NAVAL RESEARCH REVIEWS

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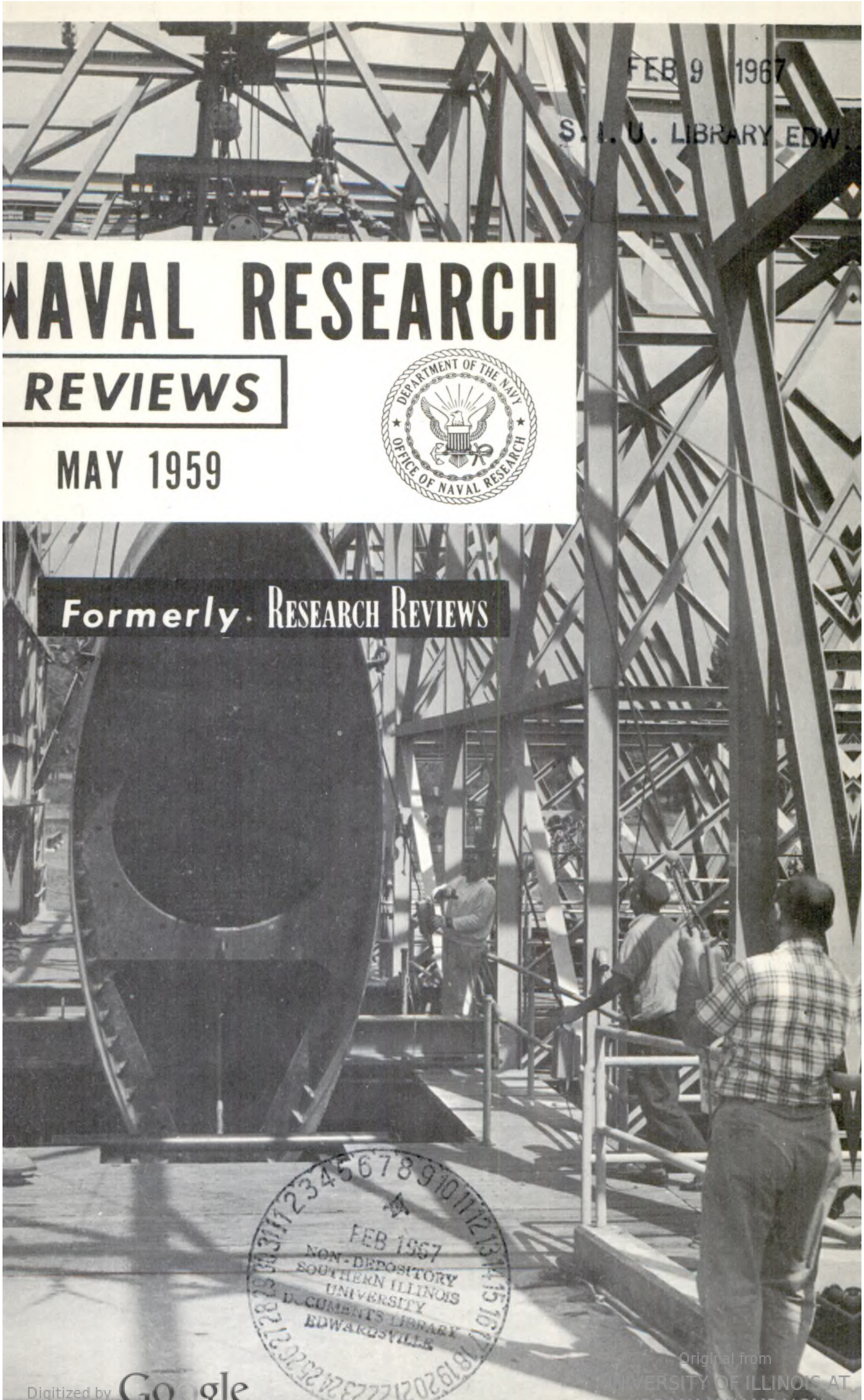


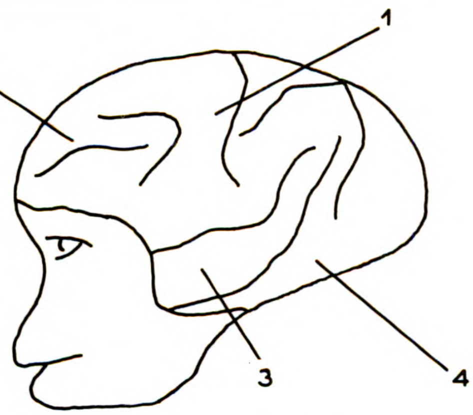


DIAGRAM OF BRAIN

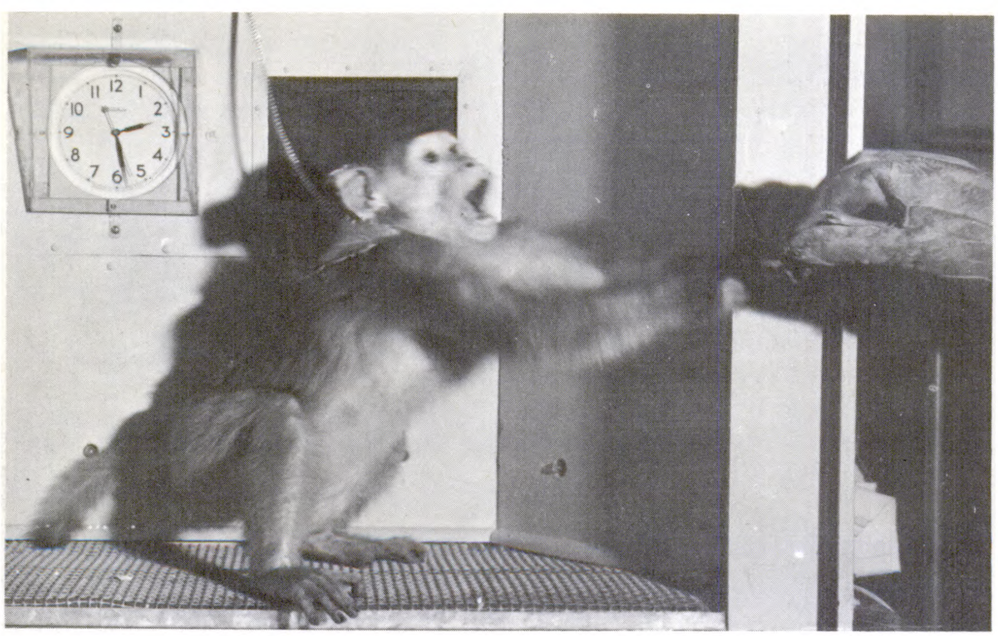
1. The motor cortex extends over the lateral surface of the brain and also within some of its folds. Its stimulation evokes a wide variety of movements (Figure 2).

2. The septal area is located in the depth of the frontal lobe. Its stimulation inhibits aggressive behavior (Figure 5).

3. The "amygdala" is in the depth of the temporal lobe. The stimulation of some of its points seems to be pleasant to monkeys (Figure 3).

4. Stimulation of the tectal area, located in the depth of the posterior part of the brain, may induce "fear" (Figure 4).

The Macacus rhesus monkey is usually aggressive, as shown below. But when electrical stimulation is applied to the septal area of his brain, his mood changes. An indication of this change is given in Figure 5, page 6.



Control of Behavior by Electronic Stimulation of the Brain

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In the present age of guided missiles it should not surprise us to learn that some scientists are trying to guide the most powerful weapon in the world—the brain—by electronic means. Fortunately for mankind, the cerebral functions are so complex that harnessing of the spirit by electric forces is, I believe, out of reach. However, it is possible today to evoke movements, aggression, and docility, to modify leadership, sexual drive, and social relations, and in general to influence many patterns of behavior by electrical stimulation of the brain. For the past ten years in my laboratory at Yale I have been studying these problems by means of electrodes implanted permanently within the brain of cats and monkeys.* Electrical stimulations were applied and recordings made of the cerebral electrical activity for periods of months in the same animal. The procedure is neither painful nor uncomfortable, and during testing the animals are fully conscious. Electrical stimulation of the brain is in no sense an electrical shock; it is a very mild unfelt current applied to a selected cerebral structure. It acts to cause a response in the same way that a visual or auditory stimulus triggers a cerebral area to register something seen or heard.

The technique involves the use of two types of assemblies of electrodes (Figure 1). Electrode needles comprise a tiny bundle of six Teflon-insulated stainless-steel wires of different lengths which are cemented together with Plexiglas. Electrode plates consist of six Teflon-insulated silver wires ending in tiny silver balls encased in a thin (1-mil) sheet of polyethylene. Both electrode assemblies terminate in a subminiature radio-tube socket through which electrical connections are easily established.

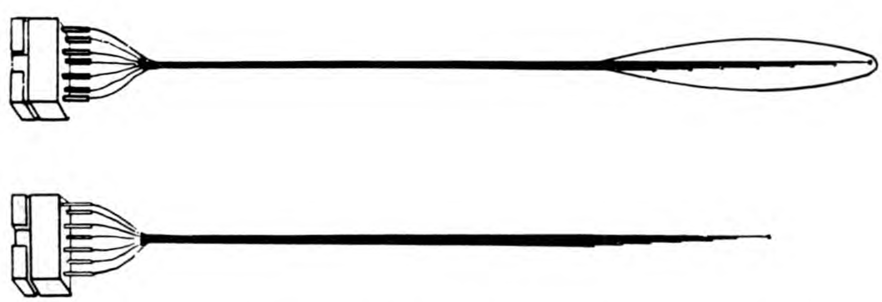


Figure 1 - Multielectrode plate (above) and needle (below), used respectively for exploration of the surface and depths of the brain.

*This research has been supported by the Office of Naval Research and the Foundations Fund for Research in Psychiatry.

After selecting the exact anatomical point for implantation (with the aid of stereotaxic maps of the brain) a small burr hole is made in the skull. Plate electrodes are placed manually over the surface of the brain. The needles are positioned properly by a brace holding the head of the animal in a fixed position and a micromanipulator which lowers the shaft to the desired depth. In general, two to four assemblies are implanted in each animal, with a total of 12 to 24 leads. This multiplicity of points is needed to establish controls and to study correlations between different cerebral areas. The operation is completed by anchoring the leads to the skull with dental cement and metal sutures to prevent the animals from pulling out the electrodes. The only part of the unit visible on the scalp is the socket, and this becomes almost invisible as the hair grows up around it. Of more importance, however, is the fact that the intracerebral leads cause no disturbance and that after a week or two the animals appear to be completely unaware of the sockets affixed to the head.

MOTOR ACTIVITY

Under the influence of electrical stimulation of the brain the cats and monkeys performed like electrical toys. Depending on which "button" was pressed by the investigators, one of a great variety of motor responses was evoked. These involved movements of virtually all parts of the body—forelimbs, hindlimbs, tail, trunk, head, and ears. Many of the effects resembled spontaneous activity. In some cases, however, spontaneous and evoked movements worked together to produce combined responses. For example, if we offered a piece of meat to a cat the animal would spontaneously raise a paw to take it, but if, at the same time, we stimulated the particular part of the motor cortex that causes this same effect, the raising of the foreleg would be exaggerated. On the other hand, the spontaneous and evoked movements sometimes cancelled each other out. In this case the "will" of the animal apparently opposed the response evoked by the mild electrical excitation, and the movement would not be made. However, when stronger stimulations were applied this opposition broke down, and the animal responded as "directed." These performances indicated that electrical stimulation of the brain may interact with normal brain functions.

Complex motions such as yawning, sneezing, licking, shaking the head, and hopping were also elicited by cerebral excitation. As these movements were evoked, the animals adjusted their posture for the best performance of the response (Figure 2) and avoided any obstacles in their path. Even if we tried to impede the response by holding the animals, they struggled to free themselves in order to follow the command of the cerebral stimulation. They seemed to enjoy the experiments, or at least did not appear to be disturbed by them, for while they were taking place the cats often purred and the monkeys looked peaceful.

Electrical stimulation of the brain evoked not only a great variety of movements characteristic of the normal activity of the animals but also a few involuntary responses, such as counterclockwise rotation of

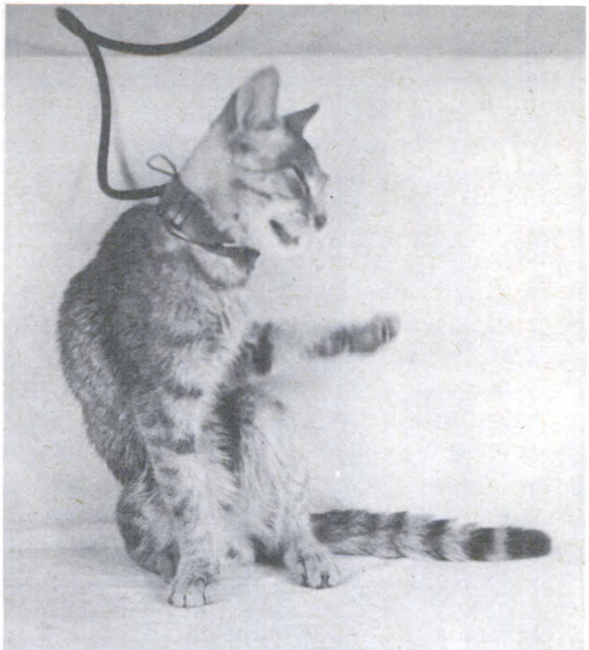


Figure 2 - Electrical stimulation of the right motor cortex of cats evoked raising of the left forelimb, with good postural adaptation. The movement was not uncomfortable for the animals, which purred during the experiments.

one eye. Another type of excitation caused the cats to "freeze" in the positions they occupied at the moment stimulation was begun and to hold those positions until the stimulation ceased, at which time they resumed their normal activities. In one case, an animal stopped licking, its tongue protruding from its mouth; in another, it stood motionless between two steps of a stairway.

EMOTIONAL BEHAVIOR

Although stimulation of the cerebral motor cortex caused a wide variety of movements, as we have seen, it seemed to have no effect on the emotional life of the animals. However, emotional reactions can be evoked by stimulation of other areas of the brain. For example, excitation of some areas located in the inferior part of the brain (amygdala and hypothalamus) can evoke rage reactions. In the literature on this subject some doubt has been expressed as to the exact nature of these effects. Are they "true" emotional experiences? Or are they only external manifestations without conscious perception of the emotion?

To study this problem we experimented with a simple emotional response—the fear which is evoked by noxious sensation. When certain stimulation, such as an electrical discharge, is applied to the feet of a monkey, the following effects are produced:

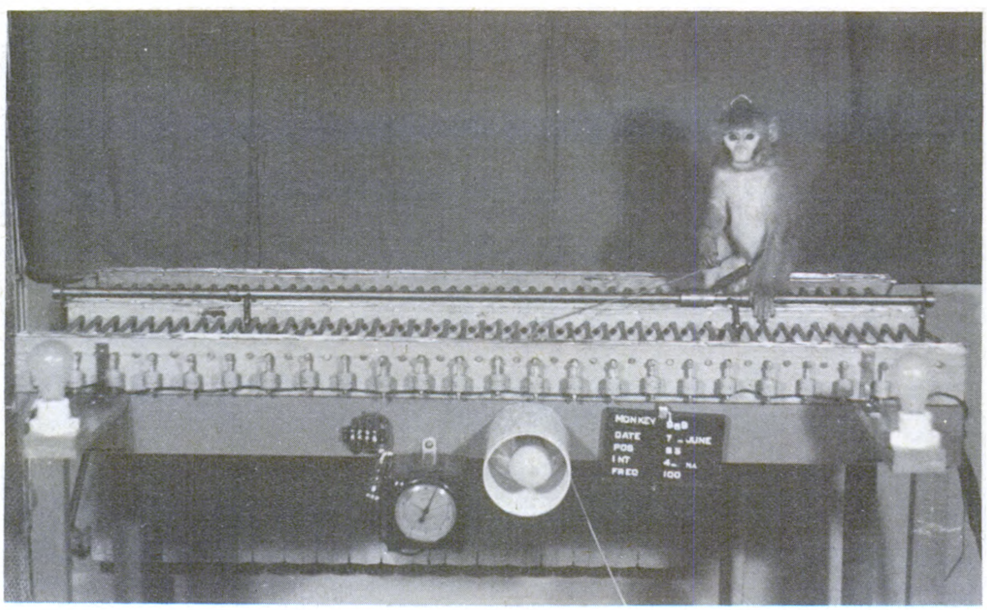
- Defensive-offensive movements.
- High-pitch vocalization.
- Involuntary manifestations, such as pupillary dilatation, urination, changes in respiration, and an increasing heart rate.
- Anxiety.

The same set of responses can be evoked electrically by stimulating specific points of the brain. As the effect of stimulating each of these areas was rather specific, we were able to trace the structures probably concerned in the integration of fear and pain in cats and monkeys. An interesting fact is that the so-called sensory cortex is not involved in this system, meaning that the superior integration of fear and pain occurs in other cerebral areas which probably include structures located deep in the center of the brain (thalamus and posterior hippocampus).

As has been demonstrated many times, animals can be conditioned to avoid an unpleasant experience. They may learn, for example, to press a lever that will avert an electrical shock to the feet. In order to determine the similarity between the effects of peripheral noxious stimulation and direct stimulation of specific cerebral structures, a group of monkeys was trained to turn over one cup in order to obtain food, and to turn over a different cup in order to avoid a shock to the feet. When the monkeys had been trained so that at least 90 percent of their responses were correct (that is, enabled them to avoid the electric shock) different points of the "fear" system of the brain were stimulated electrically. This excitation caused the animals to turn the same cup they had been trained to turn when they received actual shock to the feet, which indicates that stimulation of some points of the brain was associated by the animal with responses it had learned previously to avoid an unpleasant experience.

In another set of experiments, a monkey was placed on a table on which he could move freely, as shown in Figure 3. When he was on one side of the table or the other, depending on the particular experi-

Figure 3 - On this testing table, a monkey has considerable freedom of movement while undergoing brain-stimulation experiments. Stimulation of some cerebral points seemed to be "attractive" for the animal, while stimulation of other areas was "unattractive."



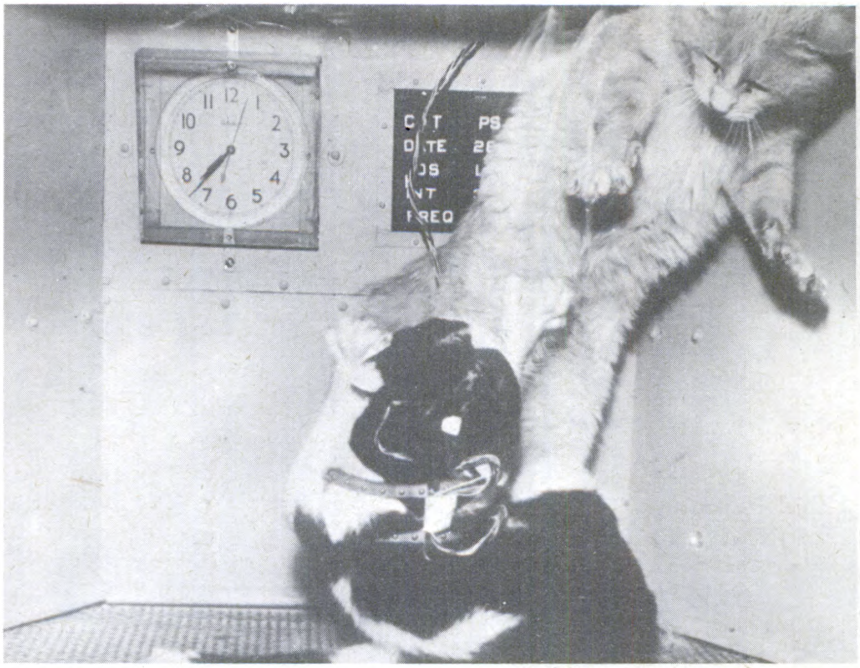


Figure 4 - Well-oriented aggressive activity may be evoked in the cat by electrical stimulation of the tectal area. The two cats shown here were "good friends" before this stimulation was applied.

ment, certain areas of his brain were stimulated. We found that when some points in the septum and amygdala were excited, the monkey spent more time on the side of the table on which he received the stimulation, whereas when other points of the amygdala were excited he spent less time there. In this way we were able to show that stimulation of some cerebral areas seemed attractive to the animal, while stimulation of other areas seemed unattractive. Neutral areas were also found.

Repeated electrical excitation of the motor cortex for weeks or months did not produce observable modifications in spontaneous behavior of the animals. Such modifications did occur, however, after experiments in which fear was evoked by direct stimulation of the brain. For example, when the subjects of these stimulations were again placed in the cages in which the "fear" experiments had been performed, they would immediately show signs of anxiety, manifested by biting, restlessness, and attempts to escape.

The tectal area, located in the infero-posterior part of the brain, was one area found to be responsible for aggressive behavior. When we stimulated this region in experimental cats, the animals reacted violently. Ordinarily tame and peaceful, the animals now hissed, spat, bit the observer's gloves, and became rather dangerous to handle. The awareness, purposefulness, and good orientation of the aggressive behavior were tested by placing two cats in the same cage. As soon as the tectal area of one was stimulated, it attacked the control cat and a fight began, as shown in Figure 4. Social relations, which had been excellent before the stimulation was applied, changed after a few experiments, and a lasting state of distrust between the two animals was created.

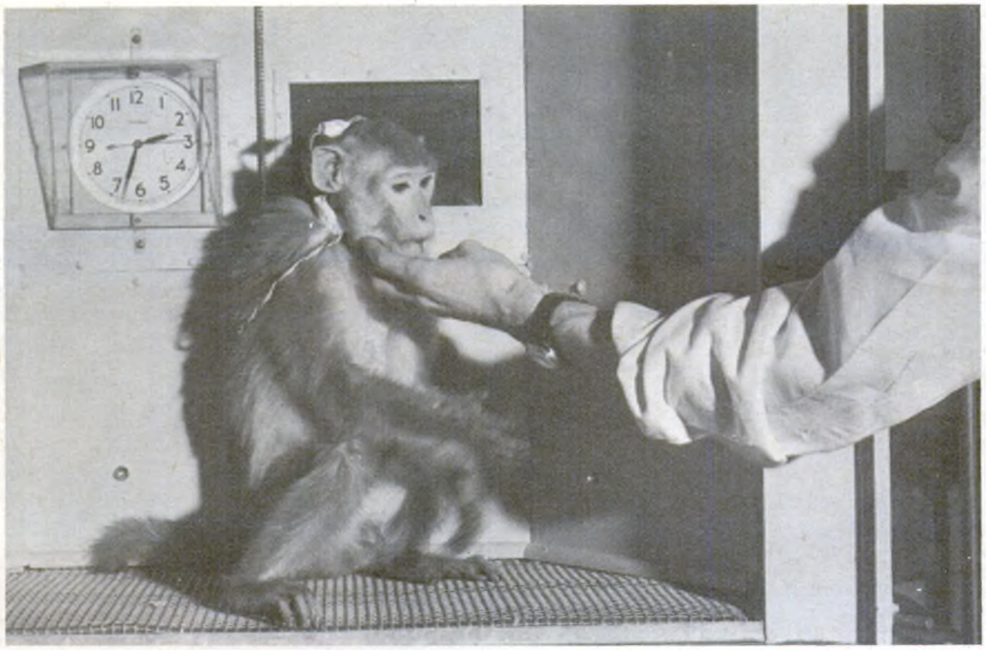


Figure 5 - When electrical stimulation is applied to the septal area of the usually aggressive Macacus rhesus monkey, the animal becomes tame. One can then touch his mouth. Compare with photograph on inside front cover.

In both cats and monkeys we have shown that aggressive behavior can be modified by direct stimulation of the brain, the aggressiveness increasing when the tectal area and certain points in the amygdala are stimulated, and decreasing when the septal or anterior cingulate region (both situated toward the front of the medial part of the brain) is stimulated. The effect of exciting the latter regions in the spontaneously fierce rhesus monkey was spectacular. During the stimulation, these animals could be handled easily and their mouths touched (Figure 5), but as soon as the excitation ended they resumed their normal aggressiveness, as shown on inside front cover.

SOCIAL BEHAVIOR

As a means of learning more about the role played by the brain in animal behavior, we expanded our work to encompass animal colonies. The advantage of studying animals in social groups is apparent when one takes into account the many interrelated activities and conflicting situations that arise in the group environment—sexual relations, grooming, play, and the struggle for food—to mention only a few. To facilitate our observations we developed a technique for making continuous photographic recordings of the behavior of members of the colonies. A 16-mm. moving picture camera operated by a timing mechanism made one picture every 2 seconds in the monkey colonies, and one picture every 9 seconds in the cat colony, in which there was less activity (between 4,000 and 16,000 frames every day). The pictures were then analyzed to determine the different types of behavior exhibited, such as aggressiveness, sleep, motor activity, grooming, and mounting, and the frequency and duration of each category was tabulated. After a control period of several days, we began to stimulate different cerebral structures of certain animals for an hour each day for several days.

The important fact revealed by this investigation was that social activities could be modified by direct stimulation of the brain even when the stimulation lasted only for very brief periods, and that these effects persisted for several days. The cats subjected to electrical excitation of the amygdala showed a statistically significant increase in what we might call contactual activities: the stimulated animal sniffed and licked the other cats and rubbed and nuzzled against them more often and for a longer time than during control periods. It was interesting that the increase of contactual activities lasted for several days after stimulation was discontinued, proving that lasting changes had been made in the function of the excited point. This was confirmed by recordings of the cerebral electrical activity of the stimulated animals, which showed for several days special waves of high voltage, probably related to the modifications of social activities.

The studies discussed in this article reveal that several aspects of animal behavior can be modified by direct stimulation of the brain. Although this constitutes an important step, I do not think that it will be possible to control human behavior by a combination of surgery and electronics. However, useful applications may be expected. Implantation of electrodes in the human brain has already begun—mainly as a diagnostic aid in epilepsy—and implanted catheters are now being employed successfully in the treatment of shaking palsy. Moreover, considering that emotional disturbances are the principal problem in many mental illnesses, and that emotional behavior can be modified in animals and in humans by cerebral stimulation, most rewarding results appear to await further work in this field. The challenge to intensify our research of the animal and human brain is therefore very great.

CAPT James A. English, DC, USN, Head, Medicine and Dentistry Branch, Office of Naval Research, and Head of the Dental Branch in the Research Division, Bureau of Medicine and Surgery, has been elected Vice President of the International Association for Dental Research.

Dr. Emanuel R. Piore, a former Chief Scientist of the Office of Naval Research and now Director of Research for IBM, has been appointed by President Eisenhower to the Science Advisory Committee.

A new viewing device developed for Army tanks helped the Navy's atomic submarine SKATE probe a path through the ice on its journey to the North Pole. Mounted in a shock-proof container on the SKATE, the super-sensitive viewer--similar to a television camera--gave the crew inside the submerged submarine a look at the ice above. This was the first actual use of the instrument, which was built primarily for mounting in a tank to permit fire direction against enemy targets at night.

The Bio-Dynamics of Launch and Reentry

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During recent years, the word "dynamic" has come into rather wide use. Unfortunately, as the word has become more popular, its meaning has become less precise. Whereas in the formal language of the physical scientist the term is applied to an area of physics which deals with the relations among force, mass, and the exchange of energy, in the language of the man on the street it can mean a great deal more. In this article, the meaning given to the word is intended to match rather closely the formal one, except that as combined with "bio" the implication is that some of the forces under consideration are of biological origin and that some of the masses involved represent parts of or entire biological organisms. Needless to say, studies of biodynamics are of the utmost importance in planning manned space flights. This becomes clear when one considers the stresses man will be subjected to upon leaving and returning to earth.

ACCELERATION TOLERANCE

Very large forces with which man has had little experience will be imposed upon the occupants of space vehicles during their escape from the surface of the earth or from similar large masses. With present fuels, the practical requirements for escape dictate that relatively high accelerations be sustained over relatively short periods of time. An illustration of a changing acceleration pattern over a short period of time is presented in Figure 1. This pattern does not represent the result of precise calculations for a specific vehicle. However, it does give a reasonable indication of the rate, maximum level, and the total elapsed time of the acceleration which will be required to put a manned vehicle into orbit around the earth or to enable such a vehicle to escape the immediate vicinity of the earth on the way to the moon. There is no question but that a man, if provided with adequate mechanical support and restraining equipment, can tolerate accelerations such as those illustrated without injury, and without even serious discomfort.

If man is to return to the surface of the earth or to the surface of any other large body after traveling in space, his vehicle must be slowed down to speed ranges in which a parachute can be employed or a landing can be made by means of conventional aerodynamic control of the vehicle. This deceleration may also impose severe forces on the man.

The ability of a man to tolerate forces of acceleration varies considerably with the orientation of the forces with respect to his body.

*Presented at the Military Surgeons 65th Annual Convention, November 17, 1958.

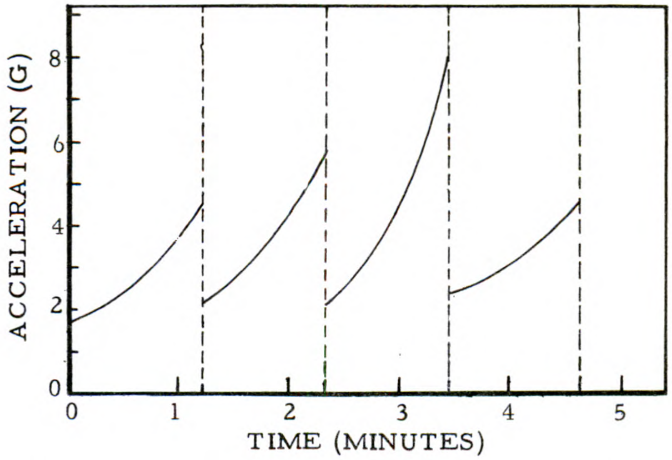

Figure 1--An acceleration pattern for a multi-stage orbital vehicle.

When a force acts to accelerate the body in the head-to-foot direction, so that blood and internal organs move toward the head, man can only tolerate a maximum acceleration equal to 3-1/2 times that of the earth's gravity. Of course, the duration of exposure must be considered, too. If the line of action is reversed, he can withstand a force equal to about 4-1/2 times the acceleration of the earth's gravity before blackout occurs during extended periods of exposure. On the other hand, if the orientation of the force is approximately perpendicular to the long axis of the man's body, his tolerance becomes very high. At the present moment, however, it is not possible to say exactly how high this tolerance is.

Recent work at the Navy centrifuge at Johnsville, Pa., by C. C. Collins and R. F. Gray, has demonstrated man's tolerance to acceleration forces higher than 20 Gs for a period of several seconds. This is illustrated in Figure 2. Both of the investigators who sustained this acceleration pattern feel that with slight improvements in support they could tolerate even greater stress. The support which was employed, illustrated in Figure 3, is a molded contour couch which was developed

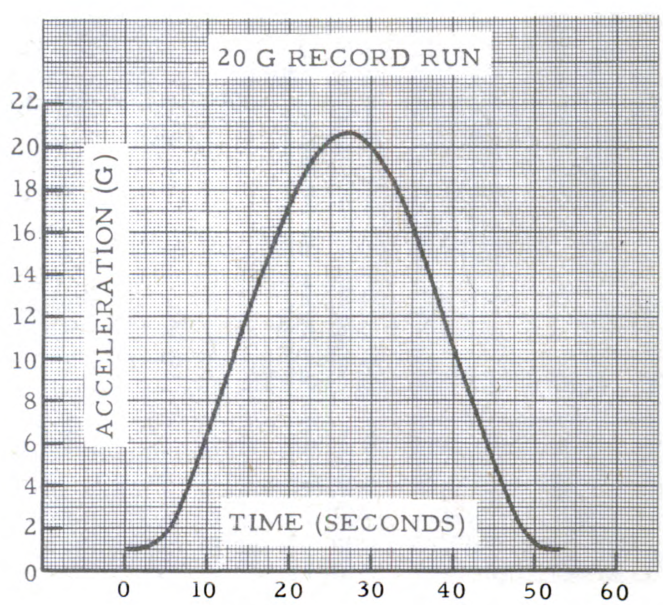

Figure 2--An acceleration time-history which is within man's tolerance limits.

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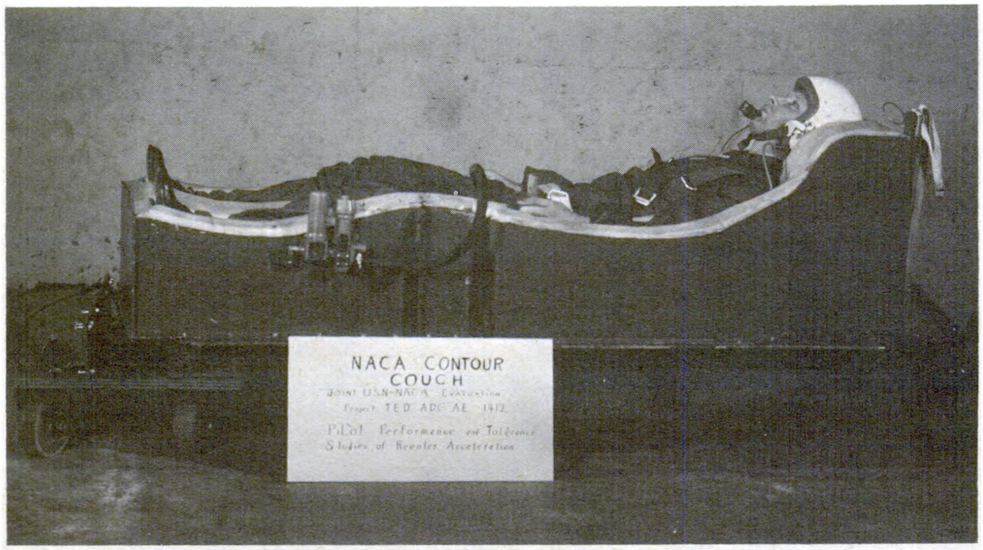


Figure 3--Couch developed by the National Aeronautics and Space Administration for high-acceleration exposure.

in the Langley Laboratory of the National Aeronautics and Space Administration. Use of this couch tends to minimize deformation of the chest cavity, and thus enables one to tolerate higher levels of acceleration before chest pains are experienced or breathing is completely prevented. The ultimate limitation on the time one can stand such exposure while "seated" on this kind of couch will undoubtedly be determined by the subject's ability to breathe. It may therefore be necessary to limit the duration of very high acceleration exposures in space vehicles to periods during which a passenger can comfortably hold his breath.

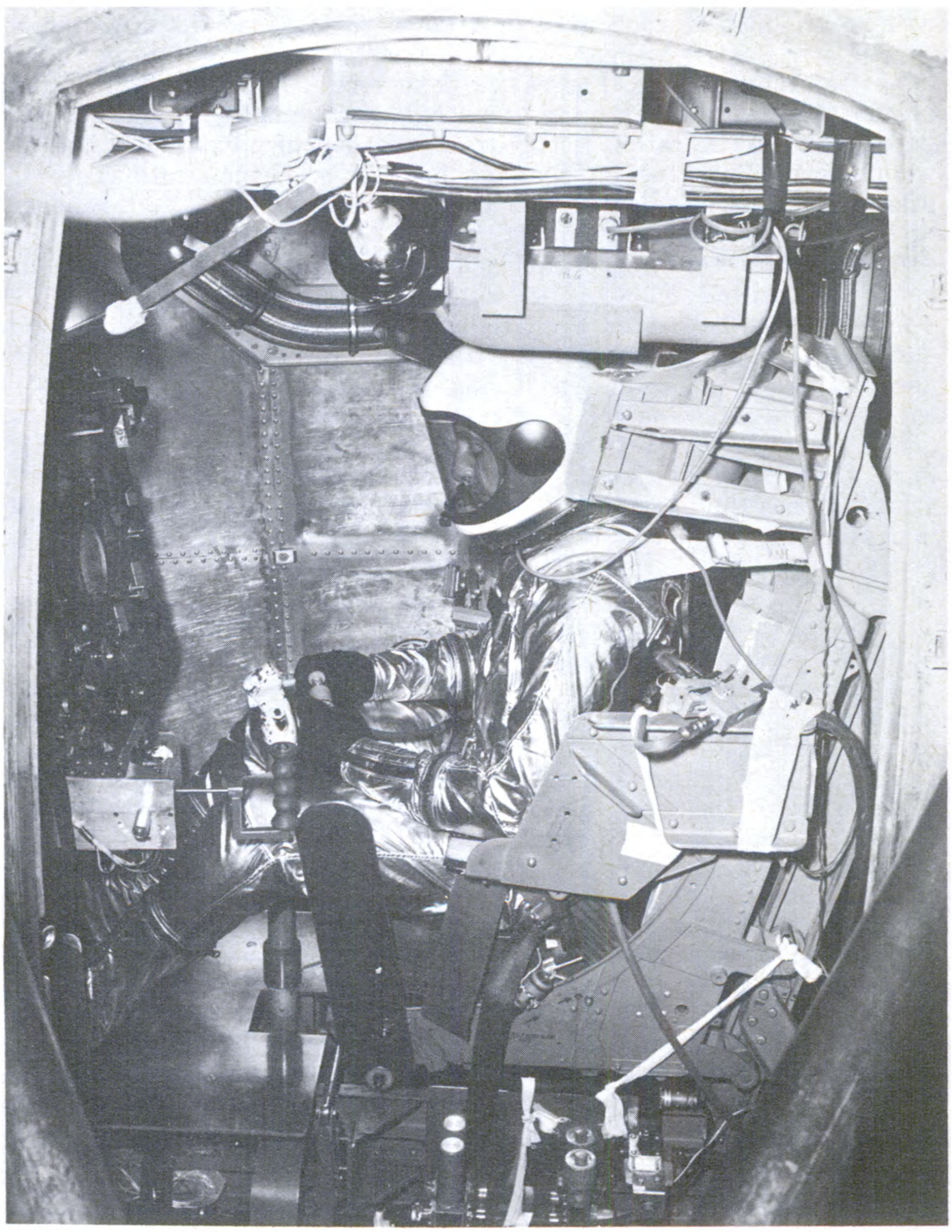
The vibrations which will undoubtedly be encountered during the exit flight of a rocket vehicle pose a problem which has been given less publicity than the problem of acceleration. The human being has relatively low tolerance to vibrations with amplitudes of a fraction of a centimeter at frequencies from 5 to 100 cycles per second. In fact, vibrations in certain frequency regions over this range can cause severe discomfort, injury, and even death. However, it now appears that this problem can be solved through adequate design and damping of vibrations.

ACCELERATION AND PERFORMANCE

It should be evident at this point that if man is to be just a passenger in a space vehicle, the accelerations and vibrations he will experience will not prevent his passage into space. Important problems do arise, however, when we consider what the occupants of some of our pioneering space vehicles may be required to do while subjected to these stresses. Man has some remarkable abilities which can be very useful in controlling a space craft. For example, he can compensate for unforeseen contingencies, such as those which recently prevented our moon rockets from reaching their intended destinations. In order to perform automatically the kind of jobs that a man can do, elaborate computers would be required. These machines would add both weight and volume to the space vehicles and would also impose a severe penalty in terms of increased fuel requirements. It is therefore important, certainly in our early attempts to put manned vehicles into space, to use man's abilities to the fullest possible extent.

But when we consider utilizing man to best advantage in such an undertaking, we are confronted by a whole new set of problems. We are convinced that he can tolerate the accelerations and the damped vibrations which will be encountered in exit and that he can endure the

Figure 4--A simulated cockpit of the North American Aviation Corp.'s X-15 aircraft, with test pilot Scott Crossfield at the controls.



stresses to be experienced on reentry, but we know little about his motor performance capabilities under these conditions. We must learn what tasks he is capable of performing during these critical periods.

It seems likely that our next step toward space flight will be made with the X-15 research rocket aircraft which has been built by North American Aviation Corp. In Figure 4 we see a photograph of a simulated cockpit of this vehicle. The pilot, who is shown wearing a reflectorized full-pressure suit, is confronted by a complex instrument panel which displays a wide variety of information. He must exercise control over the vehicle during most of its flight. He will have to regulate precisely such things as the angle of climb, the altitude of his craft, its angle of attack, and in future multistage vehicles, perhaps even the time of initiation and termination of thrust from the final stage. This will be an imposing job which will require continuous concentration.

As illustrated in Figure 4, designers have already made the assumption that such exacting tasks can be accomplished better during exposure to acceleration if the arms are supported and the hands and wrists manipulate special controls instead of the conventional center stick. The pilot's job will be complicated by the fact that the response of his craft to control manipulations will change with the decreasing density of the atmosphere during his exit flight. By the time he has reached an altitude of about 40 miles, the air may be so thin that the vehicle cannot be guided by changing the orientation of aerodynamic surfaces. Control of the vehicle's altitude will thereafter depend on the use of auxiliary rockets. The firing of such rockets is accomplished with the left-hand control in Figure 4. Once a manned satellite has gone into orbit, the vehicle will move at a constant speed, its centrifugal force just compensating the gravitational attraction of the earth. The pilot may then have to modify his muscular responses considerably in performing precise control movements, for he will be operating in a gravity-free state.

It seems reasonable to assume at the present time that the pilots of the earliest manned satellites will be expected to play an important role in their recovery. These vehicles will be decelerated in orbit and will begin to spiral in toward the earth. The pilot's job will be to control their descent. Many important factors must be taken into consideration in planning for this operation: Deceleration of the craft must begin early, or the speed will be too high when the denser atmosphere is reached, and excessive heating of the skin of the vehicle will result. Early deceleration can be achieved by presenting the vehicle to the thin upper reaches of the atmosphere in a "pancake" altitude, which will result in the greatest possible drag. However, as the atmospheric density increases, the deceleration of the craft will increase at an alarming rate if this attitude is maintained. The pilot must be very careful not to exceed the acceleration design limitations of the vehicle, not to mention his own limitations. To complicate matters, he will have to get information from a variety of sources. Special inertial instruments will have to be used where the atmosphere is too thin for conventional methods of speed and altitude measurement. At lower altitudes, where accuracy is exceedingly important, more conventional instruments will probably be used.

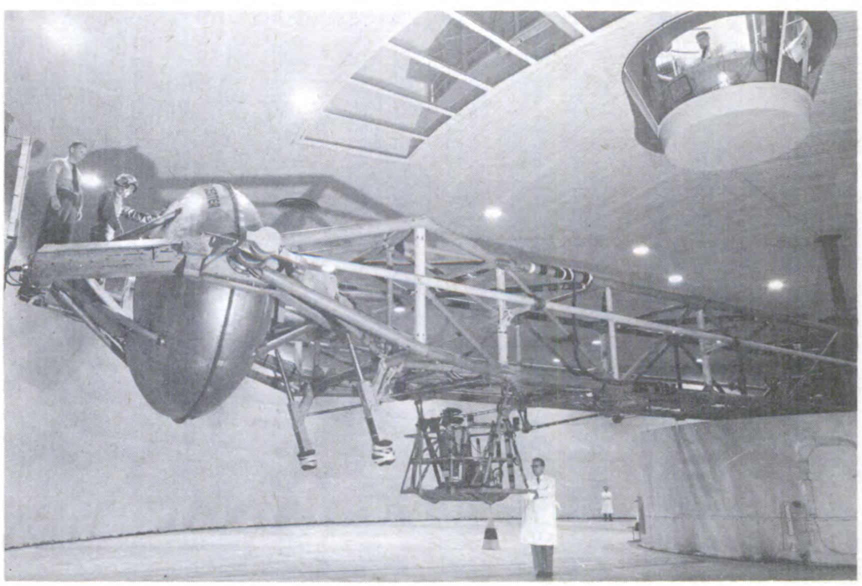
Just as was the case during exit, the response of the vehicle will vary continuously with the increasing density of the atmosphere. The pilot's compensations for the sluggish performance of the craft at high altitudes will be completely inappropriate at lower altitudes. Conceivably, a slight deviation from optimum in a pilot's control movements may induce oscillations which will result in changing accelerations. These may vary between 5 and 8 Gs in frequencies of nearly 1 cycle per second and may last for as many as 20 seconds, even if the pilot is able to damp them out relatively quickly.

THE CASE FOR BIODYNAMICS

It is possible to balance the controls in such a way that the forces required to operate them are independent of the acceleration which prevails at any given moment. Unfortunately, this cannot be done with the pilot's limbs. Fluctuations of acceleration will vary the effective weight of his arms and hands and may result in inadvertent movements of the controls. During reentry into the earth's atmosphere it will be necessary for the pilot to foresake all those adaptations which he was required to learn for appropriate performance under conditions of zero gravity. With each change the range of frequencies over which his muscles can be expected to exert control will undoubtedly change and so will the optimum characteristics of the controls he is operating.

If a pilot is to be required to manipulate controls during changing patterns of acceleration complicated by changes in the response characteristics of his vehicle, it is important that the entire control problem be subjected to a precise engineering study. Only in this way will it be possible to achieve optimum design of control mechanisms and pilot restraint equipment. The complications are such that the problem must be studied empirically under conditions which are as accurate and as precisely regulated as possible. Fortunately, this can be done in the Navy's centrifuge at Johnsville, illustrated in Figure 5.

Figure 5--The Navy's giant centrifuge at Johnsville, Pa.



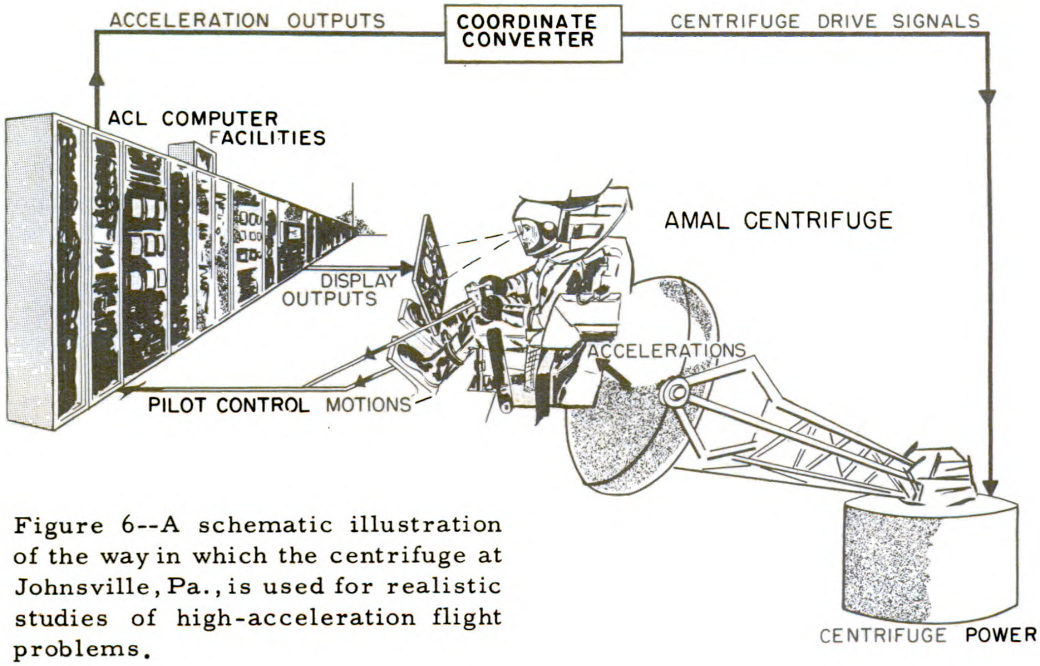


Figure 6--A schematic illustration of the way in which the centrifuge at Johnsville, Pa., is used for realistic studies of high-acceleration flight problems.

Investigators at Johnsville have already studied the pilot's control function in the X-15 under realistic conditions, including linear accelerations which will be encountered, using controls like those which will be employed in the aircraft. Figure 6 illustrates schematically the way in which this work was done. The simulated cockpit of the X-15 (Figure 4) was installed in the centrifuge gondola. Signals which resulted from the pilot's control manipulations were transmitted to a large analogue computer which calculated the responses of the aircraft and fed back appropriate signals to the instrument display panels. Additional signals were fed back into the centrifuge control system so that the accelerations developed by the centrifuge were appropriate for the pilot's control manipulations, the altitude and speed of the vehicle, and other conditions. At the present time, other projects concerning systems even more advanced than the X-15 are being conducted.

HUMAN ADAPTABILITY—A MIXED BLESSING

In spite of the tremendous potentialities of the centrifuge for studying problems which man may encounter in space before he actually gets there, there is a real danger that our efforts may be inadequate. In designing our entries for competition with the Russians in the conquest of space, our engineers are required to apply precise quantitative principles to all aspects of a given system except those which interact directly with the pilot. Here, they rely on man's tremendous flexibility and adaptability. By observing such simple capabilities as the directions in which man can move his limbs, the distances he can reach, and the forces he can exert, engineers are building systems which any clever pilot, given appropriate training, can operate adequately in nine out of ten situations. Many of these control systems are relatively crude, however, and push the pilot to the near limits of his ability, even in static simulators. Any small unforeseen contingency may drive the pilot beyond his limits of ability and cause the system to fail.

To some people this state of affairs may appear to present a fine challenge to pilots. But even after we have done our utmost to match instrument displays and controls to the human pilot there will still be adequate challenge for even the most daring of men. We must therefore increase our efforts in the systematic study of the dynamic relations between a pilot and his controls. In addition to conducting investigations of the maximum forces he can exert and the range of movements of which he is capable, we must study subtler problems, such as the frequency response characteristics of his limbs in various positions under different conditions of acceleration. The only alternative to this kind of study is a completely automatic system, the development of which would perhaps unnecessarily delay our advance into space.

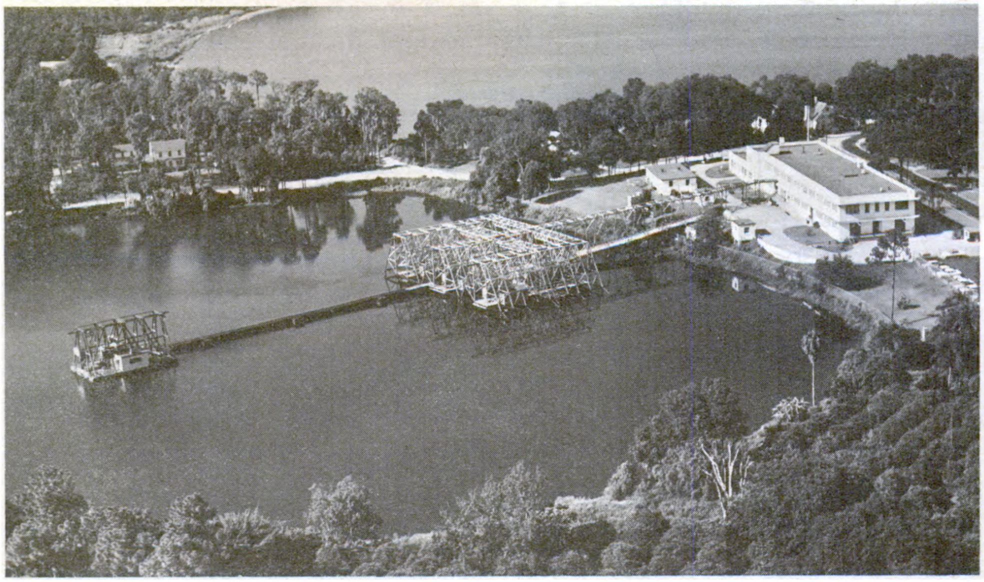
If we are going to use the pilot most effectively we must conduct a thorough engineering study of his sensory and motor capabilities under changing conditions of acceleration and design the equipment which he will use accordingly. It will be far better to study him in advance of his actual mission, rather than after the importance of this kind of study is dramatized by tragic failure of our pioneering attempts.

Conference on Quantum Electronics - Resonance Phenomena

An international conference on Quantum Electronics -- Resonance Phenomena will be held at the Shawanga Lodge, Bloomingburg, New York, September 14 to 16, 1959. The conference, which is being sponsored by the Office of Naval Research, will consider basic problems in physics and electronics which are important to the increasing use of molecular and atomic resonances in masers, atomic clocks, and related devices, as well as the application of "quantum electronics" to scientific problems. Among the topics to be considered are:

- Paramagnetic resonances and relaxation.
- Frequency and time standards based on atomic or molecular resonances.
- Low-noise amplification by stimulation emission.
- Optical spectroscopy of paramagnetic salts.
- Generation of millimeter waves by maser techniques.
- Application of cyclotron resonances in solids to electronics.
- Generation, amplification, and detection of infrared or optical radiation by resonance techniques.
- Applications of "quantum electronics" to radioastronomy, high-resolution spectroscopy, and tests of relativity.

It is intended that this will be a working conference rather than a tutorial meeting. Consequently, attendance is being limited to those who are active in appropriate fields of research.



Aerial view of Navy Underwater Sound Reference Laboratory, Orlando, Fla. The steel structures in the lake are piers from which measurements are made on Navy underwater sound equipment. The main laboratory building is at upper right.

The Underwater Sound Reference Laboratory

John M. Taylor, Jr.
Scientific Staff Assistant
Underwater Sound Reference Laboratory

Our Navy's modern sonar devices are vastly different from the crude apparatus first used to listen to underwater sounds. One of the earliest means of detecting unseen ships at sea was by listening through tubes fastened in a giant stethoscope-like arrangement to watertight blisters below the waterline on the hull of a ship. This early technique relied entirely on the sounds made by ships themselves as they moved through the water and on the sensitivity of the human ear to detect the sounds.

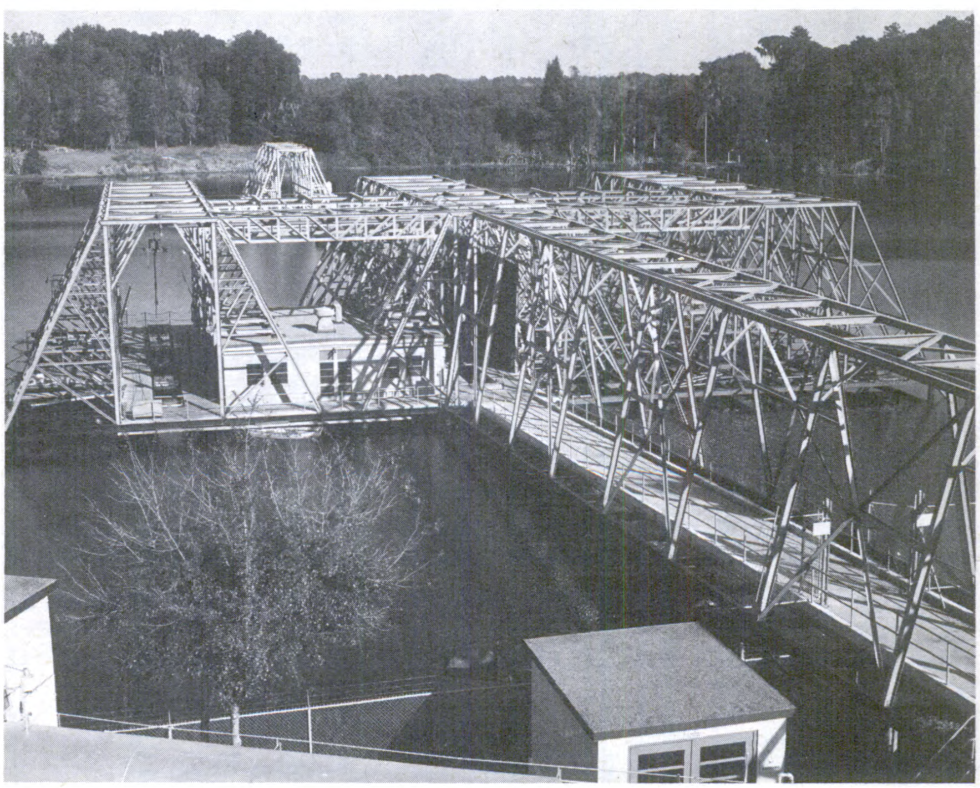
The development of electroacoustic devices made it possible to detect and amplify sounds so faint they would have been missed by even the most sensitive unaided human ear. The new technology also made it possible to direct a beam of underwater sound waves through the water and listen for echoes from other ships, underwater obstacles, or the bottom.

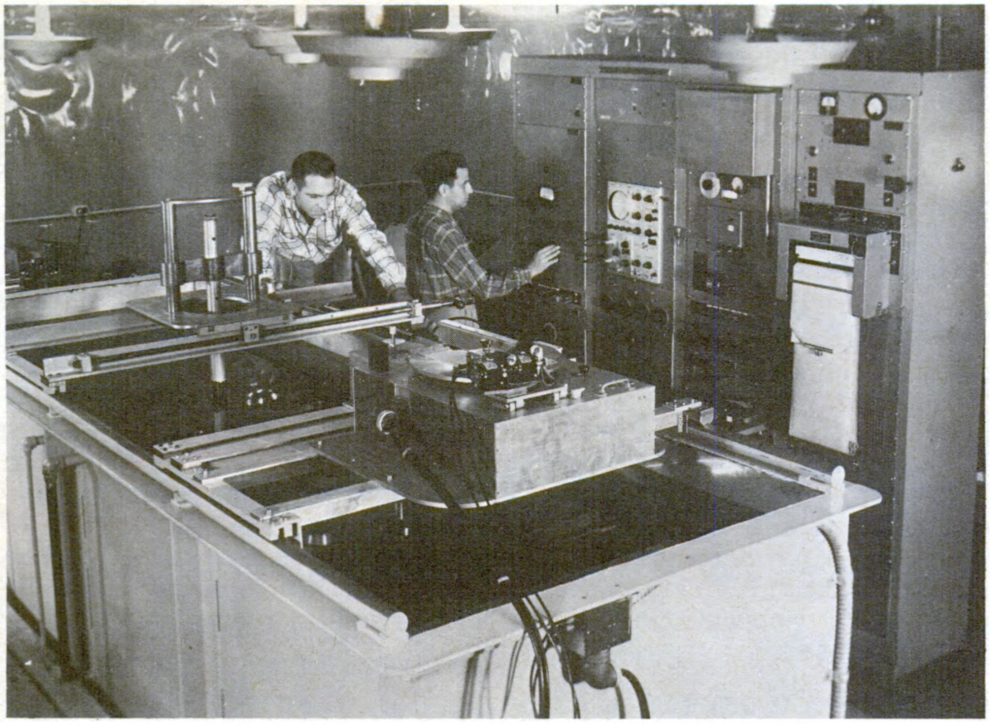
The Navy gradually developed special equipment for detecting the approach of other ships and submarines, aiding navigation, signalling from one ship to another, providing information for accurate aim in firing shells and torpedoes, and for other purposes. Essential in all of these applications are an underwater loudspeaker and an underwater microphone, called by scientists underwater-sound transducers, or just transducers.

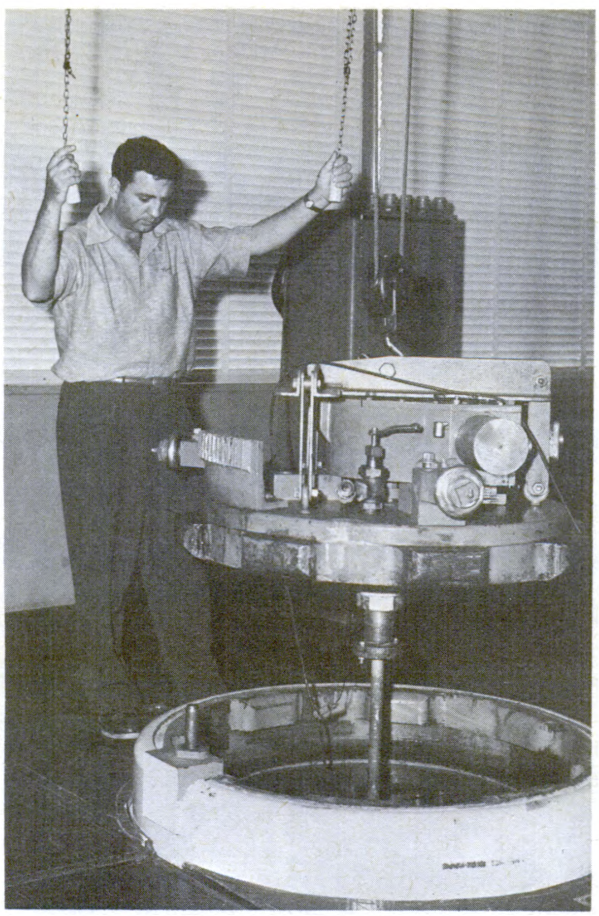
The Navy has had to perform most of the necessary research and development in underwater sound in its own laboratories because commercial interest in the devices is slight. But scientific research and technical development cannot proceed very far without methods and equipment for making precise measurements. The Navy's principal laboratory for specialized measurements on underwater sound devices is the U. S. Navy Underwater Sound Reference Laboratory (commonly called the USRL) of the Office of Naval Research. It is located at Orlando, Florida.

In carrying out its assignment, the USRL performs research and development in three categories: methods of measurement and data processing; transducers and acoustic materials; and measuring systems and instrumentation. The Laboratory also provides various other services for the Navy: As a disinterested party it evaluates and calibrates experimental, developmental, and preproduction sonar equipment. It keeps a stock of various kinds of measuring equipment for loan to other naval activities. It maintains close liaison with naval and industrial activities doing sonar research and development, and provides information and advice about methods and equipment.

The four piers at USRL as seen from the roof of the Laboratory building. From these piers, measurements are made on transducers suspended in the lake. One of the wells from which the measurements are made is visible in the branch of the pier at left. Measuring systems on the piers cover the frequency range from about 40 cycles per second to 150 kilocycles per second.

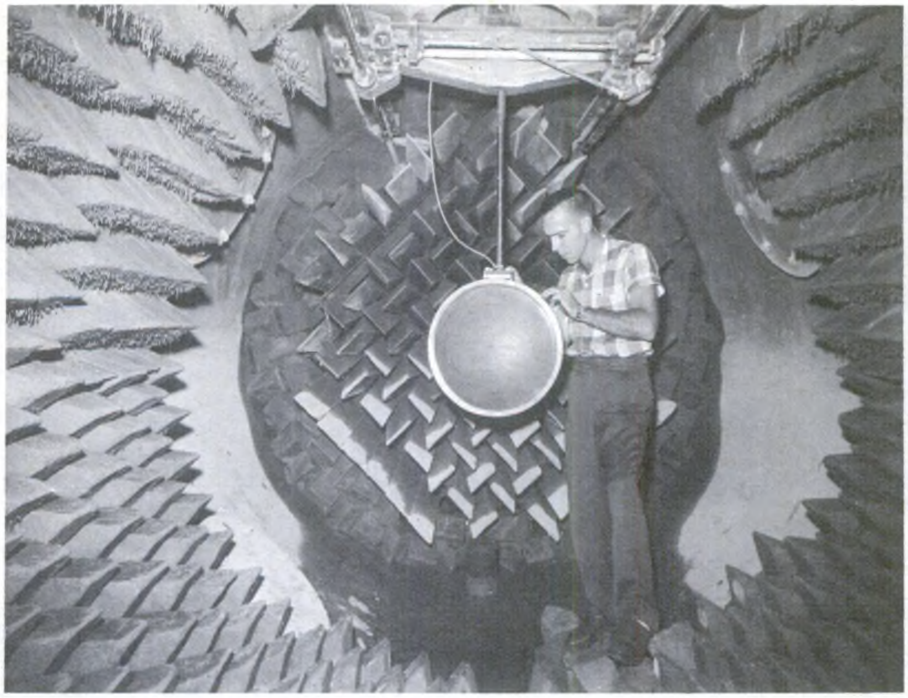






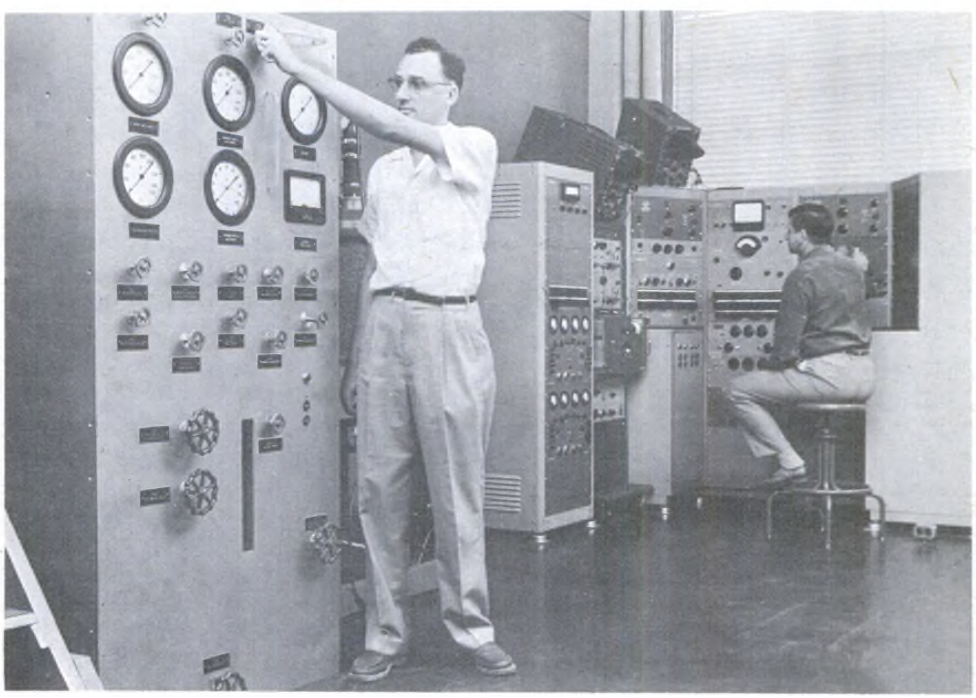
The USRL high-frequency tank in which measurements are made on underwater sound transducers. Equipment mounted on rails on top of the tank is used to suspend underwater sound transducers in the tank and to position them accurately for measurements.

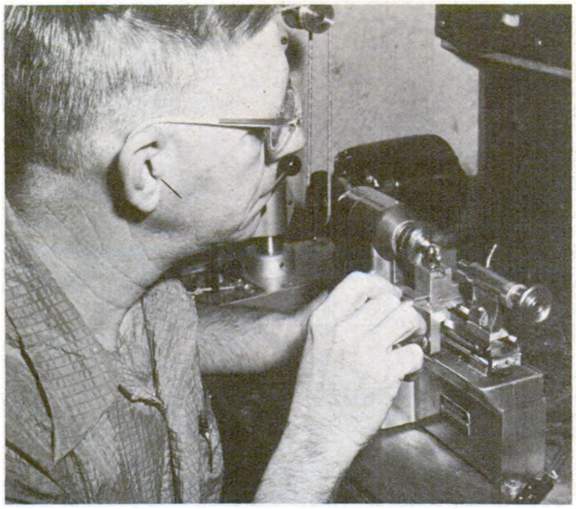
The 9,500-gallon tank used in the Pressure Laboratory is below floor level. Above, one of the heavy access ports is lowered in place preparatory to sealing the tank and building up its pressure to 1,000 pounds per square inch. The mechanism on top of the cover is used to rotate transducers about a vertical axis so that measurements can be made of the directional properties of its sound beam.



Interior of large anechoic pressure tank. The wedges along the side and at the end of the cylindrical tank absorb sound and reduce echoes from the tank walls.

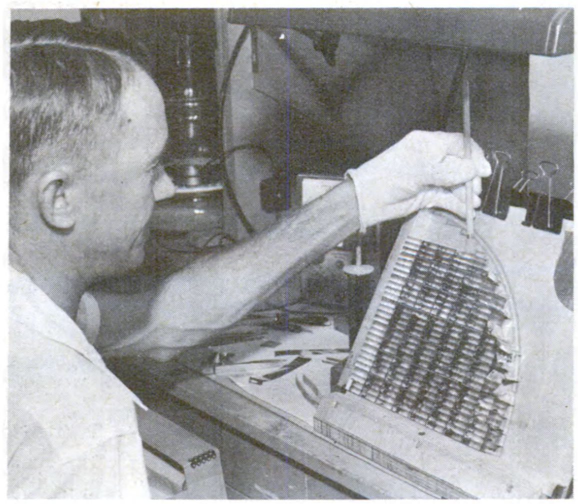
Underwater sound measurements at frequencies between 0.3 and 500 cycles per second are made in the Low-Frequency Laboratory. The heavy 1,000-psig low-frequency tank is hidden by the control panel at left.





Building an underwater sound transducer involves a large amount of precision machine work like that shown at left being done on a jeweler's lathe in the Transducer Laboratory

A USRL technician assembles an array of piezoelectric crystals that will form part of an underwater sound transducer



The USRL has the most complete facilities in this country for making underwater sound measurements—perhaps the most complete facilities in the world. Unique equipment of the USRL includes a 9,500-gallon tank in which the water temperature may be controlled from near freezing to about 40° C., and pressure may be controlled from a few pounds per square inch to as many as 1000 pounds per square inch (the pressure at an ocean depth of about 2,300 feet). The lining of this tank consists of an array of special sound-absorbent wedges made of portland cement and sawdust. The wedges reduce echoes and reverberation in the tank to a level that does not interfere with measurements. Over at least a portion of the sound-frequency spectrum the tank is an underwater "anechoic" chamber.

Specialized equipment at the USRL permits the calibration of transducers to frequencies as low as 0.3 cycle per second under severe conditions of temperature and static pressure, and a special high-frequency tank permits measurements at frequencies as high as about

3.5 megacycles per second. This range of frequencies extends from well below the lowest pitch the human ear can hear to about seven octaves above the highest pitch most people can hear. The problem of providing equipment to produce, transmit, receive, and measure sounds throughout this tremendous range is far greater than that of even the most fanatical audio hi-fi addict. Yet, the USRL has succeeded to a remarkable extent in satisfying the Navy's requirements throughout most of this range.

The old trick of allowing ships to give themselves away by the noise they make is still put to good use by both our Navy and others. Modern listening devices are capable of picking up and amplifying sounds much fainter than could be heard through the old listening tubes and at frequencies or pitches outside the normal range of human hearing. It is therefore essential that our ships move through the water as quietly as possible. Special equipment that measures just how much noise our ships make indicates the effectiveness of efforts to reduce the underwater noise radiated by our ships. The USRL maintains, for the Bureau of Ships, a variety of such noise-measuring equipment, and supplies this equipment on loan to shipyards and the Fleet for use in continuing noise-survey programs.

The USRL has developed several important new calibration techniques, most of which have been published in the Journal of the Acoustical Society of America. Also, several new types of standard transducers have been designed and made available to naval activities and industrial contractors having a need for them in sonar development work. Standard transducers and other specialized equipment have been supplied on loan to naval activities and industrial contractors in nearly every state in this country and to activities in many foreign countries.

The Laboratory was established in 1941 by the Bell Telephone Laboratories and the Western Electric Company for the National Defense Research Committee—a World War II government research and development organization. It was operated by the Columbia University Division of War Research from May 1942 to March 1945, at which time it was made a field station of the Naval Research Laboratory. It became an independent laboratory of the Office of Naval Research in October 1946. Military control of the USRL is exercised by the Commandant, Sixth Naval District.

The Navy has received an Edinburgh International Film Festival certificate for its technical film, "Color Vision Deficiencies," made by Audio Productions of New York City for the Bureau of Medicine and Surgery. The 20-minute 16-millimeter film was produced in both sound and color.

The exhibition certificate was presented to the Navy by British Ambassador Sir Harold Caccia. RADM W. T. Hines, USN, Deputy and Assistant Chief of the Bureau of Aeronautics, accepted the certificate for the Navy. During the past 15 years, more than 30 national and international prizes have been awarded the Navy for its motion pictures.

Research Notes

The Mystery of Brittle Fracture

On January 16, 1943, a T-2 welded tanker named the SCHENECTADY lay at her fitting-out pier in Portland, Ore. The sea was gentle and the weather mild. Suddenly, with a report that could be heard more than a mile away, the tanker broke in two like an eggshell. There was no warning, and there had been no precedent—no vessel had ever before fractured so completely from beam to beam.

The breaking open of the SCHENECTADY's hull, while a classic example of what technologists refer to as brittle fracture, was unique only in that it was so complete and because it occurred without warning. Of the 500 welded Liberty ships that had been constructed up to that time, 10 had sustained serious hull fractures. A survey made 10 years later cited 250 such casualties in welded ships over 350 feet long; 19 broke completely in two or were abandoned after severe cracking.

Steel ships are not the only victims of brittle fracture. On January 31, 1951, the Duplessis Bridge in Quebec, Canada, suddenly collapsed as a result of brittle fracture; this happened only two weeks after a 10-day inspection of all bridge components. One of the most disastrous brittle fractures in history occurred in Cleveland, Ohio, in October 1944, when a cylindrical gas pressure vessel collapsed, taking 128 lives. Riveted structures have also been subjected to brittle fracture. Perhaps the most eerie spectacle resulting from such breaks occurred in Boston, Mass., on January 15, 1919, when a huge molasses tank suddenly split open and disgorged its contents into the city's streets. Twelve men and many horses were drowned in the flood or died of injuries sustained at the time of the accident; houses nearby were severely damaged, and even a portion of the Boston Elevated Railway structure was destroyed.

Precisely how and why a steel structure will break suddenly are questions that have not as yet been answered satisfactorily. However, the problem has been the subject of much investigation, and significant headway has been made toward solving it. The most recent manifestation of this effort and the rewards it has brought was made through the International Seminar on the Atomic Mechanisms of Fracture, held at Swampscott, Mass., a month ago. During the Seminar, 30 scientists and engineers from England, Germany, Australia, France, the U.S.S.R., and the United States spoke on the causes of fracture in metals, ceramics, and polymers. The proceedings were of interest not only to shipbuilders, but also to a number of industries new to our age, such as the fabricators of rocket casings, jet-turbine rotors, jackets for nuclear reactors, and long-distance gas and oil transmission lines.

The Seminar was under the general direction of the National Academy of Sciences—National Research Council and was sponsored by the National Science Foundation, the Office of Naval Research, the interagency Ship Structure Committee, and the Air Force Office of Scientific Research. Each of the sponsors is active in this field of investigation.

Although it was not expected that the meeting would disclose the fundamental mechanisms of fracture, it was hoped that promising new avenues of research would be revealed. With the aid of new techniques in the microscopic study of metals and their alloys, there is now some indication that brittle fracture is the result of a combination of micro-cracks, flaws, and voids in the crystalline structure of metals, whose observation under high-powered microscopes may ultimately lead to accurate predictions of failure. There is hope, too, that additional research into the microstructure of metals, ceramics, and polymers will permit the production of materials whose strengths more closely approach the theoretical maximums. It is estimated, for instance, that theoretically perfect steel could resist a stress of 2 million pounds per square inch, whereas the strongest steel that can now be made can resist only 500,000 pounds per square inch—and only after very careful processing, which places it far out of reach of commercial users.

Fortunately, many of the engineering problems concerning brittle fracture have already been solved—sufficiently, at least, to control the steady attrition of ships of the American Merchant Marine. Brittleness in the steel itself has been reduced by improvements in composition and steel manufacturing, but equally important has been the development of the notch-brittleness test. It was discovered that steel samples that would meet one set of standards in a traditional test for tensile strength would fail a similar test for brittle fracture if the material were notched before the test and subjected to temperature changes which occur in temperate climates. Broader understanding of the notching phenomenon led to many improvements in ship structure, the most important being in the design of hull openings for hatches and ladders. These, it turned out, were true Achilles' heels, for out of their square corners raced the cracks that doomed 53 of 72 Liberty ships whose cause of hull failure was known. Understanding of the notch effect provided the solution; hatch corners were rounded on later Liberty ships, and cutouts in sheer strakes were eliminated entirely. The frequency of failures was thus reduced from about 60 to 2 per 1,000 ship-years.

The Solion

A remarkable new electrochemical device that bids to replace the transistor in many electronic uses has been developed by the Naval Ordnance Laboratory. The device, called solion, is a product of a new technology developed by NOL called chemtronics, which involves the movement of ions in solution. The uniqueness of the solion is the way in which its electrical charge is carried—by ions in solution rather than by electrons, as in the vacuum tube and transistor.

The most striking of the solion's characteristics is its extremely low power requirement, 100 to 1,000 times less than that for transistors. It is also highly sensitive to low-energy stimuli. Other features are inherent stability, long life, simplicity of operation, lightweight, and ease of manufacture.

The Navy has devised several elemental types of solion units which can be combined for use as specialized transducers, very low frequency amplifiers, long period oscillators, and other devices.

Biologist Solves Acoustics Riddles

The Agassiz Medal of the National Academy of Sciences has been awarded to Dr. Martin Wiggo Johnson, Professor of Marine Biology at the Scripps Institution of Oceanography, La Jolla, Calif., in recognition of his original contributions to the field of oceanography. The medal was presented to Dr. Johnson during the annual meeting of the Academy in Washington late last month.

Although Dr. Johnson's accomplishments in marine biology are many and varied, he is best known outside his profession for two different investigations he made in the field of underwater acoustics during World War II.

The first resulted from a stream of complaints from naval commanders about background noise jamming their underwater listening devices. They reported that in certain areas their hydrophones picked up a sound very much like that of grease sputtering in a pan; it was often loud enough, they said, to drown out the one sound they were listening for: cavitation noise from propellers of enemy submarines. Dr. Johnson, then serving with the Division of War Research at the University of California, provided the answer to the riddle. He traced the noise to the snapping shrimp, found in many parts of the world. This tiny crustacean, averaging less than an inch in length, has developed an unusual cocking mechanism which enables it to hold an oversize claw open under great tension; when the mechanism is released, the claw snaps shut with a sharp report. Large beds of snapping shrimp, Dr. Johnson was able to demonstrate, produced the sounds picked up by the Navy hydrophones.

Although the riddle was thus solved, the military problem posed by the snapping shrimp remained to be dealt with. But, as is so often the case with the results of basic research, a far more practical application came from the opposite quarter. U. S. intelligence reports, early in the war, indicated that the Japanese navy was relying almost exclusively on acoustic equipment for the detection of American submarines. If the steady tattoo of snapping shrimp nullified our underwater listening devices, it would also nullify those of the enemy. Dr. Johnson assembled charts of the Pacific Ocean and, drawing upon his knowledge of the ocean habitat, circled those areas in which the temperature, depth, and current were ideal for the occurrence of large beds of snapping shrimp, Dr. Johnson's predictions of shrimp-bed locations provided U. S. submarines with a constellation of acoustic hiding places all along Japanese supply routes.

Dr. Johnson was once again called upon to use his knowledge of marine organisms in solving what seemed to be a problem in instrumentation when serious discrepancies began to turn up in fathometer readings. These instruments, which measure the time it takes for a sounded tone to be reflected from the ocean floor, were recording different depths for the same location. In some cases, fathometers in perfect working order would indicate bottom at several thousand feet above the real bottom, as indicated positively by sounding lines.

Dr. Johnson believed that a vast cloud of marine organisms, was acting as a scattering layer which reflected the ping of the fathometer and caused false readings to be taken. An examination of fathometer readings, collated according to time of day, furnished the necessary proof: the scattering layer rose to the surface each night, following the endless cycle of plankton, the passively drifting life of the sea.

Dr. Johnson's study of these minute organisms also led him to contribute notably to his sister profession of physical oceanography, for he was able to show how the distribution of planktonic life identified various types of water masses and permitted the tracing of their movements.

The Agassiz Medal was established in 1911 by Sir John Murray, the eminent British oceanographer, geographer, and naturalist to honor his late friend, Alexander Agassiz, distinguished American oceanographer and member of the Academy, son of Louis Agassiz, who was one of the charter members of the Academy. Sir John specified that the Agassiz Medal should be awarded to scientific men in any part of the world for original contributions in the science of oceanography.

Cod are Odd

If the spawning cycle of the cod were not so unusual, the Department of the Interior would not have called upon the Navy for help in understanding it. Cod spawn at the surface of the ocean, placing their eggs at the mercy of wind, waves, and weather. Soon after the eggs hatch, the young fish head for the bottom. If the water is more than 600 feet deep, the tiny fish die. This makes the continental shelf of the Atlantic seaboard an important place in the life cycle of the cod.

Why was the Navy asked for help? The Bureau of Commercial Fisheries is faced with the problem of determining whether the ocean drift takes the young fish away from their haven on the "shelf." The Navy responded by dropping 1,000 drift bottles ("pop-bottle" size) along part of the upper half of the Atlantic coastline. Each bottle dropped contains the necessary instructions for reporting the finding. The Bureau wants to know where and when the bottles are found. For each bottle tag that is returned to the Bureau's Biological Laboratory at Woods Hole, Mass., 50 cents will be paid.

Space Handbook

A publication entitled "Space Handbook: Astronautics and its Applications" is now available at $0.60 per copy from the U. S. Government Printing Office. The 252-page illustrated book contains a detailed index and extensive bibliographic material on all phases of "space information," including recommendations as to required "basic research." The report was prepared by the RAND Corporation for the Select Committee on Astronautics and Space Exploration, U. S. House of Representatives, 85th Congress, 2nd Session, and is dated December 20, 1958.

Measuring Imperfections in Crystals

As part of a project he has undertaken for the Office of Naval Research, Professor A. R. Lang of the Gordon McKay Laboratory at Harvard University is developing an X-ray technique which permits the delineation of very small imperfections in relatively thick crystals. The technique, which is particularly applicable to the detection of dislocations in "as-grown" crystals of metals, reveals imperfections by recording X-rays which are refracted by the crystal as they pass through it. This is in contrast to radiography, in which the rays are differentially absorbed by the crystal. The value of the new method is that it makes possible the detection of imperfections in films greater than 2,000 angstroms in thickness (20 millionths of a centimeter; the thickest that can be analyzed by the electron microscope).

To detect dislocations, a sheet of X-rays is made to sweep across the surface of a relatively thick crystal slice. The rays are so directed that they strike almost, but not exactly, normal to the surface of the crystal. This causes them to be refracted slightly as they pass through the sample. Upon emerging from the crystal on the opposite side, the rays pass through an analyzer slit, whose orientation and movement correspond at all times to the orientation and sweep of the incident beam. The X-rays then expose a sheet of photographic film.

If the crystal were perfect, the refraction of all segments of the incident sheet of rays would be identical and an exposure of uniform density would result. But if the crystal were imperfect, segments of the sheet of rays would be scattered beyond the bounds of the analyzer slit, and an exposure of variable density would result. This variability describes precisely the location and nature of the imperfections in the crystals.

ONR Branch Office, Boston

Heat Sterilization of Vaccines

Vaccines are commonly made by killing or weakening special preparations of bacteria or other organisms which are responsible for diseases. When injected into the body, the vaccines cause the production of antibodies, which are natural antidotes to the diseases in question. A difficulty that arises in making the vaccine is to kill the offending organisms used for the vaccine without destroying their ability to call forth antibodies when they are injected into the body. For this purpose, such chemicals as formalin or merthiolate are commonly used. But as these agents become a part of the vaccine, they raise a further problem: they themselves may complicate the reactions to the vaccine.

Through an investigation made for the Office of Naval Research by Dr. R. B. Read, Jr., and Professor Warren Litsky of the University of Massachusetts, the discovery has been made that it is not always necessary to use such chemicals in making vaccines. The material to be sterilized can be passed through a fine tube and heated rapidly to a temperature which will kill the organisms yet preserve enough of their antigenicity to afford the protection needed.

Much of the development work in the use of the University of Massachusetts heat-sterilization apparatus in vaccine production has been done on the common food-poisoning bacterium, Salmonella. Recently, however, the method has been applied to other diseases. It has been learned, for example, that the procedure can be utilized in the more difficult undertaking of producing effective vaccines against viruses. So far, it has been used successfully in the development of vaccines for combatting influenza among human beings, and for providing protection against the Newcastle virus, which produces a very contagious disease in chickens. The method has also been applied to the production of vaccines used in connection with Adenovirus, a highly infectious disease in humans. Of significance is the fact that the method lends itself well to quantity production of vaccines.

An interesting line of research that is soon to stem from this work is testing the vulnerability of the antigenic factor to heat above the minimal killing level. The margin of safety will be carried up 10 degrees and the product tested stepwise at intervening diminishing levels. Another line of investigation it has given rise to hinges on the fact that in the clinical use of poliomyelitis vaccine, the antigenic strength of the remedy is being augmented by the inclusion of attenuated live organisms in the vaccine. With the collaboration of Dr. Albert Sabin of Cincinnati, and Dr. Kaprowski of the Wistar Institute, "polio" vaccines of Types I, II, and III are to be utilized to determine whether the living vaccine can be heat-sterilized without undue loss of potency.

ONR Branch Office, Boston

Miniaturization Award

One of ten awards—A certificate of Excellence—has been given to an ONR contractor by the Miniaturization Award Committee, a group composed of representatives of government, industry, and the press, for its contribution to miniaturization techniques. The contractor—Servomechanisms, Inc., Goleta, Calif.—was selected for the award for producing an evaporated magnetic film stepping strip which can be used as a logic or memory element in high-speed digital computers.

The device utilizes magnetic domain areas in the thin magnetic film to move information along pre-selected paths. Thus, in a sense, it duplicates the action of a magnetic drum, which mechanically carries information past one or more read-out heads. However, the evaporated magnetic film stepping strip requires no moving parts to do this. An additional advantage is that its storage density is equal to or greater than that which exists on the surface of a magnetic drum. Furthermore, the elimination of the drum and drive mechanism permits a remarkable reduction in the overall size of the memory and logic elements.

The Miniaturization Award Committee's top award went to the Glenn L. Martin Co. for its work on a radio-isotope power supply.

On the Naval Research Reserve

"Recent Advances in Physical Sciences"

A highly successful two-day seminar on "Recent Advances in Physical Sciences" was conducted under the auspices of Naval Reserve Research Company 3-8, New York City, April 3 and 4. The meetings, which were held at St. Peter's College, Jersey City, N.J., were attended by more than 100 reserve officers.

The seminar was organized by NRRC 3-8, which is under the command of CDR L. J. C. Murphy, USNR, and was sponsored by the Commandant, Third Naval District. CAPT Perry Y. Jackson, USNR, of the St. Peter's faculty and chairman of the program, arranged an impressive panel of speakers. Included were heads of the physics, chemistry, and biology departments of St. Peter's College and other faculty members. The list of speakers also included two scientists from Brookhaven National Laboratory--Dr. Harvey McChesney and Dr. Herbert Suskind--and one from St. Thomas Institute in Cincinnati--Dr. James R. Sagurton. The program was highlighted by the Saturday luncheon speaker, Dr. John E. Flynn, Special Consultant of the Office of Naval Research.

The program, arranged for the orientation of the layman, included discussions of the following subjects: Plasma Method for the Determination of Ultra-High Temperatures, Physics Analysis of the Sub-Critical Nuclear Reactor, The Brookhaven Synchroton, Nuclear Reactors and Fuels, Effects of Radiation on Materials, Electron Radiation and Mitosis, Aspects of Nuclear Chemistry, Radiobiology and Mutation, Polarization Effects, and Physics and Metaphysics.

CAPT Perry Y. Jackson, USNR, Second from Left, Chairman of the seminar, explains an experiment in his laboratory.

Present at the Reserve Assistants conference were (left to right) first row: CAPT C. H. Fuller, Jr., CAPT J. P. Aymond, Miss E. Kehoe, CAPT M. L. McCullough, Jr., LCDR W. B. Lower, LCDR H. A. Wellemeyer, LT C. S. Lardis. Second row: CDR E. L. Huie, CDR J. A. Jones, LTJG D. W. Thorin, LT J. J. O'Connor, CDR W. C. Avery, LCDR N. L. Fish, CDR J. A. Sharpe.

Reserve Assistants Meet in Washington, D. C.

The annual conference of Reserve Assistants of ONR Branch Offices was held at the Office of Naval Research, Washington, D. C., on April 7 and 8. CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research (Research Reserve) was the conference chairman. In opening the meeting, CAPT Aymond introduced CAPT A. B. Metsger, USN, Deputy and Assistant Chief of Naval Research, who commented on the part the Research Reserve plays in the over-all program of the Office of Naval Research. CAPT C. H. Fuller, Jr., USN, Director of Schools and Special Programs of the Naval Reserve Training Command, also spoke on the first day of the conference.

The meeting was attended by all Reserve Assistants from the branch offices of ONR; CDR W. C. Avery, USN, Training Officer; Miss Eleanor Kehoe, Training Specialist; and CAPT M. L. McCullough, Jr., USN, Washington Area Commander for Naval Reserve and representative of the Commandant, Fifth Naval District.

Representatives from the Bureau of Naval Personnel who made excellent presentations were CDR F. B. Guest, Jr., USNR, Head, Naval Reserve Training Section; CDR E. L. Huie, USNR, Head, Specialist Programs and Special Projects Branch; CDR J. A. Jones, USN, Head, Officer Classification and Mobilization Operations Branch; and LTJG D. W. Thorin, USN, Technical Assistant for the Leadership Program.

Other subjects discussed at the conference included mobilization procedures, recruiting activities, promotion cycle, and administrative matters in connection with the Program.

Another Research Reserve Company Formed

On January 1, a new Research Reserve company--NRRC 3-14, Kingston, N.Y.—was established. The activation ceremonies were held on March 19 at the International Business Machines Engineering Laboratory. LT Jerome L. Krumpelman, USNR, is serving as the first Commanding Officer of the company, which is composed almost entirely of IBM employees. There are 13 charter members, and the applications for four others are being processed. Several of the members of the company were formerly attached to the Poughkeepsie Panel of Naval Reserve Research Company 3-1, New York City.

Attending the activation ceremonies were the following naval guests: RADM C. C. Wood, USN, Commandant, Third Naval District; CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research (Research Reserve); CAPT H. S. Knerr, USN, Office of Naval Research, New York; CAPT H. Stevens, USNR (Ret.), former Commanding Officer of NRRC 3-1; LCDR W. B. Lower, USN, Assistant for Research Reserve, Third and Fourth Naval Districts; CDR F. E. Trani, USNR, Public Relations Officer, Naval Training Center, Poughkeepsie; and LCDR J. F. Bonner, USN, Commanding Officer, Naval Training Center, Poughkeepsie. A special civilian guest at the meeting was Mr. C. F. Lynch, Manager of Engineering Administrative Planning and Control, International Business Machines Engineering Laboratory.

Present at activation ceremonies for NRRC 3-14 were (left to right) first row: CAPT H. S. Knerr, MR. C. F. Lynch, RADM C. C. Wood, LT J. L. Krumpelman, CAPT J. P. Aymond, CAPT H. Stevens, and CDR J. D. Quale. Second Row: CDR J. L. Norman, LT W. R. Peary, LTJG G. E. Bills, LCDR J. F. Bonner, LT J. Vislocky, LCDR W. B. Lower, LCDR N. J. Smith, LT R. S. Jordan, LTJG K. J. Pietkiewicz, LTJG R. C. Brainerd, CDR F. E. Trani, LTJG W. Rudman.

Seminar in Aviation Medicine

The Fourth Annual Reserve Research Seminar in Aviation Medicine was held at the U. S. Naval School of Aviation Medicine in Pensacola, Florida, March 8 to 21, 1959. Forty-two reservists attended. Of these, 26 were from the Navy, 12 from the Air Force, and 4 from the Army. Many scientific disciplines were represented, including mathematics, physics, chemistry, biology, physiology, pharmacology, psychology, internal medicine, ophthalmology, and engineering.

The Chief of Naval Air Training, VADM Robert Goldthwaite, USN, welcomed the group, and his staff presented a description of training and operational problems encountered in modern naval aviation.

The Chief of Naval Research, RADM Rawson Bennett, USN, described advances in basic research which contributed to important developments in naval aircraft, ships, submarines, and fire power.

Scientists from the School of Aviation Medicine discussed the physics of the upper atmosphere, basic satellite physics, and biological factors in space flight. The latter included a demonstration of the equipment, procedures, and animals used in the missile shot sponsored by the Army at Cape Canaveral last December.

At outlying fields, the reservists observed both ground-school and flight training procedures, including academics, navigation, instrument flight operations, communications, escape and rescue, as well as helicopter and jet operations.

At Eglin Air Force Base presentations were made on the mission of the Air Proving Ground Command, new developments in weapons and weapon systems, and human-factor problems in air operations. A visit was made to the standards laboratory, where measuring tools and devices are calibrated and checked. At the technical data processing facility the reservists observed the analysis of complex engineering data and their translation into codes which can be manipulated by IBM and electronic computing devices. In the Climatic Laboratory, Army, Navy, and Air Force operational equipments were being subjected to temperatures ranging from -65° F. to 120° F., and to various degrees of humidity, wind, and vibration. A tour down the flight line permitted glimpses of all the newest developments in aircraft and firepower undergoing tests at the Air Proving Ground Center.

One day was spent aboard the aircraft carrier USS ANTIETAM, which is assigned to the Naval Air Training Command. Following briefings in the wardroom and ready rooms, preparations for battle were observed during General Quarters. Visits were made to all departments of the ship, in each of which the activities were described by the officers in charge. Later, carrier qualification operations were observed from the bridge. Both propeller and jet aircraft were catapulted and recovered, while helicopters fore and aft on the starboard side served as plane guards. The ANTIETAM maintains an outstanding safety record, however, and no accidents occurred during the cruise in the Gulf of Mexico.

Participants at the Seminar in Aviation Medicine.

One of the more interesting presentations was given by CAPT Charles F. Gell, MC, USN, Special Assistant for Medical and Allied Sciences in the Office of Naval Research. He showed photographs and movies of unusual hazards encountered in naval aviation and demonstrated research techniques used in their study and control. Another interesting lecture was on the radiation hazards encountered in the manufacture and handling of radioisotopes in nuclear reactor stations, given by CAPT V. E. Senter, MC, USN.

Some of the most interesting and provocative presentations were those of Dr. H. J. Schaefer on the physics of the upper atmosphere and basic satellite physics. The reservists were unanimous in their praise of Dr. Schaefer's lectures, which provided new information and were stated in terms all could understand.

The seminar was planned and directed by CDR Henry A. Imus, MSC, USNR, a member of the NRCC 6-74 of Ellyson Field, Florida. CDR Richard Trumbull of Naval Reserve Research Company 5-10, Bethesda, Maryland, conducted the seminar as Chairman and as escort officer on all field trips. The Office of Naval Research, the Naval Air Training Command, and the Naval School of Aviation Medicine sponsored the seminar with the approval of the Bureau of Naval Personnel, the Bureau of Medicine and Surgery, and the Bureau of Aeronautics.

The next Seminar in Aviation Medicine will be held at the U. S. Naval School of Aviation Medicine in March 1961, alternating with the Seminar in Submarine and Diving Medicine which is given at the U. S. Naval Medical Research Laboratory, Submarine Base, New London, Connecticut.

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Selections for Promotion in Staff Corps

The March issue of Research Reviews listed line officers of the Research Reserve who were selected for promotion to the grades of Captain and Commander. The Chief of Naval Personnel subsequently released the names of officers selected for Captain and Commander in the various staff corps. Congratulations are extended to these officers who are listed below along with their respective companies:

FOR CAPTAIN,
MEDICAL SERVICE CORPS

Walter L. Wilkins	9-8

FOR COMMANDER,
MEDICAL SERVICE CORPS

Robert W. Harrison	1-2
Louis J. Pecora	4-11
Robert F. Jaeger	5-3

FOR COMMANDER,
MEDICAL SERVICE CORPS

Maynard Eicher	5-10
William D. Murray	12-4

FOR COMMANDER,
MEDICAL CORPS

Victor P. Bond	3-9
James S. Robertson	3-9
Duard L. Walker	9-14

Researches on Tooth Decay

Many investigations of tooth decay have utilized rats as subjects because these animals are plentiful, they can be obtained at relatively small cost, and, through their long association with man, they have developed similar food habits.

It is known that one important factor in tooth decay is carbohydrate in the diet; on a pure fat and protein menu, rats show little or no disturbance of dental health. Recently, dental investigators working on a contract for the Office of Naval Research discovered that the structural make-up of the teeth is also a factor in susceptibility to tooth decay. The studies which led to this finding were made by Dr. J. H. Shaw of the Harvard School of Public Health, in collaboration with Drs. R. M. Grainger and K. J. Paynter of the University of Toronto Dental School. During the past winter, about 90 percent of the effort in Dr. Shaw's laboratory has been devoted to further study of this relationship in several strains of rats.

A chief difficulty in the study of the causes of tooth decay in rats is variability in susceptibility to that disorder from animal to animal. Accordingly, a major phase of the researches at the Harvard laboratories has been to develop a strain of rats in which susceptibility is more consistent than it is in other available strains. Considerable success has been achieved recently in this effort. For example, the time required for decay to become evident in groups of experimental rats has been reduced from 100 days to 60 days. This improvement in homogeneity of the strain should lessen the number of experimental animals needed to obtain definitive results in further work.

ONR Branch Office, Boston

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.

From a special pier on a lake at the Navy's Underwater Sound Reference Laboratory, Orlando, Fla., a large sonar dome is lowered into the water for measurement of its sound-transmitting properties. See article beginning on page 16.