity. To understand why this is so, one should have at least a rough idea of how large synchrotrons operate. Here are a few of the significant features.

- All synchrotrons are designed so that the charged particles traveling in them are forced to move in a circular path by means of intense magnetic fields.
- The particles fed into the machine (usually protons) are given increasingly high velocities, once each revolution, through the action of a strong electric field.
- While the accelerator is in operation, its interior is kept evacuated so that the particles will not encounter air molecules, with which they would collide, causing them to scatter.
- The controlling action, or "focusing," which is exercised by the synchrotron's magnetic fields, is essential to the success of an accelerator. If it were not applied, all of the particles would be "lost" before reaching their target because they must travel a total of 100,000 miles during the acceleration cycle without straying outside the confines of the vacuum chamber. The unique feature of the ZGS is the manner in which the focusing is achieved.
- As the protons are accelerated, once each revolution, the strength of the magnetic field is increased in synchronism with the increasing speed of the particles, so as to keep them on the desired constant circular pathway.
- Ultimately, the top speed for which the accelerator is designed is reached. Then, by various ingenious schemes, the particles are steered to their target, which, upon bombardment, releases sub-atomic particles for study.

Two general types of synchrotrons are in use today—strong focusing and weak focusing. The former collimate the particles by alternately focusing and defocusing them in a way comparable to the focusing and defocusing of light when it passes through a series of convex and concave lenses lined up in alternating order. In this way the focusing action can be stronger than would otherwise be possible, and stability can be maintained. An advantage of this technique is that the particles can be confined to a relatively narrow aperture, which means that the magnet width can be less, and thus the expense lower. The disadvantage of strong focusing is that the particles can be admitted to the machine only during the time taken for the first protons introduced to complete one orbit. After that time the small space in the chamber is filled to capacity. Thus the intensity of the beam is relatively low.

Weak-focusing machines utilize the focusing action only. Their magnets are usually so constructed that the field is always stronger toward the center of the circle that the protons travel. Under the influence of this focusing action, the protons oscillate to some extent in both vertical and radial directions, but are forced to remain within the confines of the magnetic field at all times. The chief advantage of weak focusing over strong focusing is that particles can be

*In this first test, the beam injected and contained in the synchrotron had an energy of 50 Mev. Acceleration to the highest energy of which the ZGS is capable was achieved on September 18.

injected during many turns of the first particles admitted. Thus, more protons are injected and a more intense beam is created.

The weak-focusing ZGS differs from conventional weak-focusing machines in that the magnetic field is constant along the entire width of the aperture. However, the pathway is divided into eight magnet sections, and the ends of these sections are cut so that there is more magnet on the inside of the orbit than on the outside of the orbit. Thus the particles are focused only at the ends of these sections. In a complete revolution, the particle is subjected to a higher average magnetic field on the inside of the orbit than on the outside of the orbit. Therefore, conditions similar to those prevailing in conventional weak-focusing machines are provided.

The principal advantage of this configuration is that the magnetic field can be stronger than in the conventional weak-focusing machine. Because of this strength, the particles can move in a small ring, thus reducing the cost of the magnets.

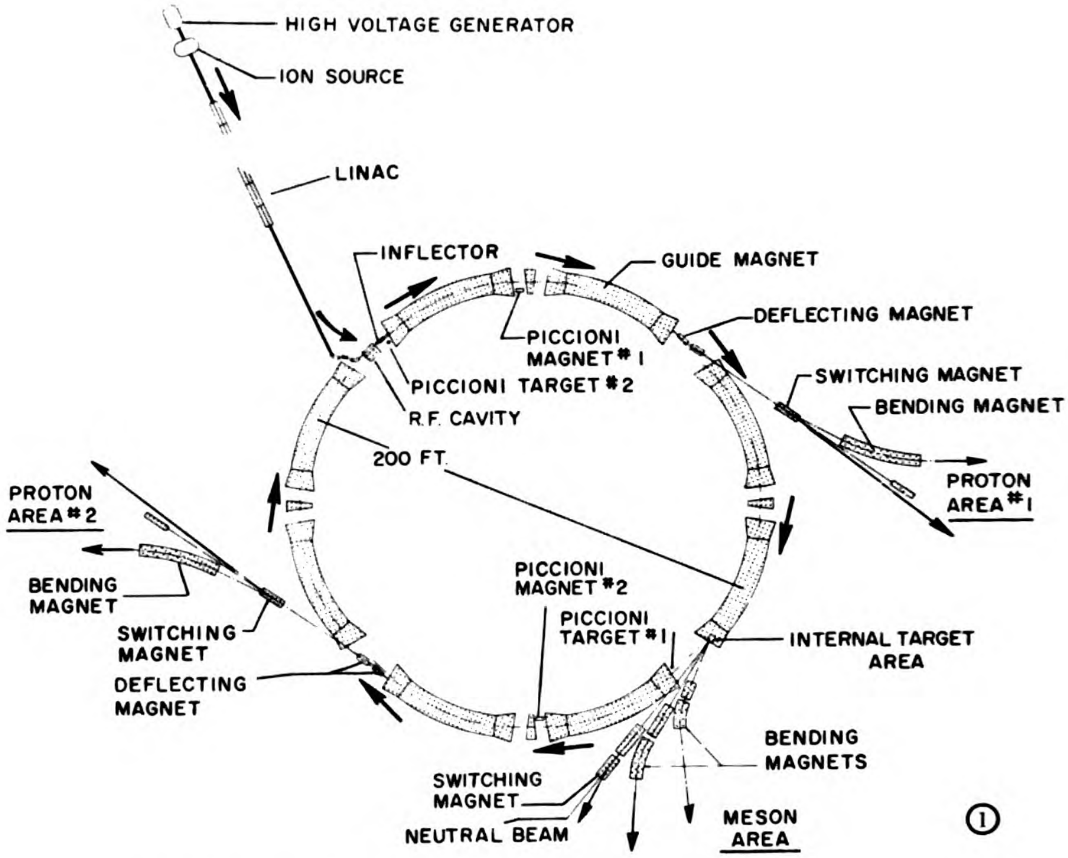
Although the design and building of the ZGS has been supported entirely by the AEC, the machine is of considerable interest to the Navy for several reasons. The first is the Navy's deep-rooted involvement in nuclear physics. Through the Office of Naval Research, the Navy inaugurated the first extensive programs of nuclear physics investigations undertaken by the Federal Government, and for years carried the burden of expense for the development of research capabilities in this field. For example, all but a few of the high-energy particle accelerators put in operation immediately after World War II were built under ONR sponsorship.

ONR will also have direct ties with the ZGS. At least two of its contractors—Professor M. M. Block of Northwestern University and Professor L. W. Jones of the University of Michigan—will use the machine to conduct studies of "elementary" particles for the Navy.

The Navy also contributed in a valuable way to the construction of the ZGS—by providing 10,000 tons of surplus battleship armor plate. The armor plate is used for shielding.

Nevertheless, the most significant events in the decade-long history of the ZGS relate to the activities of the men who conceived the idea for the machine and worked out its scientific design—among others, Dr. Martyn Foss and Dr. Lee Teng, both of Argonne. Dr. Foss is now at the Carnegie Institute of Technology, and Dr. Teng is the Director of the Particle Accelerator Division of the Laboratory.

That history began in the late 1940's, when nuclear physicists in the Midwest began discussing the advantages of having a high-energy accelerator located in that region. At that time, however, reactor technology was the subject of most interest to the new AEC, so the prospect was shelved temporarily. It was revived again, early in the fifties, but because considerable money had already been appropriated for the design and construction of the Cosmotron at Brookhaven National Laboratory and the Bevatron at the University of California, the bureau decided to see how satisfactory those machines proved to be before building another one. The Cosmotron and Bevatron went into operation in 1952, and proved themselves almost immediately, stimulating new interest in a large accelerator for the Midwest, not only among researchers



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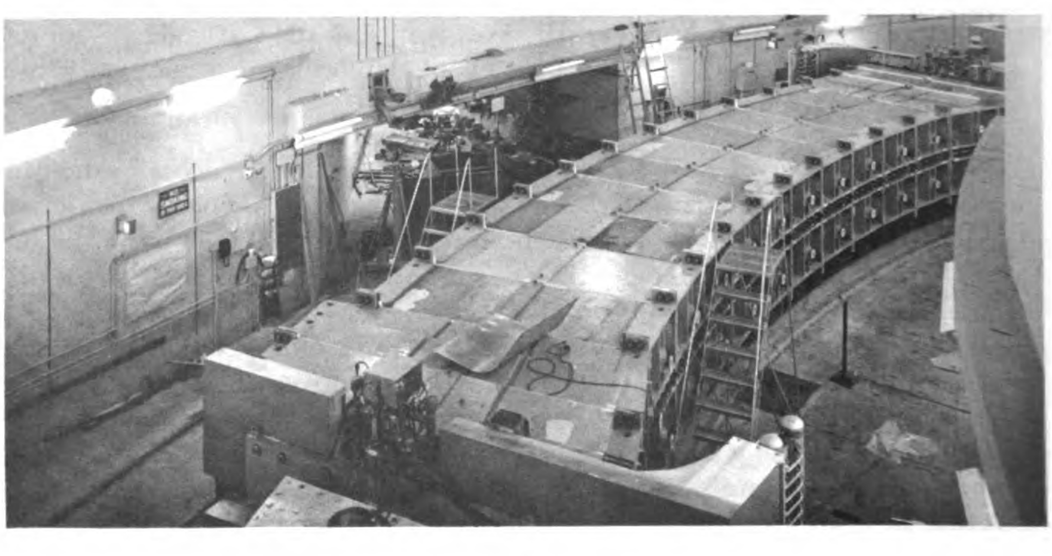
1. Schematic drawing of the Zero Gradient Synchrotron

2. One octant of the ZGS ring magnet. Tunnel to the proton area appears at center of photograph at left of octant.

3. The motor-generator set used to power the ring magnet (shown here during installation). The system consists of a wound rotor motor, two generators, and a 90-ton flywheel, all on one shaft.

4. The 50 Mev linear accelerator.

5. The Cockroft-Walton preaccelerator and the ion source. Seven hundred and fifty kilovolts is generated at this point.



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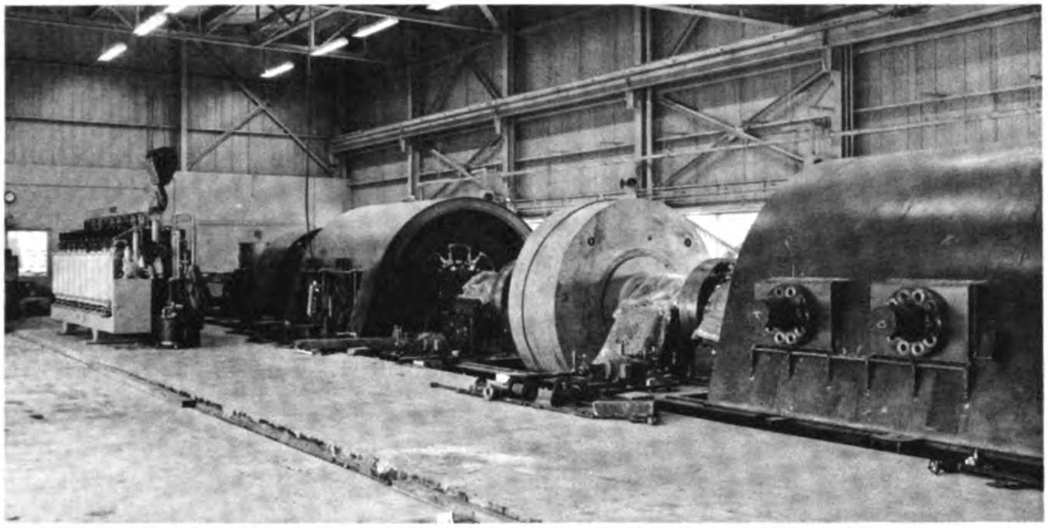

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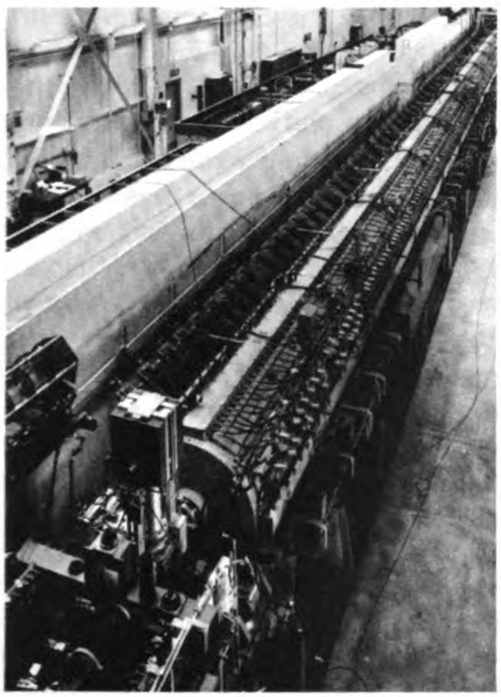

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at Argonne, but also by other scientific groups in the region—so many, in fact, that a Midwest Accelerator Conference was formed to guide thinking along those lines. In 1955, a preliminary design for a high-energy accelerator—not for the ZGS, however—was submitted at the Laboratory, but it was turned down, primarily because of complications in construction it would have entailed. Then, in the following year, a rough plan for the ZGS was prepared. This plan was approved informally in 1957—to enable the scientific and engineering designs to be completed—and formally in 1959, when construction of the machine began.

Now the ZGS and associated equipment comprise a huge facility that sprawls over several acres at Argonne, both above and below ground. Last August, the editor of *Naval Research Reviews* was guided through this complex by the Particle Accelerator Division's Associate Director, Dr. Ronald Martin. From the standpoint of an observer, the many unusual features of the ZGS are indeed impressive. To point out just a few—

- *Linear accelerator.* Protons are injected into the synchrotron by means of a linear accelerator that consists essentially of a resonant cavity about 37 inches in diameter and 110 feet in length. The cavity, which is operated at 200 megacycles, contains 124 drift tubes, each containing a focusing magnet. By the aid of this system, the protons are accelerated to 50 Mev and maintained in a well-focused beam only a few millimeters in diameter. The protons are then conducted by means of a series of bending and focusing magnets into the synchrotron. Only a few years ago, this device, by itself, would have been considered an advanced accelerator.

- *The magnet's cooling system* maintains the temperature of the magnets within a 6°F range at all times, even when the magnet is being pulsed to a peak current of about 11,000 amperes.

- *The building that houses the synchrotron* was constructed in the same ring shape that the magnets were. It is slightly more than 200 feet in diameter and is 30 feet in cross section throughout the ring. In the center of this "doughnut" is another building approximately 88 feet in diameter and 78 feet high, containing four floors of equipment, with a control room on the 5th, or top, floor.

- *Beam extraction.* Beams of high-energy protons circulating in the synchrotron can be extracted at one point along their route of travel by means of deflecting magnets. After extraction, the particles are guided and collimated by bending and focusing magnets into one of the two experimental areas that adjoin the ring building. Three beams of secondary particles (scattered protons, various kinds of mesons, and anti-protons) can be made to enter the second experimental area at the same time. Because of the high intensity of the beam of circulating protons, the beams of secondary particles are expected to be the most intense produced anywhere in the world.

- *The experimental areas.* A building 104 by 220 feet has been erected for conducting experiments primarily with mesons, and a building 104 by 240 feet has been built for work with protons. (A second proton building is being planned, and the circulating proton beam will be extracted into this area also.) Because many investigations will require the application of beams that are much longer than the buildings adjoining the synchrotron, an area has been prepared outside of these structures for setting up experimental equipment and shielding. A separate building also has been erected for housing bubble chambers, one of the principal tools for detecting and analyzing nuclear interactions; one such chamber, already installed, was constructed at a cost of $3 million.

- *Shielding.* The building in which the synchrotron is housed is surrounded by a thick concrete wall and covered over by a mound of earth 400 feet in diameter at the base, 50 feet high, and 200 feet in diameter at the top. Separating the synchrotron from the experimental areas is a wall of steel 12 feet thick, 10 feet high, and 100 feet long. The wall weighs 3,000 tons. Large quantities of concrete and steel blocks are available to enclose targets set up in the experimental rooms so as to confine the radiation produced when the targets are struck by beams from the synchrotron.

- *The production of power* for the synchrotron is a major operation in itself. During one 4-second cycle of operation (the magnetic field being increased to its highest value, kept at that value for .2 second, then reduced to 0), the average power dissipated in the magnet is 6.9 megawatts.

• *The eight large magnet sections* of the synchrotron form a ring 200 feet in diameter. The important function of the magnets has already been explained. As the behavior of the machine is dependent on maintaining the magnets in very careful alignment with one another, each section is supported on caissons (concrete pillars 39 inches in diameter) sunk 90 feet into the ground, where they rest on bedrock. The linear accelerator is supported in the same way.

• *Radio-frequency cavity.* In only one second after a beam of protons is injected into the synchrotron, the magnetic field of the machine is raised from 500 gauss to its maximum value of 21,500 gauss. While this increase is occurring, the speed of the protons must be increased also, in synchronism, so that the orbit of the particles remains within the magnet. This acceleration is provided in a radio-frequency cavity located between two of the magnet sections. During the one-second period in which the protons circulate in the synchrotron, a radio-frequency voltage is applied across the cavity with a variable frequency accurately adjusted so that the protons gain energy (~ 10 kilovolts) each time they pass through it—a total of about 1,000,000 times—increasing momentum in proportion to the increase in magnetic field until the maximum energy (12.5 Bev) is reached.

These facilities will be utilized for some of the most important studies of matter ever to be made. The work will be done by many investigators simultaneously, each probing for knowledge of different facets of the large question mark that signifies the atomic nucleus. These studies will go forward on an around-the-clock schedule as the ZGS accelerates one pulse of protons to 12.5 Bev, or a lesser energy, every four seconds, with only occasional stops for maintenance of the machine.

In other ways, the future of the machine cannot be assessed. What new discoveries will be made—painstakingly over the years or serendipitously in a matter of hours or days—no one can foretell.

A propitious note was sounded on the day the accelerator produced its first pulse of protons. More than one year before, a timetable was established for construction, and August 1 was set as the day for which the workers would aim to produce the first proton beam. That deadline was met—exactly. As Dr. Martin has stated, enthusiasm for completing the job—not just for the sake of meeting the deadline—increased at a happily surprising rate during late spring and early summer. As the engineers and technicians saw the multitude of components fit together, they became increasingly aware that what they were fashioning was comparable to a great key and lock, and that the key was about to be placed in the lock and turned.

The role played by many of the "elementary" particles in the structure of matter is still something of a mystery. With the building of the ZGS, the means for gathering evidence to solve that mystery has been greatly improved. As the "lock" is opened, perhaps a larger part of the structure of the "elementary" particles will be illuminated.

Prepared with the generous assistance of Dr. Sol Krasner, Nuclear Physics Branch, ONR (now Dean of Students of the Physical Sciences Division, University of Chicago) and Dr. Ronald Martin, Associate Director of the Particle Accelerator Division, Argonne National Laboratory—R.D.O.

Liquid-Ammonia Reserve Battery for Navy Missile Fuzes

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Almost everyone, at some time in his life, has flicked the switch on a battery-operated system of some sort only to find that it wouldn't work because the battery was dead. If the battery is in an apartment-dweller's flashlight, the problem that arises is not likely to be a serious one. If, on the other hand, it is in a missile fuze, the problem can be a deadly serious one.

To take care of the Navy's need for reliable electrical reserve-type power sources for missile-fuze systems—sources that can be assembled in an inactive state, stored indefinitely without deteriorating, and that will remain inert until needed—various types of chemical batteries have been developed in the past 15 years. Since high voltage and high current for a short discharge time are the characteristics sought for these batteries, a new kind of chemoelectric energy-conversion system was desired—one that would far surpass in these respects the present limited performance of the well-known Leclanche, silver-zinc, and thermal systems.

Reserve batteries now installed in missile fuzes are activated either by the introduction of a liquid electrolyte, such as fluoboric acid, just prior to the need for power or by assembling the cells with an electrolyte that is not conductive in its solid state, but which becomes conductive upon being changed to the liquid state. Although such batteries are useful as reserves, they are not considered to be entirely suitable for this service.

As early as 1947, ammonia cells were proposed for use in reserve batteries by G. & W. H. Corson, Inc. To date, however, no ammonia batteries have been developed to the extent that they meet all of the restrictive specifications for missile-fuze applications, except in prototype form. One reason this development has been delayed is that most of the early experiments conducted on the batteries involved ammonia gas, which cannot be activated rapidly and uniformly. Condensation of the vapor in the electrolyte generated heat, and the heat retarded further condensation and raised the temperature of the electrolyte. The result was that, under some conditions, activation with ammonia vapor required several minutes instead of the desired one second.

Prospects for resolving these and other problems were so poor at one time that the plans of Government activities for developing ammonia batteries were nearly dropped. To make the outlook for continued work in this area still darker, early enthusiasm led to overselling, which in turn created an over-pessimism that seriously limited the underwriting of important new research and development of this reserve battery concept. The effects of this general pessimism are still felt.

But in 1960 the urgent need for a greatly improved battery for advanced missile-fuze systems led scientists at the Naval Ordnance Laboratory, Corona (NOLC) to join forces with G. & W. H. Corson, Inc. (and its recently formed subsidiary, Livingston Electronic Corporation) to work out a prototype for a new 11-watt, multiple-section, liquid-ammonia reserve battery.

The key specifications for the proposed NOLC battery were that it be capable of activating within 1 second; remain operative within ±5 percent voltage limits for three minutes; produce 1.8 volts at 1 ampere, 180 volts at 0.05 ampere, and −30 volts at 0.01 ampere; and have a volume of less than 6 cubic inches. The battery would also be required to be fully effective under both storage and discharge conditions at any temperature from −55° to +75°C, without preconditioning or pretesting in any way.

Some of the specific goals defined in the hardware feasibility-study program were to (1) design an activator mechanism that would combine in a small space both the ammonia reservoir and the transfer device, (2) prove that liquid activation could be accomplished over the wide temperature range required, and (3) demonstrate by means of hardware the reproducibility of cell voltages over the temperature range.

The basic geometry of the multiple-section NOLC battery was selected to allow for packaging that will meet the space requirements of various missile fuzes. Because of the relatively low energy requirement, the cells can be very thin. In the typical cell stack, one full cell comprises a 0.005-inch bimetal sheet of magnesium and silver, a 0.005-inch glass-fiber anolyte pad with potassium thiocyanate, and a 0.015-inch glass-fiber catholyte pad with ammonium thiocyanate, **m**-dinitrobenzene and carbon. The cells are parallel-connected in a high-current A section and series-connected in a high-voltage B-C section.

Punched-out components make up the cells, which are assembled in a molded polypropylene case. In each section of the case, channels are either molded or drilled for rapid passage of the liquid ammonia during activation. After the cells are positioned in the case, the lead wires to the end cells in each section are connected to the terminal plate (Figure 1). The case itself is designed to withstand the pressure of 1000 pounds per square inch that the gas generator maintains in the activator section to ensure that the ammonia will remain in a liquid state at all temperatures.

The activator section (Figure 2) occupies roughly half the total volume of the present design. On the thinned center of the bulkhead that separates the ammonia chamber from the cell section rests the point of a lance supported by a drive disk outside the chamber. Adjacent to the drive disk is the small gas generator.

The battery is activated as follows:

- The gas generator is triggered electrically. (If a percussion primer were substituted for the electric bridge wire, it could be triggered mechanically. For special laboratory purposes, pneumatic or hydraulic triggering could also be used).
- Upon initial movement of the drive disk, the lance pierces the bulkhead.
- As the ammonia chamber collapses, the ammonia is transferred into the battery case via the puncture made by the lance.
- The ammonia is routed through the battery to the system feed channels.

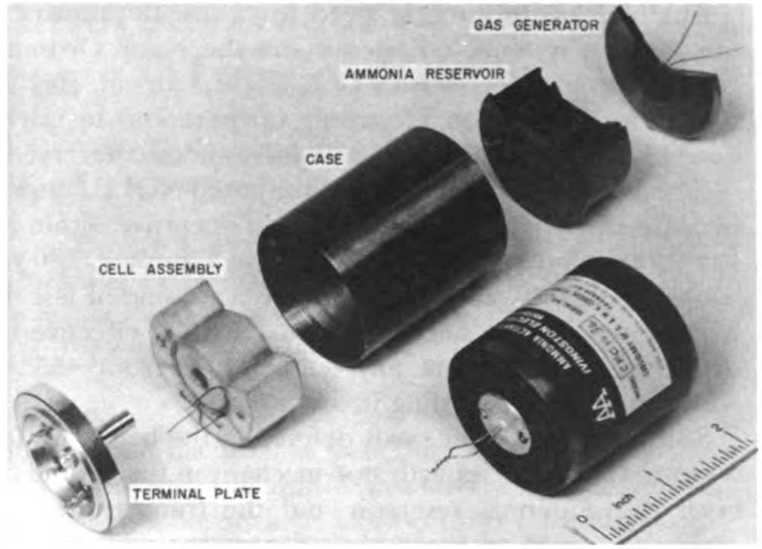


Figure 1

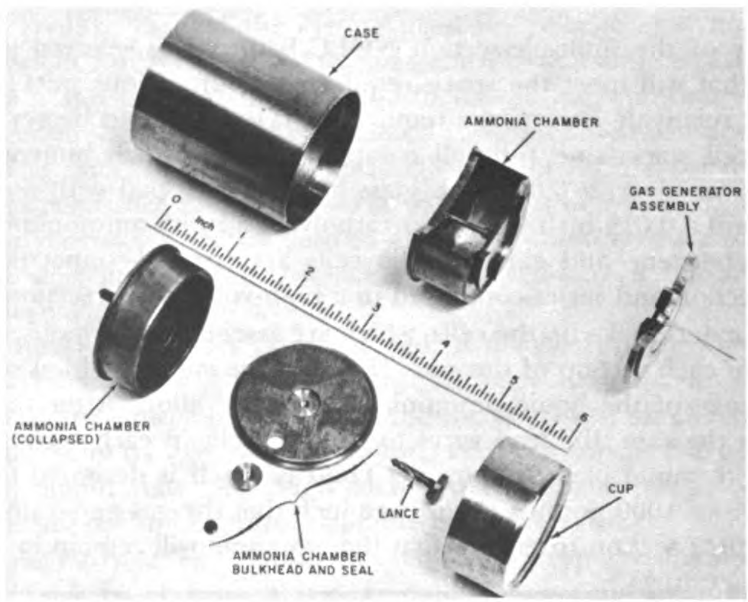


Figure 2

Figure 1 – Components and assembled battery.

Figure 2 – Activator section.

Figure 3 – Dispersed battery system
with central activator.

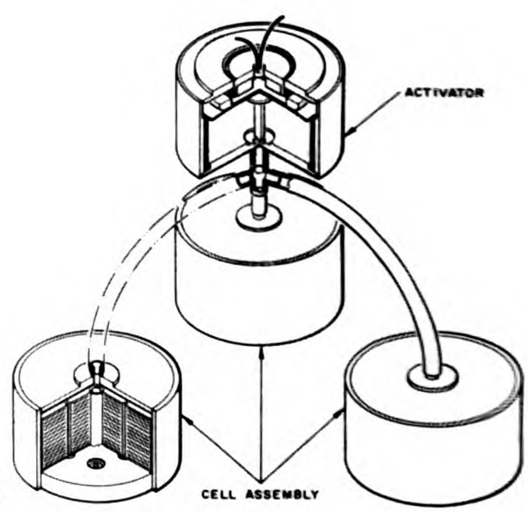


Figure 3

- The ammonia permeates the glass-fiber pads, dissolving the salts to form the electrolyte and starting the flow of current in the battery.

These operations have taken place in laboratory tests over the full temperature range within a quarter of a second.

The NOLC prototype has achieved the specific goals set for it in the two-year feasibility study. It has given the full 11-watt output for at least 3 minutes within ±5 percent voltage tolerance over the temperature range from −55° to +75°C. All ordinary environmental conditions of shock, vibration, and acceleration have also been met successfully. The present prototype weighs half a pound and delivers 1.1 watt-hours per pound, compared with 0.12 watt-hour per pound for the nearest comparable production model of a thermal battery.

The NOLC liquid-ammonia reserve battery was designed for a specific application. Given a different set of operating parameters, a different design would result. For instance, not only can the battery fit into a small space, but the cells can be separated from one another and located in a number of places, while still being served by one centrally located activator, as shown in Figure 3. In some situations, this one asset might make its use mandatory. Some needs might also be met by placing the battery in a plastic case, rather than in a steel one. Although the NOLC battery was designed for a short life, the ammonia system has promising capabilities for long discharge times as well, if such are required.

The liquid-ammonia type of battery, with the higher quality and lower cost anticipated in production, can probably replace the thermal type wherever a system requires a reserve battery. Using energy density (watt-hours per pound) as a yardstick, liquid-ammonia batteries can already provide a tenfold increase over thermal batteries now in production for similar applications. Nevertheless, the present prototype is considered to be merely the first, and relatively primitive, model in a long line of increasingly more sophisticated, higher-energy reserve batteries.

The designing of reserve batteries admittedly poses numerous difficulties because of the requirements of small size, short discharge time, high reliability, fast activation, indefinitely long shelf life, and ability to withstand severe environmental conditions. To reach the desired balance among the factors of weight, volume, chemical energy source, and packaging, further research is needed. More efficient designs and significant increases in energy density are forecast for fuze batteries, particularly of the single-section type. For example, there is underway a plan for a 30-volt, 3-ampere model that would weigh about 0.7 pound and discharge for 5 minutes—a rating of 10 watt-hours per pound. Future designs or refinements of existing designs may develop still higher power levels, still faster activation, and improved voltage regulation.

The inventions and findings that have come out of the NOLC and Corson effort may find application not only in missile fuzing, but also in such varied activities as emergency power supplies, communications, and aerospace programs. The important thing to battery technology is that the liquid-ammonia reserve battery is now a working reality. All that remains is for the design engineer to apply this new tool to the needs of the future.

At the Naval Research Laboratory and at a number of other Navy facilities, scientists, engineers, and technicians are using microscopes, jewelers' glasses, and other instruments of magnification to examine the objects on which they are working. They peer into small ovens and bell jars and move minute bits of ceramic or other materials around with the aid of tweezers. What they are striving for—and actually accomplishing—is the redesign of the "big black box" into an electronic system so small that it will fit easily in an aspirin box.

In the keynote address to the Second Conference on the Navy Microelectronics Program, held in Washington, D.C., in October 1962, RADM Bernard F. Roeder, Assistant Chief of Naval Operations (Communications), described the black box as follows:

"The big, bad, black box has been the most expensive necessity ever laid on the Navy. The appetite of this outsized, short-lived, fragile beast is voracious and insatiable. For example, sprawling and prone, it consumes valued shipboard space; consumes logistics support; demands too many attendants and keepers to make it as well behaved as it is; is responsible for more down time than up; during its short life it is estimated to cost its owners from four to ten times its initial cost. Overall, it has taken a huge bite out of the operational Navy. In short, the beast is on report with a list of charges as long as your arm, yet the Navy has had to live with it in crowded spaces."

Miniaturizin

Left, a germanium thin film is in
for analysis of som

Right, a semiconduc
is magnified to th

This is the monster which scientists and engineers must miniaturize yet make perform more reliably and economically than ever before. A comparable job might be that of a zoologist crossbreeding elephants until they are as tiny as fleas yet able to fell larger trees and pull heavier loads than they could when they were large and clumsy.

At NRL, work in microelectronics is concentrated in two main areas. One of these is thin films, the other is the bulk approach.

Some of the research in thin films is purely fundamental. In efforts to learn more about the basic properties of certain materials, scientists in the Solid State Electronics Branch are using a bell-jar vacuum system to evaporate thin films of semiconducting material onto small ceramic substrates about the size of a quarter. Right now they are working with gallium arsenide and high-purity germanium—two very promising materials which have potential use in miniaturized active devices analogous to transistors and diodes.

When these men use the word "thin," they really mean just that. These tiny films are only about one inch square; and after they have been removed from their supporting substrates, it would take up to 100,000 of them to make a stack one inch high.

When the deposition process has been completed, the thin films are subjected to exhausting analysis by the most exacting devices to obtain a complete characterization of the electrical, optical, and crystalline properties of the films.

In the other approach, bulk silicon material is used to fabricate microelectronic circuits to see how they will work as integetrated components of a larger system.

The construction of one of these miniature devices begins with a tiny semiconductor—resembling a dime in shape, but much smaller—which is "doped" on both sides with impurities to provide the proper electrical characteristics and then coated with a layer of gold. A scribing device is used to separate the surface into as many as 350 smaller semiconductor units, and the surface is probed to find which of these tiny subunits possesses the appropriate characteristics needed for the particular job to be done.

The tiny semiconductor is then joined to a transistor-type can by ultrafine gold wire leads which connect the pins along the perimeter of the can to the appropriate subunit. When finished, the whole assembly is about the size of the gem in a college class ring.

: Black Box

ray spectrogoniometer
features.

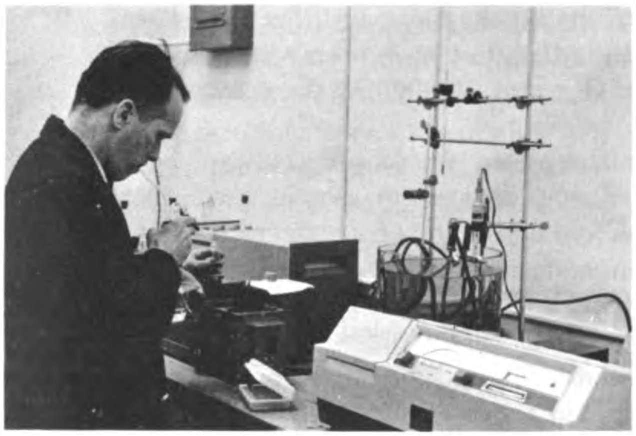
in the head of a pin (see arrow)
:ap on an optical comparator.

All of these processes must be performed under some sort of magnifying device, of course, if the scientists are to see what they are doing. To watch them work is to recall to mind the fairy tale of the wee wee woman in the wee wee woods.

This bulk work is being done in the Security Systems Branch, which also uses the results of thin-film research to construct operating thin-film circuits. These include an audio oscillator and simple counters.

When asked how far microelectronics could go, one of the scientists replied, "Well, how small is small?"

Apparently what lies beyond is difficult to predict at this point, except, perhaps, further miniaturization. The end of the vacuum tube may or may not be in sight, but microelectronics offers the first promise of retiring the big, black box to the Smithsonian Institution as a gargantuan electronics object for future generations to behold.



An instructor conducts an experiment in the Academy's new chemical instrument room, which was equipped by the Office of Naval Research.

RESEARCH AT THE U.S. NAVAL ACADEMY

John R. Smithson

Professor of Physics
United States Naval Academy

The primary responsibility of the faculty of the U.S. Naval Academy is to prepare midshipmen for graduation in such a manner that they will become dedicated to a career in the Naval service and will have potential for future development. In accomplishing this mission, both the adminsitration and faculty believe that the various departments should engage in some research activity. One very practical reason for this belief is that opportunity for research enables the Academy to attract and hold a high-caliber civilian faculty. Another consideration is that the growth and enthusiasm of the junior officers, who serve as instructors, can be increased greatly by providing them the means for completing work toward master's theses while on their tour of duty at the Academy. Third, participation in research helps keep the faculty more active and up-to-date in its fields of specialty and results in a better intellectual atmosphere for midshipmen. Fourth, opportunity is provided for certain talented midshipmen to get an introduction to research as co-workers of faculty members. And, finally, the research results, we hope, are worthwhile contributions to knowledge.

Research, in varying degrees, is carried on in all the academic departments of the Academy. The contributions to Naval history by members of the English, History, and Government Department are well known to persons interested in this subject. The Engineering Department has been very active in research, also, primarily through model studies it has made in its tow tank and wind tunnel with the support of the Bureau of Ships. This discussion, however, is devoted primarily to research in the Science Department, with which the author is more familiar.

Two major types of research are needed at the university level: that which aims at extending the body of knowledge in a given field and that intended to improve the teaching of existing knowledge. The second type, long neglected in many major universities, has received much more recognition in recent years. The programs of the National Science Foundation, of some private organizations (the Ford Foundation, for example), and of such professional groups as the American Institute of Physics have contributed much to research and development concerning instructional methods and materials. For a number of years the Naval Academy's Science Department has given much time and attention to such aspects of instruction as the development of more effective student laboratory procedures, the design of new and novel lecture demonstrations, and the preparation of more valid and reliable tests and examinations. As evidence of the extent of these activities, one might point out that at the 1962 fall meeting of the Chesapeake Section of the American Association of Physics Teachers one of two invited papers and six of eleven contributed papers were presented by members of the Department's Physics Committee.

Before 1961, many members of the civilian faculty were engaged in research, but very little of this work was done at the Academy because of the limited amount of money made available for the purpose. Generally, research was carried on in the summer at one of the universities in the Washington-Baltimore area to satisfy part of the requirements for the doctorate degree. This situation changed in 1961, however, when the Office of Naval Research began providing funds to the Science Department for the purchase of equipment, to obtain technical and clerical help, and to meet publication costs.

High Energy Muons

The first projects finished with ONR support were two related master's theses by LT G. L. Buckwalter and LT T. D. Tuttle, both under the direction Dr. C. L. Cowan of the Catholic University of America. LT Buckwalter developed a liquid scintillation detector and LT Tuttle a Cerenkov detector for studies of high-energy muons. These instruments were used in conjunction to investigate the interaction, with small energy transfer, of high-energy muons with heavy nuclei. LT Tuttle has been detached from the Academy, but LT Buckwalter has transferred from active duty status to the civilian faculty and expects to continue this work as his Ph. D. thesis.

Angular Distribution of Neutrons

A third dissertation for a master's degree in physics at the Catholic University of America has been completed in the department by LT G. T. Hageseth on "The Angular Distribution of Neutrons from the $C^{12}(t,n)N^{14}$ Reaction at 1.75 Mev." The C^{12} target was bombarded with tritium using the 200 Mev Van de Graaff accelerator at the Naval Research Laboratory, and the plates were then brought back to the Academy for reading.

To explain the mechanism of nuclear reactions of the type LT Hageseth studied, two theories have been set forth: the compound-nucleus theory of Niels Bohr and the direct-interaction theory of S. T. Butler. The compound-nucleus theory assumes that the target nucleus absorbs the incident particle to form a compound nucleus, which disintegrates by ejecting a particle, leaving a residual nucleus. The direct-interaction theory is applied to nuclear interactions that occur in the same order of magnitude of time as required for the incident particle to traverse the nuclear diameter. The theory pictures the incident particle separating into neutrons and protons in the vicinity of the nucleus, with part being captured to form the final nucleus and part passing on as ejected particles. The two theories predict different angular distributions of the ejected particles.

The purpose of LT Hageseth's study was to measure the angular distribution of ejected neutrons and compare the results with the predictions of the two theories. His measurements indicated that a direct-interaction model is more applicable to the reactions than is a compound-nucleus model.

Abrupt Pitch Changes

A very interesting research project is being conducted by Mr. H. M. Neustadt of the Electrical Sciences Committee. For many years Mr. Neustadt has been trying to develop an electronic musical instrument. Such an innovation appeared worthwhile and certainly long overdue, as not a single new musical instrument had been introduced since the saxaphone was created about a century ago. From the beginning, however, Mr. Neustadt was troubled with a problem which seems to be characteristic of all electronic versions of musical instruments developed to date—namely, that a "click" is heard when there is a sudden change of pitch at constant amplitude.

Mr. Neustadt's curiosity about the phenomenon led him to an investigation of how conventional wood winds and brasses make abrupt pitch changes of more than a semitone without the ear hearing a "click." He determined that (1) tone generation decreases and may stop momentarily even if the air supply is held constant at the mouthpiece—that is, oscillation decays at the old frequency and then builds up again at the new; that (2) the ear does not perceive that the oscillation is interrupted; and that (3) if the pitch change is made without interruption—that is, at constant amplitude—a "click" is heard arising from the transient frequencies. To demonstrate these effects, Mr. Neustadt built the electronic device pictured below. In May 1963, he operated the instrument during a presentation he gave before the New York meeting of the Acoustical Society of America.

Vibration Modes of Metal Plates

Several years ago, Professor E. R. Pinkston, Chairman of the Physics Committee, made an extensive experimental study of the vibration modes of square metal plates with free boundaries. These plates were driven by magnetostriction, and the nodal lines were observed by placing fine sand on the plates. The results were in striking agreement with the theoretical solutions given by W. Ritz in 1909. In 1960 Dr. Charles Thorne at the U.S. Naval Ordnance Test Station, China Lake, California, taking advantage of modern computer techniques, computed the modes for similar rectangular plates with fixed boundaries. Professor Pinkston is now preparing an apparatus for an experimental study of plates of this type for comparison with Dr. Thorne's theoretical results.

Raman Spectroscopy

Dr. G. D. Gutsche and LCDR P. A. Phelps of the Physics Committee are planning work in Raman spectroscopy to begin this spring. Raman spectra arise from the scattering of light by the molecules of transparent gases, liquids, or solids as the result of absorption and emission of light by the molecules. They show up as extra spectral lines in the vicinity of prominent lines in the spectrum of the incident light. As the scattering involves changes in the rotational and vibrational energy states of the molecules, one can, by studying Raman spectra, make determinations about the rotational and vibrational states of numerous molecular compounds and of the configurations of constituent atoms. With the development of the laser as a high-intensity source of coherent light, investigations of Raman spectra that have previously been either impossible or technically not feasible have now become experimentally practicable. Dr. Gutsche and LCDR Phelps plan to construct a spectrograph similar to that of Bass and Kessler at the National Bureau of Standards and to use a laser source. They will first look at the spectra of some halogen substitution products of benzene that Dr. Gutsche studied some year ago by means of a conventional light source.

Instrument System for Recording Electrical Admittance

Development work on an instrument system for the automatic observation and recording of the complex electrical admittance of passive elements, such as transducers, will be started early this year by Professor G. E. Leydorf of the Electronics Committee.

Over the past 20 years, a considerable amount of work has been done on instrumentation for the automatic observation of complex impedance (ratio of voltage to current). This work was started by Dr. Hunt at the Harvard Underwater Sound Laboratory during World War II, it was continued under Dr. Haeffner at the USN Underwater Sound Laboratory, and it was carried on further by private industry under contract with the Naval Research Laboratory. In this development, Professor Leydorf has played a major role.

Although the impedance plotter has proved to be extremely useful in evaluating the characteristics of sonar transducers, it has one unfortunate limitation: the impedances must be investigated at low power levels, typically several milliwatts. However, by measuring the admittance (reciprocal of the impedance) of the unknown element, and by using modern switching techniques, it should be possible to make measurements at operating power levels. During the forthcoming studies, Professor Leydorf will seek to develop such a method.

Research in Chemistry

Three research projects undertaken as doctor's dissertations for Georgetown University have been in progress in the Chemistry Committee of the Science Department. Mr. O. W. Rollins has completed his dissertation, which is a part of research being directed by Dr. Louis C. W. Baker concerning the preparation and characterization of isopoly and heteropoly tungstates and molybdates, with emphasis on heretofore unreported compounds. The study consists essentially of carrying out preparations analogous to those used for known compounds and then obtaining a chemical characterization of the products—which means doing much chemical "detective" work, including analysis, spectrophotometry, cryoscopy, potentiometric titration, electrolytic analysis, and single-crystal studies. From all of the "clues" found by these techniques, the researcher tries to construct a formula. Mr. Rollins has prepared three heretofore unknown molybdates, the formulas for which are compatible with all of his data.

The other two chemistry dissertations, which are in progress but not far enough advanced to report on, are listed here by title only. Mr. F. J. Gomba is making "Polarographic Studies of Hexaquochromium (III) Perchlorate and Certain Mono-substituted Complexes," and Mr. J. G. Zimmerman is studying "The Kinetics of Anation of Neutral Monaquo Octahedral Complexes."

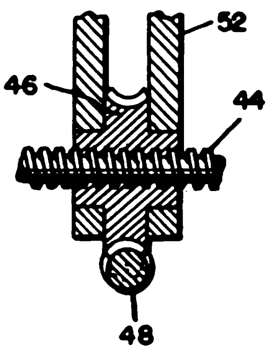
During the current academic year, two new research projects in chemistry have been started by officers who have recently reported to the Academy. LTJG B. T. Sheehan is measuring the velocity profiles throughout a mixing vessel under different mixing conditions and methods as a means of learning more about oxygen transfer in fermentation broths. This work is aimed at increasing the efficiency of certain processes involved in the industrial production of antibiotics. LTJG R. M. Speights, Jr., and LTJG J. W. Ehrmantraut are investigating the theory of photometric titrations. Their goal is to obtain a reagent which will allow the selective determination of lead in the presence of transition metal ions.

Research by Outstanding Midshipmen

In the extensive curriculum revision which began at the Academy about four years ago, provision was made for a midshipman who showed unusual interest and talent to undertake a science research project in his senior year for three semester-hours credit. In the past two years, three of these projects have been completed in chemistry. Each of these midshipmen has done a literature search on his subject as his term paper for the English, History, and Government Department and then carried on some original research under the direction of a faculty member. During the academic year 1962-63, Midshipman Charles La Blonde, working under the direction of Professor W. M. Smedley, did an outstanding job of a preparation of phenyldioxane. Midshipman La Blonde presented a paper on his research at the Eastern College Science Conference on May 3, 1963.

Beginning with the current academic year, the Superintendent of the Naval Academy, RADM C. C. Kirkpatrick, has instituted a new program for a select number of exceptionally capable midshipmen of the senior class. This is the Trident Scholars Program, which has attracted considerable attention (see *Time,* November 8, 1963). Under this program each student follows an individually tailored schedule of studies and carries on a research project during the year. Of the six midshipmen selected for the program during its first year, two are in the Science Department. Midshipman B. J. Haynes, under the direction of Associate Professor O. W. Rollins, has prepared a heteropolytungstate of gallium, which is believed to be a heretofore unreported compound. He is now engaged in a chemical characterization of this compound and hopes to obtain the formula. Midshipman L. P. Brooks, with Assistant Professor G. L. Buckwalter as advisor, is studying the effects of nuclear radiation on some solid-state devices. Specifically, Midshipman Brooks is measuring certain characteristics of selected transistors and then remeasuring these characteristics after the transistors have been subjected to various amounts and types of radiation. The aim is to determine if it is feasible to express an operational half-life for transistors which are exposed to radiation.

The factor most responsible for limiting scientific research at the Academy now is probably lack of space where such work can be carried on. When the proposed new science building, Michelson Hall, is completed, we hope that our research activities will grow and be of increasing benefit to the faculty, both officer and civilian, and to the midshipmen.



INVENTIONS

Preventing Pressure Surges in Controllable Pitch Propellers

The controllable pitch propeller differs from the conventional propeller in that each of its rotating blades can be turned about its radial axis to vary the pitch, or "bite," in both the forward and backward directions. In effect, therefore, it can be considered to consist of two or even many propellers, all attached to the same propulsion plant. This means great versatility of ship movement as well as elimination of the need for reverse gears, reversing engines, and reverse elements in turbines. Because of these advantages, controllable-pitch propellers have been installed in all types of vessels—from the largest Naval ships to the smallest fishing boats and tugs.

In designing propellers of this type, more moving parts and more seals have had to be introduced into the propeller hub than were included in conventional propellers, with the result that greater difficulty was experienced in lubricating the system properly. Particularly troublesome was the breaking of blade seals as a result of the pumping action that took place in the hub cavity, which is filled with oil to lubricate all parts of the hub mechanism. A pressure was built up on one stroke, and a vacuum on the other. If the fluctuations in pressure caused a blade seal to leak, the oil was then forced out on one stroke, and sea water was drawn in on the next stroke. The hub parts would then be subjected to excessive wear and thus would eventually become inoperative.

Last May 7, Patent No. 3,088,524 was issued to John W. Barden, an employee of the Bureau of Ships, on a "Pressure Equalizer for a Controllable Pitch Propeller." The invention provides a piston and cylinder to push out the volume of oil not needed on the stroke which formerly increased the pressure of the oil and to take in the volume needed on the stroke which formerly created a vacuum. By this means, it assures that the hub volume will remain the same at all times, thus preventing the occurrence of pressure surges which rupture blade seals and allow sea water to enter.

The invention is now being used on several types of Navy ships as well as on some foreign vessels.

The Bonding of Rocket Propellants and Nozzles

The gases that burst forth from the tail end of most solid-propellant rockets, to provide the thrust needed for flight, escape not only through a nozzle at the rear of the rocket, but also through an interior nozzle at the rear of the fuel chamber. Because of the tremendous heat generated by solid propellants,

—Continued on page 24

RESEARCH NOTES

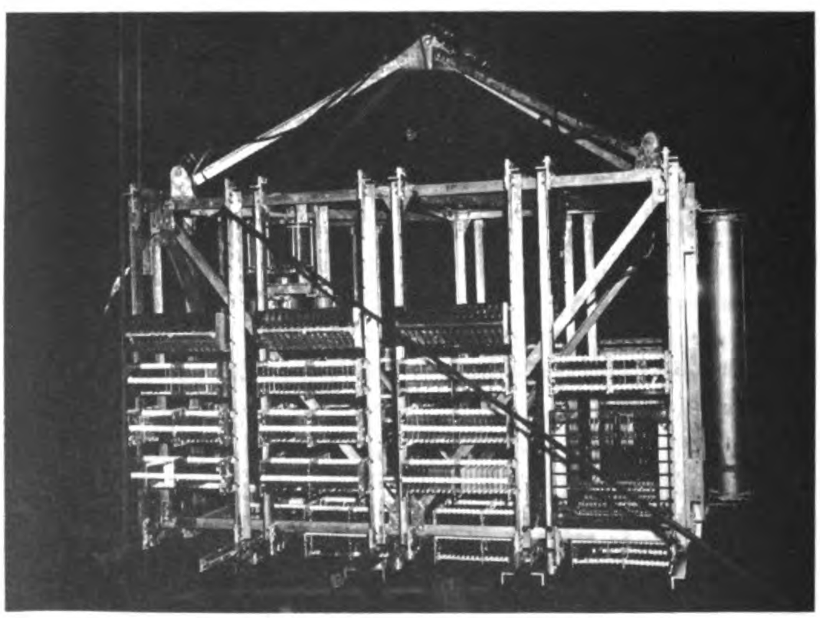
Submersible Test Unit Recovered from Deep-Ocean Floor

In what may well mark a notable first in man's exploration of the deep ocean, the Naval Civil Engineering Laboratory, Port Hueneme, California, recovered on February 5 a submersible test unit (STU) from an ocean-floor depth of 5640 feet. Retrieval of the unit is part of a program to test materials and techniques in deep-ocean environments. As far as is known, nothing so large had been placed at and recovered from so great a depth previously. The STU is one of several such units being placed on the ocean floor and recovered by the Laboratory in a series of deep-ocean test exposures at depths ranging from 2500 to 18,000 feet for periods up to 48 months.

The submersible test unit was lowered to the ocean floor in October 1963 at a site approximately 70 miles south of Pt. Arguello. It carried 1337 specimens of 515 different materials, and it weighed 5400 pounds loaded. The STU itself was made of corrosion-resistant aluminum members bolted together to form an open frame 12 × 12 × 12 feet.

Twenty-six civilian and service agencies including Bell Telephone Laboratories, U.S. Steel, Aerojet General Corporation, U.S. Rubber Co., Goodyear Rubber Co., Reynolds Metals, E. I. DuPont DeNemours and Co., Scripps Institute of Oceanography, a number of Naval laboratories, and the Bureau of Weapons are cooperating in the NCEL tests.

NCEL is also developing in-house facilities to duplicate deep-ocean conditions so that field results can be checked and selected parameters controlled. The materials-test program, of which the submersible test units are part, is one of a number of deep-ocean scientific and engineering programs being carried forward at the Laboratory.



The submersible test unit board ship immediately a retrieval. The unit is 12 12 by 12 feet in size.

Buzz and Buzz Buzz

The population of the Naval Missile Center's porpoise pool jumped from three to five last month as a 300-pound male and a 220-pound female joined the select group in the marine compound. The two full grown mammals, named Buzz (the male) and Buzz Buzz (the female), will remain in their new home indefinitely.

The porpoises were captured in early November near Gulfport, Miss., then taken to Animal Behavior Enterprises, a commercial animal training establishment in Hot Springs, Ark. At the training "camp" the porpoises were subjected to two and a half months of domestication exercises—to teach them to accept cut fish instead of the live fish to which they had been accustomed, to be around humans, and to permit humans to be in the water with them and to attach various experimental apparatus to them—all in preparation for testing to be conducted at Point Mugu.

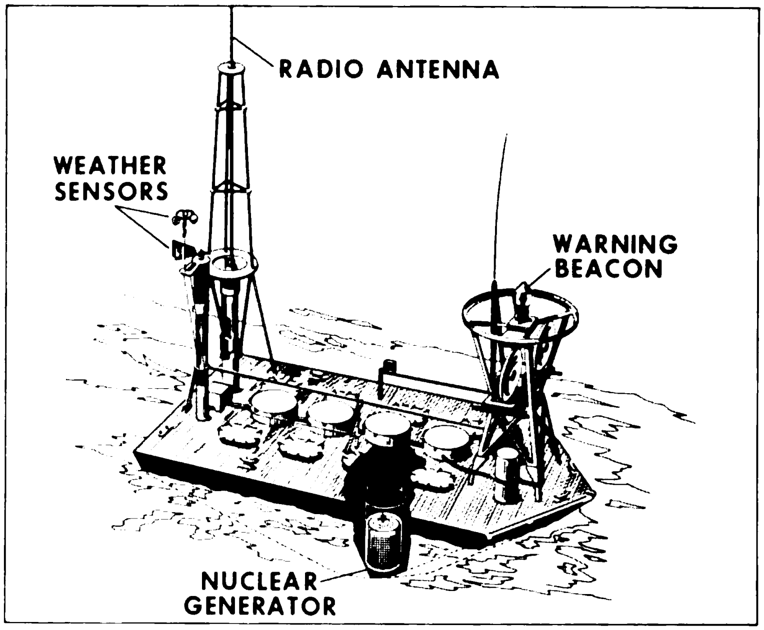
The porpoise research program underway at Point Mugu is under the direction of the Naval Ordnance Test Station, China Lake, California.

Tank Warfare Without Live Ammunition

Realistic tank-versus-tank combat training that does not rely on live ammunition has been demonstrated at Fort Knox, Kentucky, for the Army Armor Board. Aircraft Armaments, Inc., Cockeysville, Md., under contract to the Naval Training Device Center, developed what is called a "Hit Indicator for Direct Fire Weapons" for the Center's Army Participation Group. This training device for the 105 millimeter tank gun takes the guesswork out of determining which tank fired first or which tank has been put out of action.

Prior to the use of this trainer, decisions by personnel often led to unrealistic and inaccurate results. Therefore, a study was undertaken by NTDC to develop a system which would automate these decisions. The result—the hit indicator—consists of an RF data link and infra-red electro-optical data link bore-sighted with the weapon for hit-and-miss determination. The device, which is battery-operated and fully transistorized, is made up of three major items: a target/weapon unit, mounted in the gun tube; antenna/beacon unit, mounted on the turret roof; and a control unit, mounted on the recoil guard. A hit is indicated by the ignition of a smoke candle mounted on the tank's exterior. Simultaneously, the hit tank is rendered inoperative, in which condition it remains until an umpire places it back into action. Firing each round requires the insertion of an ammunition card, which simulates ammunition resupply.

To operate the device, a tank gun is fired, resulting in an omnidirectional radio transmission. All targets within range receive this RF signal and, in return, flash an infrared light source within a coded time interval that differs for each target. A photoelectric telescope, mechanically and optically centered within the barrel of the firing gun, detects the infrared flash of the target tank, at which time a second omnidirectional RF signal is transmitted. A hit indication is triggered only by the target under fire, since it is the instantaneous time of the specific target's flashing infrared light coinciding with the second RF signal that allows for ignition of the smoke candle.



The Moored "Nomad"

The first atomic-powered NOMAD weather station—forerunner of a world-wide network of unattended weather stations—is now on duty for the Navy in the middle of the Gulf of Mexico. The station, which is mounted on a small boat moored at 20° N. Lat. and 90° W. Long., radios air temperature, sea temperature at and below the surface, barometric pressure, and wind speed and direction every three hours. If the weather becomes severe, a storm sensor in NOMAD causes the transmission frequency to increase to once each hour.

NOMAD, which stands for Navy Oceanographic Meteorological Automatic Device, consists essentially of a 20- by 10-foot boat, meteorological equipment, electronic apparatus, and a power supply. The latter, called SNAP-7D, is the largest of a series of radioisotope generators developed by the Martin Company of Baltimore, Md., for the Atomic Energy Commission's SNAP (Systems for Nuclear Auxiliary Power) program. It is 34-1/4 inches high, 22 inches in diameter, and it weighs about 4600 pounds, including shielding. The generator was designed to produce electric power continuously for ten years without recharging. This capacity eliminates the costly and sometimes hazardous maintenance needed by relatively short-lived conventional batteries. (See cover.)

Inside the generator, heat from the decay of radioactive strontium 90 in 14 small capsules is converted directly into electricity by 120 thermocouples which surround the fuel. The fuel is strontium titanate, a compound of titanium and strontium 90, a waste product of nuclear reactors. About 20 pounds of the fuel is sealed in a special high-strength, corrosion-resistant metal, which will enclose it safely for at least 500 years.

Similar generators provide electricity for navigational beacons and satellites in addition to other types of remote weather stations. One of these devices, SNAP-7C, a 10-watt unit, has been furnishing the power for an unmanned Navy weather station at Minna Bluff, Antarctica, for two years. Three other units are powering the radio transmitters of military satellites.

The Advantages of Understanding Fish "Talk"

More than 17 years of continuous research on fish and other marine organisms have convinced a University of Rhode Island scientist that through an understanding of fish "talk" and through related knowledge, fishermen can be helped to increase their catches in the sea. The help would be given by means of fixed, unmanned, underwater listening devices similar to those the Navy now uses to track enemy submarines. If fish of commercial interest were to swim near these posts and "talk," the sounds would be picked up and rebroadcast to fishermen in the area. Also a possibility is the broadcasting of man-made sounds underwater to attract some marine animals, to frighten others away, and even to herd fish or contain them in selected areas.

The scientist who has suggested these fishing methods is Marie Poland Fish of the URI Graduate School of Oceanography and the director of the world's largest underwater bioacoustic library. Mrs. Fish's broad knowledge of undersea sounds was gained in part through studies carried out under the oldest continuous biological contract held with the Office of Naval Research. Each year she has accumulated hundreds of miles of audio tape. When a new sound is discovered and analyzed thoroughly, it becomes part of the "Reference File of Biological Sounds," maintained since 1954 at the request of the Navy. Although this library contains sounds recorded by researchers all over the world, about 98 percent of the material was compiled by Mrs. Fish and her associates.

The evidence that fish "talk" is quite conclusive to the bioacoustic librarians. Usually, the animal sounds are associated with "colony life." For example, if you capture one fish of a school, a characteristic sound will be produced by others present, and the entire group will flee. The "talk" is also associated with such activities as breeding and competitive feeding, and, in the case of nocturnal fish, with carrying out their activities in the dark. Some marine animals may have quite extensive vocabularies; for example, studies of sounds made by white whales held in captivity have revealed a wide repertoire of recognizably different types of sounds that, used singly or in combination, have specific meanings.

The value of the knowledge gained through investigations of marine animal sounds can be indicated by a few examples:

- Sonarmen need to be able to distinguish between sounds made by submarines and by animals so as to identify correctly sound-producing objects underwater. Sounds identified incorrectly could lead to such mistakes as sinking a whale because it was thought to be an enemy submarine.
- Knowledge of bioacoustics also figures prominently in the design of torpedoes and mines that are activated by sound.
- The research has also proved worthwhile in other unexpected ways; for instance, when one of the Texas towers toppled into the Atlantic with part of its crew aboard, Mrs. Fish was able to tell salvagers that the noises heard were from nearby whales, not survivors trapped in the underwater wreckage.

Mrs. Fish's research on marine animal sounds began with a review of more than 1500 submarine war patrol reports, including underwater sound logs and recordings, if available. Later it involved the auditioning of about 400 of the sound-producing organisms in the Western North Atlantic Ocean, ranging from shrimp and crabs to porpoises, whales, sea lions, sea cows, and many kinds of fish. Every animal studied was found to have a characteristic sound "signature."

The next step was to determine what mechanisms various organisms use to produce sounds. Fish have neither vocal cords nor ears, as we commonly think of them, but various parts of their anatomies serve in a similar capacity. For instance, many species have air bladders with which they control their depth in the water. Some fish squeeze this organ with imbedded muscles to make a variety of noises. Other sounds are produced by long muscular "strings" attached to the bladder that can be made to vibrate. In both instances the air bladder operates as a sounding board. Still other species snap their fins, scrape their "gill teeth" together, or manipulate other parts of their anatomy.

Vast as is Mrs. Fish's underwater bioacoustics library, it is far from complete, for there are thousands of animals in the sea whose sounds have not yet been recorded and analyzed. The work is still going forward, and it will probably continue to do so for a long time.

Inventions — Continued from page 19

it has been the practice in the past to separate the interior nozzle from the fuel. Space was needed between these components to avoid igniting the fuel immediately behind the nozzle as a result of the high rate of heat transfer through the graphite or graphite and metal, of which nozzles were made. Thus the fuel would burn in the most efficient manner—uniformly, from its central channel outward until it was all consumed.

Although the arrangement served this purpose well, it had several important disadvantages. It resulted in a decrease in the motor loading density of the rocket. It necessitated the installation of an elaborate gas-sealing system—to prevent the hot gases from escaping through the space between nozzle and fuel and reaching the aft end of the motor, where they might damage the motor case. And it required that the nozzle be installed as a separate unit, which meant that the nozzle would be both fragile and expensive to manufacture.

In their efforts to find a way to eliminate the gap between propellant and nozzle, Mr. R. F. Vetter, R. A. Miller, and S. H. Herzog of the Naval Ordnance Test Station, China Lake, California, invented a nozzle made of heat-resistant resin that is molded under extreme pressure and temperature. Nozzle inserts made of graphite or some other suitable material are attached to the molded resin, which is then bonded directly to the composite propellant grain. Such a design enables the engine to accommodate more fuel, because it does away with the gap between nozzle and propellant; it increases the nozzle's resistance to mechanical shocks; and it does not heat up to such an extent that it ignites the fuel to which it is bonded.

On September 17, 1963, Patent No. 3,103,784, entitled "Plastic Internal Rocket Nozzle," was issued to the inventors covering the ideas behind the concept. The patent protects the invention not only for the patent holders, but also assures the Navy of the right to apply the concept to the design of its many types of rockets.

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ON THE NAVAL RESEARCH RESERVE

Plans Changed for Training Device Seminar

A change has been made in the date and place of the Research Reserve Training Device Seminar, Port Washington, New York.

Date: The seminar has been scheduled for the period May 24 to June 5 instead of June 14 to 27 as announced previously.

Place: Officers will be ordered to report to the representative of the Commanding Officer and Director of the Naval Training Device Center at the U.S. Naval Air Station, New York.

These changes have been made in anticipation of congested conditions in New York City brought on by the World's Fair.

From Enlisted Man to Ensign in NRRC 3-4

Michael A. Vince, DM2, a member of Naval Reserve Research Company 3-4, accepted a reserve commission as an ensign in brief ceremonies at the U.S. Naval Reserve Training Center, Rochester, New York, last December 3. The oath of office was administered by CAPT Louis P. Zicari, USNR, the commandant's local representative. CAPT Zicari commended the diligence and contributions to the Naval Reserve Program made by Mr. Vince in his remarks to the more than 100 reservists who assembled for the occasion.

ENS Vince is a 1963 graduate of the University of Rochester. He is continuing his education in the Graduate School of the College of Engineering and Optics of the University, while employed by the Xerox Corp. as a physicist. He is the second member of the company to receive his commission from enlisted status while a member of the unit. The other two officers are the commanding officer and the executive officer.

M. A. Vince takes oath of office prior to receiving reserve commission. Administering oath is CAPT L. P. Zicari.

IN THIS ISSUE

VOL. XVII NO. 3

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington, D.C., 20390. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

EDITOR: Richard D. Olson

NAVEXOS P-510

Engineers ready SNAP-7D, a 60-watt nuclear generator, for installation in a Navy NOMAD weather boat. The atomic-powered NOMAD, forerunner of a world-wide weather-reporting network, is now sending regular weather reports from the middle of the Gulf of Mexico. *See page 22.*