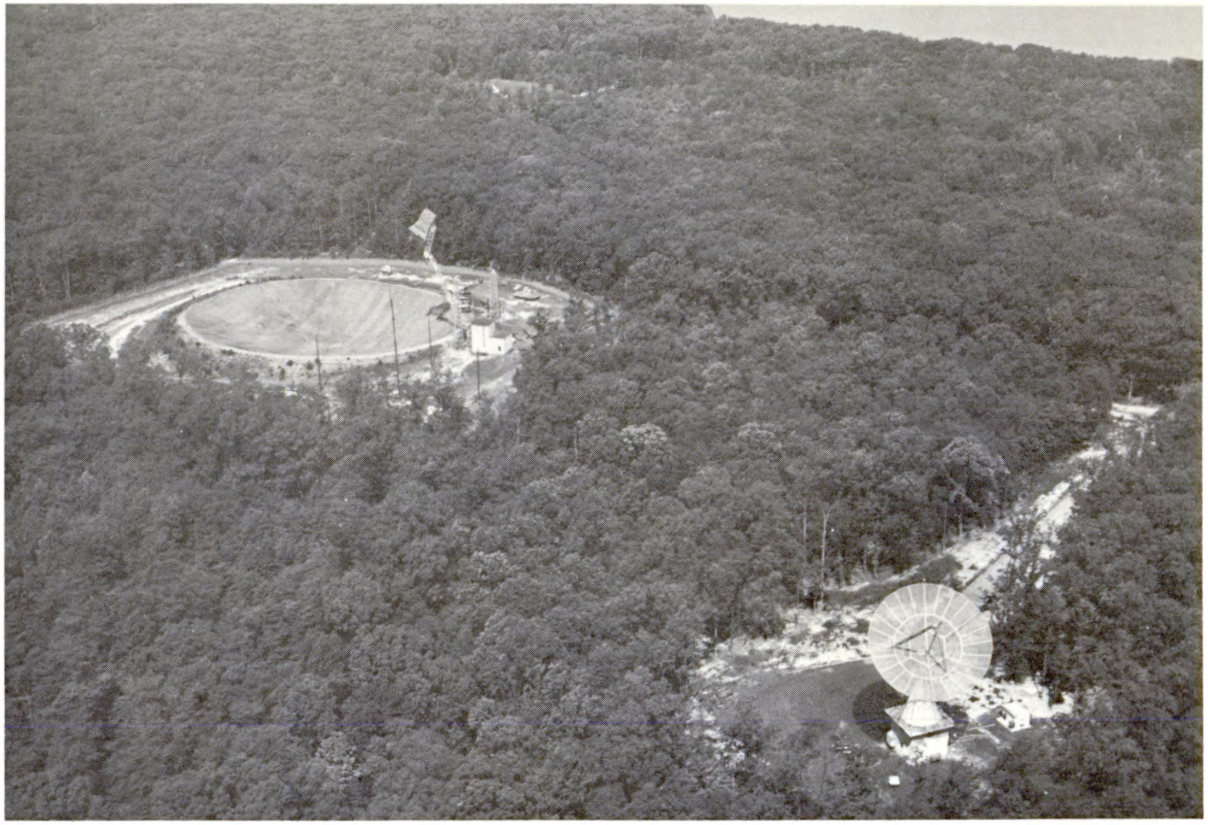
AVAL RESEARCH
REVIEWS
EPTEMBER 1959



NRL's two "radio telescopes" at Stump Neck, Maryland, used for pioneering experiments in moon-relay communications. The one at left is a stationary bowl 263 feet long by 220 feet wide. Its beam can be given limited directivity by swinging the long boom supporting the antenna horn. The 60-foot antenna, at right, is steerable to any point in the sky.

The Role of Radar in Space Research

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When we think about the exploration of space we visualize a rocket ship blasting off for a trip around the solar system. Let us not forget, though, that astronomers have been exploring space for hundreds of years. Lately, radio astronomy has made significant contributions to the understanding of the universe. Similarly, radar has assumed an increasingly important place in space research. Finally, rockets and satellites permit direct contact with outer space.

These various methods complement each other and provide independent descriptions of the solar system. Compared with either astronomical or rocket explorations, radar is unique in that it obtains its information by measuring the effect of matter in space on a known transmitted signal. This allows accurate distance determinations to various solar bodies and provides an independent method to describe features and composition of some extraterrestrial surfaces.

RADAR ASTRONOMY PROBLEMS

Radar investigations are necessarily confined to the solar system. In this region radar can investigate the densities, distances, and dynamic properties of ionospheric clouds and solid bodies. The results of these investigations may also provide greater insight into phenomena occurring outside the solar system. Some of the accomplishments in this field and several proposed projects will be discussed in this article.

IONOSPHERE

The exploration of space by pulsed radio signals began in 1925 when the Carnegie Institution of Washington and the Naval Research Laboratory jointly obtained echoes from the ionosphere—the upper layers of the earth's atmosphere which are continually ionized by solar radiation. The results of such measurements are very important to space research, because the atmospheres of the sun and of some of the planets and probably the spaces between these bodies contain ionized gases. To obtain pertinent information through radar reflections from ionized gases one must understand the complex reflection and scattering mechanisms. When the return signal is carefully analyzed, deductions can be made concerning the density and kinetic temperature of the reflection medium, as well as the group motions of the electrons and magnitude and direction of any magnetic field present.

Many other studies of the ionosphere are being conducted by radar. Echoes received from man-made satellites, aurorae, lightning, and from several unidentified sources have helped to explore the behavior of the ionosphere. Electron densities and electron motions at different heights, and measurements of the earth's magnetic field have been obtained from an analysis of these echoes. There has been considerable success in relating these observations with weather, communications, solar activity, and even with cosmic rays. In the future, information may be gained concerning electron temperatures, Stoermer ring currents and possibly Van Allen belts at distances of several earth radii.

ION CLOUDS

In 1947, J. S. Hey and G. S. Stewart, of the British Ministry of Supply, detected echoes from meteor trails—columns of intense ionization left in the wake of meteors. Initially, these columns are long and thin, but with the passage of time they spread to form patches or clouds. The velocity of the meteors, and the drift, height, shape, persistence, intensity, and number of meteor trails can be deduced from radar echoes. Also, ionic clouds produced by atomic blasts, hot rocket exhausts, and high-velocity rockets in the ionosphere have been detected at the Naval Research Laboratory. As an important consequence of these studies, it has been shown that such ion clouds can support a communications or monitoring system between widely separated points on the earth's surface.

MOON

Radar astronomy was first brought to the attention of the world when the Army Signal Corps contacted the moon in 1946. The first lunar radars used long pulses, low frequencies, and narrow bandpass receivers. Owing to the limitations of the equipment, it was not possible to tell whether the echoes were coming from the entire exposed surface of the moon or from a smaller area. More recently, J. H. Trexler of the Naval Research Laboratory discovered that most of the radar return seems to come from the central area on the moon, less than 300 miles across. This was an important discovery. If the moon reflected like a rough surface, as was previously supposed, the impinging radar pulse would be unevenly reflected—some portions of the pulse coming from the relatively closer central region of the lunar sphere, and other portions coming from the more distant edges of the moon. The moon would be unsuitable as a communications reflector. The actual echo pulse is a discrete, recognizable signal. Using this property, Trexler sent voice and music signals to the moon and back. Subsequently, the authors of this article made precise measurements of the distance to the moon at a wavelength of 10 centimeters. Accurate measurements of the distance to the moon from various points on the earth improve our knowledge of the size and shape of the earth. Of course, this information would also be valuable for navigational purposes. Measuring radar range to the moon for an extended period should result in an independent determination of the lunar orbit. From this a new determination of the gravitational constant is possible.

In 1954, W. A. S. Murray and J. K. Hargreaves of the University of Manchester related the slow fading of the moon echo with Faraday rotation changes (Faraday rotation is the shift in polarization of an electromagnetic wave as it traverses the ionosphere in the presence of the earth's magnetic field). By measuring the total Faraday rotation, Murray and Hargreaves found that the total electron content in the earth-moon path was twice the amount expected from standard ionospheric measurements.

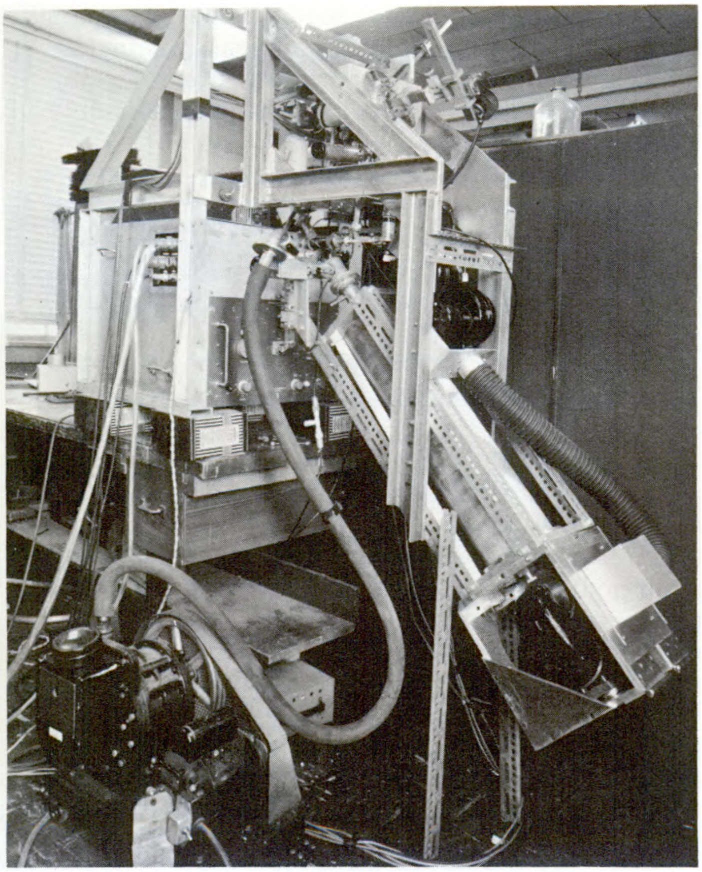
Another way of obtaining this information would be to use two synchronized pulse radars, one at about 100 megacycles and the other near 3,000 megacycles, and measure the frequency dependence of the propagation time between the earth and the moon. From this the total number of electrons along the beam path could be calculated.

A radar system specifically designed for evaluating the surface characteristics of an extraterrestrial object would be worthwhile. Lunar echoes from radars employing variable pulse widths and narrow antenna beamwidths can yield considerable information about the surface of the moon. For example, they can show the variation in height between mountains and plains near the center of the lunar disk. Large spikes, which appear in the initial portion of the echoes obtained from the radar used by the authors, have been attributed to flat areas on the surface. The fast "fall-off" of these spikes led the authors to speculate that the average roughness of the moon's surface may be comparable to that of sandy soil. This estimate lends credence to the suggestion that the moon may be covered by a layer of dust. Refined echo analysis could give electrical characteristics of the reflecting surface from which one could estimate the surface composition.

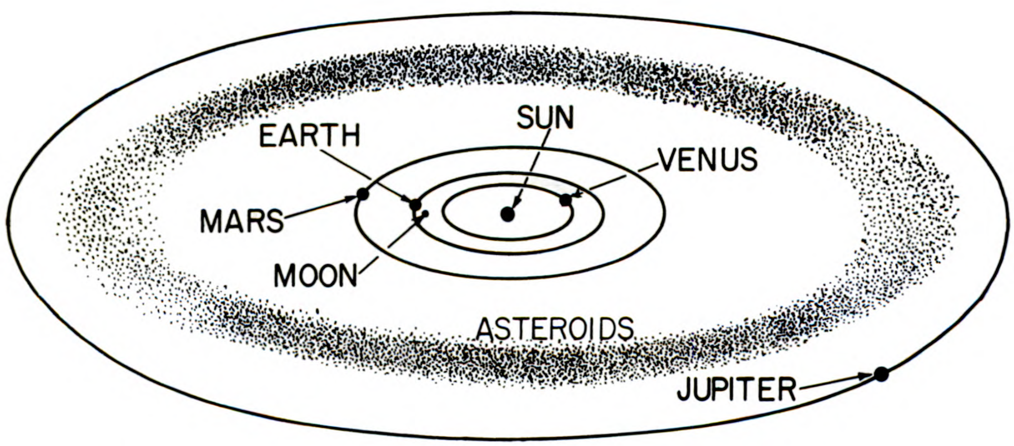
VENUS

A recent breakthrough in radar astronomy occurred when contact was made with the planet Venus, which approaches the earth more closely than any other planet in the solar system. Scientists at the Lincoln Laboratory of M.I.T. accomplished this feat in 1957, during a near approach of Venus to Earth. However, the return signals were so obscured by noise that it took a year of effort using the most advanced analysis techniques and high-speed computers to uncover the echo. This month Venus is again in inferior conjunction with the earth, and many of the world's largest radars, including the 250-foot radio telescope at Jodrell Bank, England, will be focused upon it.

Radar measurements of the distance to Venus will provide a better determination of many astronomical distances. The astronomical unit is the fundamental unit on which the scale of our universe is based, and is defined as the mean distance from the earth to the sun. Relative distances of the planets from the sun and from each other are known quite accurately in terms of the astronomical unit, but the absolute distances are known only to about 0.1 percent. Therefore, an accurate measurement of the distance to Venus could improve our knowledge of all astronomical distances. The surface of Venus is always obscured by clouds of dust or vapor. The amplitude pulse shape and fluctuation of radar echoes from Venus could be analyzed to inform us of some of the properties of the surface. In addition, the planet's rotation period could be estimated from the Doppler frequency spread of the echoes.



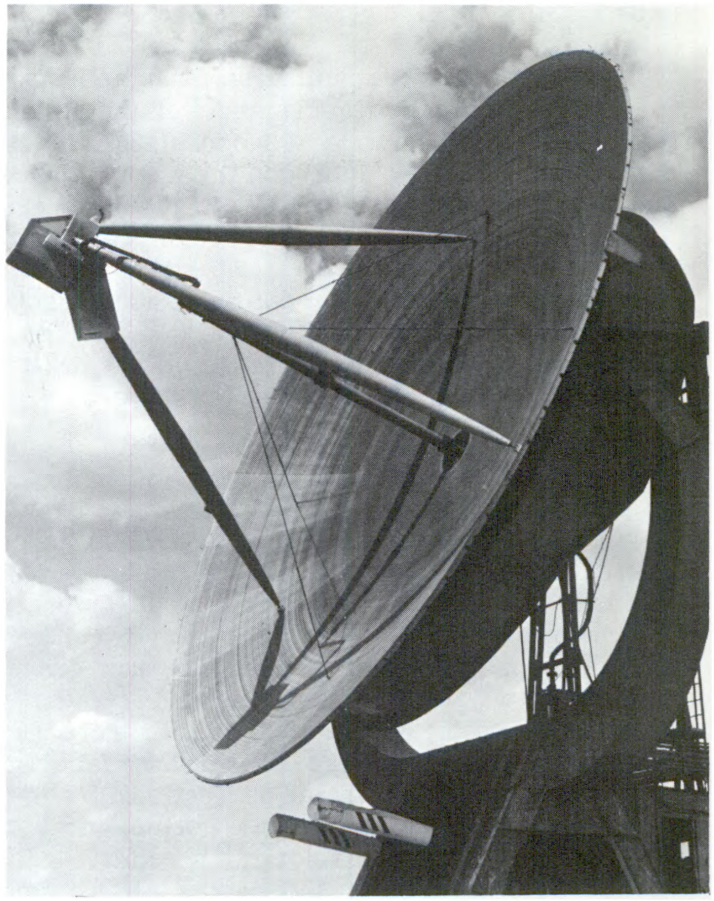
MASER amplifier prior to mounting on 50-foot radio telescope, shown at right.



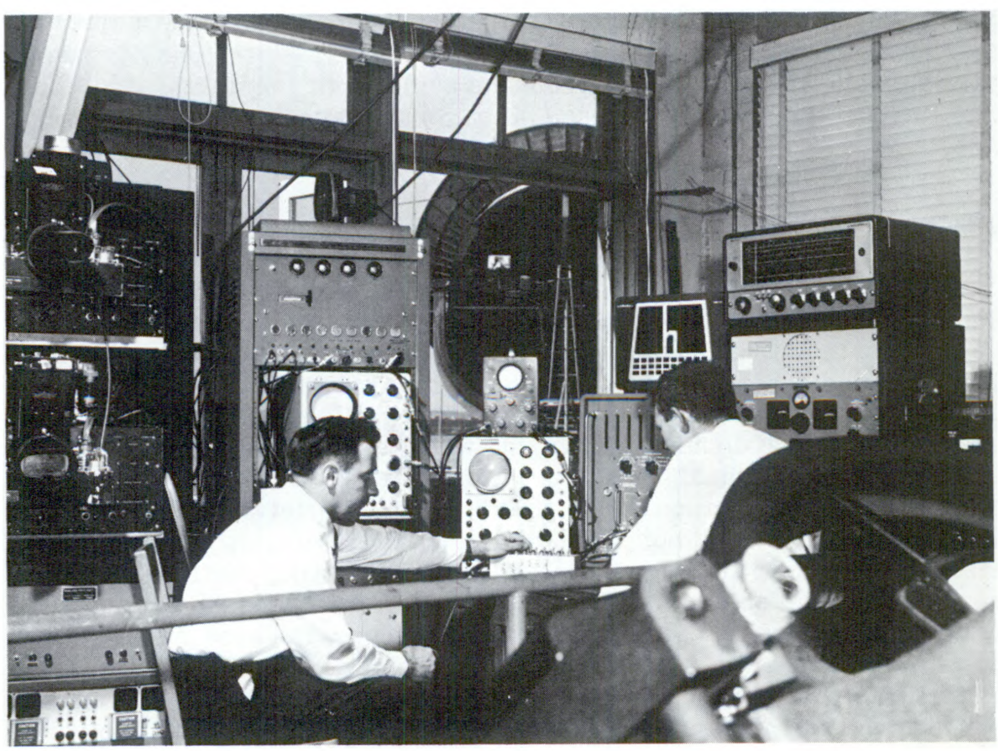
Part of the solar system showing likely radar targets. Information concerning these targets is given in the box below.

Object	Angular diameter	Round-trip time for radar signal	Distance in Astronomical Units
Sun	30'	17 min.	1.0
Moon	30'	2.5 sec.	0.003
Venus	60"	5 min.	0.3
Mars	17"	10 min.	0.6
Jupiter	45"	70 min.	4.2

Right, NRL's 50-foot radio telescope, with MASER amplifier mounted on tripod.



Below, the authors' moon-radar timing, monitoring, and recording equipment. In background, through window, can be seen the antenna on which the radar transmitter is mounted.



ASTEROIDS

The present determination of the astronomical unit depends largely upon trigonometric measurements of the distance to the asteroid Eros; its orbit is well known, and it occasionally passes quite near the Earth. Other asteroids also approach the Earth; for example, in 1937, Hermes passed at a little more than twice the moon's distance. Although most of these asteroids are small—probably less than five miles in diameter—it is likely that they have a high radar reflectivity. This leads to the interesting possibility of obtaining radar echoes from asteroids. If the orbit of an asteroid is sufficiently well known, radar contact could aid in checking the astronomical unit. If the orbit is not accurately known, such contact might help determine the orbit.

SUN

Let us now turn to the largest radar target in the solar system—the sun. The sun subtends about the same solid angle from the earth as does the moon, and therefore would intercept an equivalent amount of radar signal. However, the longer return path would result in a greater signal loss. Moreover, the sun generates a large amount of radiation, which would tend to mask radar echoes. The amount of attenuation of the signal in the sun's corona, and the corona's back-scattering directivity are little-known factors. These considerations imply that to obtain usable reflections from the sun we need a very large antenna, a powerful transmitter, and a bandpass determined by the assumed rotational velocity. A relatively low frequency is required to reduce absorption in the corona. If we can obtain solar echoes at several different frequencies we will have a powerful tool for investigating the vertical distribution of electrons in the sun's atmosphere. Another fascinating possibility is the detection of the streams of charged particles known to be flowing from the sun toward the Earth. We would like to know the velocity of these streams and how they disperse during their trip.

TECHNICAL PROGRESS

The techniques of radar astronomy are still in their infancy; yet considerable progress has already been made. A little more than 12 years ago the Army Signal Corps and, coincidentally, a Hungarian, Z. Bay, obtained echoes from the moon. Both investigators used relatively small antennas and low-power transmitters. The Army Signal Corps overcame this handicap by employing a very narrow bandpass receiver to obtain a good signal-to-noise ratio; however, this limited bandpass prevented the determination of the fine characteristics of the echoes. Z. Bay designed a novel signal-detection system, an ingenious mechanical-chemical integrator utilizing a rotating switch to obtain range-time increments and an electrolysis process to indicate the relative signal power in these range elements. Present moon radars do not require such specialized signal-detection methods because of overall improvement in the radar art. Yet when we start looking for echoes from the sun and the planets, the signals will be small compared with the noise, so we must resort to information-processing techniques.

RECEIVERS

The signal-to-noise ratio for radars that will be used to probe the planetary bodies can be improved by reducing the receiver noise. The optimum in noise reduction will probably be obtained through the use of special solid-state amplifiers such as the ruby MASER (Microwave Amplification by Stimulated Emission of Radiation). One such MASER amplifier, built by C. H. Townes, J. A. Giordmaine, and L. E. Alsop of Columbia University, and installed in the 50-foot radio telescope at the Naval Research Laboratory, has been used by the astronomers to measure radiation from some of the planets and from several radio stars. Using this device, the receiver sensitivity of a theoretically perfect receiver—even if that receiver were situated in outer space—would still be limited by noise from the galactic background. Electronic computers can be applied to separate signals from background noise. Present auto-correlation techniques are capable of detecting signals in the presence of random noise even though the power in the signals is less than the noise power by a factor of 100 or more. We have already noted that this technique was effectively used in the M.I.T. Venus experiment.

TRANSMITTERS

The art of manufacturing high-power transmitters is steadily advancing; 30 megawatt klystron amplifiers are already being produced, and one can talk about radar transmitters having peak powers of 100 megawatts or higher.

ANTENNAS

The most severe equipment requirement of a space-research radar will be that of obtaining a very large steerable precision antenna. This is necessary to obtain a beam pattern comparable in size with the subtended angle of the planetary target. The 250-foot parabolic antenna in operation at Jodrell Bank, England, is the largest antenna at present. Yet, this radio telescope cannot be used effectively at the higher radar frequencies. The design of a large steerable microwave antenna will require the solution of some rather difficult engineering problems.

Space research by means of radar offers definite advantages since a controlled signal of known characteristics is used as a probe, and distance can be measured accurately. Radar investigations of the ionosphere have proven exceptionally valuable to weather and to communications research. Echoes from the moon and from artificial satellites have pointed out the possibility of using them for communications and as reference points for mapping the earth. Radar investigations of the sun and the planets are promising fields for future work. Extremely large antennas, powerful transmitters and special receivers will be needed. Although the cost of this equipment will be high, it will seem small when compared with the value of the information it will make available.

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Protecting Navy Inventions

Snyder 61870

Read

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Patent Administrator
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Just about every day the scientific laboratories of the Department of Defense and its contractors come up with some new item or items of hardware for military use. In a single system, these may number into the hundreds and may involve a decade or more of research and development and millions of dollars in expense. Obviously, with so large an investment in its inventions, the military services are deeply concerned with the problem of maintaining unrestricted use of them. For the Navy this problem is particularly acute because of the many fields of science and technology involved in building, maintaining, and operating the Fleet, comprising as it does surface and sub-surface craft of nuclear and conventional power, carrier-borne aircraft, a tremendous complex of weapons systems, and vast electronic communications, detection, and warning systems. To keep ahead of potential enemies it is necessary that the Navy continue to push through the frontiers of science and technology. Inventions are the natural result of the continuing struggle to improve our defense, and they flow from the laboratories of the Navy and its research and development contractors in ever increasing numbers.

With inventions playing so vital a role in our defense, the question arises, how can the Government insure its free and unhampered use of them? Or, expressed in another way, how can it prevent others from subsequently acquiring patent rights in these inventions and requiring the Government to pay to use them?

Put yourself in the position of the Assistant Chief for Patents for a few minutes. Before you are about three dozen invention disclosures made by Navy personnel at Navy laboratories on the air-to-air missile Sidewinder (see box, next page). You are advised that more than $25,000,000 will be spent on procurement of the missiles next year. How would you make certain that the Navy would be free to use these inventions indefinitely, without payment of royalties?

PRIOR INVENTION

You might assume that the inventions are already adequately protected because Navy employees apparently were the first to make them, and because the Government's policy is not to secure patent rights for commercial exploitation of its inventions. Furthermore, the courts have ruled (Corona v. Dovan, 276 US 358; 1928) that one can defend against another's patent on the ground of prior invention if he has the research records to prove his point. Thus, the laboratory records of the work leading to the invention might be sufficient in themselves to defeat patents obtained later by other inventors. But search as you may, you cannot find a single case in which the Government has successfully established a defense of prior invention, based solely on records, when sued for patent infringement.

You also know that Congress has refrained from enacting general legislation which would permit the Government to use unpublished records in its own files as a defense in infringement suits against it. The Government would like such records to carry as much weight as printed publications (which have been accepted as evidence by the courts) in deciding patent infringement claims. In view of the Congressional attitude, would a court give much weight to a defense based on unpublished Navy records?

In addition, you must consider the problem of producing Government witnesses and records in defense of a claim which may be filed many years from now. Navy employees leave the service to take jobs in private industry, others die, some retire and just disappear, and of course even if the key employees can be rounded up, their memories are likely to have become dim. Records are sent to storage after a few years, and they are automatically destroyed after a certain period of time. Moreover, future employees, not having had a hand in making the invention, will not get very excited over it. To them it is ancient history, and they will begrudge the time spent in rehashing old technology.

Another question arises. The inventions have been reduced to practice in the laboratory. Will they be modified or improved when turned over to manufacturing firms for volume production? Will the Navy's record of prior invention be sufficiently complete to protect the inventions against improvement patents? Will the records be read by a court to give the same protection as a broad claim in a patent? Previous experience indicates a tendency to accept records only for what they show. Thus, if the Government relies on its records alone there is a chance that others may get improvement patents in fields in which the Government is entitled to broad basic protection.

Graph showing Navy Patent {Appl. / Grants} by years

SIDEWINDER MISSILE PATENT COVERAGE

The Sidewinder is a slender missile, 9 feet long and 4-1/2 inches in diameter, powered by a solid-fuel rocket motor and guided by an infra-red system located in the nose cone. The incoming infra-red wave from the target is fed into the guidance and control component, also located in the head of the missile, where the signal is translated into electrical energy for operating the control fins. The fuze and warhead are located just behind the control fins, and the rocket motor is in the after section.

The engine of the target plane is the source of infra-red energy upon which the Sidewinder homes with deadly accuracy. The capabilities of the guidance system are such that at a five-mile range an infra-red scanner having a diameter of three inches can distinguish between the motors of a single twin-engine plane.

The number of inventions incorporated in the missile, other than in the fuze and motor, are as follows: seeker, 18; gyro, 5; servo and power supply, 3; voltage supply, 4; gas generator package, 4; and flight control, 1.

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SECRET USE

The picture is further complicated by the fact that the inventions on the Sidewinder are classified for security purposes. We do not want the enemy to know how the missile works, because if he did know he would probably develop countermeasures which would render it ineffective. However, prolonged secret use may be a bar to patenting by the secret user. Would Navy use of a classified missile be considered by a court as "secret use," and would such use not be a bar to a subsequent inventor patenting the inventions first made by the Navy? Would such patents then be enforceable against the Navy under the "secret use" 2) doctrine? According to the Atomic Energy Act of 1954, prior knowledge and secret use by the Government prevent others from patenting an atomic energy invention, but no similar provision has been enacted for other inventions of defense interest.

4(?) The Invention Secrecy Act also has a bearing upon the question. Suppose a private inventor independently makes an invention corresponding to a Navy invention for which a patent is not sought, or makes improvements on that invention. If his application is placed under a secrecy order, the Government is liable for damages resulting to him due to that order. The Navy's official records would not bar issuance of the patent to him after the secrecy order was removed. Whether or not the Navy could, through its office records alone, avoid liability for damages to the private patent holder is not known. There is no case in point, but the equities would appear to be with the applicant.

If you want to try to outguess the courts, you can go right ahead. But if you guess wrong, it is not just your professional pride that will be hurt. The Government's pocketbook will also take a beating because the Navy will be required to pay a reasonable royalty to the holder of the adverse patent. Suppose, for example, that a fair royalty rate is one per cent. On $25,000,000 of procurement—roughly the amount determined for Sidewinder for one year—the Navy would have to pay royalties amounting to a quarter of a million dollars for that year alone.

PUBLICATION

So much for doing nothing but sitting on our hands. Let us now consider publishing the inventions. For important inventions, publishers would be fairly easy to find. But could they be found for all of the 2,400 inventions received each year by the Navy? Obviously, no.

Another drawback to this approach is that technical publications do not usually give as detailed a description of an invention as do patent specifications. Generally, they take a reporter's view, telling mostly what the invention can do, not how it does it. Unless the invention is 6 described in such detail as to permit one skilled in the art to duplicate the invention, it will not be a bar to subsequent patenting by a later inventor.

Still another argument against publication is that it does not provide a medium for the description of classified inventions.

But assuming that an invention is unclassified, that we have a publisher for it, and that the published description is sufficiently detailed to constitute anticipatory art, will we achieve the protection we seek by putting it in print? The answer is no. For one thing, publication would not be a bar to a patent on the same invention to another inventor if filed prior to publication or within one year thereof, notwithstanding the fact that the Government inventor was the first inventor. Publication also has the disadvantage of permitting others to broaden the scope of pending applications to cover the published invention and thus subject the Government to adverse claims of patent infringement. Then there are always the few who borrow ideas from others, so through publication one would be handing the invention to them on a silver platter. Armed with the legal right to swear back of the publication date where the application is filed within one year thereof, the Navy would be powerless to know what ideas were "borrowed" from it until years later when the adverse patent issues. By that time it would be entirely too late to do anything about it. Only by filing an application can the Navy determine if others are trying to patent Navy inventions. Publication will not do this for us.

For one year after the date of publication, then, the published invention would be a sitting duck, just asking to be picked off by those more astute individuals who have related applications in the Patent Office and those unprincipled individuals who don't, but soon will have.

PATENTING

We have one more choice—filing an application for a patent on the invention. With a quarter of a million dollars at stake in royalties during the first year of use of the Sidewinder, would it not be wise to spend about $25,000 on the preparation and prosecution of applications covering all of the inventions used in the missile? This would place applications in the Patent Office to provoke interferences with conflicting applications filed by others. It would permit an orderly and timely determination by the Patent Office of the issues of inventorship and priority at a time when witnesses and records are available.

The filing of applications would establish the Government's rights in its inventions and would insure free and unhampered use of them indefinitely. There would be no need—at some time in the future—for the Government to dig up old records and witnesses to establish its right to use the inventions. The patents would establish a prima facie ownership by the inventor and the Government. Also, fewer infringement claims would be made, for most of the issues that would arise later would be decided by the Patent Office in interference proceedings.

When the patent issues it constitutes a publication valuable for its technical detail and completeness. It becomes prior art, used by the Patent Office in determining and delineating the rights of others to patent grants in the same field. Incompleteness of disclosure is difficult to prove in a patent.

Filing also helps to establish the true inventors of major contributions to the arts and sciences and to give credit where credit is due. Nothing is more damaging to the morale of a Government scientist or engineer than for a later inventor to obtain a patent on an invention first made by the employee and for the latecomer to be held out as the leader in that particular field.

Howard L. Forman
Patents - Their ownership and adm. by US Govt.

By now the answer should be clear as to why the Navy files patent applications. But to emphasize the point, let us consider two specific examples, one wherein an application was not filed on a Navy invention, the other in which an application was filed.

THE CROOK CASE

Newspaper articles a few years ago reported that Professor Crook of Catholic University had won a $5,000,000 patent infringement suit against the Government in the Court of Claims. The facts of this case show what can happen when sound patent practices are not adopted by Federal agencies.

In 1926, Professor Crook filed a patent application on a shielded ignition system for internal combustion engines to prevent radio interference. His patent issued in 1927 and expired in 1944. In the early part of World War II, thousands of United States military planes were equipped with shielded ignition systems. Professor Crook offered to license the Government, but his patent was construed to cover ungrounded systems, whereas the services were using a grounded system.

The grounded system used by military planes was developed at least one year before Professor Crook's invention by a Navy lieutenant stationed at the Anacostia Naval Air Station in Washington, D. C. The lieutenant and his assistant, a young civilian engineer, built and tested the system at least as early as 1925. However, no patent application was ever filed on this invention.

Professor Crook filed suit in the Court of Claims in 1943, eighteen years after the Navy's early work. By that time, records of the Navy work, which were stored at the Air Station on the bank of the Potomac River, had been destroyed by floods. In 1942, the civilian assistant, then a commander in the Navy, was killed in an air crash in the Aleutians. Only the former lieutenant remained to dispute the claim of Professor Crook. His verbal testimony, unsupported by documentary proof, was insufficient to overcome the validity of the patent, and the court found for the professor, holding that his patent was sufficiently broad to cover the system used by the Navy. 81 USPQ 534

Had the Navy filed a patent application on the lieutenant's invention, an interference would have been declared by the Patent Office between the applications of Professor Crook and the lieutenant. All witnesses and records would have been available to prove the lieutenant was the first inventor of the broad invention. If Professor Crook had succeeded in patenting anything, it would have been only the ungrounded system, and such a patent clearly would not have covered the grounded system in military use.

This case illustrates the danger of relying upon records and witnesses to establish a defense to an infringement claim. It also points out that a long time may elapse between the making of an invention and the need to prove it.

The sequel to this story is that the case was reopened by the court to consider new evidence. This evidence was obtained through a very costly world-wide search for a printed publication describing the invention—a 1921 technical publication of Marconi's Wireless and Telegraph Company. By chance, the document was located in England by a former Navy supplier of the patented device, and the court found the Crook patent invalid. 95 USPQ 325

For a few hundred dollars spent in filing a patent application, the high cost of the trial—estimated to be more than $50,000 for the Government alone—could have been avoided. If the publication had not been found, the cost to the Government would have increased a hundredfold.

DUAL-PURPOSE GUN CASE

Now let us look at another case in which the Navy did file an application. At the start of World War II, five Bureau of Ordnance engineers working on increasing the rate of fire of guns invented an automatic loading, fuse-setting, and ramming mechanism for the 6-inch, 47-caliber dual-purpose gun, extensively used during the war for both surface and anti-aircraft fire. A patent application was prepared on this invention. It took one patent attorney about a year to prepare the application. His annual salary was less than $5,000.

On such an involved and complicated gun, it wasn't expected that any other applications claiming the same invention would be encountered. But an interference was declared between the application and one filed by a British inventor who had worked for the British Navy. The interference resulted in knocking out the broad claims of the British application and limiting it to the electrical system disclosed. The Navy obtained its patent on the hydraulic system it invented. Had the Navy case not been filed, the British-owned U. S. application would have issued with claims of sufficient breadth to cover the Navy's gun, and the U. S. Government would have been required to pay a royalty on the adversely held patent. Because of the extensive procurement of the guns, the royalties saved by reason of filing an application are conservatively estimated to have amounted to more than $1,500,000. Ref

Such cases are not unusual. The Navy is presently involved in 57 interferences. There are 53 infringement claims before it for administrative settlement. There are 39 patent infringement suits pending in the Court of Claims in which Navy infringement of privately owned patents is alleged.

These figures serve to point out that the Navy files applications on its inventions primarily as a defensive measure, just as do many large corporations. Relying on records or on publications to prove prior invention involves too great a risk when so much of the taxpayers' money is at stake. The Government has no special privileges under the patent laws. To protect any rights it may have in inventions it must use the same procedures prescribed for private citizens. Thus, until the law is changed, filing applications is the only sure way of protecting Government inventions and establishing adequate defenses to infringement claims.

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Ex order 10096

The Physiopathology of Immersion Foot*

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Living organisms react to extremes of environmental temperature in so many ways that volumes would be required to summarize the various susceptibilities recorded within this field. No conclusion applies universally. Even boiling and freezing are not always lethal. One can say only, as by definition, that extremes are injurious, and the extremes vary so widely for different species that what is lethally cold for one organism may be lethally hot for another. The subject is halved, if infinity can be said to be halved, by consideration of only those injuries attributable to a reduction of heat, and is quartered by consideration only of animals, with the exclusion of plants. It is, of course, further narrowed by focusing solely upon mammals, and for the immediate benefit to mankind this is the usual study. However, even in mammals, by reason of adaptation of species and individuals, there are wide ranges of susceptibility to cold.

Today the physiology of cold injury in man and other mammals is divided into three main subjects: hypothermia, a term referring to lowered body temperature, frostbite, and immersion foot. Frostbite is a local injury resulting from freezing of tissue. Immersion foot and its closely allied disorder, trenchfoot, are local injuries caused by cold that is less intense but more prolonged, and tissue is not frozen.

The rate of change of temperature of a dry, homogeneous, inert object toward the temperature of the environment depends upon the mass, shape, and thermal capacity (specific heat) of the object, upon the difference in temperature between the object and the environment, upon the heat conductivities of the object and of the environment, and, if the environment is a fluid (gas or liquid), upon its rate of flow in relation to the surface of the object.

If the object is a living animal, additional factors come into play. The body of the animal is not homogeneous. Its various tissues have different thermal capacities and conductivities, and the insulation of the body is not constant. The body changes shape, produces heat, and exchanges substances with the environment. The production of heat by basal metabolism, by the specific dynamic action of food, by voluntary activity of muscle, and by shivering tends to warm the animal. Evaporation of water from the skin and from the lungs tends to cool the animal. The circulation of blood within the animal, and especially the circulation to the skin, increases the conduction of heat to or from the environment. The living animal is, of course, remarkable in its ability to regulate these activities, and hence it can make use of its environment while avoiding some of the environmental dangers. Many birds and

*The work described in this article was supported by a contract between the Office of Naval Research and the University of Pennsylvania.

mammals, including man, maintain a remarkably constant body temperature throughout their lives in spite of wide fluctuations in environmental temperature.

A peripheral part of the body, a foot for instance, is influenced by cold directly, in much the same manner as is the whole body; its production of heat is small in relation to its surface, but the body contributes heat to it by the circulation. In general, the circulation to the part is greater when the body is warm and less when the body is chilled. The body that has an excess of heat can and does provide a greater supply of blood, and therefore of heat, to a chilled limb. This is initiated, at least in part, through the influence of nerves upon the blood vessels of the limb.

In man the usual full-blown clinical picture of immersion foot consists of coldness, numbness, and swelling of feet in response to several days of chilling in cold water. After rewarming in air at room temperature the feet become inflamed and painful for weeks. When the inflammation subsides the feet are uncomfortable, and there are areas of anesthesia and of local sensitivity to touch and to extremes of temperature. The victim may be invalided for months, and for years the feet may be painful. Unlike frostbite, there is no gangrene; the blood supply is intact.

People vary in their susceptibility to immersion foot. A colleague of the author placed his foot in ice water for 45 minutes, and the foot ached for several days. Another individual did this for one hour, yet experienced no discomfort after the foot had rewarmed. One of these men kept a finger in ice water for three hours; the next day it was a little warmer than the others, but there was no pain.

Studies of immersion foot require animal experimentation in order to control the conditions under which the disease is produced and to correlate the anatomical with the physiological changes and with the duration and severity of the exposure to cold. We have found rabbits to be reasonably satisfactory for this purpose because of their long, well-developed hind legs. After the hair is removed from both hind legs, the animals are restrained in a comfortable stall with the left hind leg in water at a temperature of 3°C. and the right in air at room temperature (Figure 1). The chilled leg is anesthetized by the cold. The animals eat and excrete satisfactorily and appear to be comfortable during periods as long as five days. After rewarming in air at room temperature, the mid portion of the leg is examined for evidences of immersion foot.

First we tested the theory that immersion foot is the result of lowered oxygen content of tissue consequent to decreased blood flow. To prove this it must be shown not only that tissue oxygen is low during the period of chilling, but that maintaining normal tissue oxygen during chilling prevents the development of immersion foot. The criteria for the development of immersion foot are signs of neuromuscular disability, including inability of the animal to lift the foot at the ankle, to spread the toes, and to hop normally, and the appearance of characteristic anatomical changes in the muscles of the legs.

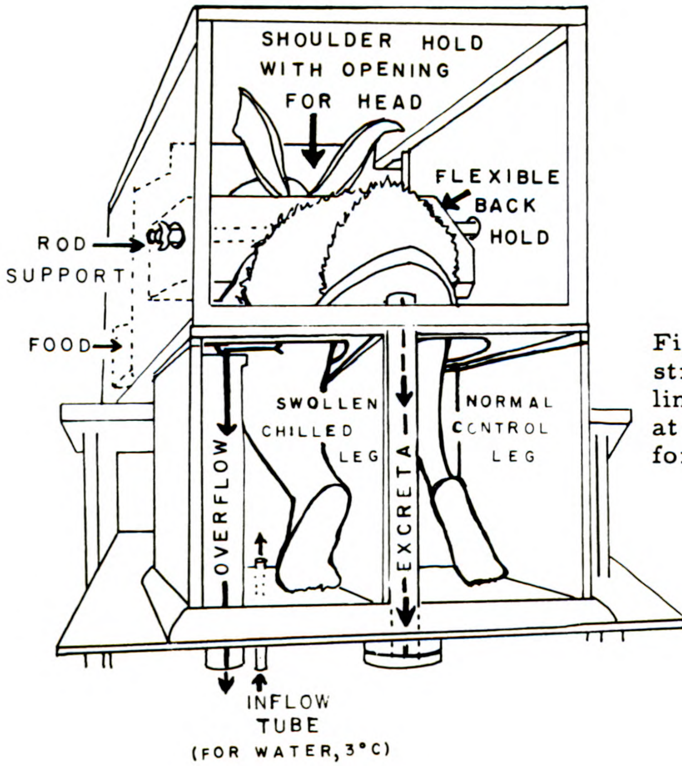
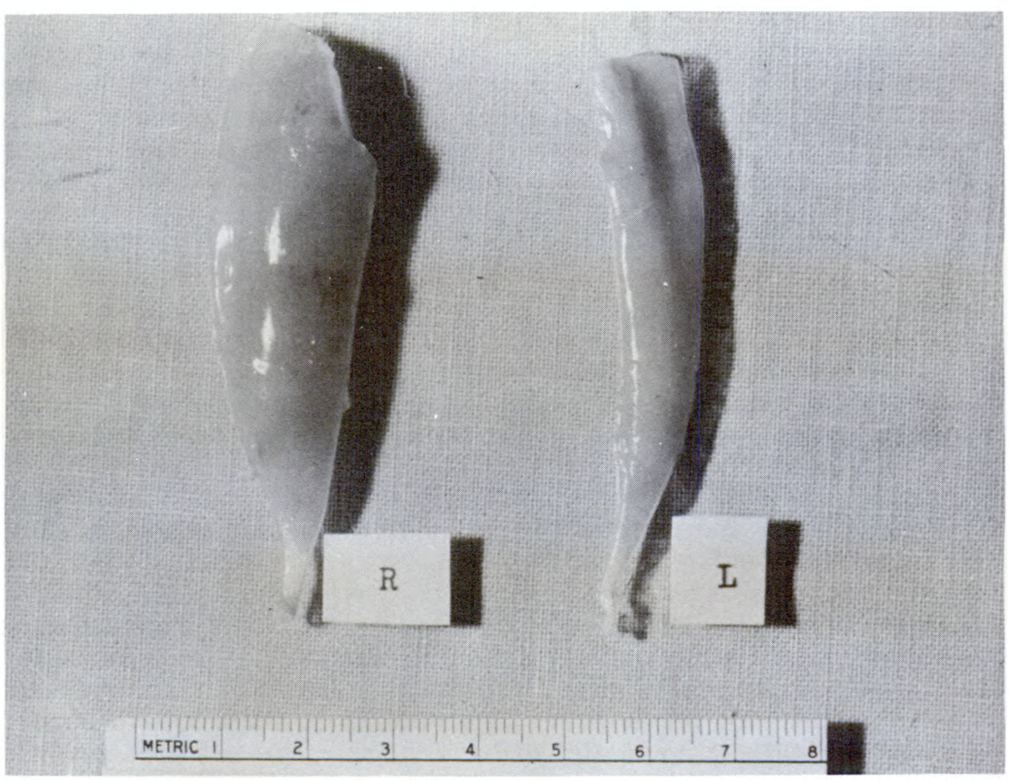


Figure 1--Stall for restraining rabbit and chilling left hind leg in water at a temperature of 3° C. for long periods of time.

Figure 2--A small muscle (anterior tibial) of lower right (control) and left legs of rabbit one month after the left leg was exposed to water at a temperature of 3° C. for 72 hours.



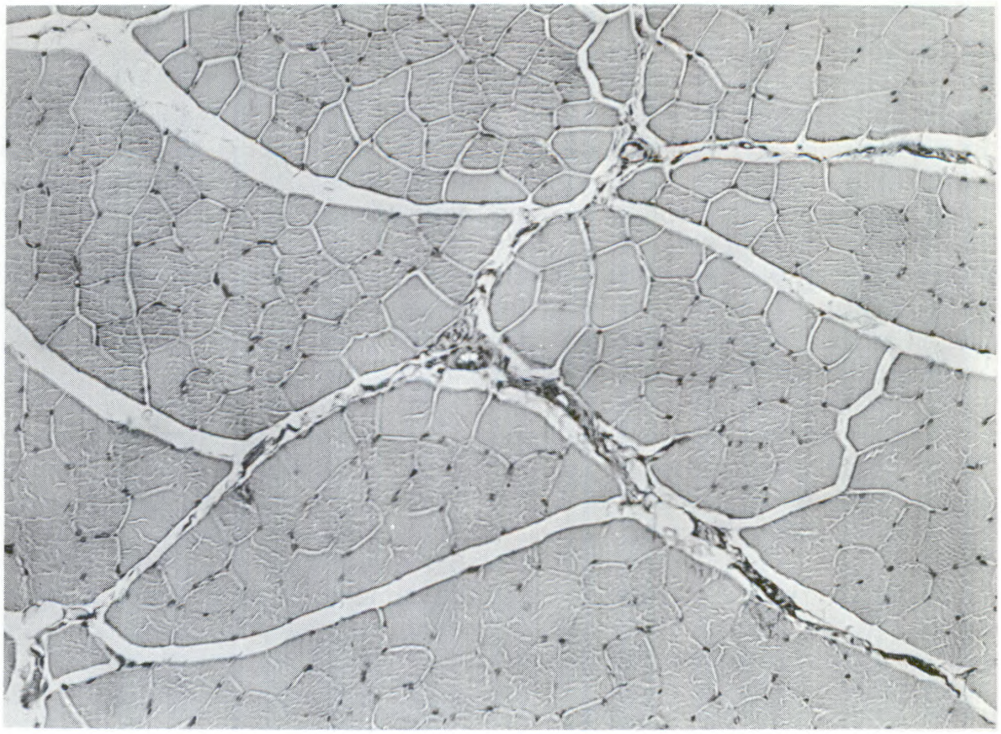
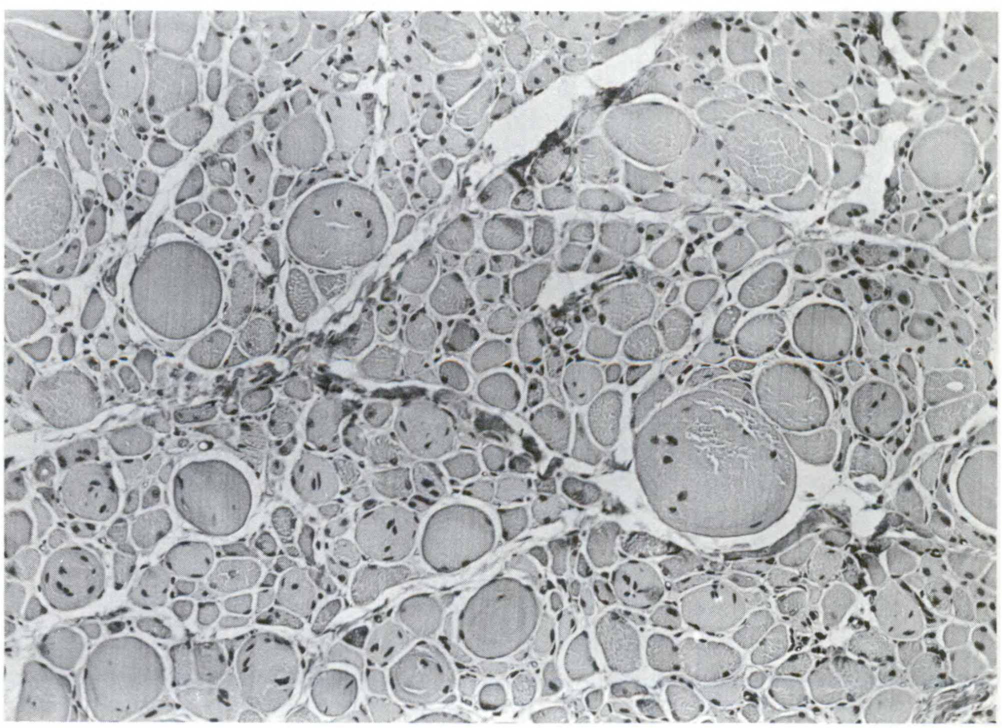


Figure 3--Above, anterior tibial muscle of right (control) leg of rabbit one month after the left leg was exposed to water at a temperature of 3° C. for 72 hours. Below, same muscle of left leg of same rabbit one month after it was exposed to water at a temperature of 3° C. for 72 hours. Magnified 150 times.



Changes in oxygen tension in the muscle of the leg were estimated by means of an amperometric technique employing a platinum electrode. Periods of chilling of 24, 30, and 45 hours were used in three different groups of rabbits. The lowest temperature of the chilled muscle was inconstant and averaged some 6°C. All animals developed some degree of immersion foot. Oxygen tension tended to decrease during chilling. When high concentrations of oxygen were inhaled during the chilling, the level of oxygen tension of the tissues became higher than it was before cooling the limb. Nevertheless, this afforded only slight protection against the development of immersion foot. Deprivation of oxygen is thus not the principal cause of immersion foot, but may be a contributing factor.

In a short series of experiments, the bodies of the rabbits were gently warmed with the hope of producing a greater circulation to the limb and of delaying immersion foot. The animals did not tolerate the heat well, and no advantage was demonstrated. This approach deserves further study. The administration of cortisone was also tried with the thought that it might prevent some of the damage by decreasing inflammation or the formation of fibrous tissue. The legs of some rabbits were exposed for 30 hours, others for 45 hours. Ten milligrams daily of cortisone were given subcutaneously for two weeks beginning the day before chilling. No prophylactic or therapeutic advantage was demonstrated.

After failing in preliminary prophylactic and therapeutic trials, we became interested in the degree of damage in the different tissues. Histologic studies showed nerve as well as muscle to be altered. There was no critical sign of damage to blood vessels, and the skin seemed relatively well preserved. Neuromuscular dysfunction posed the question as to whether muscle or nerve is the first to fail, or the first to recover. We began our investigation of this problem by studying a single fundamental characteristic of both nerve and muscle—the ability of each to utilize oxygen. The Warburg technique was used. By this method the mean uptake of oxygen per hour by a small muscle in the lower leg of the rabbit was found to be about 0.10 micromoles per milligram dry weight, and of a nearby nerve about 0.05. Immediately after rewarming the legs that had been chilled for 48 hours, the mean oxygen uptake of the muscle had diminished to 0.05, and after 120 hours of chilling, to 0.01. The corresponding values for nerve were 0.05 and 0.04, showing relatively little decrease in oxygen utilization.

Other animals were studied in this way at various intervals from three hours to six months after chilling for 72 hours. Within three days the utilization of oxygen by muscle had increased, and within a week it exceeded the value for normal muscle. One week after chilling there was histological evidence of inflammatory and reparative changes, and one month after chilling the oxygen utilization per gram of muscle had returned to normal. However, within a period of one to two months after chilling, muscle was atrophied (Figure 2) and histological changes persisted (Figure 3). Nerve exhibited little decrease in oxygen utilization at any time, and showed a smaller increment in oxygen utilization than did muscle a week after completion of chilling.

These studies provided only a part of the answer to the question concerning the relative dysfunction of muscle and nerve, since the primary function of muscle to contract and of nerve to conduct, and the part played by the neuromuscular junction, had not yet been studied.

In 1957, D. Scott and A. Sayen, in this University, studied the residual separate impairment of muscle and of nerve after completion of chilling. They measured simultaneously the height of the combined nerve action potential and the tension developed in a muscle twitch in response to stimulation of its nerve, and subsequently measured the tension produced in muscle by direct stimulation. Their studies were made following four hours of chilling, since we had previously found this period of cooling sufficient to decrease contraction of muscle for a number of days.

Three hours after completion of chilling, Scott and Sayen found that the nerve action potential had sustained little or no impairment, and that the muscle exhibited only moderate dysfunction. The separate dysfunctions of nerve and of muscle were too small to explain the total neuromuscular dysfunction; therefore, it was concluded that the main defect must be a partial block of transmission of the nerve impulse across the neuromuscular junction. These investigators have made similar preliminary measurements at various times after the completion of chilling. Three days after this relatively brief period of chilling there was some recovery of neuromuscular function. This, they speculate, may have been due to the fact that the swelling had subsided, causing a redistribution of electrolytes. During the next several weeks there appeared to be some further loss of conduction of nerve, perhaps by reason of degeneration of the myelin of the nerves. Recovery from this began within a month, and was essentially complete within six to twelve weeks.

These studies of immersion foot have revealed that the exposure of a rabbit's limb to cold water for even short periods of time apparently causes some lingering changes in nerve, muscle, and transmission across the neuromuscular junction. As with immersion foot in man, brief exposures are not serious because the changes that they cause are reversible; with longer exposures, however, permanent damage is done.

Dr. Immanuel Estermann, formerly Research Coordinator in the Office of Naval Research, Washington, has been appointed Scientific Director of the ONR Branch Office, London. He replaces Dr. Howard E. Page, now with the National Science Foundation.

Dr. Estermann brings to this assignment a wealth of experience from both sides of the Atlantic. As a former, and currently emeritus, professor in the University of Hamburg, Germany, he is very familiar with the European research environment. Having held various academic positions in the United States, he is equally familiar with the American scene, and through almost ten years of service in ONR, he has gained a deep understanding of the operations of the Navy Department in its relations to research and development. The present expansion of international cooperation in science will enhance the position of ONR London and will provide him with a challenging assignment.

Project ORCON: A Plan to Use Pigeons to Guide Missiles

Project ORCON was the code name for a study the Navy has kept under secret wraps for the past six years. The term "ORCON" is a contraction of "organic control," which, in turn, is a delightfully esoteric euphemism for using animals—in this case pigeons—as a means of guiding missiles onto a floating or airborne target. Though it may seem like a venture into science fiction, ORCON was a serious investigation, and one which produced surprisingly good results in simulated rocket flights. The Navy never had quite enough faith in the pigeons to try them out in actual missiles, but ORCON was nevertheless kept in the weapons cupboard until increasingly sophisticated electronics made nonorganic control systems obviously much more practical.

Some kind of missile guidance was used in World War II, almost from the very start. The most common applications were the various "homing" devices which employed a sensing element in the missile, activated by the magnetic field or thermal radiation or noise of the target itself. Later, in the last years of the war, radio-controlled bombs were used by both sides. But the wartime homing systems all had the shortcoming that they could be fairly easily countermeasured. Various degaussing schemes reduced magnetic fields of ships, ingenious noise-making decoys lured homing torpedoes off their course, and electronic jamming interfered with radio control.

Accordingly it became imperative to find a sensing element that couldn't be countered. In a "try-anything" approach to the problem, the wartime Office of Scientific Research and Development granted a research contract to Dr. B. F. Skinner, now of Harvard, but then heading a group of psychologists at the University of Minnesota. The scientists were asked to examine the possibility of using some kind of animal as a sensing-and-control device, because the countermeasures people have yet to come up with a "death ray" that will kill a living organism from a safe distance.

The investigators chose pigeons because they are light in weight, easily obtained, and known to be trainable. The fact that the species tested are called "homing" pigeons had no significance in the experiment. The birds were not asked to use their homing instincts; they were merely invited to peck at a distinguishable spot on a contrasting background. If they accepted the invitation and pecked at the spot they were immediately rewarded by a grain or two of corn.

The Minnesota experiments proved that pigeons could be trained to make the right choice almost every time. The University scientists then went on to propose several apparently practical ways this organic capability could be employed in guiding a missile from a miss-the-target course to a hit course. They developed a missile simulator and tried out several pigeons in it, but the war ended before the proposals could be translated into a feasible weapon-control system.

In 1948, the problem was again revived. A Navy program was established whereby NRL was to take up the investigation where Skinner left off, and to continue it until a recommendation could be made to implement organic control as a practical scheme of guidance, or to drop the idea as impractical. The problem was given to a group of engineering psychologists led by Dr. F. V. Taylor.

The weapons application is simple enough in concept if one uses the analogy of a camera equipped with a ground glass. The operator of such a camera points it in the general direction of an object, and then looks at the ground glass. If the object appears off-center on the glass, the operator turns the camera just enough to move the object to dead center. In an ORCON missile that is the task that would be performed by the pigeon.

The missile would be equipped with a lens in its nose, and a ground glass to receive the image of the target as the missile approached. A pigeon, trained to peck at any distinguishable object appearing on the glass, would be placed behind the glass. He would have an electrical contact cemented to his beak, and the glass could be gridded with wires to indicate distance right-left, or above-below center. If the missile were somewhat off course in its flight toward the target, the target-image would be displaced from center on the glass. The pecking of the pigeon at the image would then make a contact (pick-off) with the gridded glass which would, in effect, indicate how far the missile was pointed away from the target. The error signal would be automatically translated as a correction to the steering mechanism, thus causing the missile to "home" onto the target.

Obviously, a lot depended upon the inherent capability of pigeons. The initial questions to be answered were these: Could a pigeon distinguish between object and background? Could he be trained to peck at the object? How much training would he need? Would he be able to make his distinctions and peck fast enough, and consistently without lengthy pauses, to "steer" a fast-moving missile onto a hit course and keep it there? If an actual investigation with pigeons answered these questions satisfactorily, then there were more sophisticated problems connected with a pigeon's ability to distinguish between objects and backgrounds that varied only slightly in tone (a gray ship on a grey sea), and his ability to peck accurately at a target that was jumping about on the screen (because of random yawing or course corrections by the missile), and at a target expanding in size as the missile approached closer and closer.

Therefore, the investigation was divided into two phases. The first was a series of test runs with pigeons placed in a relatively simple "primary trainer," a tracking simulator in which artificial targets were moved mechanically in front of the pigeons. When a number of birds passed that test satisfactorily, a second far more complicated apparatus was devised. In this "secondary trainer" the pigeons were tested with motion pictures of ships at sea, and in realistic situations in which the target image was moved, not by programmed motions, but by the tracking successes or failures of the pigeon himself.

THE PRIMARY TRAINER

Any equipment that would simulate the terminal portion of a missile's flight toward a moving target had to be fairly complex. At a minimum, it had to include the following components:

- Some kind of cage or box to isolate the "subject."
- A movable pedestal and close-fitting jacket to hold the pigeon.
- An electrical probe, or contact, cemented to the pigeon's beak.
- A screen, or window, on which the target could be projected, electrically gridded in some manner to record the position of the peck strikes.
- Some kind of moving target.
- An automatic feeder and hopper to reward the bird.
- A recording system.

In the primary trainer, the components were kept as simple as possible. The experimental chamber was a plain wooden box fitted on one side with one-way glass so the bird could be observed without being distracted. The target was merely a square piece of metal that moved mechanically back and forth across a square opening in front of the bird; this was mounted on a backing plate fitted with vertical, evenly spaced wires connected separately to the recorder. Thus pecks on or near the target were registered as hits, and the misses were recorded as so many fractions of an inch right or left.

The training cycle alternated periods of tracking a moving target with periods of reward, when a shutter covered the target and the bird was fed. During experimental training the birds were tested with tracking runs of varying length, with targets moving at varying speeds, and with varying amounts of reward. The trainees were started on a slowly moving target, and were rewarded with corn every time they scored a hit. They quickly learned that pecking at the bullseye would mean food. Gradually the length of time between feedings was increased, and so was the target motion. The top experimental limits, in target velocity and duration of run, required the pigeon to track a target jumping back and forth at 5 inches per second, for 80 seconds without a break.

In the final analysis of the primary test it was found that peck-frequency was approximately 4 per second, and that the pigeons pecked with sufficient accuracy so that 80 to 90 percent of the contacts were either on the bullseye or within a quarter of an inch of it.

Translated into guidance terminology, the bandpass frequency of the pigeon was 7 radians per second. This was judged adequate to operate a missile servo mechanism, and the chances of scoring a target hit or effective near-miss were excellent. The NRL investigators were thus encouraged to go on to the more elaborate experiments of a secondary trainer.

THE SECONDARY TRAINER

The secondary phase of Project ORCON simulated a realistic missile situation, in that the target was now a picture of an actual ship at sea, the target image moved on the screen in two dimensions (up and down, as well as right and left), and target motion was governed by the tracking activities of the pigeon. To do all this required a complex apparatus employing some highly original electronics.

The operating center of the test set-up was much the same—a box-like compartment with a pigeon holder placed so that the bird was face to face with a lighted screen. Only now the screen was made of electrical conducting glass, that is, plate glass coated with a stannic oxide film. Through circuitry based on the Wheatstone-bridge principle, pecks on the glass were translated into distances right and left and up and down from the center lines.

Getting suitable target images was relatively simple. A jet plane was sent up with a motion picture camera to make diving runs on ships—a destroyer and a freighter—traveling at full speed in moderate seas. The resulting color motion pictures, plus a few "still" slides showing near and distant views of the same ships, provided the target material.

Making arrangements for the target images to move realistically on the screen was more difficult. The key apparatus here was a small mirror that could be turned right-left and up-down by a servo motor. The motion picture projector beamed the target pictures onto the mirror, which then reflected the images onto the tracking screen. The control loop, embracing the pigeon's beak contact and the conducting glass, provided the signals which determined which way the servo motor would turn the mirror, and thus where the image would appear on the screen.

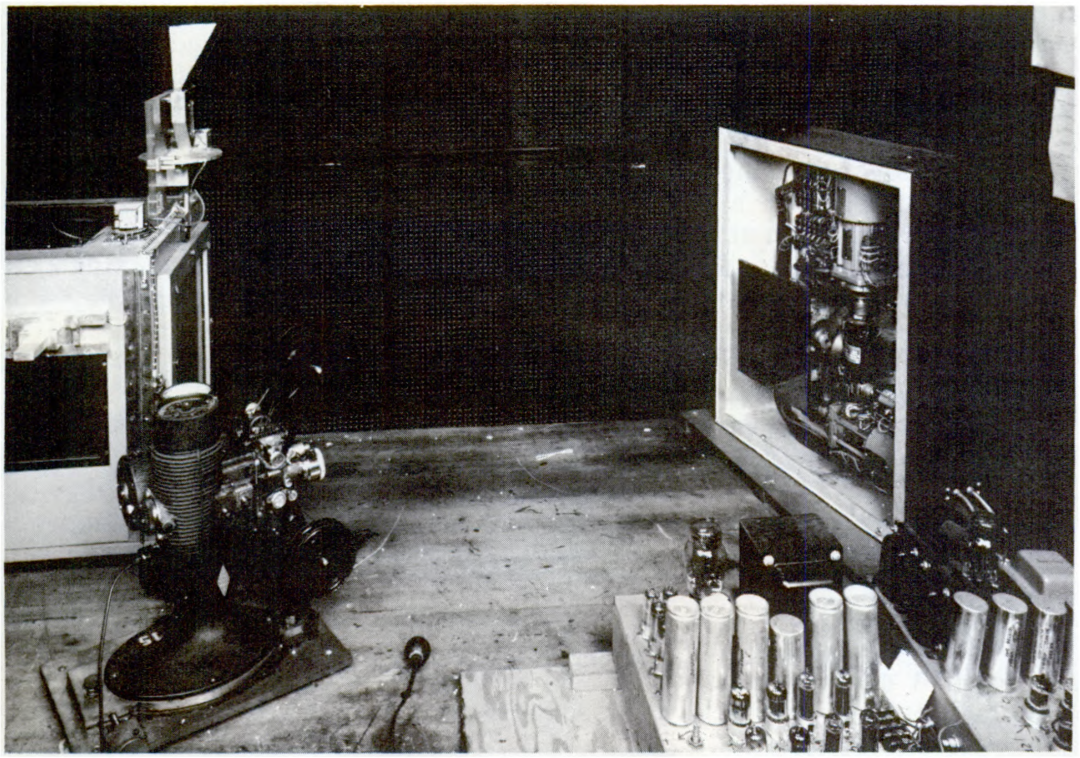
Then there was the problem of injecting realistic target motion—ship's speed—into the tracking problem. This was done by inserting a constant "drift," or turning motion, into the servo-motor control, so that if the pigeon stopped tracking (pecking) the target-image would drift quickly away from the center of the viewing screen. Thus the pigeon had to not only correct for his own pecking errors, and those introduced by the yawing of the "missile," but continually had to follow a moving target. (Of course, all the pigeon saw was an object moving back and forth across a flat plate, like a night moth in front of a lighted window.)

A complete recording system made a pen recording of every movement of the mirror, and every peck made by the pigeon. Thus at the end of each run all errors could be computed, not only in number of misses, but in distance of miss from the target image.

The rewarding system was similar to that of the primary trainer, except that the sliding shutter was eliminated. Instead, at feeding time the projector light went off and a "feeding light" came on.

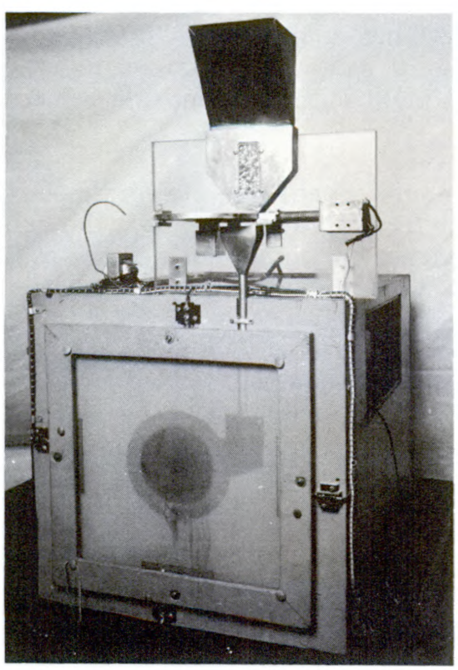
TRACKING TESTS

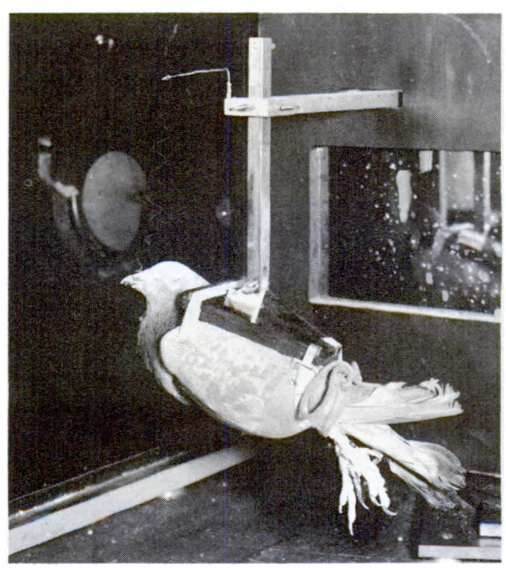
The first test series in the secondary trainer was called "centrifugal tracking," because successful pecking by the subject birds drove the target image away from the center of the screen. When the target image



ORCON SECONDARY TRAINER

Above, experimental arrangement. The mirror (dark rectangle at right) reflects motion pictures from the camera (left foreground) onto the conducting-glass face (tracking screen) of the pigeon box (left). Electrically controlled rotation of the mirror simulates target motion. Lower left, exterior of pigeon box, showing conducting-glass plate and feeding mechanism. Lower right, pigeon in holder. By means of wire leading to the bird's beak, electrical contact is made when pigeon pecks at images reflected onto the circular tracking screen.





reached the outer rim, it was programmed to remain there until the pigeon landed a peck on it. Then the bird was immediately rewarded. The purpose of this seemingly reverse procedure was to condition the pigeon to peck more enthusiastically (in hope of immediate reward) at a target that was moving toward the rim—that is, at a target escaping from the field of view. The target for this centrifugal test was invariably a color-slide view of a distant ship, making an image about a quarter of an inch long on the screen.

Eight pigeons were tested in 96 runs. Of these, 55 (55.3 percent) were successful. However, four of the pigeons averaged 79.2 percent successful, so presumably by choosing the better trackers a higher probability of hits could be expected. In well over half the test runs the pecking rate was considered sufficient to steer a missile traveling at 300 yards per second.

As a follow-up, the pigeons were tested with near as well as distant views (color slides) of the target. In the near views, in which the target image was nearly as wide as the screen, the pigeon had no specific spot to peck at, and consequently dotted his pecks all over the target—causing oscillations of the "missile." Better than 60 percent of the runs were successful, however.

The outcome of the first two series of experiments strengthened the hope that the pigeons, after being trained on two or more still views of a ship target, would be able to capture and successfully track the enlarging image of that target as it was projected cinematically. Yet it was realized that such success could not be regarded as a foregone conclusion since the transition from static views presented by slides to the ever-growing and ever-changing images of a motion picture might prove to be most disturbing.

In the third experimental series, the birds were required to track the enlarging picture of a destroyer, this time keeping the image in the center of the screen (centripetal tracking), as they would if actually guiding a missile. A test was said to be a success if the pigeon captured the drifting target and tracked it for the full run of 30 seconds. In 104 simulated missile flights, 60 (57.7 percent) were successful. The four "high rate" birds scored 80 percent, while the "low rate" ones succeeded on only 34.6 percent of the runs.

A final set of experiments was run to find out how the pigeons would do when presented with a number of varied targets and backgrounds, and when approaching the target from different angles—such as ahead, astern, and broadside.

On this, the birds didn't do so well. Even the four star pupils averaged only 40.6 percent, and the dullards 21.9 percent, for an average of 31.3. Oddly, the pigeons seemed more confused by changes in target aspect—such as direction of heading—than by changes in the target itself. Peck accuracy slumped badly when different views of the same destroyer were projected, but when the target was switched from a destroyer to a freighter—a much more significant change to human eyes—it didn't seem to worry the pigeons at all.

SUMMARY

The NRL test with pigeons proved to the satisfaction of the experimenters that pigeons could peck fast enough and with sufficient accuracy to guide a speeding missile. And under ideal conditions of contrast between target and background, the pigeon could track a target successfully, compensating for his own and missile errors.

Ideal conditions would seldom be realizable in actual operations, however. Clouds, waves, shadows, and the like would introduce elements to confuse the birds, and these could be neither predicted nor controlled. Dr. Skinner had suggested that if two or more pigeons were used they would reduce the probability of losing the target, because the peck-frequency would be increased and because a group of birds acting as a "committee," so to speak, might tend to correct each other's errors. But even under the best of conditions, ORCON could have a range no greater than that of any optical system, and it could be used only in the daytime.

So, after nearly three years of equipment development and testing, Project ORCON was regretfully abandoned, without the pigeons ever getting a chance to ride in a missile. The experience gained by the engineering psychologists, and the knowledge acquired of organic control, may have some use in the future—perhaps in homing a space vehicle on a distant planet. For the present, it remains merely a history of some fascinating experiments with some very obliging little animals.

Almost any scientific venture, however, has its offshoots; and sometimes an offshoot may have more lasting importance than the original experiment. Such was the serendipity of Project ORCON. The profitable sideline in this case was the use of electrical conducting glass in a pick-off system.

The technique was developed specifically for Project ORCON by a group of electronics engineers, some of whom also happened to be looking for better ways of presenting radar information in shipboard combat information centers (CIC). Since then, conducting-glass radar displays—on which trained plotters trace with electrical probes the course of attacking aircraft—have become a key feature of the Navy Data Handling System.

On August 11, Dr. Arnet L. Powell assumed the duties of Chief Scientist at the ONR Branch Office, Boston, succeeding Dr. C. F. Muckenhoupt. Before Dr. Powell came to the Branch Office in 1947, he held positions with the Dow Chemical Corp. and Sylvania Electric Products, Inc. Recently, he worked from time to time as Acting Chief Scientist of the Branch Office. He has also served--and will continue to serve--as a National consultant to ONR in the field of organic chemistry. As "Guest of the Massachusetts Institute of Technology," Dr. Powell will continue active research in Prof. C. Gardner Swain's laboratory on the mechanism of the Cannizzaro reaction. In addition, he will carry on numerous committee activities for the American Chemical Society, of which he is an Alternate National Councilor.

On The Naval Research Reserve

Three Seminars

Three Research Reserve seminars were held during the month of July, one at Columbus, Ohio, another at Port Washington, New York, and the third at Idaho Falls, Idaho. They dealt with the following subjects: research methodology, nuclear sciences, and weapons research and training devices. Accounts of the meetings follow.

SIXTH ANNUAL NUCLEAR SCIENCES SEMINAR

Forty-two officers representing the Navy, Army, and Air Force attended the Sixth Annual Nuclear Sciences Seminar, which ended August 1, in Idaho Falls, Idaho. The seminar, sponsored by the Office of Naval Research, was conducted by members of Naval Reserve Research Company 13-6, LCDR Mark Baum, USNR, commanding.

The purpose of the annual Idaho Falls seminars is to acquaint reserve officers, who have technical background and who are working in related fields, with operations at the National Reactor Testing Station (NRTS) and to bring them up to date on current developments in reactor technology.

The participants were in accord—the seminar was a very interesting and beneficial two-weeks training assignment. Besides attending 27 technical briefing sessions, they visited the U. S. Atomic Energy Commission's 15 operating reactors located through the 894 square miles of sagebrush land comprising the NRTS.

CDR Collins B. Cannon, a member of NRRC 13-6, was assigned to temporary active duty as seminar chairman. Other members of the local unit participated by making presentations or by conducting tours through the world's largest and most varied collection of reactor facilities—research, testing, power, propulsion, and support.

The manager of the Atomic Energy Commission's Idaho Operations Office, Mr. Allan C. Johnson, and executives, scientists, and engineers from the Commission's Argonne National Laboratory and from Atomics International, Combustion Engineers, General Electric Company, Phillips Petroleum Company, and Westinghouse Electric Corporation participated in and assisted with the seminar.

Topics discussed concerned all aspects of current technology, including basic orientation to nuclear physics and reactors, critical experiments, power testing, data handling and processing, irradiation testing of materials, hot-cell analysis, health-physics monitoring, remote disassembly inspection and maintenance, and chemical processing. Visits were made to the Naval Reactor Facilities, Aircraft Nuclear Propulsion Test Site, Materials Testing and Engineering Test Reactors, Chemical Processing Plant, Army Reactor Area, Experimental Breeder

Reactor Complex, Special Power Excursion Reactor Facilities, Organic Moderator Reactor Test Facility, and Transient Reactor Experiment Test. All officers were encouraged to participate during the briefing sessions and tours.

Other highlights of the seminar were an opening presentation by CDR E. C. Miller, USN, representing the Commandant, Thirteenth Naval District, and a closing briefing by CDR W. C. Avery, USN, who represented the Chief of Naval Research.

The busy two-week schedule concluded with a panel discussion wherein managers representing five of the USAEC's major operating contractors answered questions and discussed topics raised by the seminar group. The questions ran the gamut from queries concerning purely technical problems to points relative to national policy on applications of nuclear energy as related to power production and to propulsion.

NINTH ANNUAL TRAINING DEVICE SEMINAR

A group of 25 selected Research Reserve officers from seven naval districts attended the Training Device Seminar held at the U. S. Naval Training Device Center, Port Washington, New York. This seminar, which convened on July 20 for a two-week period, was designed to bring reservists up to date on the nation's far-reaching scientific and research program in the field of weaponry.

During their tour of duty at the Center, the reservists heard leading military authorities discuss problems and programs relating to U. S. foreign policy, the space program, missiles and rockets, Fleet air defense, Navy guided-missile training, military applications of airships, CIC problems, submarine capabilities, and the Research Reserve Program.

Top-ranking military speakers and their subjects at the seminar included: CAPT A. B. Metsger, USN, "Naval Research and Development"; RADM Luis deFlorez, USNR(Ret.), "Philosophy and History of Synthetic Training Devices"; RADM G. A. Rosso, CHC, USN, "Moral Guidance and its Relationship to Navy Training"; CAPT M. H. Rindskopf, USN, "The Submarine School"; BRIG GEN W. J. Ely, USA, "Trends and Future Developments in the U. S. Army"; CAPT Frank B. Voris, USN, "Physiological Implications of the Space Age"; CAPT L. E. Hubbell, USN, "Fleet Air Defense Today and Tomorrow"; LCDR J. A. Chastain, USN, "CIC Problems Encountered in Surface and Airborne Operations"; VADM Chas. E. Rosendahl, USN, "Military Applications of Airships"; CDR L. R. Olsen, USN, "Navy Guided-Missile Training"; and CAPT J. P. Aymond, USN, "The Reserve Research Program".

Civilian speakers at the Seminar included Dr. R. O. Burns, "Plans and Programming for Future Training"; Mr. Ansel Talbert, "Russian Space Program and U. S. Foreign Policy"; Mr. J. Gordon Vaeth, "The United States Military Space Program"; and Dr. Willey Ley, "The Space Age".

During their intensive training-device cruise at the Center, the Naval reservists discussed the latest developments in training devices with top Center engineers, scientists, and human engineers responsible for the Navy's Training Device Program.

A highlight of the reservists' tour included a two-day visit to the U. S. Submarine School at New London, Connecticut. Here they were briefed by the SUBSCOL's Officer-in-Charge, CAPT M. H. Rindskopf, on the latest advances in the U. S. Submarine Program, later the reservists witnessed the operation of submarine training devices produced by the Training Device Center for the School.

The seminar was described by LCDR G. Sewall, USNR, as "the most interesting training duty I've had. The program provided the seminar group with top-level speakers and also included especially interesting field trips to the New London Submarine Base and the Electric Boat Division plant of General Dynamics."

The seminar was the ninth of its kind held at the Center. CAPT Edward C. Callahan, USN, Commanding Officer and Director of the Training Device Center, and COL Kelvin H. Hunter, USA, Associate Director, supervised the activities. Chief N. E. Corbin, of the Center's TRADEVMAN Advisory Group, was seminar coordinator.

FIFTH ANNUAL SEMINAR IN RESEARCH METHODS

The Fifth Annual Seminar in Research Methods was held at Ohio State University from July 12 to 25, 1959. The seminar, presented by NRRC 4-7, Columbus, Ohio, was concerned with research methodology in a wide range of fields, and with the relevance of research to the solution of Navy problems. The concept of a seminar in research methods has evolved from discussions of scientific method; the question of the uniqueness of methods to different fields of research has been of interest in the previous seminars of this series. Attention has been focused on the question, is there one method of science, or does each discipline develop its own? Speakers from various fields have addressed the group on this subject. The speakers were drawn from the physical, biological, medical, and social sciences, fields in which varying degrees of control over the experimental materials are possible.

These ideas were extended in this year's seminar to an examination of the problem of integrating the material presented into a structure which would increase its relevance for the Navy. Seminar participants speculated not only on the application of research to Navy problems, but also on the development of the idea that the Navy of the future will, to some extent, be shaped by the research sponsors. The purpose of the seminar was to raise and develop questions. No attempt was made to reach conclusions on the material presented.

In order to integrate the research findings and methods, the seminar group was broken up into four sub-groups, each containing representatives of all fields of research present. Group chairmen were Col George W. Howard, USAR, Commanding Officer, Mobilization Designation Detachment, Nr. 39, Fort Belvoir, Va.; LtCol Oscar P.

Clever, USAR, of the same unit; CDR George H. Baker, USNR; and CDR Walter C. Jacob, USNR. The discussion groups considered problems of the conduct of research, differences in method in various fields, and broad questions of research management. Some of the basic assumptions of the conduct of research were examined.

The seminar was opened by LCDR D. Howland, USNR, seminar chairman and Commanding Officer of NRRC 4-7. He introduced CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research (Research Reserve) who discussed the Research Reserve Program.

In order to provide a basis for the formulation of the problems of research integration, it was proposed that the Navy be viewed as a system. The broad operational problems faced by the Navy were examined in the keynote address. CAPT A. B. Metsger, USN, Deputy and Assistant Chief of Naval Research, the keynote speaker, outlined many of the problems in an address which opened the scientific aspect of the program. Following the keynote address, a day was devoted to a study of the threat to our national security posed by Russia, and some of the general aspects of our defense system to meet this threat. This panel, chaired by CAPT R. W. Mayhew, USNR, included Dr. H. G. Grimm, Professor of History at Capital University, and RADM Henry E. Eccles, USN, (Ret.).

Following the discussion of the threat, the concepts of a system and systems analysis were presented by LCDR D. Howland, USNR, Director of the Operations Research Group, Ohio State University. Approaches to a number of systems were discussed, and a specific weapon-system study was reported in detail by members of the research team.

A day was then devoted to problems of communication, which are of importance in defining and managing a system. LT R. L. Sergeant, USNR, served as day chairman. Speakers included several University professors: John W. Black, who has been closely associated with naval problems, and Dr. Henry Moser, who developed the IACO alphabet, both of the Department of Speech and Hearing Science; Dr. R. L. Cosgriff, Department of Electrical Engineering; and Dr. Virgil Hinshaw, Department of Philosophy.

Mathematics, the language of science, was considered next, with LT R. F. Miller, USNR, as day chairman. Professor Tibor Rado of the University discussed "The Mathematics of Planning." Basic concepts of probability theory and computer languages were also discussed. These sessions provided additional insights into the general concepts of systems, with special emphasis on the communication problem.

The panels which followed were devoted to discussions of research in areas representing the primary dimensions of a system. Various aspects of the contributions of the physical sciences to systems were discussed. LT N. J. Norlie, USNR, was day chairman for a series of panels devoted to problems of metalurgical research, reliability, and defense metals.

A tour of Battelle Memorial Institute was arranged by LCDR R. W. King, USNR. A number of current projects in physical research were observed.

Moving on from the physical aspects of a system to the human factors, a day was devoted to a discussion of biological and medical sciences, chaired by CAPT O. C. Woolpert, MC, USNR. Professor C. A. Dambach, Director of the Natural Resources Institute of the University, described the attack on the sea lamprey which is being launched in the Great Lakes. Since much of the early systems analysis was related to wildlife problems, this talk was particularly appropriate. Dr. Fred A. Hitchcock, noted expert in space physiology, reported on research in this field. Discussions of research in the fields of endocrine disorders, infections, diseases, and pathology followed. As in the past, this program was voted the most interesting at the seminar.

A panel of social scientists, organized by LCDR A. Jacobsen, USNR, concluded the program. The fields of sociology, economics, and anthropology were discussed, with special reference to the broad social and cultural environment in which research is conducted. The problems of the conduct of research from the standpoint of the management of a research organization were discussed.

The last day of the program was devoted to group discussions and a final plenary session. The groups focused their attention on the broad problems facing the Navy and of relating research results to methods of attacking these problems. Procedures for identifying, measuring, and relating the various factors of a system were discussed, together with procedures for locating and filling gaps in existing knowledge. Problems of defining research tasks, selecting research personnel, and training research reservists were discussed.

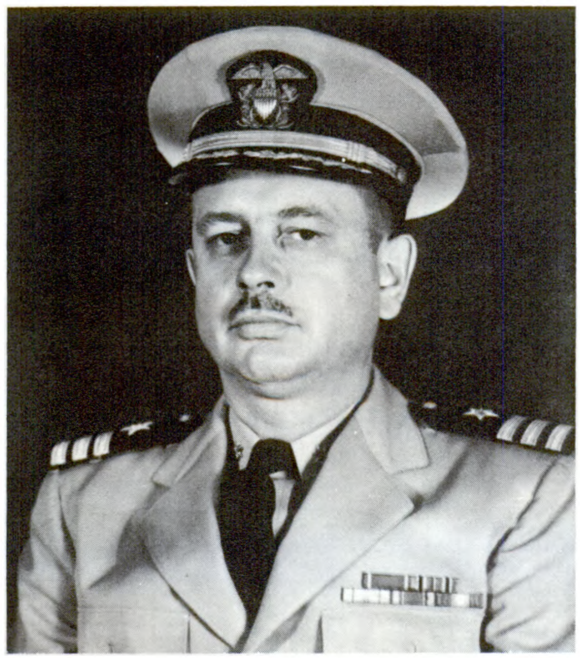
Fiscal 1960 Naval Reserve Selection Boards Announced

Selection boards to consider inactive Reserve officers for promotion during fiscal year 1960 will be convened as follows:

PROMOTION TO	DATE BOARD CONVENES
Rear Admiral (Line and Staff Corps)	November 3, 1959
Captain (Line)	January 5, 1960
Commander (Line)	January 5, 1960
Captain (Staff Corps)	February 23, 1960
Commander (Staff Corps)	February 23, 1960
Lt. Commander (Line)	March 8, 1960
Lieutenant (Line)	April 12, 1960
Lt. Commander (Staff Corps)	April 26, 1960
Lieutenant (Staff Corps)	May 31, 1960
Warrant Officer	May 10, 1960

Second Program Officer Assigned
To Chicago Branch Office

CDR Leonard P. Hoskins, USNR, reported to the Office of Naval Research Branch Office, Chicago, on July 24, 1959, for duty as Research Reserve Program Officer. CDR Hoskins will work with LT C. S. Lardis, USN, who has served in this capacity for two years. The great distances involved in visiting and inspecting the many units throughout the Eighth and Ninth Naval Districts necessitates long absences for one Program Officer. The additional billet is expected to be most beneficial to the many Research Reservists in these two naval districts.



CDR Hoskins is no newcomer to the Chicago area. He received his B. S. degree in education at Northwestern University in 1935. For the next seven years he served as a member of the high school faculty in the mathematics department at Winnetka, Illinois.

The naval career of CDR Hoskins began in April 1942, but he returned to the field of education in November 1945 for one year. The following four years, 1946 to 1950, he was in business in the San Francisco area.

In February 1951 CDR Hoskins returned to active duty in the Navy. He served as Operations Officer and Navigator on the USS AUCILLA (AO-56) from February 1951 to March 1952; Head, Training and Readiness Branch, MSTSPACAREA, March 1952 to June 1954; MSTS and Merchant Reserve Program Officer in the Twelfth Naval District, June 1954 to March 1955; with COMSERDIV 51 (Guam), April to December 1955; and Head, Personnel Department and Plans Officer NAVCOMMSTA, Guam, January to December 1956. Prior to reporting to the ONR Branch Office, CDR Hoskins served as Executive Officer on the USS VEGA (AF-59).

U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 519834

Participants at the Seminar on Research Methods, held at Ohio State University in July. See article on pages 29 through 31.

The submarine target trainer, a special training device, is explained to CAPT J. P. Aymond, USN, Special Assistant for Research Reserves, Office of Naval Research (left) by CAPT Edward C. Callahan, USN, Commanding Officer and Director of the U. S. Naval Training Device Center. The briefing culminated a two-week scientific seminar at the Center in July. See pages 28 and 29.

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.

The Naval Research Laboratory's fully steerable 84-foot radio telescope located at Maryland Point, near Riverside, Md. This instrument is well suited for use on the research problems outlined in the article beginning on page 1.