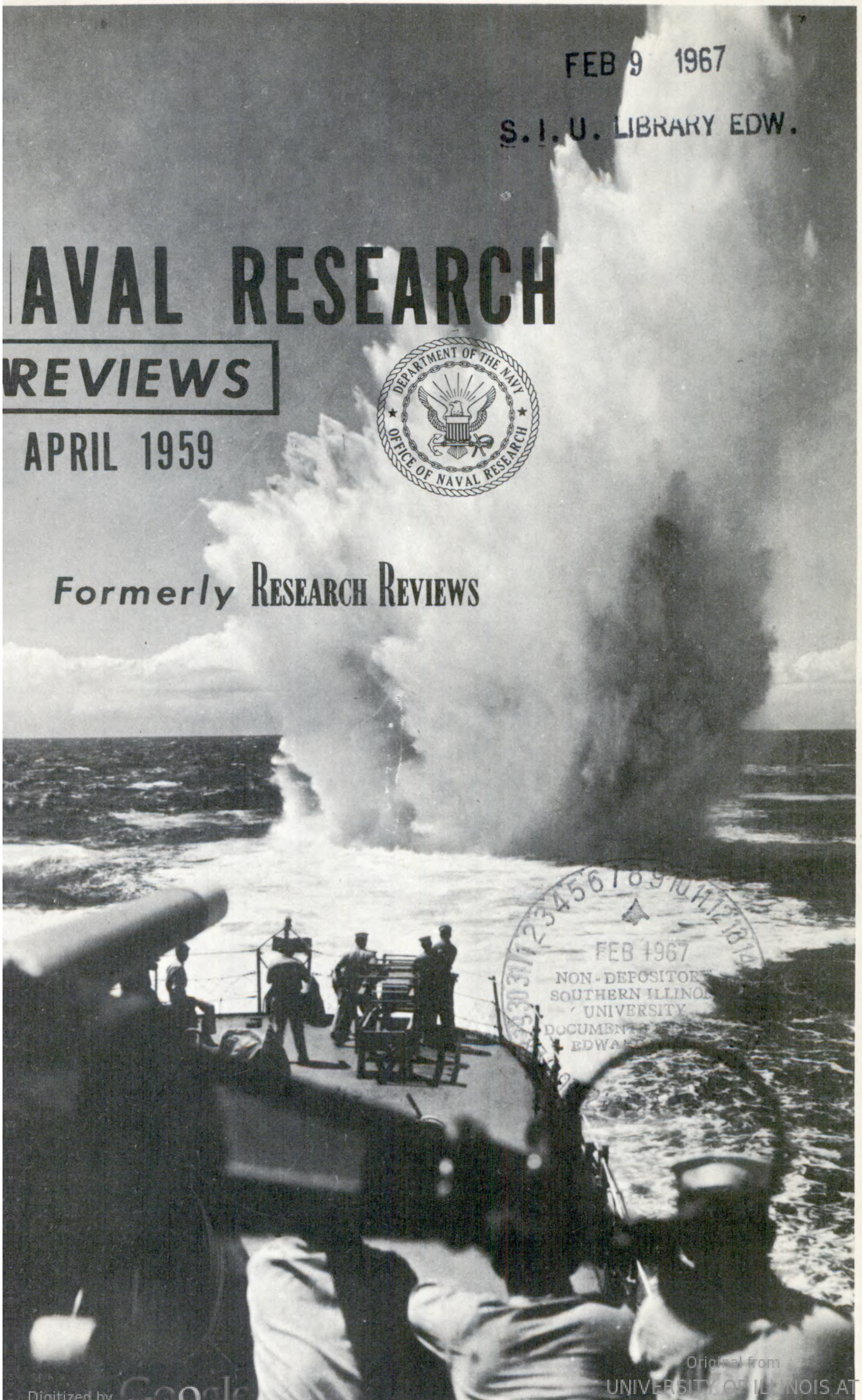
NAVAL RESEARCH REVIEWS

APRIL 1959

DEPARTMENT OF THE NAVY · OFFICE OF NAVAL RESEARCH

Formerly RESEARCH REVIEWS



There've Been Some Changes Made

On January 15, 1948, the Office of Naval Research distributed the first issue of its monthly magazine, Research Reviews. The new publication was intended to assist in the cross-fertilization of scientific ideas by bringing to the attention of scientists, naval officers, and administrators the work going on in the many fields of research in which the Navy was engaged. All the material printed in the magazine was to be prepared by ONR contractors, thereby providing information "directly from the front."

In the years which followed, the scientific coverage of Research Reviews broadened somewhat. The magazine was still concerned primarily with research conducted by ONR, its laboratories, and contractors, but also reported on investigations and facilities of other Navy laboratories and scientists. Increasingly, the magazine was becoming the "voice" for research throughout the Navy.

During the more than eleven years Research Reviews has been undergoing this evolution, its title has remained the same. The editors were aware that it was a bit out of focus: by itself it could indicate that the magazine was concerned with any or all research, whereas with "Office of Naval Research" added to it, it could indicate that it related only to ONR laboratory and contractor research. So a new title was in order, one that emphasized the magazine's Navy-wide research interests. The title selected--Naval Research--is being introduced this month.

Along with the change in title has come another innovation--a new front and back cover design. As comfortable and familiar as our "old clothes" may have been, we had worn them for more than a decade, and they were a little out of date. So a new "suit" was ordered. We asked that it fit well yet allow us room to move around in, and that it be of a simple design without looking ordinary. We're trying the new "suit" on for size this month. Our first impression is that our "tailor" did well by us.

Of course, these changes have to do only with "first appearances." What really count are the magazine's contents--the articles that appear on the other 30 or 34 pages printed each month. These pages, we are happy to say, will remain basically unchanged. They will continue to carry articles by members of one of the largest and most distinguished scientific communities in our land. As in the past, the articles will report on research and research methods and facilities of just about every branch of science in which the Navy is interested. As the Navy has a hand in virtually all areas of scientific investigation, this coverage will be very broad. We will continue, also, to present articles written so as to be understandable by the nonspecialist as well as the specialist in the various fields of study reviewed.

The Editors

Better Weapons Through Operations Research

CDR R. L. Ploss*
Commanding Officer
USS FESSENDEN (DER 142)

A fortnight after Pearl Harbor, the Japanese Imperial Navy struck at the Philippines with an invasion fleet of 80 ships. Standing in their way were five American submarines, each fully armed with torpedoes. As the slow-moving convoy approached Lingayen Gulf, the crowded ships were so many sitting ducks. Yet only one was sunk.

That historic disappointment marked the beginning of one of the outstanding weapon failures of World War II—that of the submarine torpedo weapon system. And the war was half over before we knew the causes and found means to correct them. It is that kind of battle failure we should now be seeking to prevent by intensive operations research on every weapon system now in service.

In the past, when the rate of evolution of naval weapon systems was relatively slow, the accumulated experience of operators would, over a period of time, indicate where and what improvements were needed. But the natural forces of evolution in peacetime are incapable of keeping our in-service weapon systems equal to the threats of new tactics and weapons. What, then, is the answer? If there is no answer our survival in all-out war will depend only on happenstance.

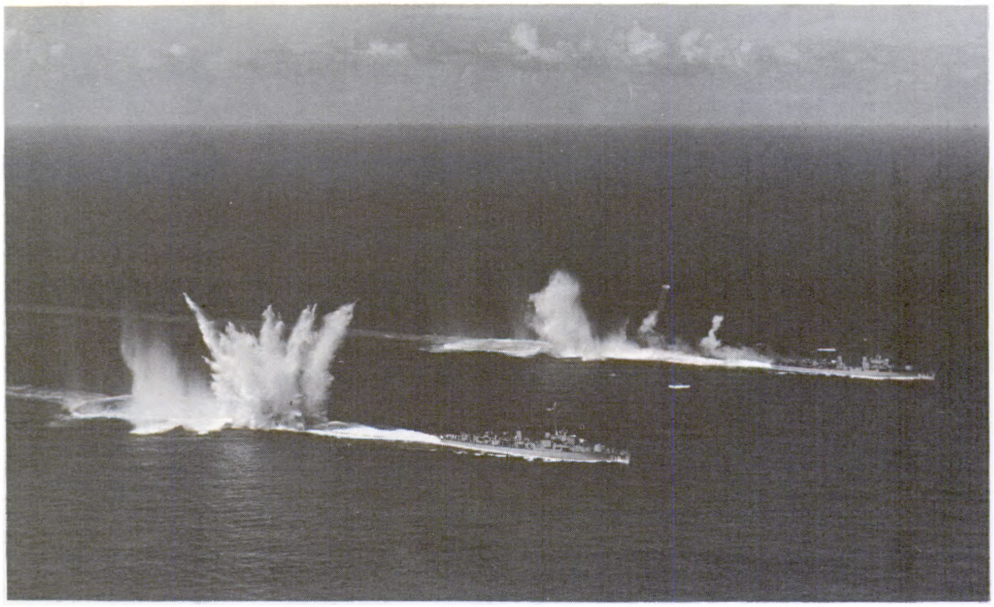
The chances are exceedingly small that a simple over-all solution to the effectiveness problem can be found by a purely theoretical analysis of raw data. Factors relevant to the effectiveness of most naval weapon systems are excessively numerous. Finding the restrictive factors is often tedious work. But once they have been isolated, ways to measure them quantitatively can be found and means taken to correct them.

It was the unknown factors that seriously restricted the effectiveness of our submarines at Lingayen Gulf. Through the concerted efforts of many people, the majority of whom were Fleet operating personnel, these factors were eventually removed. It is interesting to note that the methods used parallel those employed by operations researchers. So the story should serve as a guide for naval personnel today.

The first step was to review the opinions of the persons associated with the weapon system. The consensus was as follows:

- The tactics employed were excellent.
- The performance of the operators was exactly according to instructions.
- The weapon was completely reliable.
- Enemy ships were not sinking at the predicted rate.

*Formerly with the Naval Analysis Group, Office of Naval Research.

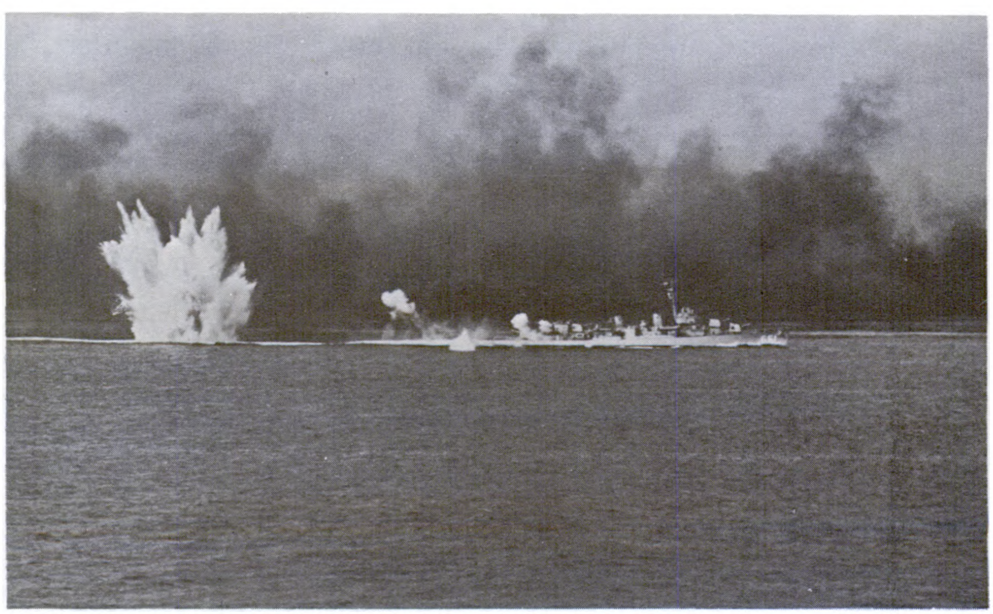


Is this tactic combat ready? Destroyers in ASW attack: Above, USS SARSFIELD and USS EPPERSON; below, USS KIDD

Does this type of ship offer the mo effectiveness for the dollar?

SOME QUESTIONS TO BE ANSWERED THROUGH OPERATIONS RESEARCH--

(See also front cover and caption)



These opinions should perhaps have been anticipated. They were asked for in the hope that they would contain clues leading to a quick solution. In this case they didn't.

The next step was to isolate the factors that could produce such a drastic reduction of effectiveness. Apparently, no operating procedures were at fault. Torpedo settings had been checked, rechecked, and checked again. Yet some of the torpedoes had missed at short range against an anchored target. The conclusion reached was that the fault lay in the torpedo itself.

Deep-running torpedoes had been a difficulty in World War I. They continued to be so in World War II. In January 1942 the Navy Department reported that the torpedo Mark 10 was running four feet deeper than set. No mention was made of the Mark 14, so it was inferred that it did not have the same deficiency. Nevertheless, tests were conducted on the Mark 14 by firing it from a submarine at a fish net 850 yards distant. The setting was 10 feet, but the torpedo made a hole in the net at a depth of 25 feet.

Correcting this factor did not increase effectiveness as expected, but it did introduce another factor which apparently had been suppressed: the problem of prematures. It was naturally expected that the magnetic exploder system was at fault. This was one we couldn't whip. Testing and quality control became very stringent, but the prematures continued. Finally, when efforts to remedy the situation seemed fruitless, all magnetic exploders were rendered inactive (illustrating an alternative to operations research: if you can't fix it, get rid of it!).

Still the torpedoes did not accomplish the kills expected of them. So, in effect, a series of field tests was initiated to determine the reliability of the torpedo exploder system with the magnetic exploder inactivated. The most enlightening test was conducted in July 1943 against a large unescorted Japanese whaling ship which had previously been hit and stopped at sea. The first shot was expected to be a real killer, but it bounced harmlessly off the side. Then, in keeping with the best tradition of scientific experimentation, eight more were readied, rechecked, and fired. All were duds! The ninth and last torpedo was brought home for inspection. A drop test ashore proved that in the case of a direct hit, the excessive force of deceleration jammed the firing pin, but when the torpedo hit a glancing blow, the lesser force permitted the firing pin to move properly. This was the payoff. Design technicians quickly corrected the deficiency, and the first load of effective torpedoes was sent to sea within three months. Effectiveness jumped, and the road was cleared for a highly successful submarine war.

This story was not told to embarass any persons identified with a particular development. Rather, it was used to demonstrate the dangers attending every weapon system untested in war. The causes for malfunctioning will not be obvious, because the system will probably have been tried out in normal peacetime exercises and the obvious causes detected. Moreover, the basic fact that the system is malfunctioning may be hidden.

We do not knowingly place in service any system component that is faulty. Yet, in the complex weapons used today, anything can happen. Only by searching out and correcting restrictive factors—one by one or two by two—can we continually improve our weapon systems. The operating forces, who have the best opportunity to detect restrictive factors, are challenged to locate the causes of inferior performance in a complex system, of which all components are believed to be satisfactory, whether that system was introduced last year or ten years ago. Only by considering every exercise shot as a test shot can we accumulate the data necessary to prove or disprove malfunctioning and isolate restrictive factors.

To this end, operations research offers a general procedure by which the Navy can obtain quantitative data on any in-service weapon system—data necessary to provide a sound foundation for improvement programs. The course of action is to make the evaluation of each system a separate operations-research project, divided into four distinct, yet interrelated and inseparable, phases. These can be expressed as a series of questions:

- Is the weapon system concept appropriate to today's threats?
  - What is it to kill?
  - When is it to kill?
  - Where is it to kill?
  - How is it to kill?

- Are the operating parameters feasible?
  - What are the environmental restrictions?
  - What are the personnel requirements?
  - What are the tactical and logistical limitations?
  - What is its reliability?

- How good is the system's performance?
  - What is its delivery accuracy?
  - What is its lethal radius?
  - What are the time delays in delivery?
  - What is its "up time"?

- What are the factors that restrict performance?

In the first phase, the purpose of the system under study must be stated with sufficient clarity to outline the project. Time consumed in specifying definitive action should be kept short (we have all heard of groups that deliberated for months before determining what the problem was), but the importance of this step should never be underrated. How can we determine the effectiveness of a system without knowing what is expected of it? By the same token, the effectiveness of a system must be measured before its final purpose can be determined. Thus, an operations-research study may start in phase one and after full cycle, end in phase one.

A first reaction of many researchers is that they would like the cognizant commander to accomplish the second phase, which is to specify the operating parameters. But these, too, are points to be studied rather than to be established by decree. It thus appears that the definition of a weapon system's purpose is dependent upon a full knowledge of its effectiveness. When an all-weather capability is reduced to something suitable only for sea states of less than two, or when a capability against all submarines is reduced to a capability against some submarines, it is evident that the weapon system's purpose has changed. Because the process of ascertaining the true operating parameters involves analysis of arbitrary directives, current tactics, and test results, this phase may run throughout the operations-research study.

Opinions and policies oftentimes gain the stature of an operating parameter. Debunking them might prove very costly in money and prestige. They may be valid, or they may be only convenient arguments for maintaining a status quo. An example of this occurred in the Civil War. The infantry was using muzzle-loading guns, which required relatively little logistic support. Substitution of breech-loading rifles was proposed in order to increase firing power, but the change was postponed because the War Department believed that the rapid-firing breech rifles would exhaust ammunition supplies in a few minutes and leave the men helpless. Passing years have made this policy appear foolish. But in 1862, the opinions of many Union generals and even the President of the United States were unable to counter the arbitrary operating parameter that there could be no logistic support for a soldier in the field.

In a more recent war, it had been decided that the ideal place to explode an underwater weapon was several feet below the hull of a target, because such an explosion would cause maximum loss of buoyancy. An analysis of actual merchant-ship sinkings, however, revealed that the majority of ship losses were caused by capsizing from hits against the side of the hull.

In testing the validity of popular assumptions or conceptions, the opinions of operators must be examined. They may provide the only evidence that a system is malfunctioning. A Canadian scientist recorded an incident that well illustrates the unusual results that may be obtained from an examination of operators' opinions. In the early desert battles of World War II, British tanks proved superior to German tanks. The British were knocking out enemy tanks at long range, with little damage to themselves. Suddenly the situation was reversed. The perplexed British gunners believed that the Germans had introduced a new gun sight of colossal proportions; and, since this was the only change they thought had taken place, they demanded new gun sights for themselves. An investigation indicated that there was no difference in the accuracy of the two sights. Later studies revealed that the Germans had increased the hardness of their tank armor without changing its thickness or appearance. The British shells were hitting as frequently as before, but were breaking up. The solution involved a change of ammunition.

The third phase is to observe a weapon system in the field, under actual operating conditions. This is the body of operations research. This is also where the ocean environment becomes most annoying. Operating units leave no tracks. The point of weapon impact is fixed for only a moment. Naval engagements are short and action-packed.

And veterans of the engagements scatter rapidly to distant duties. Yet, without these field measurements of effectiveness, researchers can only speculate. If the operating forces fail to utilize their experiences in war and peace, then specialists will have to do it for them, using second-hand information and with a serious loss of time. Obviously, more equipment is needed to properly measure weapon-system performances. But a greater need is an increased respect on the part of every operating naval officer for the importance of obtaining and analyzing operational performance data.

The final phase of an operations-research study is to quantitatively define the causes and effects of critical restrictions on system performance. The operating force must translate the findings of its operational experience into meaningful terms, as a basis for initiating system improvements. If the findings are not meaningful to the design technician or the rewriters of the procedural publications who must take the corrective action, the report might be worthless.

One cannot leave the subject of operations research without at least mentioning the people involved. The success of any endeavor depends largely upon those responsible for its implementation. Obviously, operations research is not a field for the untrained or ineffectual worker. Just what type of men <u>do</u> we want? A british scientist has described an operations researcher in terms of the following attributes:

- The conceptual ability to see a problem as a functional whole and to see what needs analyzing.
- The competence to make the necessary functional, dynamical, or statistical analyses.
- The ability to do things the simple way.
- The ability to present the answer in a straightforward and understandable statement.

These attributes not only define a good operations researcher, but also a good scientist and a good naval officer.

The Navy is Still in Business at the South Pole

Naval support of scientific projects in the South Pole region did not end with the termination of the IGY. In addition to the logistic operations underway as part of Operation Deep Freeze IV, current activities include several changes in the status of U. S. bases in the Antarctic. Little America Station, on the Ross Sea barrier, is being inactivated; while Wilkes Station, on the Knox Coast, and Ellsworth Station, on the Weddell Sea, are being turned over to Australia and Argentina, respectively. The remaining U.S. stations are the McMurdo Naval Air Facility, on the west coast of the Ross Sea, the South Pole Station, Byrd Station, and Hallett Station.

As a result of its extensive operations in the Antarctic, the National Geographic Society presented its highest honor for exploration, The Hubbard Medal, to the Navy Department early this month.

NRL and the A-Bomb

A briefing of Navy Department officials 20 years ago on the military potentialities of nuclear fission led to a Navy "first"--the first organized program in nuclear research in this country. The briefing was arranged for Professor Enrico Fermi by the late Dr. George B. Pegram, then dean of the graduate physics department at Columbia University, only a few months after two German scientists had demonstrated that not only was it possible to split the uranium atom but that an enormous amount of energy was released in the process.

Professor Fermi told the group that there was a possiblity of achieving either a controllable chain reaction or a chain reaction of an explosive character, but he was very cautious and skeptical in his presentation. Although the conferees did not indicate an interest in taking action on the matter, they did express a desire to be kept informed of further developments. Apparently, this reaction left the impression that there was no other outcome of the meeting.

Actually, one of those present was Dr. Ross Gunn, then a physicist at the Naval Research Laboratory, and it was this briefing by Fermi which led him three days later to see RADM Harold G. Bowen, Chief of the Navy's Bureau of Engineering (one of the forerunners of the Bureau of Ships). Dr. Gunn requested and immediately was granted the initial sum of $2,000 to explore the possibility of utilizing nuclear power for ship propulsion.

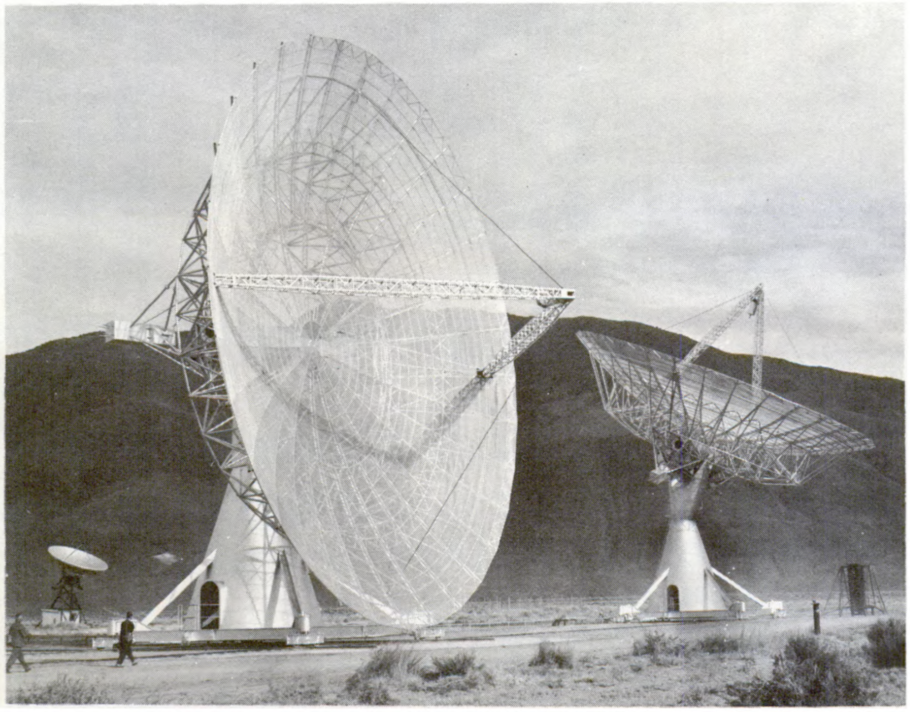
Dr. Gunn teamed up with Dr. Phillip Abelson, of the Carnegie Institute of Washington, to develop a process for separating the most useful uranium for nuclear fission from the uranium ore. Dr. Gunn was fully confident that useful energy could be obtained from the atom. Furthermore, he conceived that this energy would be ideal for propelling a submarine.

Although the work at NRL was never officially tied in with the Manhatten District atomic-bomb project, it was so successful that the Navy process was eventually utilized at Oak Ridge to provide fissionable material for the Hiroshima and Nagasaki bombs.

Third Annual Conrad Award

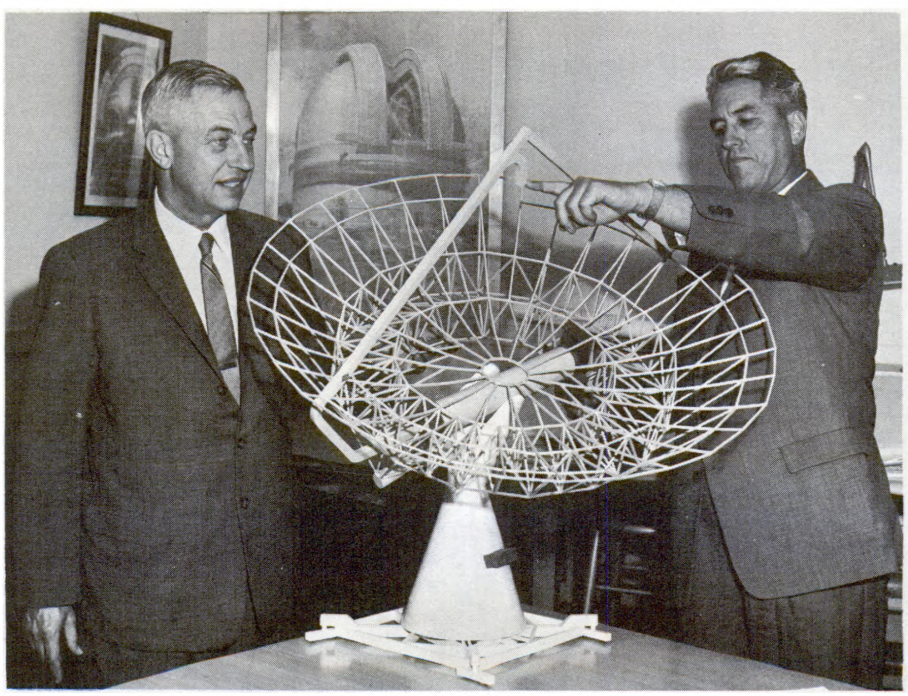
The third annual Captain Robert Dexter Conrad Award, established by the Office of Naval Research, was presented to Dr. Robert M. Page, Director of Research, Naval Research Laboratory, on March 17 at the Benjamin Franklin Hotel, Philadelphia.

Dr. Page was chosen for the 1959 Award because of his continuing and significant contributions to science—especially in the fields of radio communications, radar, and electronics--and for his dedicated service to the Navy as a civilian scientist. He built the first pulse radar system, with which he detected aircraft in flight in December 1934. After further research, he developed the theory of radar-receiver design and led in the invention and development of circuits and components necessary to the military use of pulse radar. He was a key member of that dedicated group of men who gave to NRL the right to be called the "Birthplace of Radar."



The two 90-foot radio telescopes installed recently in the Owens Valley, California, by the California Institute of Technology. The project was sponsored largely by the Office of Naval Research.

Dr. Lee A. DuBridge, President of the California Institute of Technology, left, and Bruce H. Rule, Cal Tech's chief engineer, pose with a model of one of the twin radio telescopes pictured above. Rule points to the instrument's prime focus.



Ninety Feet to the Stars

In 1928, physicist Karl Jansky of the Bell Telephone Company began a study that was destined to open up a vast new area of investigation to astronomers. Jansky's objective was to determine what was causing the static that was disrupting the Company's then new trans-Atlantic radio telephone service. Five years later, when the work was completed, the Company disclosed that the static was caused by radio waves generated by local thunderstorms, distant storms, and objects in outer space. The third cause was the one that interested astronomers, for it appeared that if they built special antennas, they could "listen" to these extraterrestrial radio signals and thereby gain information about their sources, presumably the stars and planets. As this method of observation would utilize a range of wavelengths longer than the eye can see, it would permit man to "view" much more of the universe than is possible with optical instruments. For example, by this means, one could make observations through clouds—in the atmosphere or in space—and could scan parts of the radio spectrum in daylight.

Ironically, not America—pioneer in the science of radio astronomy which thus began—but Australia, Britain, and the Netherlands were the first to exploit the new method. In recent years, however, the United States has been "on the road back" and is now making a strong bid for preeminence in the field. Most recent of the advances that are enabling the U. S. to achieve this position was the erection, late in 1958, of a pair of giant "ears" in a remote valley 250 miles north of Los Angeles, California. These 90-foot dish-shaped "hearing aids" catch radio waves from the stars and focus them to a point, just as telescope mirrors focus light. The incoming signals are then funneled into a radio receiver, amplified, and presented on pen recorders, oscilloscopes, or magnetic tapes.

The California Institute of Technology Radio Observatory, as the new installation is called, was built at a cost of $1,500,000 with funds provided for the most part by the Electronics Branch of the Office of Naval Research. The facility is located in the Owens Valley, a narrow trough between the Sierra Nevada on the west and the White Mountains on the east. These ranges, whose peaks reach altitudes of more than 14,000 feet, shield the extremely sensitive electronic "ears" from man-made radio and television transmission. The observatory was completed last December, but since that time has been going through a "shakedown" phase preparatory to being put in full operation next month.

According to designer Bruce H. Rule of Cal Tech, the structural problems encountered in building the two radio telescopes were greater than those met in the construction of Cal Tech's 200-inch optical giant on Palomar Mountain near San Diego, California. However, these difficulties have been more than offset by the high quality of the finished product. While there are a number of large research radio telescopes in use in this and in other countries (including England's 250-foot dish, which is the largest), and several more are now being built in the United States, the Owens Valley instrument will be the most versatile because of its twin antennas.

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The observatory is unique in several respects. For example, it is the first that utilizes two dishes designed to be operated either individually or as a team. Unlike other equatorially mounted radio telescopes, these are built on wheels which move on tracks. The purpose of this footing is to permit investigators to regulate the distance between the two dishes for different experiments. One dish moves on tracks aligned east-west and the other on tracks aligned north-south. The two sets of tracks, each 1,600 feet long, join at one point. All driving and mounting axes are adjustable for alignment. Also, the reflecting skin can be adjusted on its tubular steel frame at 324 points. Thus, any alignment errors on moving parts can be corrected, and abberations on the concave reflecting surface can be eliminated, thereby assuring accurate reception of signals.

This arrangement is explained by the high cost of the instruments. Obviously, several models could not have been built—as is done in the development of automobiles—to iron out errors. Provisions for adjusting the instruments to bring them within the required tolerances had to be built in. So well are the 90-foot dishes counterbalanced that a one-horsepower electric motor is all that is needed to aim them and to track the stars.

In preparing for this type of operation, the wind posed a special problem because each dish consists of more than 6,000 square feet to steel mesh, and thus is similar to a huge sail. To lower wind resistance, the sheeting is perforated with holes 3/8ths of an inch in length. The holes had to be quite small to assure that certain useful waves would not pass through the reflector and be lost. Of course, the perforations also serve to reduce the overall weight and to let rain through.

To avoid topheaviness and increase stability, the two rails on which the telescopes ride were set 35 feet apart in reinforced concrete foundations. The telescopes may be securely anchored by locking them to one of five pairs of reinforced caissons embedded in the earth to a depth of 17 feet at intervals along the tracks.

The radio telescopes are built to take winds of 80 miles per hour. However, they will not be used for exacting observations if the air flow exceeds 25 miles per hour, because under such conditions the skin frame of the reflector would probably be distorted slightly.

The two 90-foot antennas are not the only observing facilities at the site. Already operating are a 32-foot dish for picking up short radio waves (2/5ths of an inch to 2 inches in length) and two networks of wire antennas, called arrays, for collecting waves up to 40 feet in length. By comparison, the 90-foot antennas are designed to receive waves ranging in length from about 2 inches to nearly 40 inches.

The 32-foot dish, formerly at Palomar Mountain, has been used chiefly to develop electronic equipment now being installed in the 90-foot antennas.

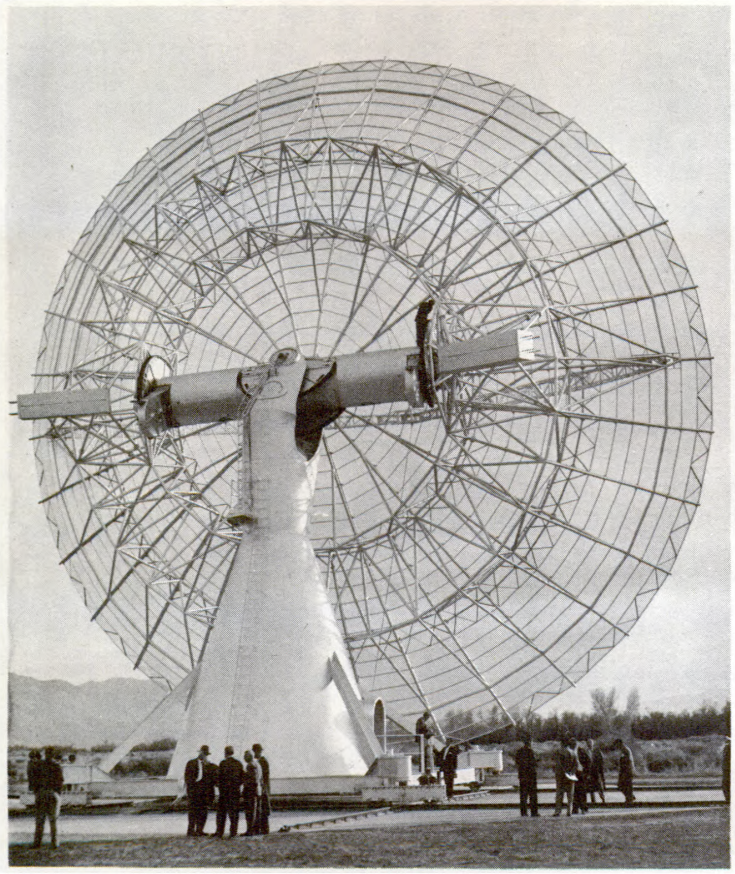
The two arrays cover two acres and ten acres respectively. Because of their size, they cannot be steered to follow the stars and therefore are used only for making observations directly overhead. For example, measurements have been made of the irregularities in the electrified upper layers of the earth's atmosphere that cause a phenomenon similar to the twinkling of visible stars. Information on this subject may prove valuable in planning communication links with space vehicles. The arrays have also been used to study radio sources in outer space. For example, an investigation was made recently of a solar eclipse of the Crab Nebula. It may be of interest to note that during the eclipse the radio signals from the supernova diminished greatly at distances up to 5,000,000 miles from the visible surface of the sun.

Other facilities at the observatory include a one-story, concrete-block building with 3,000 square feet of floor space. The building contains electronic receiving equipment, such as amplifiers and instruments to visually record the signals coming in from the telescopes. Also in the structure are living quarters for four people, two offices, and a workshop.

The ONR-Cal Tech radio-astronomy project was started by a team of five scientists headed by John G. Bolton, formerly the principal research officer of Australia's Commonwealth Scientific and Industrial Organization. Others include Gordon Stanley, a senior research fellow at Cal Tech (Stanley and Bolton discovered the first radio star in 1947); J. A. Roberts, a senior research fellow; T. A. Mathews, a research fellow; and K. C. Westfold, a visiting associate professor of astronomy.

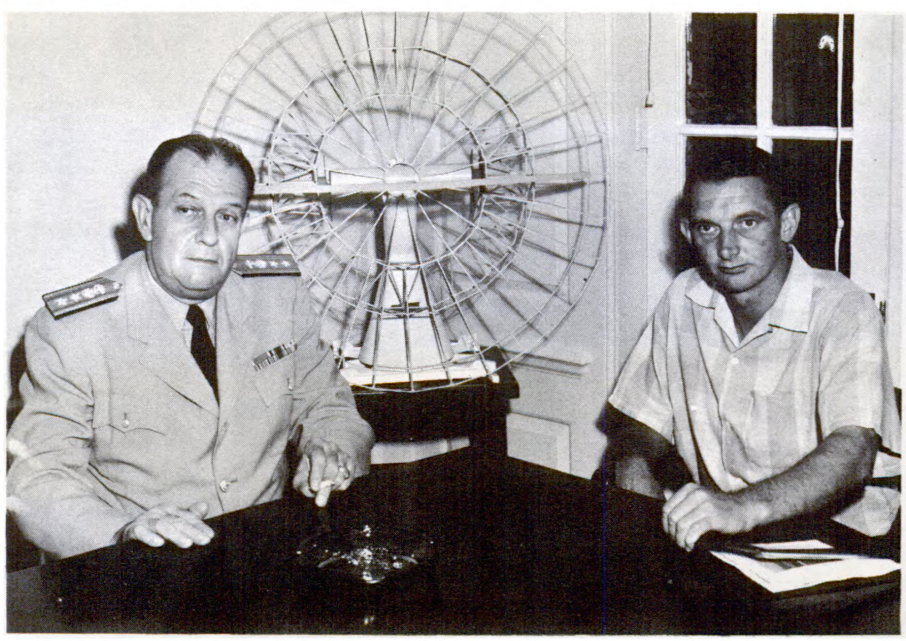
The research program, financed by ONR on an annual budget of about $125,000 will include attempts to identify hundreds of radio sources in space with visible stars so that the mechanism responsible for generating the signals can be studied. So far, only about 50 of approximately 2,000 known radio stars have been identified. Some of the radio sources that will be studied are associated with the grand catastrophies of nature, such as the remnants of an exploded star or the collision of two galaxies near the edge of the visible universe. Some of the objects that will be detected may even be beyond the range of the largest optical instruments. The research program also will embrace studies of solar outbursts believed to be streams of ionized matter, or pieces of atoms. These are thought to be responsible for the aurora borealis.

Although radio astronomy is still an infant science (it will be recalled that the first radio star was detected only 12 years ago), it is growing fast. Just as the receiving instruments of today are vastly superior to those of yesterday, so the antennas of tomorrow will be even larger and more powerful. This does not mean, however, that the Owens Valley installation will be outmoded shortly after it is put in operation. As explained by Bruce H. Rule, chief engineer of the project, "We tried to anticipate what scientists will want to use the instruments for in the next 10 years, and we tried to make them accurate and flexible enough to do these things." The new twin telescopes are thus expected to have a long and very useful life.



Rear view of one of two 90-foot radio telescopes installed recently in the Owens Valley, California, by the California Institute of Technology. Money for building the instruments was provided in large part by the Office of Naval Research.

RADM Rawson Bennett, USN, Chief of Naval Research, left, and John G. Bolton, Scientific Director of the California Institute of Technology Radio Observatory. Behind them is a model of one of the 90-foot dishes.



The Navy and Radio Astronomy*

RADM Rawson Bennett
Chief of Naval Research

The potentialities of the California Institute of Technology Radio Observatory (described on the preceding pages) are so promising that they are certain to effect major advances in radio astronomy. Here we have twin 90-foot radio telescopes or, more precisely, a radio interferometer, which can tune in with exceptional sharpness on radio waves sent out by galaxies hundreds of million light years out in space. Radio astronomy is still an infant science carried forward mainly on the shoulders of bold pioneers, such as those who planned and designed the construction of this instrument. These men are steadily pushing ahead, breaking new ground where they have little to guide them except their sound scientific instincts.

The Navy, on its part, is quite willing and happy to back these men in their endeavors. The Navy's interest in radio astronomy is consistent with its traditional association with science. It might be noted that, while it is only in the past year or so that the world in general has begun to give serious consideration to space research, the Navy has been vitally concerned with solving the mysteries of space for more than a hundred years to help us achieve the conquest of the sea.

The Navy's oldest problem, just as it has been for mariners for centuries, is the navigation of ships. From the time that man first began to sail out of sight of the shore line, and long before the invention of the magnetic compass, sailors have relied on the sun and stars for guidance, particularly the pole star. Even the compass was devised simply as a means of finding the location of the pole star when it was not visible in the sky.

It is not surprising that the Navy in 1834 created the first scientific institution in this country devoted to astronomical observations. In 1941 it was officially established by Congress as the U. S. Naval Observatory.

In radio astronomy the Navy has also been a leader. Early in 1951 there was installed at the Naval Research Laboratory, which has won renown as the birthplace of radar, one of the first large, high gain, steerable precision radio telescopes with a 50-foot parabolic antenna. Using this instrument, NRL radio astronomers in 1956 and 1957 detected for the first time microwave radio emissions from Venus, Jupiter, and Mars, and radiation from the Crab nebula. This radio telescope is noted for its combined features of a large reflector area, high precision solid surface, and close steering tolerances. Consequently, it has served as an operating model to which recent designers and builders of large radio telescopes have frequently referred.

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*From a speech delivered at the dedication of the ONR-Cal Tech 90-foot radio-telescope installation in the Owens Valley, California, December 19, 1958.

Nearly a year ago NRL completed the installation of a new radio telescope with an 84-foot parabolic dish. This was then the world's largest equatorially mounted radio telescope, which permits the greatest efficiency in operation, and the largest of any kind in the United States. Now these honors go to Cal Tech, with the Office of Naval Research happy to have helped make this possible.

The size of the antenna is the most generally used factor in rating a radio telescope. In this respect it might appear that the United States is presently well behind Great Britain, which has in operation the famous 250-foot radio telescope at Jodrell Bank. However, this can be deceptive, for size has its limitations. For example, the Jodrell Bank instrument cannot study the sky at wavelengths shorter than 21 centimeters, compared to the Cal Tech installation which will be able to pinpoint radio emanations with great precision down to at least centimeters.

Greater size brings higher gain, which is required to reach out farther into space, but it does not necessarily bring with it higher resolution or greater sensitivity, depending on the frequency of interest. It is extremely important to locate and identify radio sources that have been detected. A weak radio emission might be coming from a far distant galaxy or it might simply be a weak source from our own galaxy.

Sensitivity can be improved by blocking out the background noise, which is the main bugaboo of radio astronomy. It is why we seek isolated sites where at least man-made radio interference can be eliminated. This alone can considerably increase the effectiveness of a comparatively small radio telescope.

The reduction of the noise in the receiver itself can also strikingly increase performance. An approach to a low-noise receiver that is proving successful is the use of the solid state maser or microwave amplifier. The 50-foot reflector at NRL is using experimentally a newly designed maser that uses a synthetic ruby as the amplifier. This has increased its effective range by about ten times. It has enabled this telescope to observe the extremely weak radio waves from other planets, including Venus at the great distance of 75 million miles, and distant galaxies in collision.

Cost is also an important factor in building larger and larger antennas. When you construct a radio telescope twice the size of a previous one, the cost is not merely doubled but increases at least by a factor of four. Further increases in size raise the cost exponentially up to fantastic amounts, with anything approaching 200 feet figured in millions of dollars. At the same time you are creating massive structures. Not only that, but someone has estimated that the tonnage of materials for a modern radio telescope is equal to that of a destroyer. These are the frustrating facts of life that radio astronomers are constantly faced with.

At ONR we take some pride in that we have not stinted in our support of radio astronomy, which is only one small area of our overall research program. Since support of basic research is the principal function of ONR, our main objective in supporting radio astronomy, just as in our other basic research programs, is to enlarge our fundamental knowledge of the mysteries of the universe. From this fount all development blessings, military and civilian, flow. However, as I indicated earlier, we also expect to obtain some practical rewards directly from radio astronomy, and those have started to come in.

For example, until recently all ships at sea depended on celestial navigation with the sextant as the basic instrument. The disadvantage of the optical sextant, however, is that it can only be used when celestial bodies are clearly visible, which creates a problem when you have rain, fog, or snow. Now radio astronomy has given us the radio sextant which tracks radio waves from the sun in all kinds of weather. It works through heavy overcast with an accuracy somewhat better than can be obtained in clear weather with the standard optical sextant. Since the sun is not available at night, it is expected we can develop a radio sextant with improved sensitivity which can obtain a fix on radio stars or extra-terrestrial radio sources 24 hours a day under overcast skies. The radio sextant, incidentally, can be used beyond both the northern and southern arctic circles where magnetic compasses are ineffective.

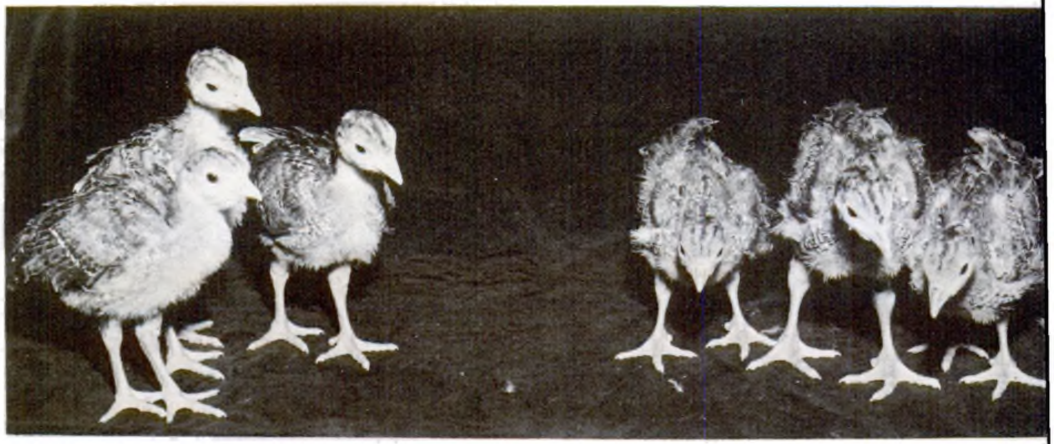
Radio astronomy is also helping to solve problems in communications. Research in this area has investigated the ionosphere and how it is affected by sonar flares to produce radio blackouts. As a result, we can now predict in advance the geomagnetic storms that disrupt radio communications throughout the world for as much as several days.

The story of radio astronomy is just beginning. The latest and largest radio telescopes we have today are still primitive instruments for exploring the radio universe. The radio telescope has so far picked up signals 300 million light years away as compared to the range of two billion light years for the 200-inch Mount Palomar telescope.

On the other hand, radio astronomy has opened a new window for man to look out into space, a window that is many times wider than that available to an optical telescope. It is the radio telescope that will in the not too distant future take us to the very edge of the universe, and eventually—if Einstein's theory of the curvature of the universe is correct—back around to our own world as it existed millions or billions of years ago.

The future for the radio telescope is both awesome and exhilarating, and the Bishop installation, which will begin operations next month, will play a prominent part in it. In Owens Valley we will see historic progress made in radio astronomy. It is a prospect that all of us—in the Navy, in the scientific community, and the plain lay citizen—can look forward to with eagerness and anticipation.

Who will be the first human to orbit the earth? According to NASA, he will be a naval aviator, very possibly, with a minimum of 1,500 hours flight time, a university graduate, younger than 40, not taller than 5 feet 11 inches, and he will possess the physical and psychological attributes suited for space flight as determined by top aero-medical scientists.

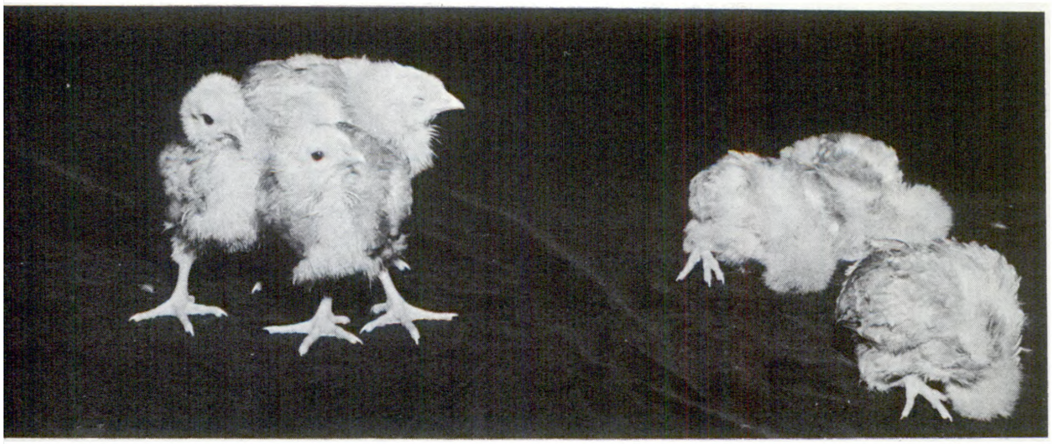


A rather typical postural change resulting from centrifugation is the duck-like stance of the turkey poults at right (photographed at normal gravity shortly after seven days exposure to an acceleration force 1-1/2 times that of normal gravity). A normal posture, such as that of the three control birds at left, is resumed after a few days at normal gravity.

Physiological Effects of Artificial Changes in Weight

Weight is not quite as simple a phenomenon as the pointer on the bathroom scales would lead one to believe. When one steps up on the scales, he is given information about only one aspect of weight—how it is affected by natural changes in body mass. But as weight is the product of the mass of an object and the accelerative force field (gravity) in which it exists, changes in gravity will also produce changes in weight. Of course, as long as man remains on the surface of the earth, gravity is about constant and its effects can be ignored. But as is becoming increasingly evident these days, man is not content to remain earthbound. He now roams the skies at very high speeds and altitudes and is even contemplating journeys into space. Thus, the exposure of man to large changes in gravity is becoming a real possibility. As these changes can be very great—ranging from many-fold increases in weight to virtual weightlessness—their effects are becoming an important topic of study.

Man began to show concern for the effects of acceleration stress at about the time the first trains and automobiles were being built. The question arose then as to whether the velocities that might be attained (perhaps as "high" as 20 miles per hour) would have adverse effects on passengers. It was soon realized, however, that velocity itself has little effect. This is indicated by the fact that man functions as well at the earth's equator as he does at the poles, even though the earth's rotation causes him to move at a speed of more than 17 miles per second at the equator. When the airplane was introduced, however, an important new element—maneuverability—entered the picture. Changes in the direction of motion combined with high speed exposed man to significant centrifugal forces. The effects of these forces were first recognized about 1921 when aviators complained that their vision dimmed while they raced



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Disorientation observed in a group of New Hampshire chicks (right) shortly after seven days exposure to an acceleration force 1-1/2 times that of normal gravity. The chicks put their heads between their feet and either walked backward or somersaulted forward. A normal posture, such as that of the three control birds at left, was resumed after about a day at normal gravity.

around pylons. Since that time, man entered the space age and thus has begun to feel some apprehension about the phenomenon of weightlessness, also. This condition will exist when the accelerative force of gravity is eliminated, as aboard space ships traveling at considerable distances from the earth.

The study of artificial changes in weight may also be important in another way. Because gravity is about constant at the surface of the earth, natural weight is not ordinarily thought of as playing an important role, physiologically. However, a great many biological phenomena would appear to be weight-related, since they are generally evaluated per unit weight. Obviously, many such things are only mass related, and the weight relationship is merely coincidental. But some things—for example, the contribution of striated muscular tonus to the metabolic rate, and the physiology of joints and other structural elements—actually may be affected by the body weight. Thus, the study of artificial changes in weight offers an opportunity to determine these and other weight-altered physiological parameters.

As the problems posed by artificial changes in weight are such critical ones, it will be well to consider what physiological effects they will have and what is being done to understand them better. Let's look, in turn, at each of the two directions of change.

ACCELERATION STRESS

Since the outbreak of World War II, many human centrifuges have been built and operated and a large amount of information gathered on the effects of acute acceleration. Thus, we can now describe rather thoroughly what happens to man when he undergoes these stresses.

Centrifugation stress affects, principally, the circulatory system. Since the densities of body fluids increase in proportion to the accelerative force, the hydrostatic pressure in the vascular system increases, making it necessary for the heart to work harder to maintain normal circulation. This strain may become quite severe; for example, under an accelerative force six times as great as that of normal gravity, the heart must pump a fluid having the normal density of iron. Thus, the head, being at the top of the vascular column in normal postures, may receive so little blood that "blackout" (from anemia of the retina) and loss of consciousness will occur. In the lower extremities, on the other hand, fluids will tend to be forced into the tissues.

High acceleration also increases the weight of the limbs, making it difficult or impossible to move them. In addition, considerable changes may occur in the tonus of muscles and in the postural reflexes. Since the majority of the body's heat is produced by skeletal muscle, this would lead to an increased metabolic rate. Other metabolic changes that may occur as the result of acceleration stress concern the absorption of phosphate from the peritoneal cavity and carbohydrate metabolism.

The physiological effects of acceleration stress may be modified by several factors. Perhaps the most obvious of these are intensity of acceleration and time of exposure. Another is the direction of the acceleration force; since most animals are asymmetric, the effect of hydrostatic pressure on the circulation will be greater when the accelerative force is applied along the major axis of the body. Of course, by changing posture, one can regulate this effect to some degree. Quadrupeds, in which the force of gravity is perpendicular to the major axis, appear to be more susceptible to the effects of acceleration than bipeds,

The Forces Responsible for Weight

The accelerative force—gravitation—is one of the basic properties of matter, yet our understanding of it has changed little since 1590, when Galileo dropped objects of different sizes from the Leaning Tower of Pisa. Galileo demonstrated that the effect of gravity is independent of the nature of an object, thus correcting the erroneous idea prevalent since the time of Aristotle (about 350 B.C.)—that the rate of fall of an object is proportionate to its size.

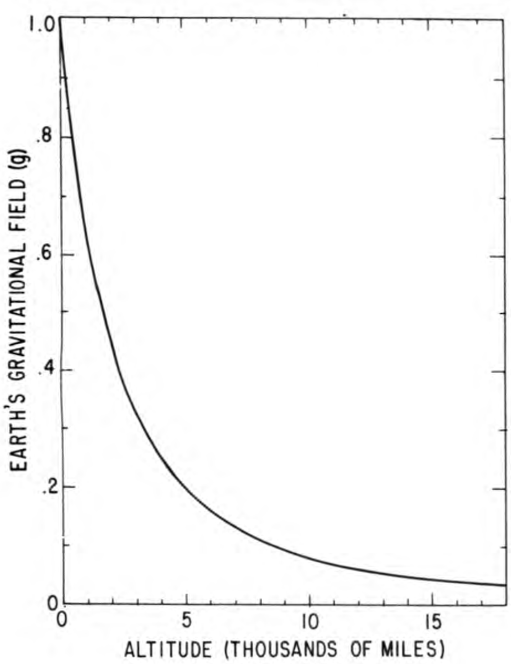
About 1670, Newton developed the Law of Universal Gravitation: "Each particle attracts every other particle in the Universe, the force being proportional to the product of the masses, and inversely proportional to the square of the distance between them." Thus, we see that as the distance between two bodies increases, the attractive force between them decreases exponentially. At different distances from the surface of the earth, the strength of this force (in terms of its strength at the surface of the earth, given as 1.0) is as indicated on the facing page.

There are other accelerative forces which have the same effect in which the force of gravity is parallel to the major axis. There also appears to be a considerable scale effect, the acceleration stress being somewhat proportional to body size. In addition, there is probably a tremendous individual variation, both within and between species.

WEIGHTLESSNESS

At present, we don't know a great deal about the implications of weightlessness. The reason we don't is that there is no known way to limit or interfere with the gravitational field to enable us to study this condition. Of course, when the accelerative force is not resisted (as in a free fall) a weightless condition exists, but only for a very brief time. Nevertheless, studies of weightlessness have been carried out under such conditions. For example, investigations have been made of man and animals in aircraft flying a ballistic trajectory; however, the periods of observation have been limited to less than a minute. Observations of longer duration (2 to 3 minutes) have been made on mice and monkeys in a missile under free fall. No significant physiological changes have been noted under these conditions, but the reason for this may be simply that longer exposure is required before changes occur.

Obviously, the next step to be taken toward a full understanding of the effects of weightlessness is to create or effectively simulate a subgravity environment that will exist for a relatively long period of time. The most likely way of doing this, without venturing into wide-open space, is to put an object in a circular path about the earth with a velocity such that the centrifugal force balances the gravitational pull. Naturally, if this satellite is weightless, any animal it carries would be weightless, also. The only drawbacks here are the difficulty and expense involved in successfully launching satellites and the inaccessibility of the vehicles once they have been put in orbit. These are so great, it is not likely that satellites can be used for routine biological experiments in the near future.

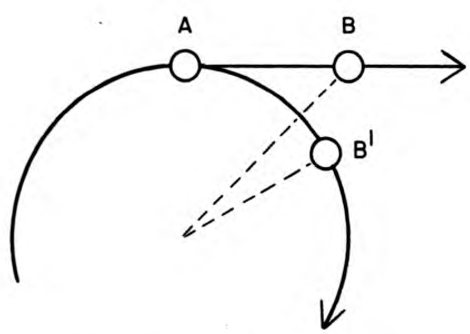


as gravity in that they also lead to the phenomenon of weight; for example, changes in rate of motion (linear acceleration) and direction of motion. The effect of change in direction of motion can be appreciated by considering a body moving at a uniform rate in a circular path, as shown in the diagram on the next page. If the body (A) is released from its circular path, it will proceed at the same velocity in a straight line tangential to its point of release. Shortly after being released, it will be located at point B, instead of point B', its position if restrained to circular movement. Thus, if the body is restrained to the circular path, it will deviate continually from its free path. According to Newton's first law of motion, "a body at rest or in uniform motion will tend to remain in

Another way of approaching this problem is to adapt animals to an accelerative force higher than that of normal gravity, then observe the changes that occur when they are returned to normal gravity. In other words, the effects of the return of acceleration-adapted animals to normal gravity might be comparable to the effects of the change from normal gravity to sub-gravity. This possibility is indicated by the fact that organisms subjected to a variety of unusual environments are often capable of changing in such a way that they become more or less normal in these environments. For example, when man is suddenly exposed to high altitude, his heart races, his blood pressure rises, he pants, his head aches—in fact, he becomes quite ill. But after a few days' exposure, these effects disappear and he feels about normal. If animals exposed to acceleration stress can adapt similarly, the effects of their return to normal gravity might be indicative of the effects of change from normal gravity to sub-gravity. Therefore, by studying these effects we may be able to predict how man will be affected by significant decreases in weight.

THE CENTRIFUGE

To examine the physiological effects of artificial changes in weight, a series of long-term animal acceleration studies was begun in 1956 at the University of California at Davis under the sponsorship of the Office of Naval Research. The first objective was to find out how animals adapt to acceleration stress. Later, the effects of returning acceleration-adapted animals to normal gravity were to be examined. Chickens and other domestic fowl were chosen for the first experiments, mainly because they are bipeds and, therefore, posturally similar to man. It was decided to start the experiments with young birds so that their growth under the accelerative force could be studied. Growth under these conditions was expected to result in considerable structural modification that would enhance adaptation.



that condition until acted upon by an outside force." The force required to keep the object in the circular path is called the centripetal force. The force with which the object tends to assume a free path, and which, increases the weight of the object, is called the centrifugal force. The centrifugal force is a function of the square of the velocity of the object and the radius of its rotation.

The device with which the authors conducted their studies of artificial changes of weight (see illustrations on pages 22 and 23) uses centrifugation to develop accelerative forces. The convenience of this method is apparent when one compares it with linear acceleration. To sustain an accelerative force 2.5 times that of normal gravity for 154 days at the earth's surface, a linear accelerator would have to travel 1.4×10^{12} miles and would have to attain the speed of light. On the other hand, a centrifuge of 6-foot radius could produce this force for the same period of time by traveling only 55,000 miles at only 15 miles per hour.

The device utilized for the studies was an animal centrifuge capable of long-term operation, specially constructed at the University. In one trial it operated continuously for six months at an acceleration force 2-1/2 times that of normal gravity with the exception of a few minutes a day required for animal care. The birds were kept in four oblong cages which were arranged for a normal husbandry.

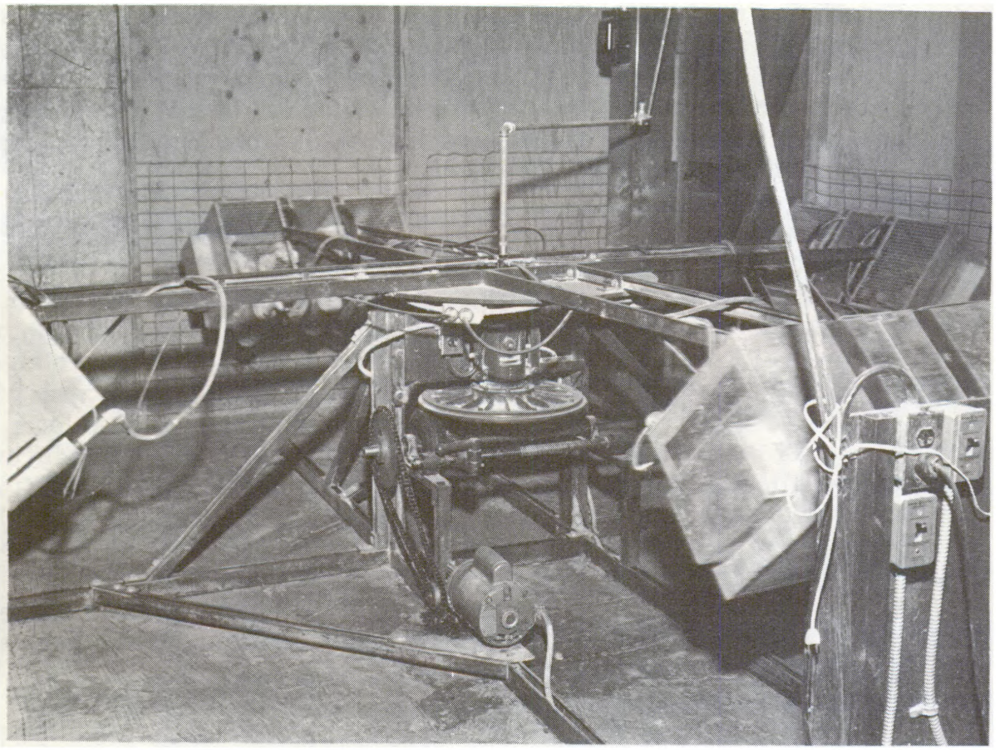
So far, two types of experiments have been conducted. One type was carried out for a relatively short period (60 days) at high acceleration (up to 4 times normal gravity); and the other for a relatively long period (6 months) at low acceleration (2.5 times normal gravity). Both were followed by post-centrifugation observation periods. The high-acceleration studies were made to determine the limit of tolerance of the animals and to develop an acceleration-resistant strain. The latter objective was to be attained by repeatedly exposing selected birds to high acceleration. This procedure (worked out in collaboration with Dr. Hans Abplanalp, geneticist in the Department of Poultry Husbandry) was followed on the assumption that many of the features believed to be required for adaptation to acceleration would be concentrated in individuals, thus facilitating their identification. Furthermore, since these birds could withstand greater acceleration, post-centrifugation changes were expected to be more apparent.

In order to analyze the causes of physiological changes observed during and after centrifugation, it would be necessary to prepare two sets of control birds, each matching one of the two principal effects of centrifugation: increased density of body fluids and increased work involved in normal locomotion. Thus, in addition to the normal controls, one would have to select a group of birds subjected to repeated exercise (as, for example, by use of a treadmill).

EFFECTS OF CENTRIFUGATION

Among the many ways in which the experimental birds were affected by chronic acceleration stress, perhaps the most obvious was repression of growth (body mass). After six months' exposure to the lower acceleration (2-1/2 times that of normal gravity) these birds were 40 to 50 percent lighter under normal gravity than the control birds. However, the birds regained most of this lost mass after they were returned to normal gravity. Another point of difference between the experimental birds and the controls was the time taken to attain sexual maturity, the experimental birds being about 37 days behind. However, this tardiness did not lead to other differences in reproduction characteristics, such as egg size and laying rate. As a matter of fact, birds exposed to the lower acceleration for as long as six months actually layed eggs (somewhat flattened) in the centrifuge.

Centrifugation also had an effect on the growth of hearts and livers, those of the experimental animals being smaller (relative to body size) than those of the controls. Leg weight, on the other hand, increased (relative to body weight). In addition, the heart rate increased, and respiratory frequency decreased. The latter two changes were reversed, however, when the experimental animals were returned to normal gravity.



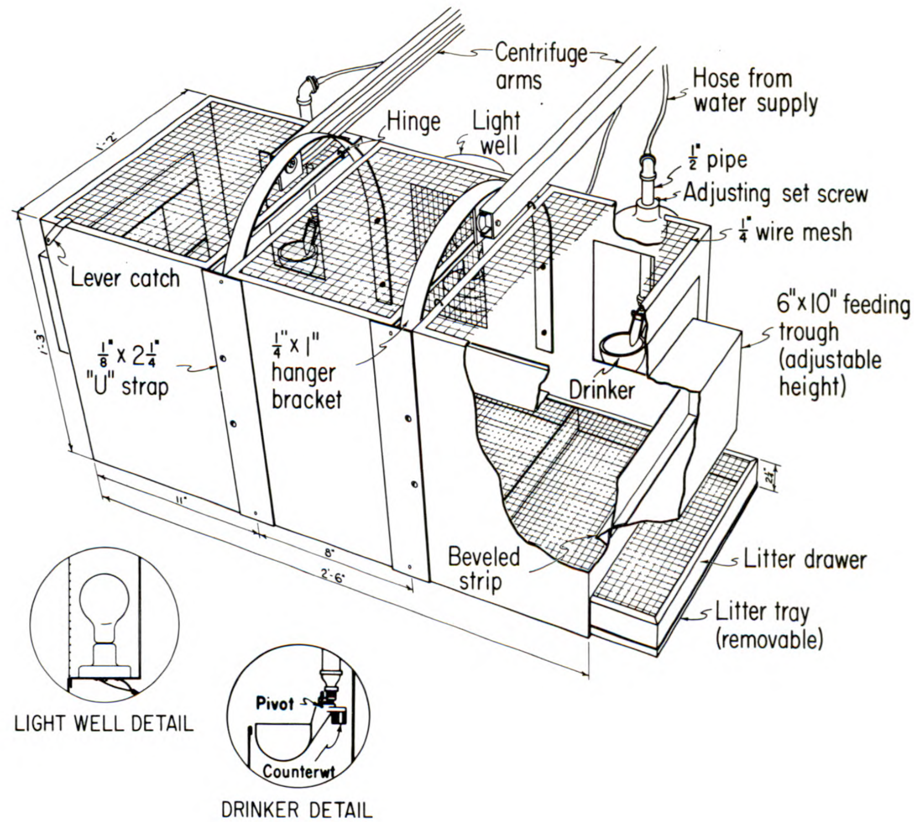
The animal centrifuge, shown in operation at an acceleration force 1-1/2 times that of normal gravity (about 25 rpm). Power is furnished by an electric motor and transferred to the centrifuge by means of a vertical wheel (with rubber tire) and horizontal friction disc. The radius of contact of the wheel on the disc can be adjusted to control the rotation rate.

Apparent neurological defects were observed, too. For example, almost all experimental birds assumed a ducklike posture upon being removed from the centrifuge (see photograph on page 16). Many of them were unable to orient themselves properly or were incapable of doing so. As shown in the photograph on page 17, some birds put their heads between their feet and somersaulted repeatedly. Curiously, these birds appeared quite normal while in the centrifuge and after a 24-hour period following their removal from the centrifuge. The nature and cause of these disturbances are now under investigation.

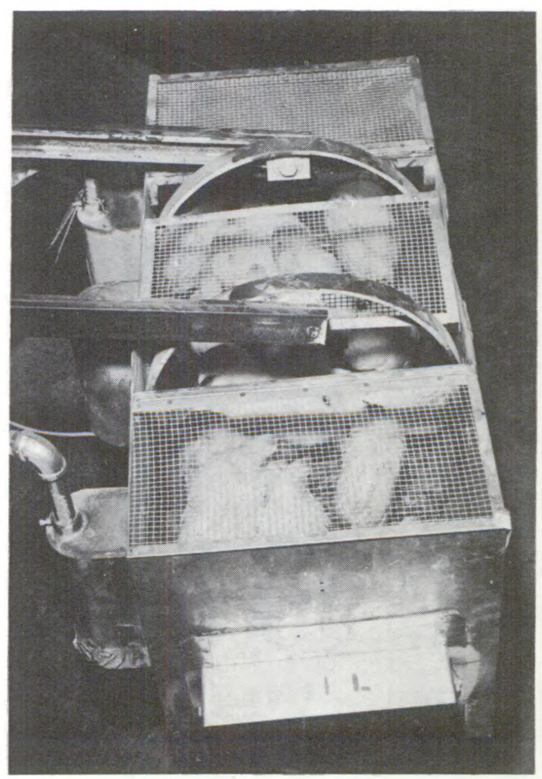
One further outcome was that many of the birds died during centrifugation. As was to be expected, the toll of lives was higher at the higher accelerations. Although all of the dead birds were examined by Dr. Livio Raggi, avian pathologist in the School of Veterinary Medicine, no consistent causes of death were established. Most of these birds died soon after they were exposed to centrifugation or after an increase in acceleration. In a steady environment, the birds appeared to adapt rapidly. No deaths occurred when the birds were returned to normal gravity after prolonged centrifugation.

EVALUATION

That our experiments have shed light on the effects of acceleration stress is clear from the preceding paragraphs. But what can be said



Animal cages, shown above and at right, are mounted, free-swinging, at the ends of radial arms so that when the centrifuge is in operation the accelerative force is perpendicular to the floor, thereby simulating gravity. The cages are oblong to minimize air resistance and to reduce the difference in radius of rotation for opposite sides of each cage. Fresh water is supplied continuously; however, it is necessary to interrupt operation for two to three minutes daily to supply feed and clean the cages.



for our attempts to simulate sub-gravity conditions and study the effects they have on experimental birds? The value of these experiments will depend on whether or not the acceleration of normal gravity is critical. If normal gravity is merely a point on a spectrum of acceleration forces from zero to the limit of biological tolerance, it should be possible to predict (by extrapolation) the physiological effects of weightlessness.

Few, if any, post-centrifugal physiological changes have been noted during the first two hours after birds were returned to normal gravity. However, some rather significant changes, for the most part reversals of those occurring as a result of centrifugation, have been noted up to 24 hours thereafter. A comparison of the results of post-centrifugation studies with some of the observations made on animals actually exposed to sub-gravity should clarify the relationship between these experimental procedures.

Our experiments with prolonged centrifugation have not been carried out to an extent that permits us to make reliable descriptions of the adaptation of animals to acceleration stress and of post-centrifugal changes that might occur. However, the general procedure seems promising. It is hoped, therefore, that our knowledge concerning the physiological effects of artificial changes in weight, and perhaps of natural changes in weight, will be increased with further work on the centrifuge.

Third Navy Science Symposium

The increasing importance of materials in the age of space travel, nuclear submarines, and intercontinental ballistic missiles was highlighted at the Third Navy Science Symposium, held at the Benjamin Franklin Hotel, Philadelphia, March 17 to 19. The symposia are sponsored by the Office of Naval Research.

The many papers presented at the meeting touched on such problems as how to combat tiny microbes which degrade high-powered aviation fuels and cause failures in electronic equipment, as well as material problems in the development of submarines capable of descending to great ocean depths. The papers also reported on various approaches to the problem of developing materials strong enough to withstand the strain of high speeds and high temperatures in both aircraft and weapons, new fabrics for airship design, and new methods to camouflage missiles. Still other discussions concerned the development of improved aircrew safety and survival equipment and the new use of an old material--metal foil--in rocket motors.

The participants included representatives of Navy laboratories, Navy contractor-operated laboratories, and other major government laboratories. The objective of the symposium was not only to acquaint those attending with materials research and development, but also to provide an opportunity for informal interchange of information.

Combating the Effects of Burn Toxin

A. R. Dawe
Chief Scientist
Chicago Branch Office
Office of Naval Research

On December 1, 1958, a fire of undetermined origin raced through a large parochial grade school (Our Lady of the Angels) in Chicago. Within a matter of minutes almost 100 children died and another 100 were terribly burned or injured. Many children were injured after leaping from second story windows. A few minutes later, St. Anne's Hospital admitted some 50 badly injured children via the Emergency Room. The remainder were hospitalized at Garfield Memorial, Franklin Boulevard, Walther Memorial, and Norwegian American Hospitals.

What transpired at St. Anne's from that moment on is an inspiring record of enlightened self-sufficiency on the part of the staff of one hospital, and by other individuals who sought by all means known to assist in relieving the pain and anguish which was rapidly multiplying across the city of Chicago. Furthermore, those who have witnessed the etiology of the disaster have been struck by the immense efforts which have been made across the nation in schools and school systems to forestall a repetition of this particular kind of catastrophy. Many fire-prevention systems and fire laws in the schools of America have been "redone" or reevaluated as a consequence of Our Lady of the Angels fire.

It is of interest to those who watch the unfolding of research in the Armed Services that investigators who had been studying burn therapy visited St. Anne's at the invitation of the hospital staff and were afforded the opportunity to observe the management of the burn casualties. Dr. Sol Roy Rosenthal of Chicago and Dr. Truman Blocker of Galveston represented the Navy. Lt. Col. Edward H. Vogel and Lt. Col. Wilford T. Tumbush of the Brooke Army Medical Center discussed with the hospital staff their experiences in burn management. All observers agreed that the patients were receiving the best possible care.

The facilities of Naval Medical Research Unit No. 4 at Great Lakes, under the command of CDR Lloyd Miller, were made available to the hospital staff, and a Navy medical officer was assigned to the hospital. (The assistance provided was recently acknowledged in a letter from Sister Mary Almunda, P.H.J.C., the very capable Administrator of the hospital, to RADM Bartholomew Hogan, MC, USN, Surgeon General of the Navy.)

At Dr. Rosenthal's suggestion, and in cooperation with the Bureau of Medicine and Surgery of the Navy, the most severely burned children received transfusions of blood from individuals who had recovered from severe burns.

Dr. Rosenthal believes the rationale behind this therapeutic point of view to be as follows: a severe burn (perhaps all severe injuries) results in a release of toxic (antigenic) material into the blood stream.

His face drawn with horror, a fireman carries an unconscious boy from Our Lady of the Angels School, Chicago, after the building was swept by fire last December 1. United Press International Photo.

This toxic material is injurious to the remote tissues of the body. The badly burned individual produces antibodies slowly, often too slowly to combat the effects of the toxin on the blood and on blood vessels. Such an individual may succumb to the toxic effects of a burn whether or not he is very severely burned. To combat this threat to the satisfactory progress of the patient, blood taken from individuals who have recently recovered after being badly burned is considered to be useful, since it is high in antibodies against the toxin. While other theories to explain the efficacy of the transfusions from previously burned patients have been advanced, there seems to be a growing agreement among authorities that such therapy is valuable and indeed may be lifesaving regardless of its mode of action.

Such blood was sought out for transfusions. A very small supply of this properly matched "convalescent blood" was obtained from victims of severe burns who had subsequently recovered. It is obvious that there are few such donors. When it became apparent that insufficient amounts of this type of blood were available in the Chicago area, the Navy Bureau of Medicine and Surgery took steps to obtain it in the Washington area from volunteer donors. Some was collected at the National Naval Medical Center, and an additional amount was collected at blood donor centers of the American Red Cross and flown to Chicago. Considering how difficult it was to obtain the supply needed, this blood might be called "liquid gold." The results of these transfusions are now being studied. Preliminary investigations made at NMRU-4 are encouraging. One of the first reports to the scientific world will be made by Drs. Rosenthal, Hartney, Miller, and Rosenbaum and colleagues at the International Physiological Congress at Buenos Aires this coming August.

Dr. Rosenthal speculates on a future for this therapy as follows: He feels that blood banks should be set up for processing and storing this type of blood, and that research should proceed as quickly as possible to confirm his theories. If the theories are sound, it may be possible to prepare a vaccination from burn toxin which can be administered to generate natural immunity.

Editor's Note: Dr. Dawe has omitted reference to the important part played by the Chicago Branch Office of ONR in the dramatic events described in his article. It should be noted that the request for cooperation of physicians and scientists in treating the children burned in Our Lady of the Angels fire was responded to promptly by CAPT Carr, Commanding Officer, and Dr. A. R. Dawe, Chief Scientist, of the Branch Office. On their recommendation, Dr. Rosenthal was invited to report on his work on burn toxin, and at the urging of Dr. Dawe and CAPT Carr, he volunteered his services in the treatment of victims. Dr. Dawe was in daily contact with Dr. Rosenthal and the director of St. Anne's Hospital during the critical period when this work was started. Also instrumental in making the program at St. Anne's possible were Dr. R. D. Reid and CAPT T. K. Ruebush of the Biological Sciences Division of ONR.

Research Notes

New Catalogue of Galaxies

At the California Institute of Technology a group of astronomers headed by Professor Fritz Zwicky is preparing a monumental new catalogue of galaxies. This work is urgently needed by astronomers because they are still using the "New General Catalogue" (NGC) which was compiled by the British astronomer Dreyer more than 70 years ago, before the days of stellar photography! Even though several "Index Catalogues" were added to it later, the time has come to bring the subject up to date.

The new Cal Tech catalogue will satisfy this requirement for it is based on new photographic observations with the 18-inch and 48-inch Schmidt telescopes on Palomar Mountain. The catalogue will tabulate the position and brightness of about 40,000 individual galaxies down to a certain minimum brightness (magnitude 15.5), and these galaxies will also be plotted on charts. This part of the work will be based on a special series of photographs obtained with the 18-inch Schmidt, which will provide for the first time a reliable photometry of these galaxies.

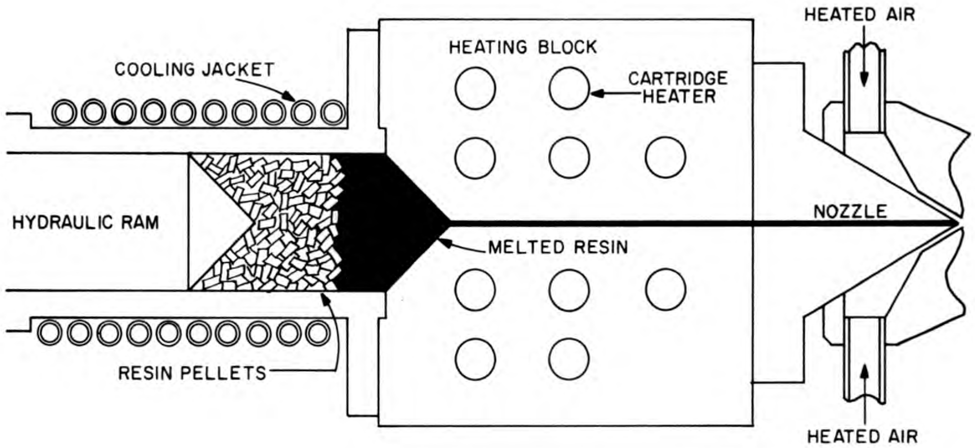
The fainter (more distant) galaxies down to magnitude 19 are too numerous to be listed or plotted individually but, inasmuch as they tend to cluster, the boundaries of these clusters will be outlined on the charts. Only the richer clusters, having more than 50 member galaxies, will be so plotted. It is estimated that about 10,000 such clusters have been located. This part of the work will use the beautiful photographs obtained with the 48-inch Schmidt, largest in the world, from which the famed Palomar Sky Atlas was reproduced and distributed to observatories.

The Cal Tech astronomers have worked for ten years on this huge project which has been partly supported by an ONR contract. The catalogue will consist of five volumes, the first of which will be published this spring. When completed it will provide the material for many studies of the large-scale distribution of matter in the universe.

—ONR Branch Office, Pasadena

Superfine Plastic Fibers

Thermoplastic fibers one hundredth the diameter of human hair are being used in the Naval Research Laboratory's aerosol filter research program. The equipment for producing the fibers uses an extrusion process in which a hot melt of thermoplastic material is forced through a row of fine orifices into two converging high-velocity streams of heated air. As the melt leaves the orifices, it is stretched to submicron diameters by the air stream and deposited on a moving screen in a random mesh. Submicron fibers have been produced successfully from polyamides, polyesters, silicone resins, and other types of thermoplastic materials.



Schematic drawing illustrating the process and equipment (injection cylinder, heating block, and nozzle) utilized in the production of superfine plastic fibers.

The equipment used to produce these fibers was developed at NRL in 1954. Since that time, however, it has been improved in several ways. As a result, extended runs now yield successive spools of fiber with essentially identical characteristics, marked improvements in physical appearance (edge definition is excellent), and smoother laydown of fiber on the collecting screen.

The development of means to produce submicron plastic fibers, coupled with another NRL capability—the generation and measurement of fine aerosols—puts the Laboratory in a unique position in the study of fundamental filtration processes.

Isolating the Mind from the Senses

In an article which appeared in Research Reviews a year ago ("Sensory Deprivation and the Human Mind," April 1958), Dr. Philip Solomon of the Harvard Medical School and Boston City College, described some experiments he directed to determine if the human mind must be in continual contact with the world around it to think successfully. The investigation, supported in part by the Office of Naval Research, was undertaken when it was noticed that patients with poliomyelitis, who had been put in respirators because of paralysis of their breathing muscles, often developed transient mental abnormalities. It was supposed that the disturbances were due to the disease. But when this supposition was tested by placing normal subjects in "iron lungs" and depriving them of the use of various senses, they, too, showed anxiety, and were beset by illusions and phantasies.

The data derived from this work are now under study, special attention being given to "TAT" tests, in which stories are made up by the subjects to fit illustrations (thus revealing preoccupations) and to psychiatric interviews in relation to the behavior exhibited by the subjects while they were in the respirators. At the same time, several other experiments involving the sensory-deprivation technique are going forward under Dr. Solomon's supervision.

One of these experiments concerns the effects of partial mitigation of sensory isolation. The investigators, Dr. William F. McClure and Mr. John Davis (a graduate student from Princeton University) are studying, particularly, the effects of changes in illumination and of companionship (presence of another subject in a respirator nearby, or of the subject's wife, conversation being permitted).

Another study has to do with the effects of sensory isolation on chronic alcoholics who have experienced delirium tremens. The aim of this work, under the immediate direction of Dr. Esther Davidson, is to determine if the isolation procedure will give rise to hallucinations like those associated with "D.T.'s." Nine subjects have been studied. The technique utilized is as follows: The subjects lie on a bed in a relatively sound-free cubicle, with black goggles over their eyes and plugs in their ears. To minimize tactile sensations, they wear foam-rubber suits over silk pajamas. While in this situation, they are subjected to several standard mental tests.

A third study being made—this one by Dr. Philip Kubansky—deals with the effects of sensory deprivation on mental processes, with special regard to creativity. The subjects—a group of Harvard undergraduates who are paid for their services—recline in very comfortable chairs, their eyes covered with halves of translucent ping-pong balls and their arms enclosed in long cardboard "cuffs." All they hear is a background humming noise. While so shielded from the world around them, they are scored on the organization, vividness, intensity, and complexity of the phantasies they report. Their rate of pay is graduated accordingly.

A fourth study, directed by Dr. Jack Mendelson, is being made of a group of Harvard students subject to either congenital or acquired deafness. The thought processes in their dreams will be compared with those of non-deaf students who have submitted to sensory deprivation.

—ONR Branch Office, Boston.

New Aids to Ship Navigation

SINS

As nuclear submarines, POLARIS missiles, and missile-testing ships, such as OBSERVATION ISLAND, become more and more prevalent in the Navy, we will read more about SINS, a revolutionary new navigational device. SINS, an abbreviation for Ship's Inertial Navigation System, provides information on ship's position without the use of celestial or man-made aids to navigation. It does this by taking advantage of three natural phenomena—the earth's rotation, gravity, and the inertia of a physical mass.

Just as the driver of an automobile "senses" the displacement of his body as he drives around a bend in the road or speeds over the brink of a hill, so SINS is equipped with components which sense acceleration changes relative to the Earth's rotation. The sensing element is an accelerometer (basically, a pendulum). Inertia tends to maintain the pendulum motionless. Ship's motion, however, displaces the pendulum, and the difference between this displacement and the displacement of the pendulum's pivot point is detected and converted to navigational units which are used to continually correct ship's position.

Actually, two accelerometers are used in SINS; one is oriented north-south and the other east-west. This orientation is maintained by means of gyroscopes. In this way, the undesirable effects of gravity on the test mass are eliminated.

SINS is rapidly being perfected through actual use in the job of pinpointing the positions of ships and missiles of the Navy. In addition to currently being installed in OBSERVATION ISLAND and COMPASS ISLAND, SINS will be an integral part of the Navy's new POLARIS fleet ballistic missile submarines. The first of these submarines is scheduled to be launched in May of this year.

RADIO SEXTANT

A new radio sextent which uses weak radio waves from the moon to establish a navigational fix has recently been installed aboard the Navy's experimental ship COMPASS ISLAND. Designed and built by the Collins Radio Company of Cedar Rapids, Iowa, the new sextant is considered a major breakthrough in navigational systems. The company has said that the radio sextant functions as a precise compass, furnishing the direction of north with more than ten times the accuracy of present marine compasses.

The conventional sextant is an instrument for measuring angular distances to the sun and stars, used especially at sea to observe altitudes to ascertain latitude and longitude. Under overcast conditions, however, the conventional sextant is useless.

The radio sextant relies on a five-foot parabolic dish antenna to pick up the moon's signals. The sextant receiver used in the system is said to be the most sensitive receiver of its type ever constructed. The receiver recognizes the slightest changes in the signals from the moon and so follows the moon's path across the sky.

After the sextant is installed in ships, special precautions will have to be taken to insure that constant variables are maintained, such as temperature and stability. A special pitch-and-roll platform has been designed by Norden Division of United Aircraft Corporation to stabilize the instrument in heavy seas.

On The Naval Research Reserve

Naval Leadership

The Naval Leadership Program was launched by the Secretary of the Navy through General Order 21. The objective of this program has been clearly stated: To reemphasize and revitalize Naval leadership in all its aspects: inspirational, technical, and moral.

With the promulgation of this order the Secretary expressed his grave concern over the breakdowns in manpower which are resulting from disciplinary problems. He said in part:

> "We care very much and worry constantly about the greatest of all our resources—our people. And we see ahead a break-through in human research and development that is more far-reaching in importance than our great achievements in nuclear, electronic, missile, and space technology. This deals with man himself. Like the nation, we have been plagued by breakdowns in manpower upon which we must depend. The services are a cross section of our country, and we inherit some of the juvenile delinquency, cynical attitudes, greed, laziness, and even open crime that have eaten into parts of our Nation.
>
> "We are facing these problems and finding solutions. We have an operations plan—'an active program'. It may well do more for the services and for America than any other possible development."

The "active program" was outlined by the Chief of Naval Personnel in BuPers Instruction 1000.14, which was given wide distribution within the Navy. (The distribution included Research Reserve companies.) It consists of continuing action on the part of the Chief of Naval Personnel and direction of appropriate action on the part of various commands to carry out fully the intent of General Order 21.

Leadership field teams to assist the various commanders and individual commands in their leadership training programs have recently been established by the Chief of Naval Personnel. These teams present techniques and procedures as well as make presentations on the subject of Naval leadership. The teams, which consist of one line officer and one chief petty officer, are located at the three following places: San Diego, California; Norfolk, Virginia; and Great Lakes, Illinois. Information on the availability of these teams to give presentations should be requested from the local District commandant.

Leadership training guidance is also provided by the Chief of Naval Personnel. This help includes discussions on effective Naval leadership as well as guidelines for heads of departments, division officers, and petty officers in carrying out this important program. The following publications are considered to be of particular interest and value to Research Reserve companies:

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 501876

Effective Naval Leadership, A Message to Commanding Officers from the Chief of Naval Personnel	NavPers 15913
Effective Naval Leadership and the Code of Conduct	NavPers 15922

It has been noted that various civilian communities are also applying the concepts that are stressed in the Naval Leadership Program with satisfying results. As a part of these communities, as well as a part of the Naval Reserve, Research Reservists are encouraged to become familiar with this revitalized leadership movement and to support it actively in order that, in Secretary Gates' words, "Our fighting men can rise to moral greatness in peace as in war . . . in that greatness lies our strength."

Research Reservists Invited to Participate in Science Cruiser Program

As part of the Science Cruiser Program, which was initiated last year, a contest will again be conducted for high school boys who present exhibits of science projects of Navy interest. Research Reservists, particularly, are encouraged to assist in judging science projects at local, state, and regional fairs. In addition to rendering a service to the Navy by this participation, appropriate duty credit is usually given by the Commandant.

The Science Cruiser Program is designed to help stimulate interest in Navy research projects and science education. The winners of the contest are, very appropriately, taken on a week's cruise on board Navy ships.

Grant Awarded to Research Reservist

LCDR W. G. Leavitt, USNR, a member of Naval Reserve Research Company 9-22, Lincoln, Nebraska, has been awarded a combined grant by the National Science Foundation and the University of Nebraska Research Foundation. Dr. Leavitt, who is Professor and Chairman of the University of Nebraska Mathematics Department, will be on leave from the University of Nebraska during the 1959-60 academic year, when he will devote his time to study at Princeton University and the Institute for Advanced Study in Princeton, N. J. He will carry on a program of advanced study and research in abstract algebra, particularly in Ring Theory and the Theory of Modules. Professor Leavitt has published a number of papers in these areas, his most recent work being on the problem of dimensionality for modules over arbitrary rings.

In connection with the Navy's observance of the first anniversary of the successful launching of VANGUARD I, on March 16, the Naval Research Laboratory presented a working model of the 6-inch VANGUARD satellite to the Smithsonian Institute. On the preceding day, Dr. John P. Hagen, Director of Project VANGUARD, was presented the Distinguished Public Service Award by Thomas S. Gates, Secretary of the Navy.

IN THIS ISSUE

NAVAL RESEARCH reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. The magazine is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: $1.50 per year in U. S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. Changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. Use of funds for printing this publication was approved by the Director of the Bureau of the Budget, February 12, 1958.

Is this weapon system combat-ready? The explosion of a depth charge off the stern of the destroyer escort USS PHILIP. See article beginning on page 1.