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RESEARCH REVIEWS

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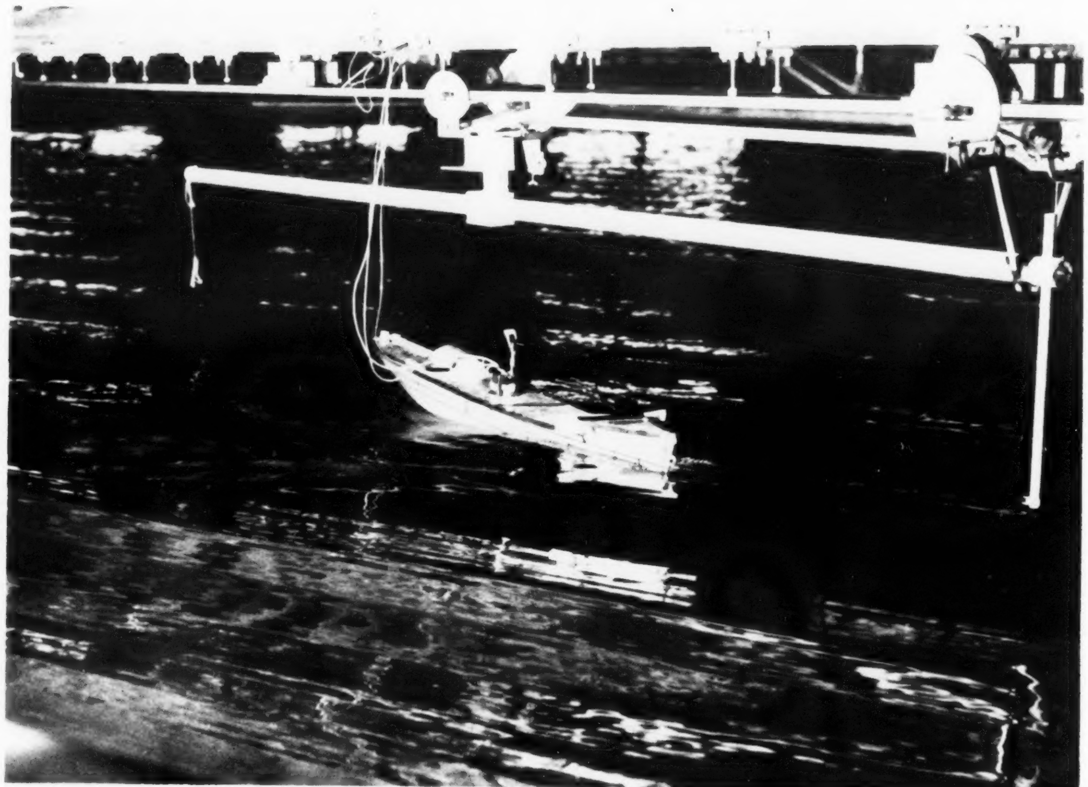

An experimental ship model being tested in the towing tank at the Stevens Institute of Technology. See article beginning on page 7 for an account of studies underway in the tank.

Ice Crystal Formation in Tissues*

H. T. Meryman

Naval Medical Research Institute

When one speaks of freezing mammalian tissue, many mental images may be brought to mind; the physician may recall the black mummified toes of the frostbite victim; the research scientist might be more inclined to think in terms of the preservation of tumors or blood by rapid freezing; while more probable for most is the image of the frozen T-bone steak in the family deep freeze. These are certainly all instances of the freezing of mamalian tissue, but are they comparable to one another? Is freezing a uniform phenomenon or does its mechanism vary depending on the subject and the manner in which it is applied?

In attempting to answer these questions in the laboratory, it can easily be shown that variations in the rate of freezing can make a vast difference in the result. Experimental evidence also suggests very strongly that different tissues vary in their response to freezing in terms of their susceptibility to injury. Although the whole story is far from clear as yet, it is possible to summarize to a fair degree the phenomena which take place when mammalian cells are subjected to freezing and thus to clarify somewhat the similarities and differences of the many kinds of freezing to be met with both in the field and in the laboratory.

One of the most important observations to be borne in mind is that freezing is a physical phenomenon. It is, by definition, a process involving crystallization; in the case of tissue, the crystallization of water to form ice. The ice formed is composed of pure water which is withdrawn from the solution in and around the cells. There are two obvious effects of such crystallization. First, the ice crystal is a physical object. Its size and location will depend upon the mode of freezing, as will be shown subsequently. If it is large or suitably located, it may have deleterious effects upon a cell or tissue solely as the result of its existence. The ice crystal *per se* is presumably inert, because the water of which it is made is no longer osmotically active. Also, in tissue, ice crystals grow in the direction of least resistance and do not characteristically display sharp corners or points. The ice crystal, then, can be considered merely as an inert foreign body.

The second effect of freezing results from the fact that water has been removed from the tissue milieu. This is, in essence, a dehydration, and the only difference between the dehydration of freezing and that of drying is the fact that the water is secreted throughout the tissue as ice crystals rather than being completely removed. These, then, are the two primary causes of tissue injury as the process is currently understood: ice crystal-foreign body formation and dehydration.

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*Reprinted from the Medical News Letter, January 3, 1958, Bureau of Medicine and Surgery.

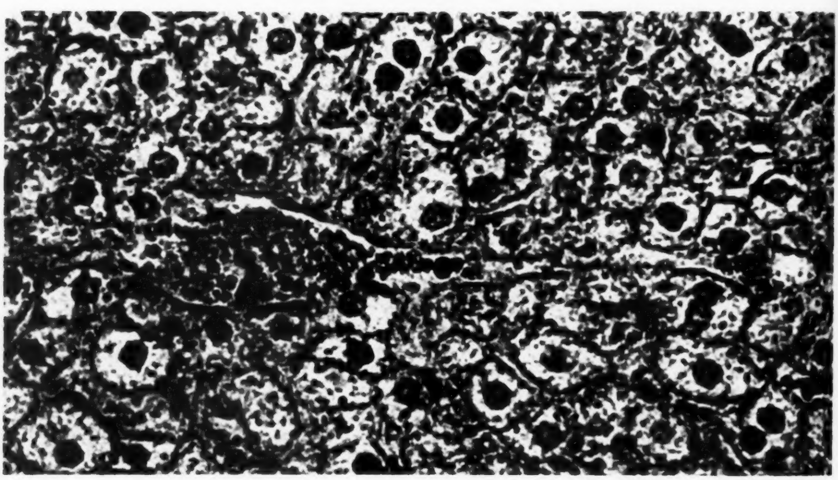
Crystallization and its attending dehydration are, as pointed out previously, physical phenomena which invariably occur when freezing takes place, regardless of the circumstances. Variations in the end result of freezing occur because of differences in the rate of freezing or variations in the physical characteristics of the material frozen. Let us first consider the effect of altering the rate of freezing. When a tissue or a cell suspension is frozen slowly, the ice crystals are found to develop exclusively in the extracellular spaces. The slower the freezing takes place the fewer are the crystals which develop and the larger their ultimate size. These extracellular crystals withdraw water both from the extracellular spaces and from within the cells, the ultimate result being that huge crystals may be formed with the dehydrated cells sandwiched between them.

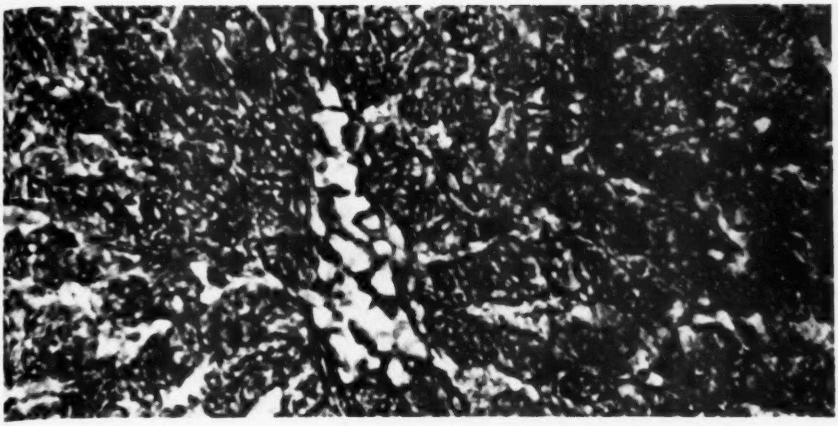
As the rate of freezing is increased the ice crystals become more numerous and smaller in size. With further increase in freezing rate a point is reached at which the tendency for extracellular crystal formation is no longer dominant and intracellular ice crystals are seen to form. The crystals produced at this critical rate are already quite small, about 10 microns across, so that the tissue architecture is not seriously distorted by their presence, as it is from slow freezing. With increasing rates of freezing, the crystals continue to be smaller in size until ultimately they appear to vanish with the creation of noncrystalline or glass ice. The rates of freezing necessary to achieve this state are exceedingly high and can be produced only with great difficulty in the

Photomicrographs Reveal Effect of Freezing on Tissues

The photomicrographs reproduced below and on pages 3 through 5 show sections of rabbit liver before being frozen, after freezing at several different rates, and after thawing. All have been fixed with formalin, stained, and reproduced at the same magnification.

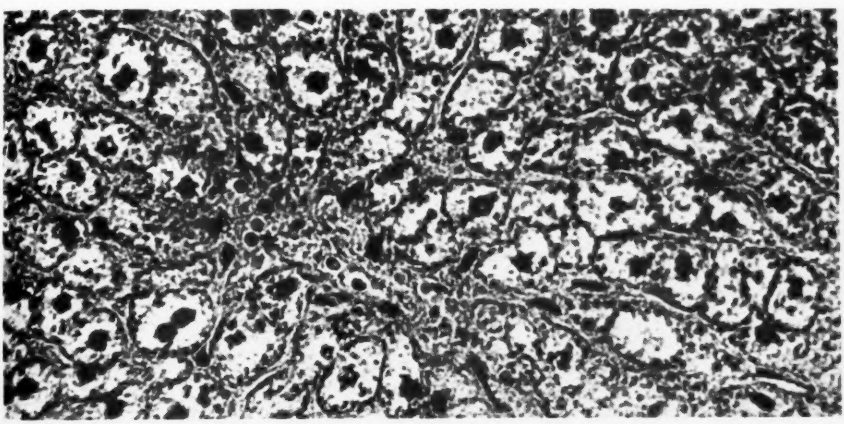
Unfrozen control section of fresh rabbit liver.





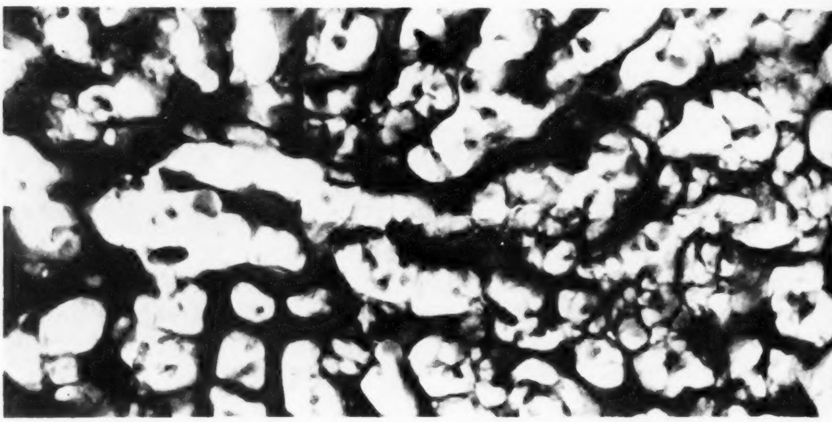
A section of liver frozen at the rapid rate of 6 millimeters per minute, then vacuum dried. The general architecture of the liver is still easily recognizable, but individual cells are honeycombed with numerous small spaces that were occupied by ice crystals before the tissue was dried.

A section of frozen liver taken immediately adjacent to that of the photomicrograph above, but which, instead of being vacuum dried, was thawed at 40°C. Only slight differences in the appearance of the cells differentiate this section and the control section (on facing page).



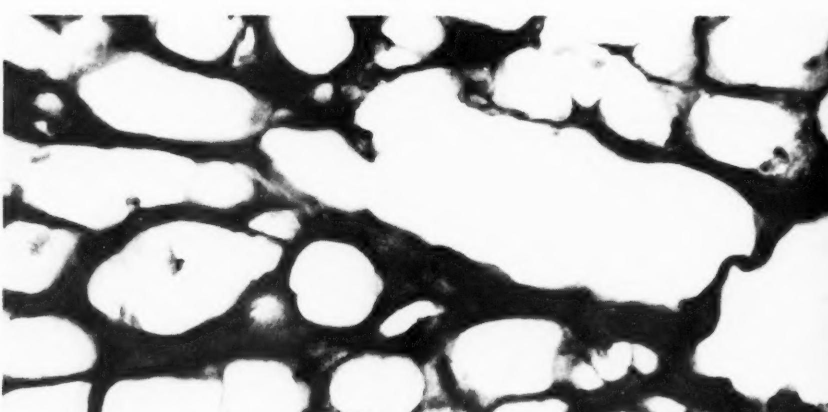
laboratory. In fact, the speed at which intracellular crystals are produced is quite rapid by conventional standards. It is estimated that a man exposing his finger to a 40-mile per hour wind at -40°C could receive a freezing injury in which some intracellular crystallization might result, presuming an absence of circulation in the finger. It is, then, apparent that clinical injuries fall within the slow freezing range as does, in fact, most experimental and commercial freezing.

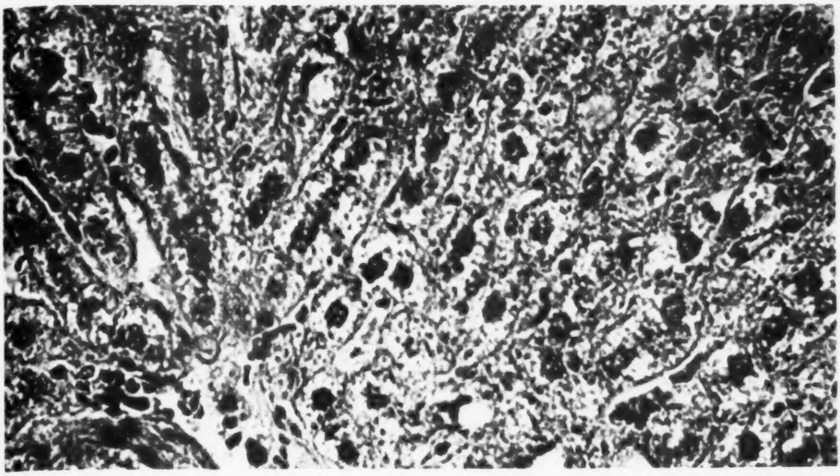
Returning to the effect which freezing may have upon a tissue, two phenomena must be considered: The physical presence of the extracellular ice crystals and the dehydration which has occurred. The distortion which may be produced by ice crystals is quite astounding when one studies histological sections which have been especially prepared to retain the tissue architecture as it existed while frozen. Crystals formed at moderate rates of freezing may be many times the size of the individual cell, while the cells are compressed between them in indistinguishable bundles. The appearance of such a section would appear to supply fully adequate evidence for the physical destruction of tissue through freezing, and it is quite amazing to discover that such is not the case. It has been most adequately demonstrated—both in the laboratory and from clinical case histories—that freezing is not necessarily lethal



This figure demonstrates the result of freezing liver at the slow rate of about 1.6 millimeters per minute. The spaces representing ice crystals are very large, the majority being nearly as large as the individual cells.

Freezing at the very slow rate of 0.5 millimeters per minute, as was done here, demonstrates very clearly the manner in which water is removed from the tissues to build ice crystals to sizes many times those of the individual cells.





More remarkable, perhaps, than the massive ice crystals produced by very slow freezing of tissue (see photomicrograph at bottom of page 4) is the complete reconstitution of such tissue following thawing. This figure shows a section of tissue from a position immediately adjacent to that of the figure at the bottom of page 4. But instead of being vacuum dried, this section was thawed at 40° C. Other than occasional vaculoes, little significant pathology is to be seen.

to tissues provided the exposure has not been excessive. Thus, it becomes clear that extracellular crystal formation per se is not necessarily lethal to animal cells.

The answer to the cause of freezing injury apparently lies in the dehydration produced by ice by crystallization. It has been thoroughly demonstrated for blood that the primary agency for injury is the increased salt concentration which results from the dehydration. It has been shown that increasing the salt concentration of blood at room temperature causes destruction of the cells to the same extent as a similar salt concentration resulting from freezing. The manner in which the high salt concentration injures the cells is not fully understood, although at least one important mechanism appears to be the denaturation of lipoproteins. The denaturation of cell constituents by high salt concentration is a biochemical reaction. This reaction will take place at a given rate depending on the concentration of the salt and the temperature at which the reaction takes place.

This provides an explanation for the observation that tissues can tolerate freezing provided the exposure is not excessive. Tissues which are frozen to only 1 or 2 degrees below the freezing point have only 60 to 70 percent of their water sequestered in ice crystals. Although this results in a deleterious concentration of salt, it is not rapidly lethal. Freezing must be -3° to -5°C or lower in order to remove sufficient water to cause a rapidly developing cell injury. However, even at such low temperatures, cell destruction does not appear to be instantaneous, and enough animal cells to permit tissue survival may recover following an exposure at -10° to -15°C for periods up to half an hour.

These, then, are the physical phenomena which take place during a tissue exposure which involves freezing. Large ice crystals are formed in the extracellular spaces and the cells are subjected to acute dehydration, which results in a biochemically injurious concentration of electrolytes. This information reveals several things about the clinical injury. In the first place, it is necessary to discriminate between injuries in which ice crystallization has occurred and those in which it has not occurred. The conventional terminology does not adequately define this difference, because frostbite, which is presumed to be a freezing injury, is generally divided into four degrees of which first degree frostbite involves no freezing and second degree shows only superficial freezing.

It is clear from an understanding of the physical events that an injury is being dealt with which takes place during the exposure at a rate dependent on the temperature of exposure. This latter is an extremely difficult variable to quantitate, inasmuch as the temperature of the exposure refers to the temperature of the tissue while frozen. This will be dependent on many physical aspects of the circumstance which include not only the air temperature, but the amount of wind and the amount of insulation available. Even a wet mitten or a frozen boot provides some insulation and can substantially reduce the rate of heat transfer. However, these are questions which do not particularly concern the clinician. He is faced with an exposure to cold which has already taken place. He is faced with an injury which has proceeded at a variable rate depending on the temperature of the tissues and for which the most important therapy is termination of the exposure. Some tissues may have been irrevocably destroyed and others not; it is impossible to predict in advance the exact extent of the injury. In any case, this is unfortunately an injury for which no therapeutic measure has as yet been conclusively demonstrated to be of value in man.

Although the laboratory may have as yet offered no real assistance to the clinician, it can at least provide him with some understanding of the mechanism of freezing in tissue and demonstrate to him that freezing can result in very real physical or biochemical injury.

Editor's Note: An outgrowth of Dr. Meryman's basic research on what happens to biologic tissues at low temperatures was the development of a technique for the possible preservation of whole blood for long-term periods. The technique utilizes liquid nitrogen, by means of which the temperature of the blood is reduced to about -90° C. In its frozen state the preserved blood looks like pink sand. No deterioration or change in properties of the blood occurs when it is reconstituted and administered to patients. Before this discovery was made, blood could be preserved only 20 to 30 days. Thus, this deep-freeze technique may prove to be very significant in the development of blood banks and blood storage methods in the future. Dr. Meryman's work on ice-crystal formation and the preservation of whole blood is an excellent example of how basic research paves the way for the future.

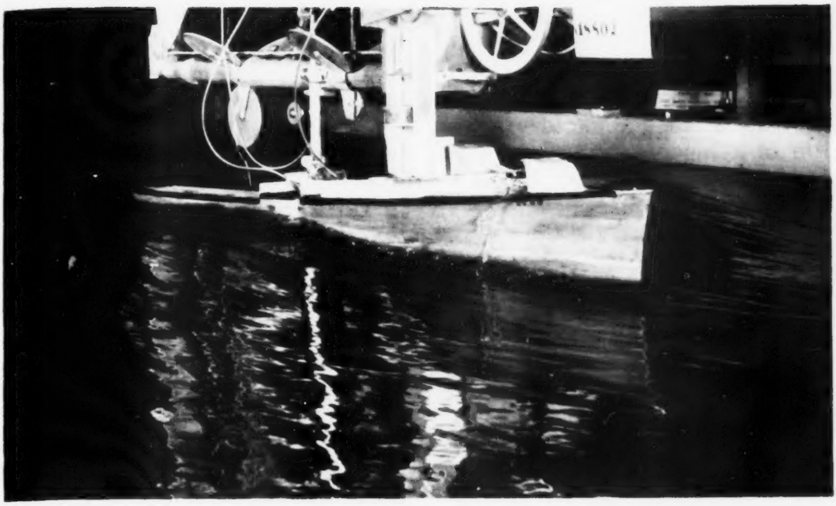


Figure 1 - Destroyer model underway at the Stevens Experimental Towing Tank.

Model Research On the Seagoing Qualities of Ships

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Mariners have always recognized that some ships perform better at sea than others. For example, in modern times the liner UNITED STATES has an outstanding record for fast passages even in bad weather. Destroyers can easily steam in circles around cargo ships of a convoy in the heaviest seas, but they cannot keep up with a large aircraft carrier or cruiser. On the other hand, it has been known that small craft such as trawlers frequently go about their business under sea conditions which are trying for their larger sister. In fact, the ferocious North Atlantic has been crossed safely many times by small craft, some 30 feet or less in length.

Questions naturally arise, then, as to why some vessels are superior to others. What is the secret of small craft design which enables some of them to survive severe gales so successfully? Are there features of design in small vessels which could be applied to improve the performance of larger ships? Is there some radical change in ship form or proportions which would make significant reductions in amplitudes of motions and would permit distinctly higher speeds at sea?

Books of naval architecture and available model research results give only partial answers to the above questions. Hence, a broad, long-range project was undertaken under ONR sponsorship at the Experimental Towing Tank, Stevens Institute of Technology, in an attempt to provide more satisfactory answers to some of these questions. (The life of a model tank experimenter is not always a happy one, for often the electronic apparatus for recording the model's pitches and heaves yields only hitches and peeves! However, when the data are finally recorded and analyzed the results are often rewarding). The ETT project consisted of two parts, one experimental and the other theoretical. The experimental part involved the comparison of the performance of a number of widely different models in regular and irregular waves (see Figure 1). The theoretical part aimed at the development of a method of calculating the motions of ships which would be a practical tool for evaluating differences in form and proportions by computation. The experimental data provided excellent material for testing the theoretical techniques.

At the beginning of the project many inquiries were made and reference books were searched in order to find several small craft of known superior seagoing qualities. Attention was focussed particularly on fishing vessels and on deep-sea sailing yachts. Professor Cedric Ridgely-Nevitt of Webb Institute of Naval Architecture was consulted on historical trends, and Dr. K. S. M. Davidson, Director of Stevens Experimental Towing Tank, took an active part in this investigation. Finally, after much discussion of the merits of different craft, two hulls were selected as the starting point for the experimental study:

- A typical European trawler, on which data has been published by Walter Möckel of Hamburg,
- A British sailing yacht of the "Gauntlet" class, which had a record of good sea performance and was known personally to Dr. Davidson.

Body plans for the two hulls are shown in Figures 2 and 4, and photographs of the completed models appear in Figures 3 and 5. Model characteristics are given in the table on page 10. A comparison with larger ship types indicates that both craft are comparatively squat and beamy, particularly the yacht. In addition, both models have high freeboard, presumably to enable them to ride the short, steep waves that larger ships knife through without difficulty.

On the basis of prior research at Stevens, it was believed that increasing length in relation to displacement* would have a favorable effect on ship behavior in waves. Accordingly, it was decided also to build and test "stretched out" versions of the two models. These lengthened models, shown in Figures 3 and 5, were built from the original body plans. Therefore, the only change was in the proportions, including the freeboard-to-length ratio (see table on page 10). Both models were given the same length and displacement as a destroyer model tested in another project (Figure 1), in order than an additional comparison of the effect of hull form alone could be made.

*Displacement (Δ)-to-length (L) ratio is expressed $\Delta/(L/100)^3$.

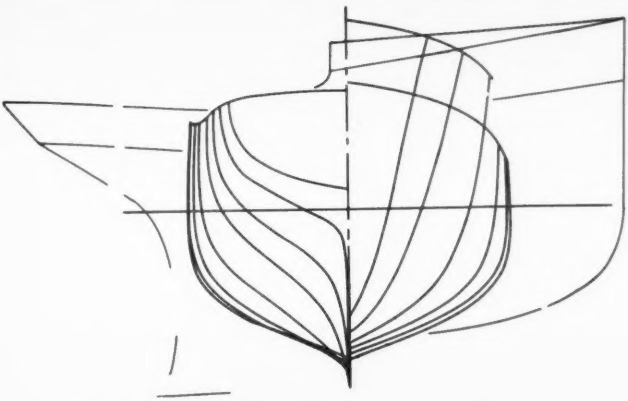


Figure 2 - Lines of parent trawler.

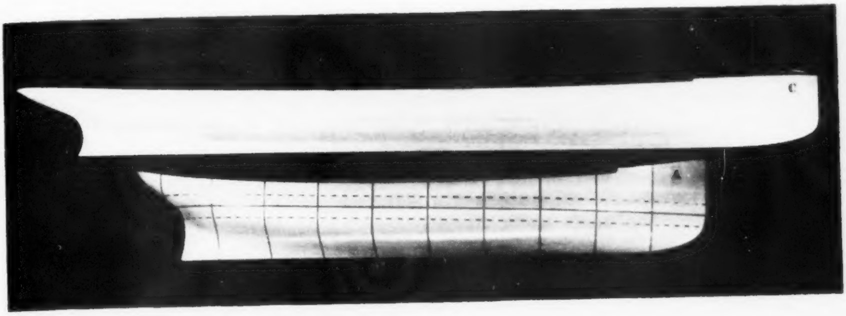
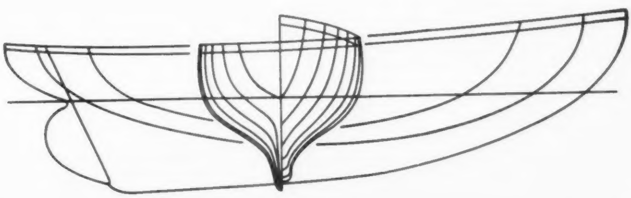


Figure 3 - Models of parent trawler (below) and lengthened trawler (above).

Figure 4 - Lines of parent yacht.



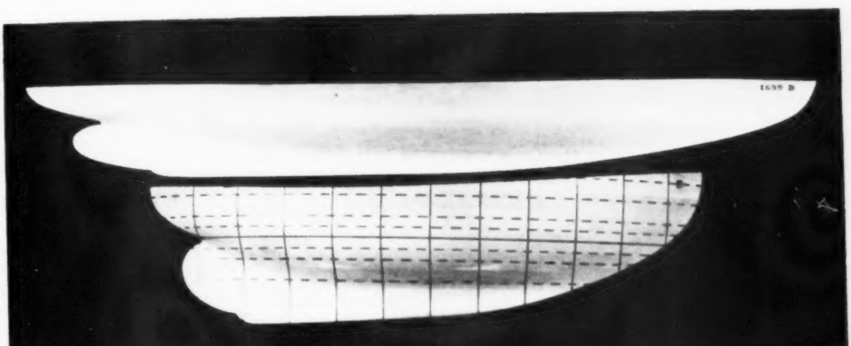


Figure 5 - Models of parent yacht (below) and lengthened yacht (above).

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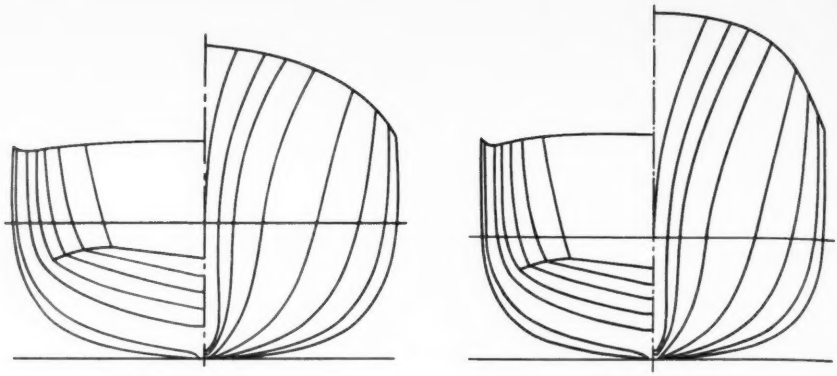


Figure 6 - Lines of destroyer (left) and lengthened destroyer (right).

Particulars of Models

	Original Trawler	Original Yacht	Lengthened Trawler	Lengthened Yacht	Destroyer	Lengthened Destroyer
Length of model (feet)	4.17	–	5.56	–	5.71	7.19
Length on load waterline (feet)	4.11	3.94	5.48	5.25	5.72	7.20
Rated load waterline (feet)*	4.28	4.28	5.71	5.71	–	–
Beam (feet)	0.74	1.22	0.555	0.709	0.608	0.535
Draft (feet)	0.33	0.69	0.255	0.417	0.208	0.186
Displacement (FW) (pounds)	33.3	50.8	24.5	24.5	24.5	24.5
Block coefficient	0.51	0.23	0.51	0.23	0.55	0.55
Displacement-to-length ratio	304	370	60	60	60	28.5
Radius of gyration (in air)	0.25L	0.25L	0.24L	0.24L	0.24L	0.24L
Natural pitching period (seconds)†	0.744	0.813	0.59	0.63	0.60	0.55
Natural heaving period (seconds)†	0.728	0.780	0.61	0.60	0.62	0.595
Freeboard at bow (feet)	0.42	0.63	0.32	0.38	0.28	0.35
Freeboard-to-length ratio	0.10	0.15	0.056	0.066	0.049	0.049

*By Cruising Club rule.

†By manual oscillation in calm water.

To explore still further the effect of ratio of length to displacement, a fifth model was built to represent the destroyer "stretched out" to exaggerated length (Figure 6). At the same time the above-water lines were modified to preserve the same freeboard-to-length ratio. Thus, including the original destroyer model, a group of six models of widely varying form and proportions were available for comparative testing in both regular and irregular waves. In addition, test results of other models of large ships were available for comparison with the group.

Regular wave trains having any desired wave length (measured crest to crest) can be generated in the Stevens tank. Six such wave patterns were set up for each model tested: 2, 1.5, 1.25, 1.0, 0.75, and 0.50 times the length of the model. The models were towed along the basin at varying speeds through each wave train, and the amplitudes of pitch and heave were measured.

A typical plot of pitching results is shown in figure 7. It will be noted that for each wave length the amplitudes of motion reach a maximum, or peak, near the "speed for synchronism", that is, the speed at which the frequency of encounter with the waves is equal to the natural pitching frequency of the model. Observations indicated that at the synchronous speeds there was also a marked tendency for water to be shipped over the bow and for bottom slamming to occur. However, the figure shows that waves considerably shorter than the model caused relatively little pitching, even at synchronous speeds. In short, the first important amplitude peak as speed increases from zero is that for the wave that is the same length as the ship (1.0).

These general conclusions apply equally to the other models tested. However, a comparison of the model results adjusted to equal displacements led to a very significant conclusion: the important amplitude peak for regular waves of model length occurred at successively

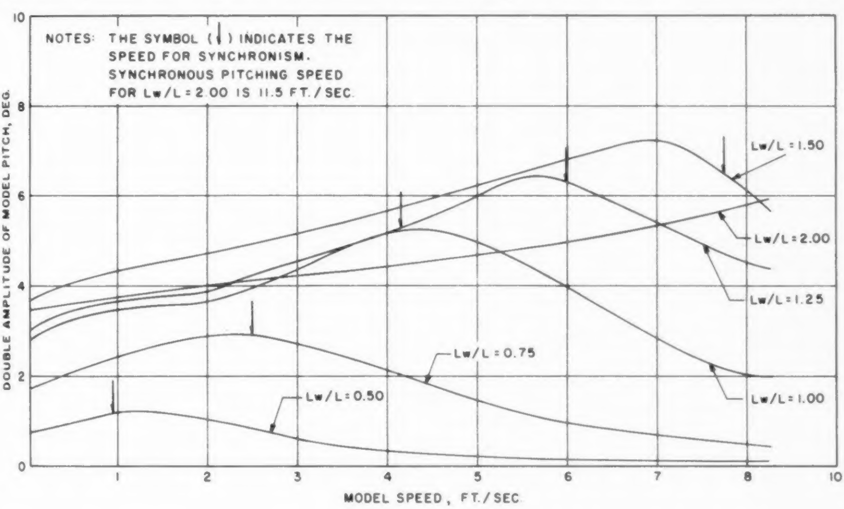


Figure 7 - Pitching amplitudes of destroyer model in regular head seas. Lw/L refers to the ratio of the length of wave to length of ship.

Approximate Limit Of Speed For Ships Having Moderate Motions When Heading Into Storm Seas.

Displacement-Length Ratio, $\Delta/(L/100)^3$	Displacement (tons)	Ship's Speed (knots)
200	1,000	3.8
	10,000	5.5
60	1,000	12.6
	10,000	18.5
30	1,000	20.5
	10,000	30.0

higher speeds as the displacement-to-length ratio was reduced. This observed trend in regular waves permitted a prediction to be made of the comparative performance to be expected of different ships when meeting actual storm seas head on. For oceanographers tell us that the irregular patterns of storm seas can be explained as the summation of many regular component waves. Since wave components shorter than the ship do not cause serious pitching, the components of approximately ship length usually determine the speed at which violent motions begin. Therefore, the higher the speed at which the amplitude peak occurs for a regular wave of ship length, the higher the speed attainable in an irregular sea before motions become violent. As explained above, a ship of low displacement-to-length ratio has a distinct advantage here—provided, of course, that it has adequate freeboard and good flare forward.

We can state as a generalization: if a certain size of vessel is considered, say a 1,000-ton trawler or a 10,000-ton ship, a design with a low displacement-to-length ratio will be able to maintain a higher speed at sea for comparable amplitudes of pitch and heave than one with a high ratio. This is borne out in the table above.

Facilities have also been developed at Stevens for generating realistic long-crested irregular sea patterns, that is, waves having the same irregular appearance as ocean waves when recorded at a fixed point, but which have straight crests extending the width of an ordinary long tank. Harmonic analysis of tank records reveals that the energy spectra, which show the relative importance of the various component waves in the irregular record, correspond to scaled-down ocean storm seas. Furthermore, average characteristics such as wave height, length, and period agree with ocean wave data. It has been found that the pitching and heaving behavior of models in these tank waves closely represents the behavior of full-scale ships in head or following seas.

Comparative tests of all the models in realistic irregular head seas resulted in conclusions such as the following

- The average amplitude of pitching and heaving motions of the lengthened trawler at 2.5 feet per second is about the same as for the original trawler at zero speed.

- Considering both models at 2.5 fps, the average amplitude of pitching and heaving of the lengthened trawler is two-thirds of that for the original trawler. The same conclusion also applies to the yacht model.

- Similarly, at this same speed the average amplitude of pitching and heaving of the lengthened destroyer is 50 to 60 percent of that of the original destroyer.

These findings confirm the conclusion derived from tests in regular waves that a reduction in the displacement-to-length ratio results in reduced motion amplitudes in rough head seas.

As previously noted, the shipping of water forward, which may be of greater significance than amplitudes of motion as such, depends on the freeboard as well as the motion amplitudes. When forward freeboard was maintained proportional to length, however, the longer the ship in proportion to displacement, the less frequently water was shipped at a particular speed in irregular waves.

Comparisons of models of the same displacement-to-length ratio led to other valuable conclusions regarding seakeeping qualities. For example, the long hull of the destroyer showed its superiority over the other slender models in respect to motion amplitudes, particularly in the vicinity of synchronism in regular waves. This resulted from the high damping characteristic of the broad, flat stern that is typical of a modern destroyer. Similarly, the lengthened trawler was slightly superior to the lengthened yacht because of the greater damping associated with the full waterplane of the former. In very high waves, however, the extreme V-sections and overhanging ends of the lengthened yacht compensated for its fine waterplane. It may be concluded, therefore, that distinct improvement in seagoing qualities can be obtained by use of V-bows and flat sterns, both of which increase the damping characteristics. Such steps are fully effective in irregular storm seas, because the most objectionable motions are those caused by the sea components producing synchronism. Under these conditions an increase in simple damping is highly effective in reducing amplitudes.

Another significant comparison among the models concerned the shipping of water forward. For example, the original yacht was drier than the original trawler, and both models shipped less water forward than the lengthened models in spite of their greater motion in irregular head seas. The dryness resulted mainly from the greater freeboard of the little vessels in relation to their length. These findings are believed to be of considerable significance. They bring to the fore the sometimes forgotten importance of freeboard, and suggest that larger ships—especially those intended for high speed—might profit by higher bows and good flare forward.

Similarly, although the destroyer was superior to both of the slender models in respect to motion amplitudes, it was the wettest of the three models. This was primarily the result of its small forward freeboard. In addition, the destroyer showed a tendency to pitch downward somewhat more than upward, apparently as a result of the combination of a flat stern and a U-shaped bow. Hnece, it can be concluded that, in addition to high freeboard and good above-water shape, a balance between the ends of a ship is a desirable feature.

An alternative to high freeboard is a foredeck which can take large quantities of water safely. This means putting the windlass and line-handling gear below deck, providing an adequate, well-shaped breakwater, and designing the deck to withstand the pressure of green water coming aboard. Comparatively small differences in the flare at the bow also seem to make large differences in the amount of solid water that is thrown clear of the bow. Models with raked stems and rounded forecastle decks in which the flare is carried well forward show an advantage over the straight-stem designs.

Considering briefly the theoretical aspects of the ship motion problem, rapid advances have been made in recent years by Professor Korvin-Kroukovsky of Stevens in dealing with ships in regular head seas. He has employed a so-called "strip method" in which the ship is divided into a number of sections, and all of the relative motion between water and ship is assumed to take place around these sections; that is, fore-and-aft flow is neglected. The coupling of pitch and heave, neglected heretofore, is accounted for using this method, and distortion of oncoming waves by the ship, which is overlooked by the customary hypothesis, is taken into account.

The present status of the analysis demonstrates excellent agreement between theory and experiment for normal ship forms. Furthermore, the agreement shown applies to phase relationships as well as to amplitudes of motion. Because of the effect of the phase lags on wet decks and slamming, it is significant to find that the cross coupling between pitch and heave has an important effect.

Calculations of motions in regular waves would be of relatively minor significance if it were not for the fact that they provide the material needed for predicting statistical characteristics of ship motions in irregular storm seas. If the spectrum of a storm sea is known or assumed, then a "superposition" method—developed by St. Denis of the Taylor Model Basin and Pierson of New York University—can be applied to the determination of the motion spectrum of the ship in that sea. In a typical application, pitch and heave motion spectra are obtained from actual records taken in irregular tank seas, and these are compared with spectra predicted from both experimentally measured responses to regular waves and from computed responses. The agreement is excellent, especially when it is recognized that the tank sea was quite severe, causing frequent shipping of water and slamming.

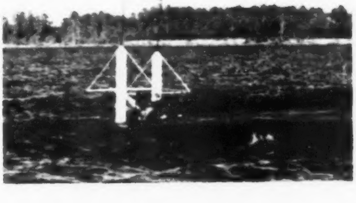
A whole new vista is opened up by the prospect of combining these new analytical methods of studying ship motions with modern electronic computing techniques. It can be visualized that, in the near future, new ship designs will be evaluated in respect to seagoing qualities very quickly by computers. And what is even more important, the effect of variations in hull form and proportions will be determined easily and rapidly in order to obtain an optimum design.

On the basis of the investigations to date, the researchers at Stevens believe that a ship similar to the "stretched out" destroyer may be the typical fast naval vessel of the future, a ship which will maintain much higher speeds in rough seas. Dr. Davidson has advocated the design, and perhaps construction, of such an experimental ship as being the best means of solving the many problems associated with higher ship speeds at sea. Among other advances, the proposed vessel will need an improved power plant, a propulsion system for transmitting large thrust to the water, an efficient structural design for so slender a ship, and stabilizing fins to control rolling.

Work is continuing at the Experimental Towing Tank on the problem of ship motions, using both the experimental and analytical approaches. Experimental facilities have recently become available at the Towing Tank for studying ship behavior at oblique headings to waves in which the models not only pitch, heave, and surge, as in head seas, but also roll, yaw, and sway. From their use, it is hoped that further answers will be obtained regarding other unsolved questions of ship behavior at sea.

Hoisting for Life

A new helicopter rescue hoist, developed by the Naval Medical Field Research Laboratory, Camp LeJeune, North Carolina, was evaluated recently in a simulated rescue mission conducted on New River, near the Marine camp. To demonstrate the hoist's rescue potential, a Marine, posing as a casualty, was dropped by boat into the river, then scooped up quickly by a helicopter fitted with the new apparatus. The hoist and the rescue operation are illustrated below.



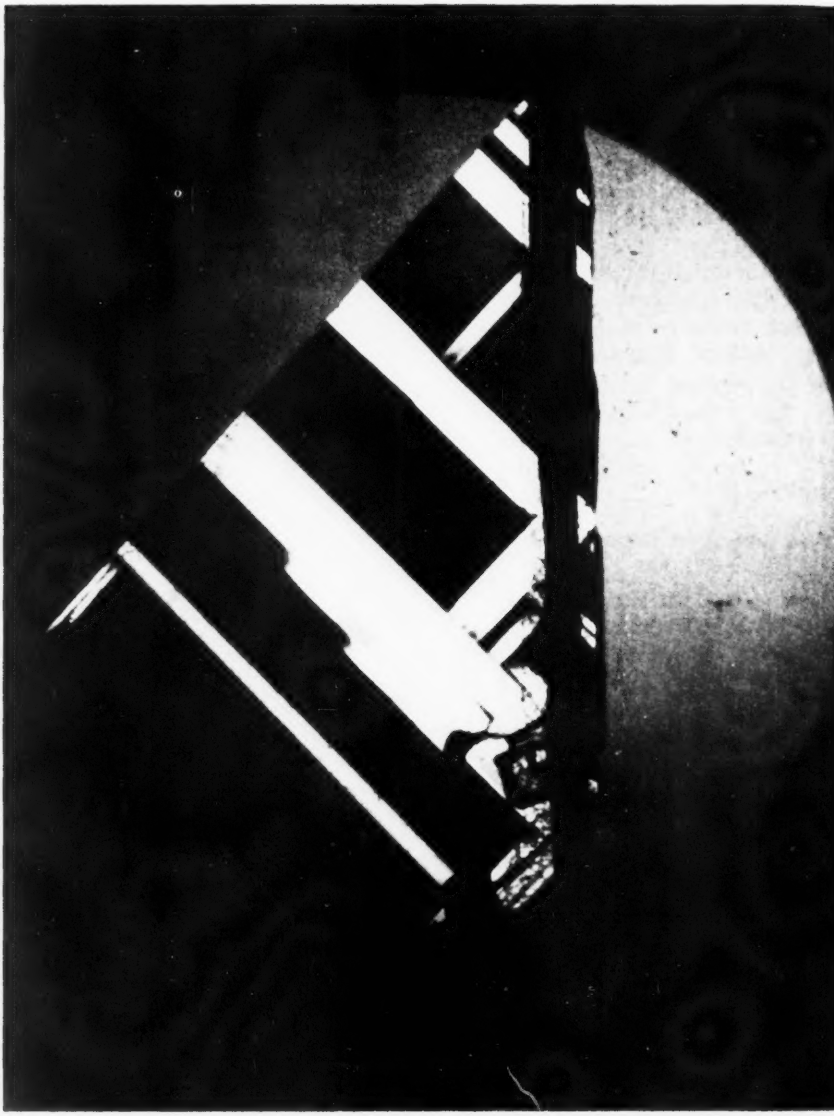


Figure 1 - Domain structure of a barium titanate crystal as shown by the polarizing microscope (magnified 10 times).

Ferroelectric Crystals

H. H. Wieder
Electricity and Magnetism Division
Naval Ordnance Laboratory
Corona, California

The beauty and symmetry inherent in natural crystals have fascinated man since the beginning of civilization. But only recently, relatively speaking, has man been able to do more with these crystals than use them as trinkets. And only within the past few years has he been able to fabricate some crystals according to his own specifications—crystals which either do not exist in nature or which are of much higher purity and much greater usefulness than those that do. Ferroelectrics are a class of crystalline materials mostly grown or prepared artificially. They have a considerable practical value, most notably for use as transducers of acoustical energy to electrical signals and potentially as information storage elements in digital computers.

Contrary to the name, practically all ferroelectric crystals contain no iron. The name merely suggests an analogy between the spontaneous electric dipole moment of ferroelectrics and the spontaneous magnetic moment exhibited by the better known ferromagnetic materials. While the former are actuated by an electric field, the latter are operated by a magnetic field. Both can store binary information, that is, the polarity of the previously stored remanent magnetization or polarization may be determined by a suitably applied magnetic or electric field.

Ferroelectric crystals are anisotropic—that is, their mechanical, electrical, and optical properties are a function of the crystallographic axis along which they are measured. X-ray spectrograms show that each crystal is composed of a large number of unit cells and that each unit cell has its characteristic spatial configuration and symmetry. The arrangement of the constituent atoms of each unit cell may be quite simple, as in the tetragonal (perovskite) form of barium titanate, $BaTiO_3$; or quite complex, as in the monoclinic rochelle salt, $NaK(C_4H_4O_6)\cdot 4H_2O$. All ferroelectrics studied to date show a distortion of the unit cell in a crystallographic direction called the ferroelectric or polar axis. When this distortion is accompanied by a relatively large change in the optical refractive index, the crystal orientation can be easily established by use of polarized light.

Unit cells of the ferroelectrics tend to align with one another in the same way those of ferromagnetic materials do, forming microscopic units, called domains. In turn, these domains tend to align with respect to each other so that the whole crystal is in a state of minimum electrostatic energy. The domain structure is readily apparent in Figure 1, which shows a $BaTiO_3$ crystal at 25° C under polarized light. The dark areas consist of so-called "c" domains, whose polar axes are perpendicular to the major crystal faces in either of two 180°

positions. The light regions indicate "a" domains, the polar axes of which are in the plane perpendicular to the "c" axis. The "a"-domains, which seem to terminate in the middle of the crystal, have a wedge-like formation which penetrates the crystal at a 45° angle to the surface. Domains have been observed in other ferroelectrics, such as potassium dihydrogen phosphate, rochelle salt, and potassium niobate. The type, orientation, and size of the domains are dependent on the lattice structure of the unit cells and the past history of the sample. There is a qualitative analogy between the mechanics and nature of domain structures in ferroelectrics and ferromagnetics.

When an electric field is applied to a ferroelectric crystal, many small domain nuclei are formed. The domains grow thereafter in the direction of the applied field. The number and rate of growth of these nuclei determine the rate of polarization reversal. In a simple crystal-

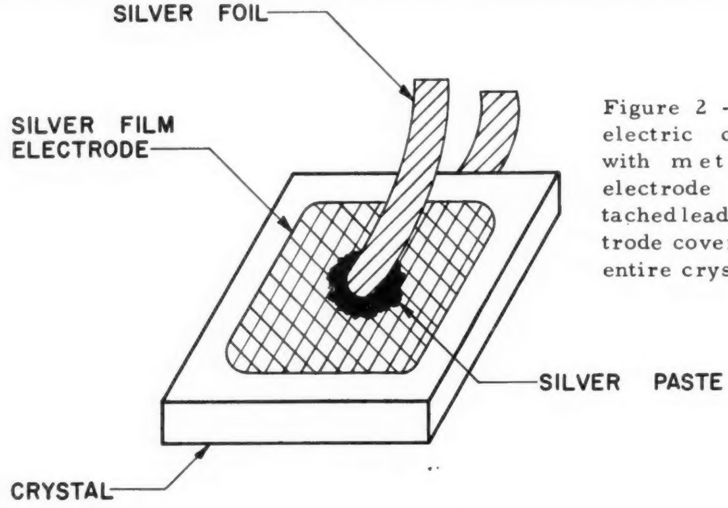


Figure 2 - Ferroelectric crystal with metal film electrode and attached leads. Electrode covers nearly entire crystal face.

line structure, such as that of tetragonal barium titanate, the motion and growth of these domain nuclei can be seen under polarized light.

For experimental purposes, a ferroelectric crystal is generally prepared in the form of a thin tabular crystal plate with metal electrodes evaporated upon the major faces of the crystal. Leads are attached to the electrodes completing the fabricated ferroelectric capacitor, as shown in Figure 2.

If a small sinusoidal voltage is applied to such a ferroelectric, then the induced polarization will be linearly proportional to the applied voltage, as it is in an ordinary capacitor. If the field becomes large, however, then this relation is no longer linear and a hysteresis loop similar to that obtained for ferromagnetic materials is obtained, as shown in Figure 3. If the driving potential is removed and the crystal shorted it nevertheless retains a polarization P_r, unlike ordinary capacitors. A large positive electric field is required to change a negative polarization ($-P_r$) to a positive polarization ($+P_r$). When the positive field is removed, the polarization will remain positive, a negative field being required to effect a negative polarization.

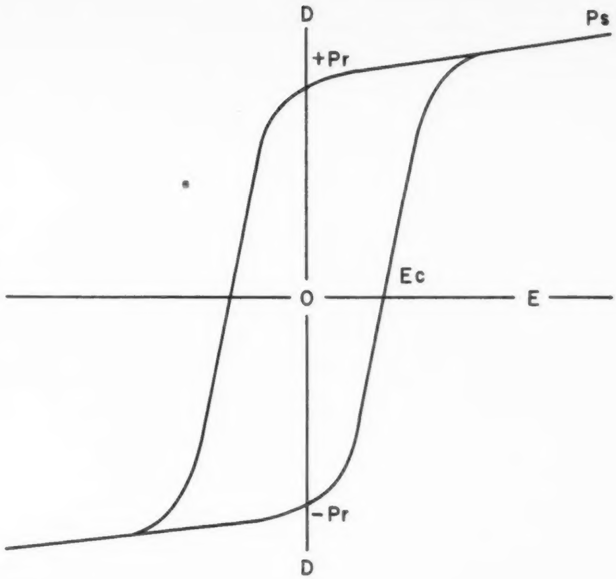


Figure 3 - Hysteresis loop of a ferroelectric capacitor. D and E are electric displacement and the electric field, P_s is the spontaneous polarization, and P_r is the remanent polarization. E_c is the apparent coercivity.

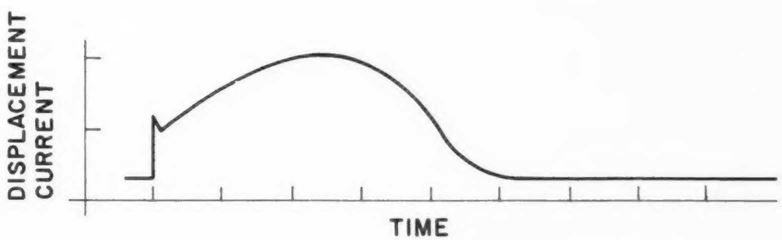
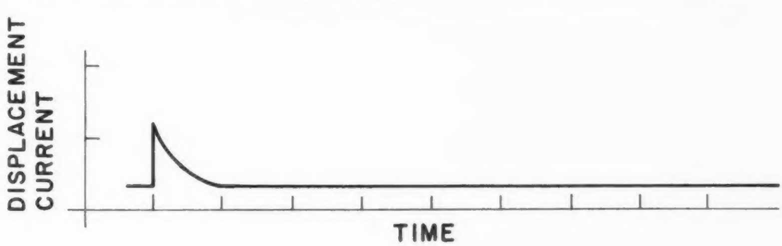


Figure 4 - Switching current transient of a ferroelectric capacitor caused by a rectangular voltage pulse applied to the crystal resulting in a reversal in the sign of the remanent polarization.

Figure 5 - A voltage pulse applied to the ferroelectric without attendant polarization reversal. Difference between the two transients is one of the useful properties of ferroelectric crystals.



The switching current obtained in response to positive or negative field pulses is of considerable practical interest, because it shows the potential of ferroelectrics as memory devices in computers. If the polarization is switched and the sign of P_r is reversed, then the transient current of Figure 4 results. If the polarization is not reversed by the pulse, then the transient of Figure 5 is obtained. This discriminative property makes ferroelectrics potentially useful as binary elements of digital computers.

Magnetic amplifiers and magnetic saturable reactors are now much used in electrical and electronic control circuitry. Both are based upon the inherent nonlinearities between an applied magnetic field and the resulting magnetic flux that are found in certain magnetic materials. In a similar manner ferroelectrics may be used as dielectric saturable reactors and dielectric amplifiers. Many such devices employing ferroelectric elements have been proven practicable and many more have been suggested.

The applications to digital computer memory devices and related circuits are being intensively explored at present. One of the great advantages of ferroelectric circuit elements is that they are voltage operated devices and their low switching power requirements make them ideally compatible with transistors.

Again, just as in magnetics, the time required for a reversal of polarization by switching decreases as the field is increased. For barium titanate, this time may be of the order of tenths of a microsecond; for guanidinium sulfate, it is of the order of milliseconds.

Ferroelectric properties, such as the magnitude of the remanent polarization, are intimately connected with the prevailing order in the crystal lattice structure. This order is dependent upon ambient temperature; that is, the detectable remanent polarization decreases with increasing temperature until all traces of ferroelectric activity disappear and the crystal thereafter behaves as an ordinary dielectric. Most ferroelectrics undergo a crystalline phase transition at the same temperature at which ferroelectric behavior ceases. Examples of anomalies are guanidinium aluminum sulfate, in which this transition occurs at a temperature higher than its dissociation temperature, and rochelle salt which has two phase transition temperatures. Some ferroelectrics have a transition temperature higher than 400° C, and others have a transition temperature that is about the same as the temperature at which nitrogen liquifies. Therefore, in order for a crystal to be designated a ferroelectric, the temperature range in which ferroelectric activity is discernible must be one that can be clearly defined.

By a substitution of isomeric atoms in the crystal lattice, considerable shifting of the transition temperature may be feasible, indicating that a form of "molecular engineering" may provide a ferroelectric material tailored to a particular requirement. Thus, the research problem for the future is obvious. As new ferroelectrics are discovered and new applications are sought, the prospect is that a host of new crystalline ferroelectric components will take their place alongside the solid-state components which are already well on the way to revolutionizing our present technology.

Research Notes

The Solid Scintillation Chamber

Professor George T. Reynolds, an ONR contractor at Princeton University, has recently announced the successful testing of a preliminary model of a new type of radiation detector that shows promise of becoming one of the most powerful tools of the nuclear physicist. When fully developed, the instrument, called a "solid scintillation chamber," will combine the advantages of two of the most effective detecting instruments now used—the bubble chamber and the scintillation crystal.

When an electrically charged atomic particle passes through the former, it leaves a line of bubbles along its path which become large enough to photograph several thousandths of a second after the particle has passed through. If the particle interacts with a nucleus within the chamber one usually sees two or more tracks emanating from a common point. By making various kinds of measurements on each of these tracks, and using the laws of conservation of energy and momentum, it is possible to get a rather complete description of the reaction. Three shortcomings of bubble chambers are: (1) they must be put into a sensitive condition before bubbles can be formed, and this cannot be done faster than about once a second; (2) they cannot be "triggered" to take pictures when a particular kind of particle passes through, but rather must take a picture of whatever passes through during the few thousandths of a second that the chamber is sensitive; and (3) to analyze thousands of bubble chamber pictures is an extremely tedious task. The process has been semi-automatized, but to make it completely automatic will be a very difficult and expensive proposition.

On the other hand, when a charged particle passes through a so-called scintillating material it causes many of the atoms along its path to emit minute pulses of light, each lasting about 100 millionths of a second. Unfortunately, the quantity of light emitted is so small it has not been possible to take a picture of the line of light sources along the track: the best that can be done is to measure the total amount of light emitted by all of the sources. Thus, with a scintillating material one can determine that a charged particle has passed through, and how much energy it deposited in the material; but one does not know its trajectory.

Physicists in many laboratories have been intrigued with the possibility of combining the pictorial aspect of the bubble chamber with the continuous sensitivity, extremely fast response time, and relatively simple construction of scintillators. Several schemes are under consideration, but they all require the development of image amplifiers several orders of magnitude more powerful than any now in existence. Several development programs are in progress, and it is hoped that within a couple of years it will be possible to use solid scintillators in elementary particle physics.

The scheme under study by Professor Reynolds makes use of filaments, about a millimeter in diameter, made of plastic scintillating material. Now, the index of refraction of this plastic is such that an appreciable fraction of the light originating within a filament is internally reflected along the filament and comes out at the ends. Instead of being emitted uniformly in all directions, the precious little bit of light is "piped" out in two directions, and it then becomes feasible to measure the quantity of light. By stacking layers of such filaments alternately perpendicular to each other, as is planned, and recording the positions of the filaments from which light pulses come, one can reconstruct the three-dimensional path of a charged particle. All of this will be done by electronic computing machines, of course.

It now becomes possible to have a "picture" of the tracks of the particles involved in an interaction, as in a bubble chamber; but unlike a bubble chamber this device has the following advantages.

- It is sensitive continuously, so it can be used with accelerators having high pulse rates, and for the study of cosmic rays.
- It can take a "picture" in 100 millionths of a second. Data can thus be accumulated at a much faster rate.
- The coordinates of the tracks can be fed directly into a computing machine for analysis, whereas in a bubble chamber it is necessary first to digitalize the coordinates from a photograph.
- By means of standard electronic coincidence circuits and combinations of scintillators it is possible to trigger the solid chamber to record tracks only when particles of a desired type are passing through. This reduces background "noise" considerably.
- The solid chamber is much simpler mechanically and less dangerous to operate than the bubble chambers, which carry flammable liquids through large changes of pressure.

INPHEXAN

Antarctic weather being what it is at this time of year—highly unpredictable—visitors to the frozen continent usually can't count on carrying out their plans to the letter, no matter how carefully they lay them. But if, by chance, all has gone according to schedule, members of the ONR-sponsored International Physiology Expedition Antarctic (abbreviated INPHEXAN), wound up their work on the continent on the 10th of this month, and, as this issue of Research Reviews is distributed, are heading homeward.

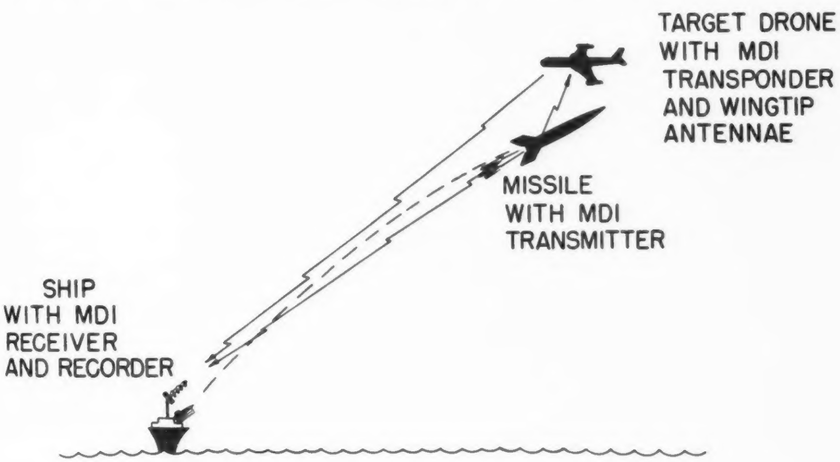
The INPHEXANs began arriving at McMurdo Sound about the middle of last December to launch a study of the human body's response and adaptation to cold. Six environmental physiologists, representing the United States, England, and Germany, and 8,000 pounds of gear made up the expedition.

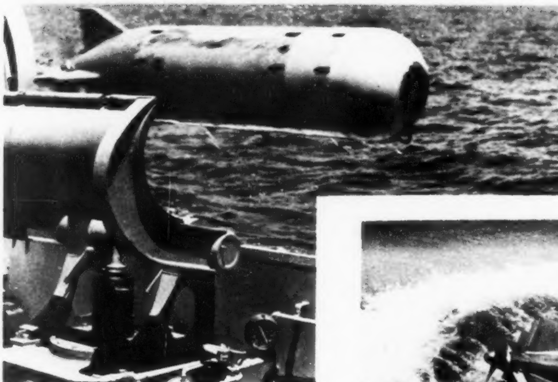
Although at this writing word has not been received on the progress of the investigations, the physiologists' plan was to study personnel stationed at several Antarctic bases, as well as to make observations on members of parties traversing various parts of the continent. Among the traverse parties earmarked for visits were the United States' Sno-cat group on the Ross Ice Shelf (Research Reviews, December 1957), the parties of Sir Edmund Hillary and Vivian Fuchs (upon their arrival at the South Pole), and a second U. S. party that is crossing Byrd Land. Unless the weather thwarts the efforts of the team, the study should be one of the most interesting and informative of its type that has been made. Members of the research group are—

Dr. Nello Pace, Professor of Physiology, University of California
Dr. Griff Pugh, British physiologist
CAPT Charles Meyers, U.S. Navy Medical Research Unit No. 1
Major James Adam, British Army Medical officer
Mr. William Siri, biophysicist, Donner Laboratory
Dr. Gerhard Hilderbrand, German physiologist

Gaging Missile Misses

In the process of refining the guidance systems of new missiles, it is advantageous to know by what margin an inaccurately guided missile will miss its target. To provide such information, the Naval Ordnance Laboratory at Silver Spring, Maryland, has developed a device called the Miss-Distance Indicator. Operation of the new system in an encounter between a missile launched from a ship and a jet plane flying at an altitude of several thousand feet is pictured below. Signals from a transmitter inside the missile are automatically sent to both the ship and the drone aircraft. A relay station, or transponder, in the target plane then retransmits the missile's signal back to the ship on another wave length. By measuring the difference between wave lengths of the two signals, which are received simultaneously by the ship, technicians can determine how many feet they come from the target. . . .and do better next time.





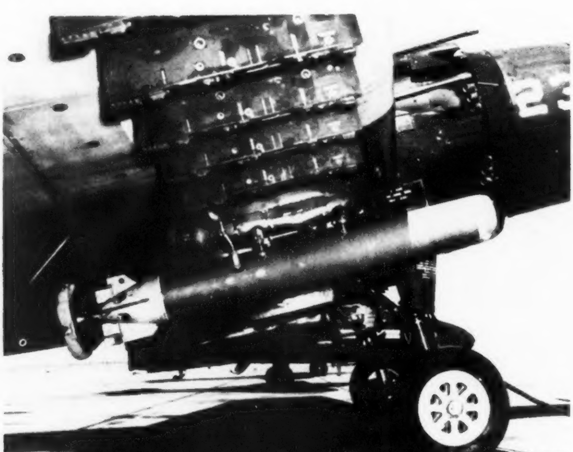
The acoustic homing torpedo Mark 32 is launched from a surface ship.

"Marks" of Progress

Recently, the Navy added two new acoustic homing torpedoes to its anti-submarine warfare arsenal, one designed for launching from surface ships, and the other from either aircraft or surface ships.

The former, called the Mark 32, is shown above. As it does not have to be fired through a torpedo tube, but can be sent on its way simply by tossing it overboard, it is a readily adaptable weapon. Also, once it is in the water, its homing system will guide it unerringly to its target.

The other weapon, the Mark 43, is illustrated below. Propelled by an electric motor, this light-weight missile is capable of searching to great depths for enemy submarines.



The submersible guided missile Mark 43, now operational with the Fleet, can be launched from either aircraft of surface ships.

IGY Review: The First 6 Months

A summary of the first 6 months of the United States IGY program was released last month in Science, the magazine of the American Association for the Advancement of Science. By hugh Odishaw, Executive Director of the United States IGY Committee, the report describes a wide range of early scientific results of this 18-month international research program of our earth and its environment.

The findings reported by Odishaw cover each of the dozen scientifice disciplines in which IGY programs are being conducted and reflect the work of hundreds of scientists and many participating institutions, including, of course, the Navy (Research Reviews, August 1957). They demonstrate also the constructive participation of many other nations.

The results range from the recovery of living organisms from record ocean depths to the reception of radio signals sent curving two or three earth radii out into space to test whether a sparse medium actually fills the void between earth and sun. They include the recovery of ice cores from depths of more than 1,000 feet in the Greenland ice cap, cores which carry in their undisturbed annual layers of snowfall a record of the earth's climate reaching back as far as 2,000 years.

At the other extreme, scientific probings into the upper atmosphere with the aid of rockets have corroborated the belief that radio "blackouts" are caused by an "extra" layer of ionized particles which occurs during solar flares in the upper atmosphere 10 to 12 miles below the lowest portions of the ionosphere. Another rocket experiment has established that this layer is caused by the sun's X-ray emissions.

Among the other findings described in the report:

- Much data of considerable value on pressure, temperature, and density of the upper atmosphere have been obtained through the United States IGY scientific rocket programs (Research Reviews, November 1957). The rockets fired include the AEROBEE-HI (Research Reviews, May 1957), AEROBEE, NIKE-DEACON and the ROCKOON (Research Reviews, August 1956). These vehicles, together with the satellites launched by the U.S.S.R., have proved very useful in gaining new information about the electrically charged layers of the ionosphere.

- Observatories located on Pacific islands have confirmed the probable existence of an "electro-jet," a narrow equatorial electric current which circles the earth in the high atmosphere. This is one of three hypothecated currents of perhaps several hundred thousand amperes circling the earth. The others girdle the north and south magnetic poles.

- The northern and southern lights occur simultaneously and with some symmetry, according to preliminary findings by British scientists. These determinations have since been supported by polar radio data obtained in the United States program.

- Research vessels of the Woods Hole Oceanographic Institution, the Lamont Geological Observatory of Columbia University, the Scripps Institution of Oceanography of the University of

California, and the University of Washington have been making extensive cruises in the North and South Atlantic, Indian, and Northeast, Central and Southeast Pacific Oceans, covering many thousands of miles.

- British and American oceanographers have tracked submerged floats of neutral buoyancy to discover that a swift current runs counter to the Gulf Stream almost 10,000 feet below it. (Research Reviews, May 1957).

- University of Chicago specialists have pinpointed a "cosmic ray equator" by systematically flying and sailing instruments around the world. Since this line departs considerably from the geomagnetic equator, the conclusion is that there are important magnetic fields in space which deflect incoming cosmic rays. (Research Reviews, December 1957).

- Seasonal extremes in Antarctic weather have been observed at the IGY South Pole Station, with a world record low of -102.1° F last September 17 and a high for the station of -2.0° F last December 15.

- The operation of an Antarctic Weather Central at Little America Station has permitted an international group of scientists to prepare the first weather synoptics for this vast continent. For the first time in history twice-daily weather maps have been prepared of Antarctica. Weather forecasting in Southern Hemisphere countries has already benefitted from this information.

- Substantial progress has been made in preparing a profile of the Antarctic continent beneath its enormous mantle of ice. The IGY Byrd Station, only 5,000 feet above sea level, has been found to rest on 10,000 feet of ice, perhaps indicating a more complex continental configuration than that long assumed. More recent investigations indicate that the South Pole's ice mantle is nearly 8,300 feet thick, resting on rock almost 1,000 feet above sea level.

- Certain intermediate seismic waves with periods of about 100 seconds, previously known to occur only in the earth's crust, have now been identified in the next layer beneath the crust, the mantle. Study of the propagation of these waves will provide much new information on the distribution of materials in the earth's interior.

- Seismologists exploring the structure of the Andes Mountains in South America have found roots of unexpected depths and are now working on their data to understand better the crustal structure under this great mountain chain.

- Scientists on an ice floe, called Drifting Station A, only a few hundred miles from the North Pole, noted during the past summer that about 12 inches of ice on the upper surface melted away, while as much as 24 inches of new ice formed on the bottom of the floe. This observation will be placed in proper perspective after further study of air, ice, and sea temperatures, ocean currents, and related factors.

- The first successful surface measurements of gravity in the open sea were made by scientists of the Lamont Geological Observatory with a sea gravimeter developed by Anton Graf of Munich, Germany. Previously, gravity values for ocean areas had to be measured in submarines at quiet depths. This condition had severely limited the amount of gravity data that could be gathered for the 80 percent of the earth's surface that is covered by water. (Research Reviews, January 1958).

Odishaw noted in the report that IGY data is already beginning to flow into three World Data Centers, in the United States, Russia, and in Western Europe-Japan. The accumulation should reach a peak early in 1958.

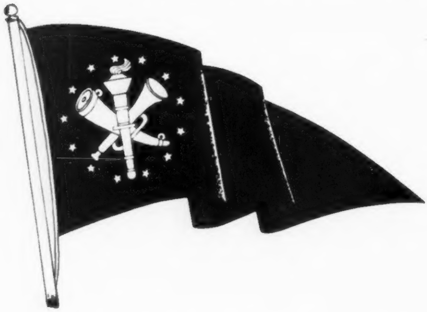
Ultrasonic Surgery Now Being Performed on Humans

The March 1953 issue of Research Reviews carried an article entitled "Brain Surgery by Sound" by William J. Fry of the Biophysical Research Laboartory, University of Illinois, Urbana, Ill. The article discussed the effects of ultra-high-frequency sound waves on nerve tissue and ended with the speculation that ultrasonic techniques could eventually be used in place of conventional neurosurgery in the treatment of many disorders of the nervous system and perhaps even to treat types of pathology now considered inoperable. (Conventional neurosurgery usually involves direct cutting of brain tissue or coagulation of tissue by electrical stimulation with inserted probes). Focused beams of ultrasound can selectively destroy tiny areas of tissue at any desired depth or location without effecting surrounding and intervening tissue.

Since 1953 Dr. Fry has developed a smaller model of his four-beamed instrument appropriate in size for use in the operating room and has carried out many more experimental studies on ultrasound effects. During the fall of 1957, the first human operations were performed in conjunction with the Iowa City University Hospital on three Parkinsonian patients. (Parkinson's disease is characterized by marked tremor of resting muscles, and peculiarities of gait and posture). The operation consisted of destroying, by means of irradiation, a tiny nerve tract at the base of the brain called the ansa lenticularis. The initial operations were unilateral, that is, the tracts on only one side of the brain were destroyed. Tremor on the opposite side was abolished as a consequence. (The right hemisphere of the brain controls the left side of the body and vice versa). The "one-sided" operation was performed first to provide controlled observations of the operated versus the unoperated side; in other words, the individual serves as his own control.

If the relief of tremor provided in these initial operations proves to be lasting, as expected, ultrasound will have made a unique contribution to neurosurgery, and a variety of applications in this field may be expected in the future.

On the Naval Research Reserve



Is Your Employer Eligible for the Department of Defense Reserve Award?

You are the important link between the Department of Defense and your civilian employer in obtaining for your organization the Department of Defense Reserve Award. To determine whether your employer may be eligible for the award, ask yourself the following questions:

- Does your employer grant leave with pay or partial pay for Reserve training?
- Does he pursue personnel policies which encourage Reserve participation or make facilities such as bulletin boards, meeting rooms, training aids, and transportation available to Reservists?
- Does he publicize Reserve activities in company publications, exhibits, and advertising?
- Do you think his service and cooperation in these or other ways merit recognition and award?

If so, then you may submit the name of your company for the award.

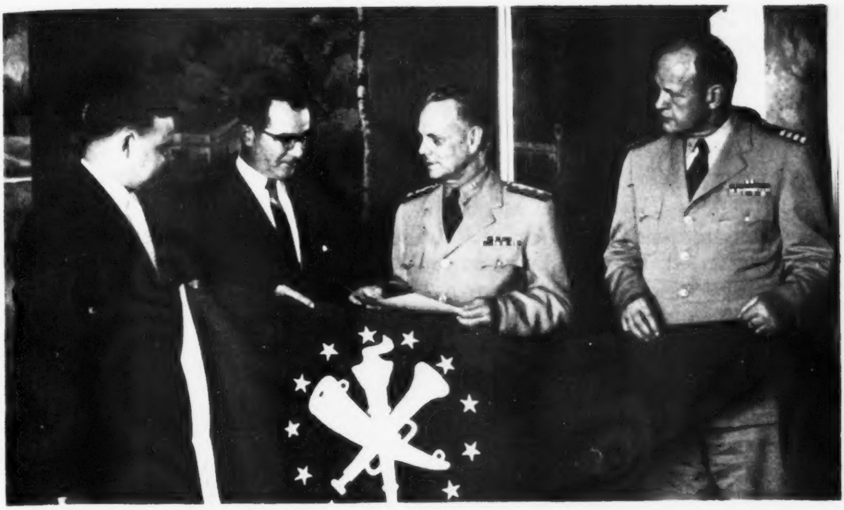
ELIGIBILITY.

The Department of Defense Reserve Award is given as evidence of the appreciation of the Department of Defense to those civilian organizations which are rendering outstanding cooperation in their policies toward Reservists and Reserve activities. Any organization employing Reservists, regardless of the number, can be nominated for this recognition.

In recommending an organization for the award, care should be taken to cite and give details of several policies of cooperation with Reserve components. To cite only one may be considered insufficient justification for granting the award.

DESCRIPTION.

As illustrated on these pages, the award consists of a certificate signed by the Secretary of Defense, with an accompanying citation and



Presentation of the pennant.

Navy sponsored Department of Defense Reserve Awards have been presented to many organizations. Among those who have received the award are universities, boards of education, newspapers, radio and television networks, shipping lines, power companies, banks, oil and chemical companies, a hardware company, telephone and telegraph companies, distillers, aircraft corporations, and publishing houses.

Along with the pennant goes this certificate signed by the Secretary of Defense.

The Department of Defense

Reserve Award Certificate

for Outstanding Cooperation with the Armed Forces Reserve

Citation presented this
day of 195

SECRETARY OF DEFENSE

a pennant. The latter is of blue cloth with a design appliqued in white of a flaming torch representing liberty in front of a crossed bugle, representing the call, and powder horn, depicting defense. Thirteen white stars, representing the principle of unity on which this nation was founded, encircle the other symbols.

PROCEDURE.

Recommendations for the award originate with the Reservist and are forwarded to the Secretary of the Navy via (1) the Commanding Officer of the Reserve company, (2) Commanding Officer, U. S. Naval Reserve Training Center, and (3) the Naval District Commandant. The name of the president or chief executive of the organization should be included in the nomination so that, subject to the approval of the recommendation, the proper individual may be notified by the Secretary of Defense. The recommendation should be submitted in triplicate on DD Form 869, Reserve Award Recommendation, which is available at Naval Reserve Training Centers. OPNAV Instruction 5061.1 is the governing instruction for the Department of Defense Reserve Award.

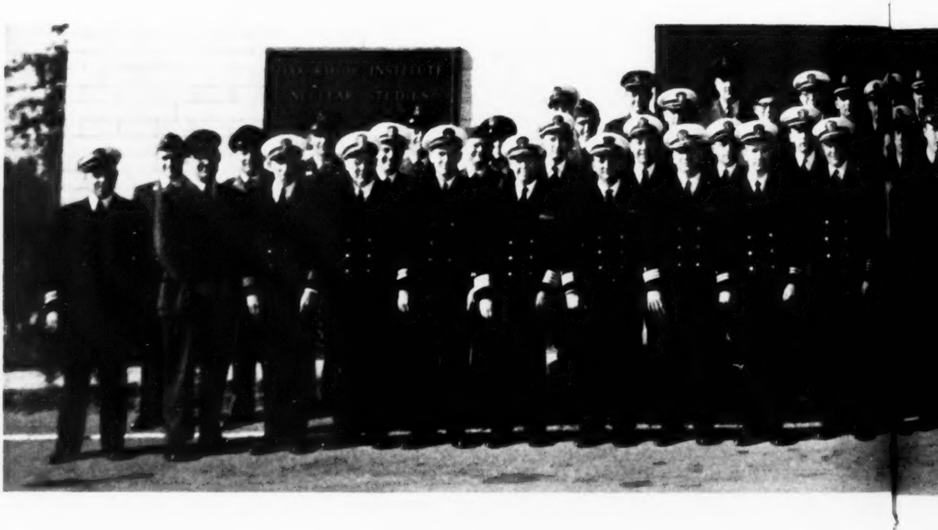
NOMINATIONS MADE BY RESEARCH RESERVISTS.

Research Reservists have nominated seven organizations that have been approved for the Award. These organizations and the Reservists who initiated the nominations are as follows:

Franklin Institute of the State of Pennsylvania, Philadelphia, Pa. (LCDR P. F. Suffredini, USNR, NRRC 4-2)

Michigan College of Mining and Technology, Houghton, Mich. (CDR Roy Drier, USNR, NRRC 9-3)

Brookhaven National Laboratory, Long Island, N.Y. (CAPT John S. Medd, USNR, NRRC 3-9)



Aerojet - General Corporation, Azusa, Calif.
(LCDR L. H. Brown, USNR, NRRC 11-9)

Phillips Petroleum Company, Idaho Falls, Idaho.
(LCDR Gilbert V. Wheeler, USNR, NRRC 13-6)

Medical College of Virginia, Richmond, Va.
(CAPT R. D. Hughes, USNR, NRRC 5-5)

Utah State University, Logan, Utah
(CDR Oliver B. Cope, USNR, NRRC 12-7)

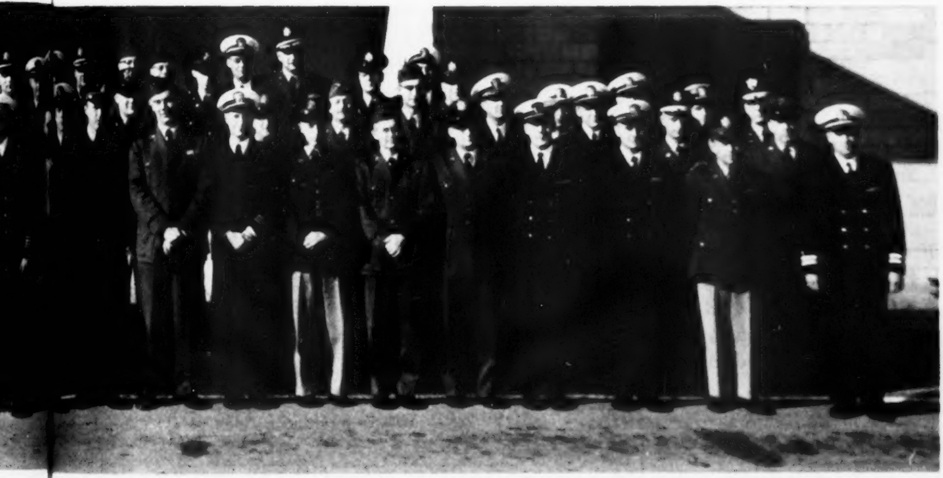
Presentations were made in the name of the Secretary of Defense by the Commandant or his representative to the first four organizations, and appropriate ceremonies to present the award to the last three will be scheduled in the near future.

AWARDS PRESENTED.

To date the Army has sponsored more Department of Defense Reserve Awards than the other services. The Navy, Air Force, and Marine Corps follow in that order. The Navy has sponsored 160 awards, as compared with 208 for the Army, 89 for the Air Force, and 23 for the Marine Corps.

Naval Reservists at Oak Ridge

The Nuclear Sciences Seminar held at Oak Ridge, Tenn., during the first two weeks in December, and described in the January issue of Research Reviews, was attended by 65 Reserve officers. Among this group, which is pictured below, are 33 members of the Naval Reserve.



From left to right, Naval Reserve officers appearing in the photograph on the preceding two pages are:

LCDR R. S. Kirby
CDR W. W. Hawes
CDR L. T. Bourland
LTJG Elvin Greene
LCDR L. Edmondson
CAPT Carl Kyselka
LCDR W. B. Roth
LT F. Bensey, Jr.
CDR H. W. Hoyt
LCDR R. M. Norman
LCDR F. Briggson

CDR A. E. Kohr
CDR A. R. Lyle
LCDR R. M. Rome
LT W. A. Pryor
LCDR E. Lindsey
LCDR H. W. Heding
LCDR N. Knoepfler
LT C. F. Johnston
LCDR R. C. Fite
LT J. B. Ludtke
LT R. W. Cloyd

CDR R. W. Beecher
LCDR S. Campbell
LCDR A. S. Morrow
CDR E. I. Wyatt
LT W. J. Olsson
LTJG H. C. Krass
LT H. E. Cochran
LTJG W. Sutherland
LCDR F. L. Bonham
LT L. E. Schrier
LCDR R. E. Costa

Some Statistics

The following figures were compiled from data submitted in the annual reports forwarded by Research Reserve companies for fiscal year 1957:

Companies	110
Panels	7
Members	2,391
Ready Reserves . . . percent	74
Standby Reserves . . . percent	26
Average attendance at drill meetings . . . percent	76
Earned a Satisfactory Federal Year	1,674
Selected for promotion	295
Promoted	223
Received Active Duty for Training	960
Captains	35
Commanders	234
Lieutenant Commanders	317
Lieutenants	258
Lieutenants (JG)	116
Completed correspondence courses	1,249

Into the Wild Blue Yonder

Of all those persons who have proposed the idea of rocketing themselves into space, the first man who seriously tried to do something about it was perhaps the bravest. The first, according to Chinese history, was a scholar and scientist named Wan Hu. He hit upon the idea of propelling himself with the crude rockets known to the Chinese at that time. So, after lashing several dozen of these "Jato" units to his sedan chair, he proceeded to have all the rockets fired simultaneously. We do not yet know just how successful Wan Hu was, for in the blast that followed he disappeared, and nothing has been heard from him since.

-- From "Guided Missiles in War and Peace," by Nels A. Parson, Jr.

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New Clearinghouse for Foreign Scientific Literature

Secretary of Commerce Sinclair Weeks announced late last month new measures to increase scientific knowledge through establishment of a Foreign Technical Information Center within the Department of Commerce.

To finance prompt action on the new project, the Department is requesting a special appropriation of $300,000 (contained in the supplemental request transmitted to the Congress by the President on January 22) to initiate the program. In addition, the President's budget for 1959 includes $1,250,000 for the Department's Foreign Technical Information program.

The new program will set up a central clearinghouse in the Commerce Department's Office of Technical Services, headed by John C. Green. The Center is to collect, evaluate and distribute valuable foreign scientific and technical literature for the use of American scientists and engineers.

Arrangements have been made to obtain from the National Science Foundation, Atomic Energy Commission, the armed services, the intelligence agencies, and other sources copies of abstracts and translations of foreign technical articles, monographs, and books. It is estimated that these will be supplied at an annual rate of 50,000 abstracts and 10,000 complete translations.

The items will be catalogued in the library of the Office of Technical Services. It is planned that the abstracts will be published and released to the technical press, and that copies of translations will be made available to the public.

A staff of engineer-translators will be added to review and analyze foreign publications and select those of greatest value. It is planned to appoint a scientific advisory committee to assist in the selection. Arrangements will be made for full translations of important articles and studies. Among the materials the engineer-translators will receive are copies of 200 important Russian scientific journals.

The new Center will operate a coordination service to eliminate duplication of translating among U. S. public and private agencies and by friendly foreign governments. In its own translation work, the Center will concentrate on technology.

The cooperation of industry, universities, libraries, and commercial translation firms will be sought in feeding information to the Center.

LAST MONTH WITH VANGUARD: It is the editorial policy of Research Reviews to report only that information regarding Project VANGUARD which has been officially released by the Department of Defense. There were no releases during the month prior to the deadline date of this issue.

In This Issue

COVER PHOTO: Photomicrograph of a section of rabbit muscle frozen at the slow rate of 0.6 millimeters per minute. The large white areas represent ice crystals that have formed between the fibers. For a discussion of basic studies of ice-crystal formation in frozen tissues, see article beginning on page 1.

RESEARCH REVIEWS reports highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. Research Reviews 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; $.15 per individual copy. Approved by the Bureau of the Budget, February 28, 1955.