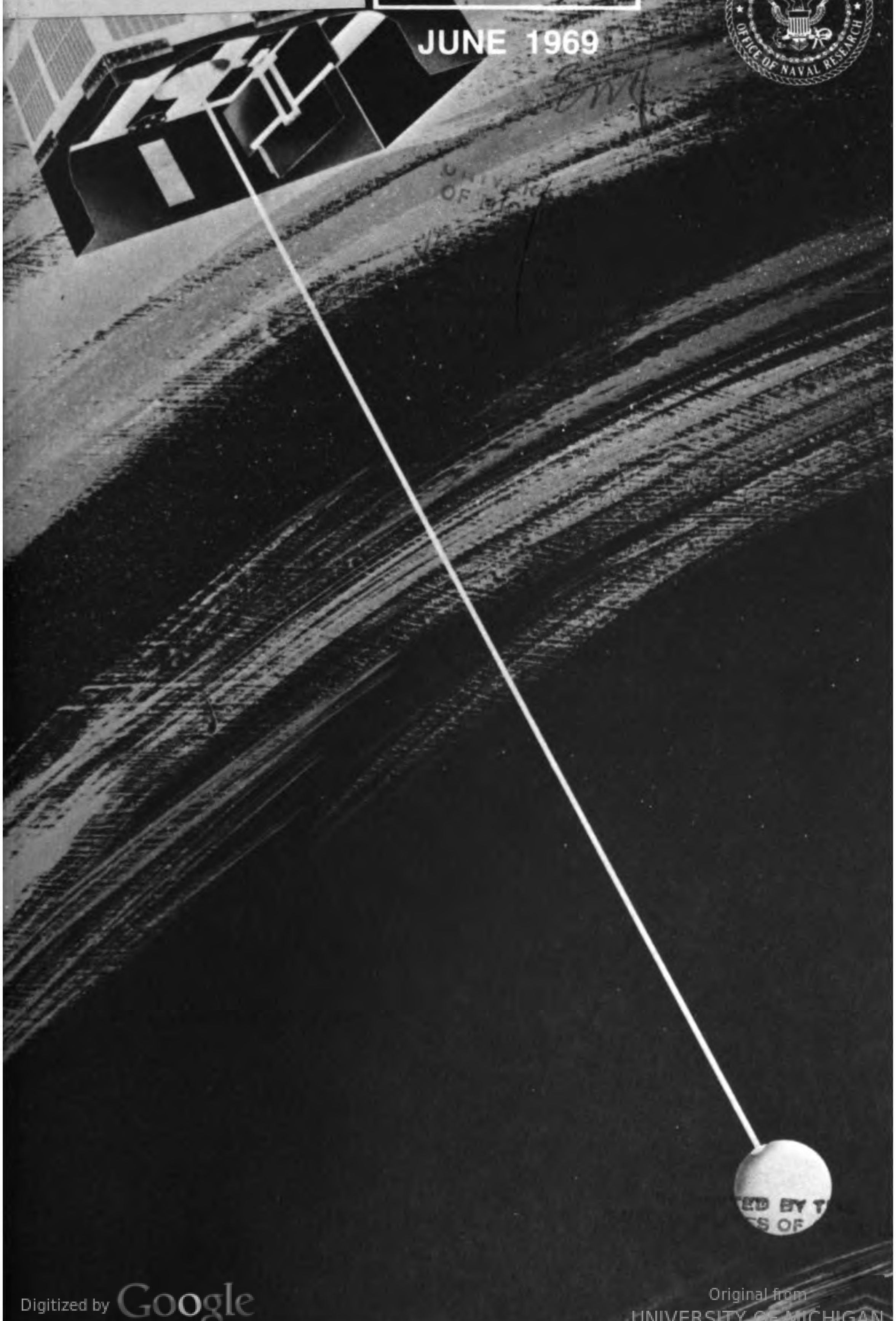
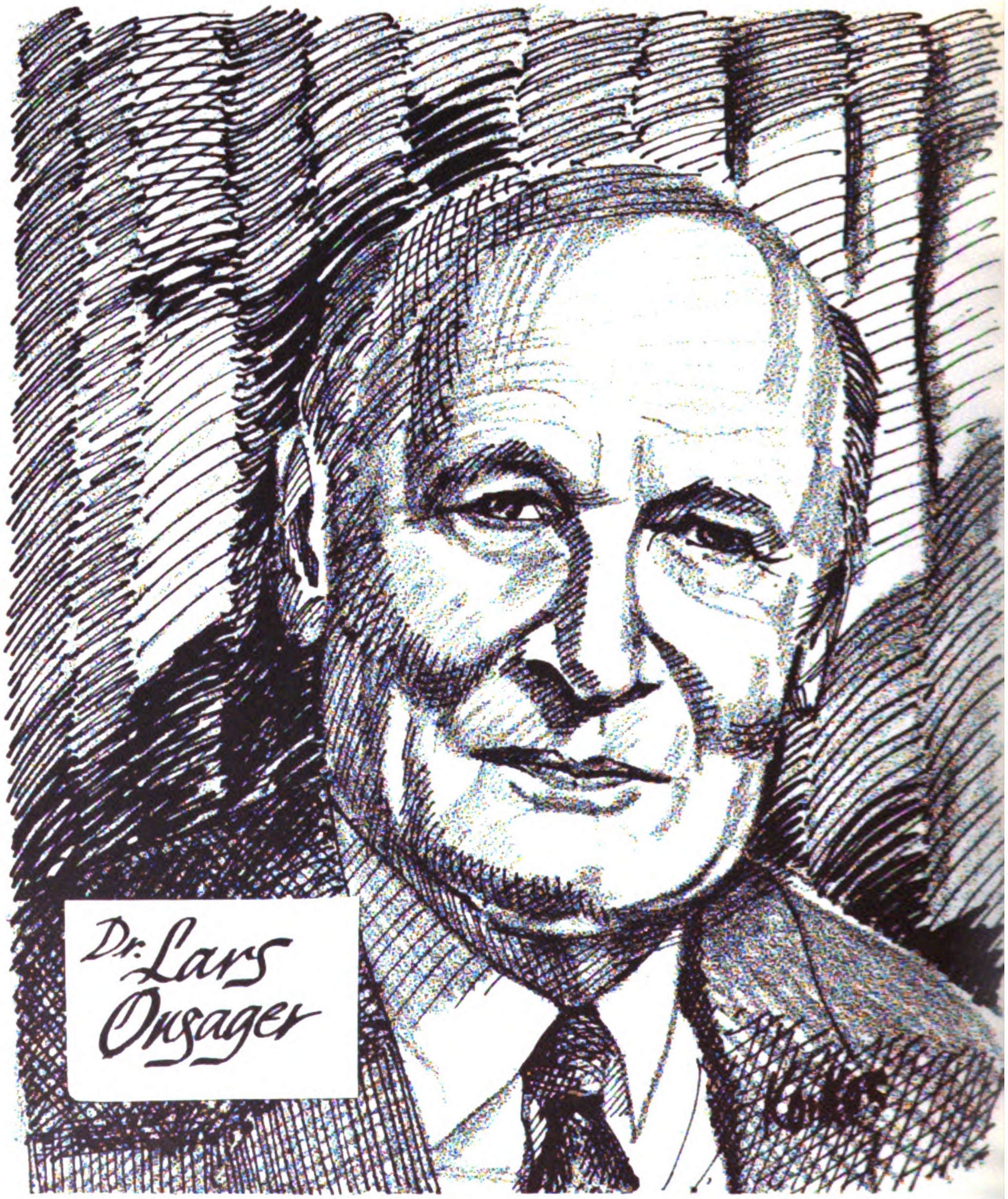
NAVAL RESEARCH REVIEWS

JUNE 1969





DR. ONSAGER IS MOST RENOWN FOR HIS WORK IN STATISTICAL MECHANICS. IN 1968 HE WAS AWARDED THE NOBEL PRIZE FOR THE DISCOVERY OF THE RECIPROCAL RELATIONS BEARING HIS NAME, WHICH ARE FUNDAMENTAL FOR THE THERMODYNAMICS OF IRREVERSIBLE PROCESSES. DR. ONSANGER HAS BEEN AT YALE SINCE 1934 AND HAS BEEN AN ONR CONTRACTOR.

THE NORWEGIAN-BORN ONSAGER'S CONTRIBUTIONS TO SCIENCE INCLUDE WORK ON THE TRANSPORT PROPERTIES OF ELECTROLYTES, THE THEORY OF DIFFUSION AND DIELECTRIC PROPERTIES OF LIQUIDS, AND DIELECTRIC PROPERTIES OF LIQUIDS TO THE THEORY OF STRUCTURE AND ELECTRICAL PROPERTIES OF ICE.

Semiautomatic Signaling in Tactical Voice Communications

CDR R. C. Handford
Office of Naval Research
Washington, D. C.

Today it is commonplace to think of automation of functions hitherto performed manually. In most walks of life the impact of automation has begun to be felt, and in some areas the development has been very rapid. One such area is communications. We have become used to direct dialing long distance phone calls, but we still remember the previous time-consuming procedures using a set of switchboard operators to place our call. Today the ships at sea effectively employ automation of many communications tasks, and this has led to significant improvements in speed, accuracy and reliability. What about the tactical voice communications between ships operating in the same force or vicinity? Is current technology adequate to provide improvements through automation of some of the functions of tactical voice circuits? Would a dial (or push button) telephone system without switchboards be practical in tactical radio communications? Many ideas for such systems have developed over the past several years. One such concept involves the use of a set of conventional narrow width channels wherever available in the radio frequency spectrum, just as in today's tactical circuits. Free (not busy) channels are selected from an assigned set of frequencies by an automatic signaling device and assigned to those who wish to transmit. The assignment lasts until the conversation is over. Then the channel is released and becomes available to other subscribers. The system accepts calls from any of its subscribers so long as any one of the assigned frequencies is free. Each transmission is directed to a specific receiver or group of receivers as desired, just as in a telephone system.

Theoretical investigation of this operational concept led to a current program to identify and evaluate technologies and signaling functions appropriate for a signaling device, as the initial step toward implementation of the concept. A subsequent step would address the problem of an automatic switching unit for selection of frequency assignments.

Signaling is defined herein as the portion of communication traffic which does not contain the actual information (or text) to be exchanged. It involves primarily the call establishment functions of ring up and ring back. Many are familiar with the currently used type of signaling exchange:

"Bull Durham, this is Red Rover, over."
"Red Rover, this is Bull Durham, over."

With a semiautomatic signaling device, such voice transmissions are replaced by coded signals.

Functions and Technology

The questions initially asked were:

What specific signaling functions are most appropriately automated? What specific technology is most appropriate to an evolutionary automation of tactical voice communications?

Specific signaling functions selected for theoretical and experimental evaluation in a signaler are as follows:

- The *channel status* function is a light which is on if the circuit is busy. It is required because the communications frequencies need no longer be monitored continuously.
- The *ring up* function initiates the call, activates audio and visual alarms at the addressee station, and displays the calling party identification for the addressee.
- The *ring back* function notifies the calling subscriber that his ring up signal has been received and that the called subscriber is ready to receive the message.
- The *subscriber busy* function notifies the calling subscriber that the called subscriber is busy on another circuit but will return the call when free.
- The *preempt* function is used to override an existing call and to permit a higher priority call to be placed. The existing call is not cut off the air. Rather, a preempt alarm is sounded at the beginning and end of a preselected waiting time (perhaps five to ten seconds, depending on the operational functions on the circuit). This provides the busy parties an opportunity, if appropriate, to speed up and finish their exchange while still establishing a maximum reasonable delay for the high priority traffic.
- The *hold call* function provides a busy subscriber with an indication that he is being called by another party. It permits the caller to return his work knowing that the called party will return his call when free.
- An audible *tone keying* button is also available for use in poor communicating conditions when coded tones may prove more reliable than voice traffic. Morse code or other signals may be used as desired.

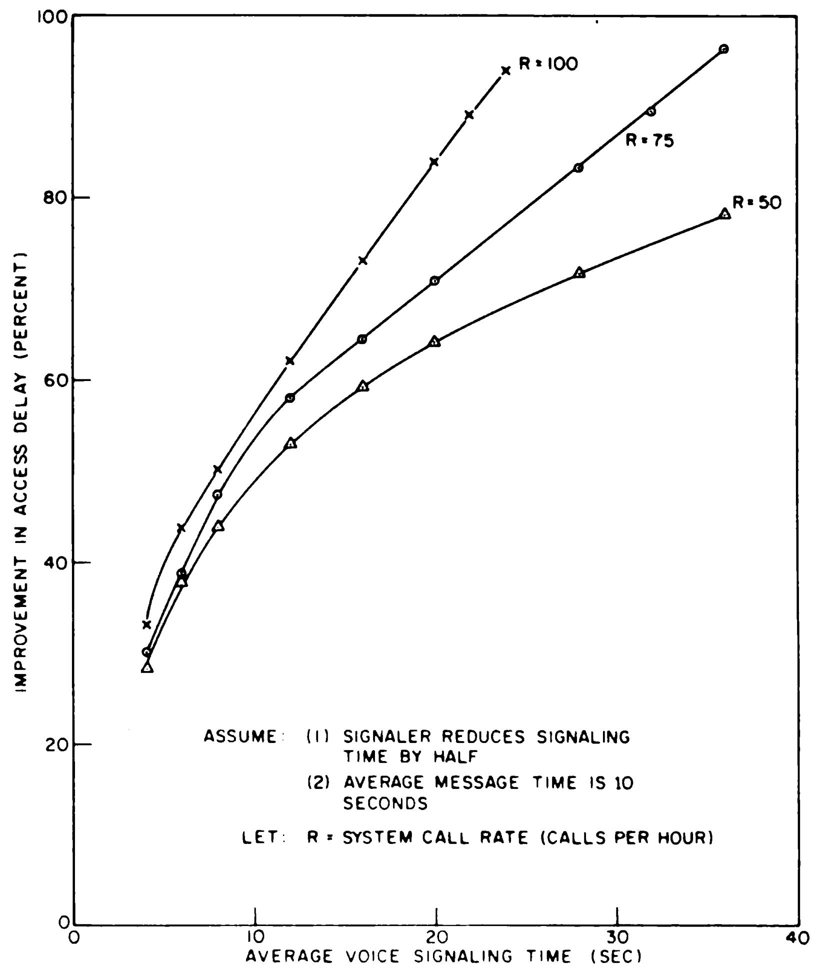
The technological investigation has resulted in concepts for design of a digital signaler to be injected into the communication system between the telephone handset of the speaker (or subscriber) and the currently used Remote Phone Unit (RPU) or radio transmitter. Thus, the signaler does not replace and is compatible with existing equipment. Communications with unequipped users are possible because the subscriber with the signaler can bypass the system at any time and revert to current manual procedures. A signaling function, like ring up, is manually activated using a push button. Resulting voltage forms are converted into binary coded words. Supporting symbols and redundancy are added to enhance signal reliability. Transmission rates for the binary coded signals are such that the transmission time for any given signal is less than one second. The signal modulation is performed by tone shift keying in the regular voice frequency band assigned. Receipt of the signal at the addressee station is performed both by a visual light and an audio alarm. Additionally, the identification of the calling party is visually displayed to facilitate positive call establishment. Pictured is one of the first experimental signaler models under evaluation by Destroyer Development Group II.

Experimental digital signaler under evaluation by Destroyer Development Group II

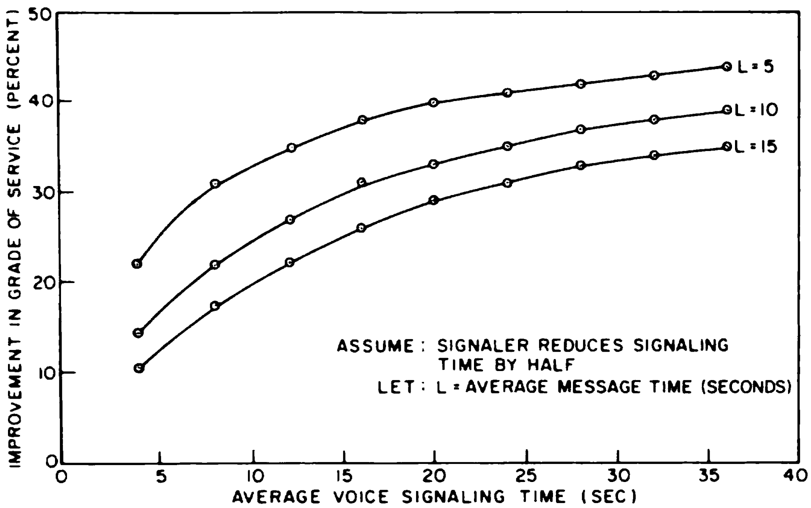
Analysis

What is the nature and degree of improvements to be expected from ise of semiautomatic signaling? One of the most obvious improvements s a reduction of signaling time on the circuit. Signaling time is defined is the circuit time used in the performance of the signaling functions. Iessage time is defined as the circuit time used in the exchange of nformation (or text). The sum of signaling and message times is the iolding time (or circuit busy time). The impact of reduced signaling ime on the effectiveness of tactical voice communications can be xpressed in terms of Grade of Service and Mean Access Delay. The Grade of Service is the probability that a calling party will encounter a lelay when wanting to place a call (or simply the probability that a circuit is busy). The Mean Access Delay is the average time a calling party must wait to place a call provided that a delay is encountered. Any reduction of signaling time will produce corresponding improvements in both of these effectiveness parameters.

Some idea of the degree of potential improvements may be obtained from a theoretical analysis of queueing theory models relevant to a telephone situation. The two graphs presented are measures of the percent improvement in Grade of Service and Mean Access Delay if use of a digital signaler is assumed to reduce average signaling time by fifty percent. The model used to construct the graphs in Erlang's Model for a single channel queue. In the graph for Grade of Service, the improvement is a function of average signaling time and average message time. In the graph for Mean Access Delay, an additional parameter is introduced to measure the improvement. It is the system call rate, or the total number of calls established in some unit of time. As an indication of the average voice signaling times which might be expected, recent measurements by Destroyer Development Group II on board the USS Courtney (DE 1021) resulted in average call up and answer



Mean access delay improvement through use of digital signalers



Grade of service improvement through use of digital signalers

times of 6 seconds for discrete (one addressee) calls and 25 seconds for five station net calls.

It appeared from the beginning that a simple queueing theory analysis would be inadequate for thorough treatment of this problem. One important consideration was the desire to model a situation in which the calling party did not stand by the radio waiting for a free circuit (as assumed in the Erlang model), but rather returned to his work in hopes of not encountering a busy circuit on trying again after a brief interval. A second consideration was the problem of simulating a situation in which a channel was available but the addressee was busy on another circuit, a possibility when using a signaler with a multiple channel capability. The modeling of a preempt situation was another difficulty. Therefore, an event step Monte Carlo computer simulation was designed. In the simulation of a communications network which is considered representative of the busy hour of an amphibious assault landing, improvements of 28 percent in grade of service and 51 percent in access delay were obtained. Simulations using a signaler with a two-channel capability and using the same amount of traffic per channel, resulted in improvements of 64 percent in grade of service and 38 percent in access delay.

Experimental Program

One of the very important contributions of the Office of Naval Research involves the interface between research and development. Emerging scientific and technological opportunities are monitored continuously in order that relevant applications to advanced weapons systems may be identified and evaluated. Efforts are closely coordinated with various offices of the Chief of Naval Operations and the Chief of Naval Material. In this communications improvement program, the conceptual analysis and theoretical simulation has been performed by the Office of Naval Research, and coordinated with the staff of the Assistant Chief of Naval Operations (Communications). When the concepts were defined and theoretically analyzed to warrant an experimental development program, the Naval Ships Systems Command initiated sponsorship of fabrication of experimental signalers for experimentation within the research program. This has facilitated a smooth and timely transition from research analysis of concepts to development of effective equipment. Experimental signaler models have been fabricated for use both in laboratory and shipboard tests. Emphasis in these tests to date has been placed on measurement of various elements of signaling time and on human factors engineering of a variety of design concept alternatives. Completed measurements both in the laboratory and on board the USS Courtney (DE 1021) indicate that signaling time reductions on the order of 50 percent may be anticipated. Tests at sea in an operational environment are now planned to investigate the impact of that environment on the signaler concepts and theoretical analyses performed.

Implementation

The introduction of new systems into the fleet can be a costly and somewhat disruptive process. This is especially true if replacement of equipment and interaction of equipments between ships are involved. Before a decision to replace existing equipment can be made, there must be assurance that the increased effectiveness to be realized must be sufficient to justify the cost of both the equipment replaced and that procured. In the case of equipments involving ship interaction, either the new equipment must be operationally compatible with that replaced or groups of ships which operate together must be modified simultaneously. The program concept described here is evolutionary in nature and is composed of a series of steps to minimize cost and disruption during implementation. Also, each succeeding step is subjected to analysis to facilitate modifications during development and implementation so that the final product will result in a maximum improvement in voice tactical communications.

Concepts of communications technology have been evaluated to derive practical applications for introduction of automation into the signaling elements of tactical voice communications in a shipboard environment. Results of this effort to date indicate that use of semiautomatic digital signalers will significantly improve tactical voice communications through more efficient utilization of existing equipment. This will be accomplished primarily by reducing the time needed for signaling traffic and by using faster and more positive call establishment.

Critical Properties

Robert G. Morris
Office of Naval Research
Washington, D.C.

The Office of Naval Research is supporting work in the field of critical properties or phenomena, which is a new field of research for ONR. A common example of a critical phenomenon is magnetism, which is called critical because certain conditions, the most important of which is temperature, are critical to its existence. Below 1043°K iron is magnetic; it is called ferromagnetic and its electron magnetic moments line up to give a strong magnetization in one direction (Figure 1a). Above 1043°K iron is not magnetic in the sense that one can make a permanent magnet out of it, and it is called paramagnetic. Thus 1043°K is the critical temperature for the ferromagnetic-paramagnetic transition in iron. The magnetization of iron as a function of temperature is shown in Figure 1a. Because Pierre Curie was the first to realize this phenomenon, this critical temperature is frequently called the Curie point or Curie temperature. For nickel the Curie point is lower, 633°K; and in an exotic material such as europium sulfide (EuS) it is only 16°K nearly as cold as liquid helium.

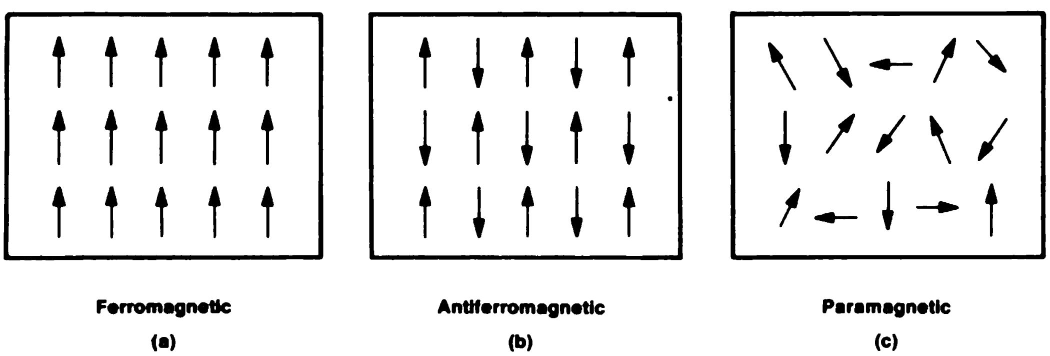


Figure 1 – Arrangements of electron magnetic moments in solids. Ferromagnetic order is typified by a net moment, or a non-zero resultant of all the individual ordered moments. Antiferromagnetic order is typified by a zero resultant of the individual ordered moments. The paramagnetic state is disordered, with no net moment. The diagrams represent simple examples. In many cases the arrangements are more complicated. But the basic distinctions of a net moment for ferromagnetic and a zero moment for antiferromagnetic ordering remain.

Ferromagnetism is not the only kind of magnetism. Electron magnetic moments or spins may align below a critical temperature so that they tend to be antiparallel and usually produce zero net magnetization (Figure 1b). This critical temperature is referred to as the Neel point, named after the contemporary French physicist who studied antiferromagnetism. Many of the rare earth elements exhibit antiferromagnetic behavior such as chromium, manganese and unlikely compounds like FeTe and CoF_2.

Other Critical Properties

Magnetism is not the only example of a critical phenomenon. The transition which normal metals make to become superconductors is another. In this case the electrical resistance to a direct current drops precipitously to exactly zero (Figure 3a). Up to now the highest critical temperature for the superconducting transition is 21°K, somewhat limiting their application. In addition, transitions from a disordered to an ordered alloy (from an irregular arrangement of metal atoms like ABBABAAAB.... to a perfectly regular arrangement like ABABABAB...), and from normal to superfluid liquid helium are also examples of transitions which occur under the right critical conditions.

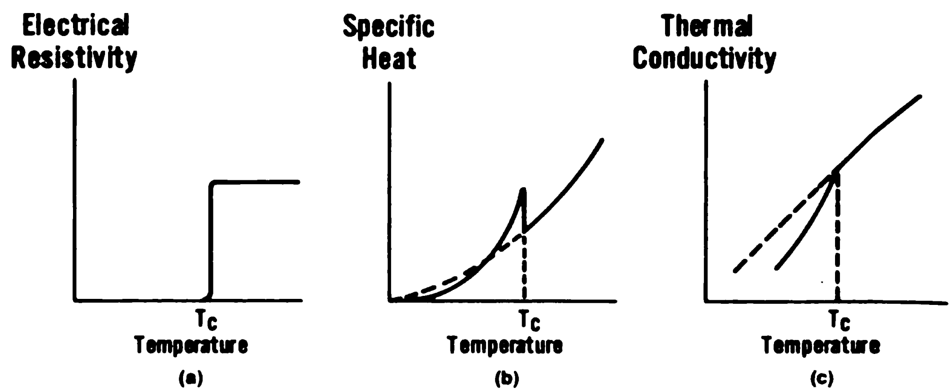


Figure 3 — Behavior of electrical resistivity, specific heat and thermal conductivity at the superconducting transition. Schematic drawings show typical behavior, but not necessarily the behavior of all superconductors. The transition gets its name of course from the zero resistance below the critical temperature T_c.

Physical states of matter such as ferromagnetic and paramagnetic, or superconducting and normal are referred to as phases, a generalization of the old solid-liquid-gas idea. The change from one phase to another is a phase transition.

Phase transitions are termed first-order or second-order depending on whether heat is absorbed or given off during the change. Thus when ice at zero degrees C absorbs heat to become water at zero degrees C, we say it is a first-order phase transition. Boiling and sublimation are also first-order transitions. Because the change from the ferromagnetic to the paramagnetic phase involves no heat, it is termed second-order. The other examples mentioned earlier are all second-order phase transitions, which are certainly the most interesting.

Thermodynamic Critical Point

A well-known example of criticality is the critical point of the pressure-temperature diagram for a gas (Figure 4). Generations of physics students have learned that the distinction between liquid and vapor can no longer be made after the pressure and the temperature have exceeded a certain pair of values. For water the critical point occurs at 647°K and a pressure of 218 atmospheres. For pressures and temperatures above these values, the liquid-vapor (boiling) transition no longer occurs. The reason is simply that the liquid density equals the vapor density at the critical point so that the states or phases become indistinguishable.

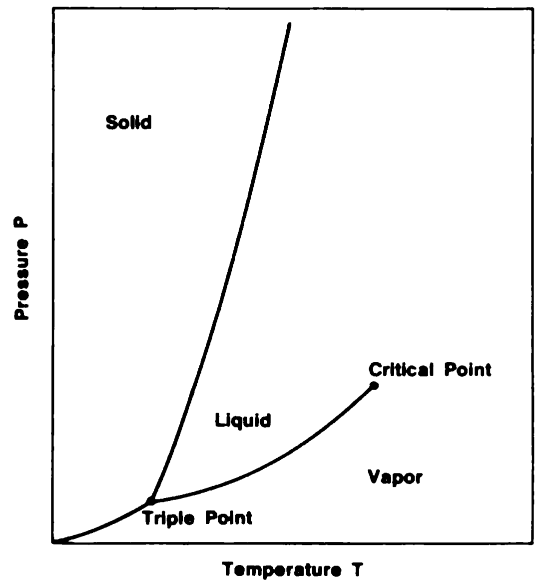


Figure 4 – The classical thermodynamic critical point. At this point the liquid density equals the vapor density. For pressure-temperature values in excess of those at this point there is no liquid-vapor transition.

Critical Opalescence

In addition to the physical interest associated with the density equalities at the critical point, it was noted that the appearance of the vapor was startling as the critical point was approached. The cause was large scattering or reflection of light by the substance, so that its normal transparency was replaced by a milky glow or opalescence. Once the critical point was passed, the substance reverted to its clear transparent form. This critical opalescence is caused by time fluctuations of the density over regions of large length (with respect to the wavelength of the light). The density of the substance may be thought of as fluctuating between the value for the liquid and the value for the vapor. As the critical point is approached, these fluctuations grow in size and oscillate more slowly. Since light reflection is affected by the relative density as well as the size of the scattering "particle" it is not surprising that this drastic change in the density distribution at the critical point has a pronounced effect on the light. Light scattering at the gas critical point is an example of a property associated with a criticality – in this case the density change—which is quite different from the physical property actually undergoing change.

It is perhaps worth mentioning that although the liquid-vapor transition is a 'simple' first-order transition, the behavior of the density *at the critical point* is typical of a second-order transition. We are not cheating in our definition, since if the liquid and vapor are indistinguishable at the critical point, then indeed no heat is required for the transition. The behavior at the critical point is, of course, a limiting case of the behavior at other temperatures and pressures.

Professor C. O. Alley and his group at the University of Maryland have begun work under an ONR contract to study critical opalescence at the critical point of 3-methylpentane-nitroethane with laser light. This bright, coherent light source will allow them to study the changes in frequency of the scattered light and the coherent (in-phase) scattering from the density fluctuations.

Thus while light scattering is a sidelight of the critical density behavior in a gas, other critical behavior is found to occur in related physical properties at magnetic transitions, the superconducting transition, order-disorder transitions in alloys and the transitions between normal and superfluid helium. It is less well known, for example, that specific heat, thermal conductivity and electrical resistivity exhibit anomalies in many materials at the magnetic transition—in addition to the change in magnetic state. This is shown schematically in Figure 2. Similarly,

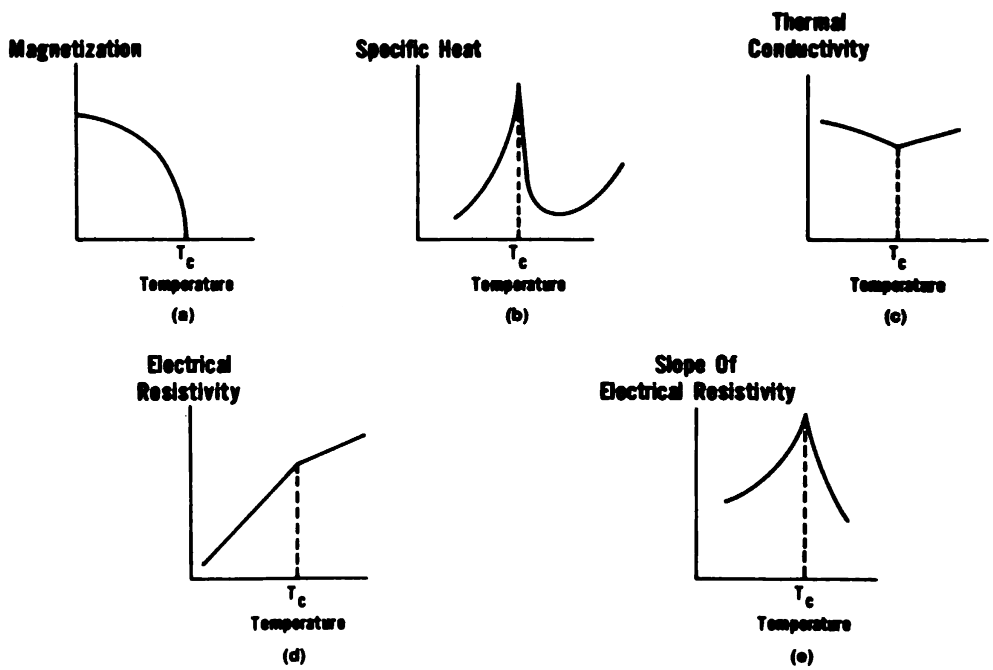


Figure 2 — Physical properties at the ferromagnetic-paramagnetic transition. In these schematic drawings the material is ferromagnetic for temperatures below T_c, the critical temperature, and paramagnetic above. The behaviors shown are typical of many ferromagnetic materials so far studied, but not all such materials behave in the ways shown.

the startling disappearance of all electrical resistance at the superconducting transition has somewhat eclipsed anomalous behavior of the specific heat and the thermal conductivity in these materials at the same transition (Figure 3). The specific heat of liquid helium at the superfluid transition exhibits the lambda-shaped peak which has actually given its name to the transition, the lambda point (Figure 5).

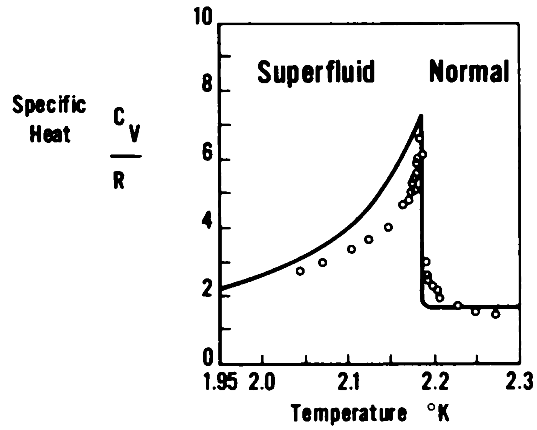


Figure 5 — The temperature of the transition between superfluid and normal liquid helium takes its name from the shape of the specific heat of the helium across the transition, lambda point.

Another ONR group at Fordham University under Professor Joseph I. Budnick will study electrical resistivity, thermoelectric power and magnetization in magnetic materials near the transition temperature. It was Budnick, together with Craig, Goldburg and Kitchens, who discovered the behavior of the temperature derivative (or slope) of the electrical resistivity shown in Figure 2e.

Theoretical work on the same type of problems is being sponsored by ONR at the University of Rochester under Professor Karl H. Bennemann. His efforts are concentrated on an understanding of the electrical and thermal conductivities of magnetic materials near the critical points.

Where this work with critical properties will lead is not known, but applications of similar ideas are already being developed. An example is critical point writing, under study by IBM at San Jose, California. A laser beam focused on a thin magnetic film, magnetized and held near its critical point, raises the temperature of the focus spot and lowers the magnetization by a large amount (Figure 2a). A small externally applied magnetic field is then able to reverse the magnetization in the film at this spot, although it is not powerful enough to affect any other unilluminated portion. Later, the magnetic state of this spot can be sensed either optically, by Faraday rotation, or magnetically, and the stored information recovered. High density of storage and extremely fast writing and readout times make this particular critical property magnetization itself a possible technological application of importance in the near future. Whatever is found out about any one critical property will be of great interest in understanding all of them.

Gamma Radiation Kills Snails, Carriers of Schistosomiasis

Northwestern University environmental engineers have found a new way to kill snails—bombard them with massive doses of gamma radiation from cobalt 60, a radioactive metal.

If a practical means of irradiating snails in moving irrigation water can be found, the research findings of Northwestern's Mirza Farvar and Herman Cember may point the way to control of schistosomiasis (snail fever), one of the world's worst unconquered parasitic diseases. The snail-borne disease afflicts some 125 million persons.

Farvar and Cember, visiting assistant professor and professor of civil engineering at Northwestern's Technological Institute, described their snail-killing experiment at the November meeting of the American Public Health Association in Detroit.

Cember believes it may be practical to kill snails by passing irrigation water through shielded pipes containing encapsulated cobalt 60. Gamma rays from the cobalt 60 would not harm humans or the water, he says—but the lethal radiation would kill all the snails.

Since the world's proliferating snail population in areas of schistosomiasi infestation is largely supported by irrigation water, gamma ray irradiation would eliminate one cause for the disease's spread.

Ironically, efforts to increase world food production through irrigation have been the principal means by which schistosomiasis has been spread in recent years. One consequence of Egypt's construction of the Aswan High Dam, for instance, may be an increase of schistosomiasis in Egypt.

Some facts about schistosomiasis:

- Over 125 million people in the Far East, Middle East, Africa, eastern South America, and the Caribbean suffer from schistosomiasis. About 10 percent of these suffer irreversible pathological changes such as cirrhosis of the liver. About two percent are totally disabled. About one percent die from the disease.
- Most cases of schistosomiasis are found in Africa, especially Egypt, but some six million cases exist in Latin America, including Puerto Rico. Puerto Rican migrants to mainland U.S. have sometimes been schistosomiasis carriers.
- Two species of U.S. snails are potential schistosomiasis carriers. However, the urban character of the U.S. plus the high state of U.S. sanitary facilities makes its spread to the U.S. unlikely.

Puerto Rican snails (*Australorbis glabratus*) ranging in age from about three to five months were used by Farvar and Cember. Earlier experiments by the Northwestern engineers indicated that relatively heavy doses of radiation would be needed, as did an experiment by

A. P. Szumlewicz of the National Institutes of Health in which Szumlewicz used x-rays. Szumlewicz used x-rays totaling three to 30 Kilorads produced by a Van de Graaff generator operating at two Mev, in doses delivered at a rate of one to 1.5 Kilorads/minute (*Science*, April 17, 1964, p. 302-303).

The snails, immersed in water in five groups of 20 snails each, were irradiated at rates of from 75 to 250 Kilorads per hour. Within half an hour, all the snails showed marked radiation injury. Observed microscopically, they appeared shrunken within their shells, and failed to respond to touching. Snails exposed for one hour to 150 to 250 Kilorads all died within one-half hour to 11 days after exposure.

Schistosomiasis is caused by several species of small blood flukes or flatworms known as schistosomes. The worms pass through several stages that require snails and human beings as hosts. The schistosomes leave the snail host in the form of small parasites called cercariae. The cercariae swim in the water seeking a human host, without which they will die in 24 to 36 hours.

Encountering a human, they burrow into his flesh, causing a painful sting. Via blood vessels they make their way to the liver, where they grow into adult male and female worms. The worms migrate through the blood stream to the veins of the bladder or intestines, where the females lay eggs. The adult female is about 12 mm (1/2 in.) long and lays chains of eggs about 0.15 mm (0.006 in.) in size. A single worm can deposit eggs for five to 20 years at from 300 to 3000 eggs per day.

Some of the eggs are excreted in urine or feces. Under unsanitary conditions, they may get into the local water supply. In warm water, they hatch into larvae which seek one or another particular species of snail as host. They migrate through the soft tissue of the snail and go through several stages before producing cercariae. The cercariae are now ready to seek a human host, and the schistosomes's life cycle is complete.

Some of the eggs must be excreted to complete the schistosome's life cycle, but other eggs accumulate in the human body, traveling through the bloodstream to the lungs, liver, kidneys, heart, brain, or central nervous system. The eggs pile up and may block the normal flow of body fluids in these organs.

After about a month, the schistosomiasis victim suffers from a high fever, general aches and pain, diarrhea, and extreme weakness. This stage lasts about 10 weeks. In the second, chronic stage of the disease, the tiny eggs usually go on piling up in the liver, and severe cirrhosis may occur. The spleen may swell up to gigantic size. Eggs lodged in the lungs may cause a condition resembling tuberculosis.

Mention of schistosomiasis has been found in ancient Egyptian documents dating from about 4000 B.C., and schistosome eggs have been found in mummies dating from 1000 B.C. So far, the schistosomes have won their war on snails and humans. The blood flukes that cause the disease were identified in 1851 by Theodor Bilharz, a German parasitologist. Schistosomiasis is sometimes called bilharziasis, after Bilharz.

According to Cember, existing means of controlling snails are:

- Chemical pesticides such as sodium pentachlorophenate, which kill snails and eggs, but do not work in running water. Pesticides also may kill fish and other life.
- Paving irrigation canals. Snails require moist areas with vegetation to live. The paving eliminates the vegetation that clogs unpaved irrigation canals. Most irrigation canals in underdeveloped areas are unpaved.

Schistosomiasis might also be prevented by better sanitation. This would require a massive public health program, including an educational program that would change the habits of hundreds of millions of people who use streams, ponds, and ditches as drinking fountains, bathtubs, laundries, and latrines.

Laboratory for Atmospheric Probing

A Laboratory for Atmospheric Probing to study phenomena ranging from the dynamics of severe storms to the mechanisms of clear air turbulence has been established by the University of Chicago and Illinois Institute of Technology (IIT).

The jointly-operated laboratory will be administered by the University, according to David Atlas, Professor of Meteorology in the Department of Geophysical Sciences at the University of Chicago. Atlas will serve as Director for the Laboratory for Atmospheric Probing (LAP).

Using the latest electronic equipment, LAP will investigate techniques of observing and measuring the atmosphere from a distance and seek to improve man's understanding of the mechanisms of the atmosphere.

LAP will study the processes of clouds and precipitation and ways to artificially modify them, the growth of hail, dynamics of severe storms including tornadoes, methods of detecting tornadoes, origin of clear air turbulence, and techniques for detecting such turbulence.

To accomplish this, LAP will use ultrasensitive radar, radio scatter systems which bounce electromagnetic waves off atmospheric turbulence, laser radar, and radiometric devices which detect microwave and infrared waves emitted by the atmosphere.

The initial program, however, according to Atlas, will be based largely upon powerful radar units such as two now available.

Lester C. Peach, Professor and Chairman of Electrical Engineering at IIT, will serve as Associate Director of LAP.

The joint laboratory, according to Atlas and Peach, will exploit the strengths of the University of Chicago in atmospheric sciences and those of IIT in engineering, instrumentation, and signal theory. The combination, they believe, should make LAP one of the most powerful research groups of its kind in the world.

Rarefied Gas Dynamics

L. Talbot, F. S. Sherman and F. C. Hurlbut
University of California, Berkeley

When upper-atmosphere exploration by research rockets began immediately after World War II, the Office of Naval Research was quickly involved, directly through the activities of the Naval Research Laboratory and indirectly through the sponsorship of University research directed toward a better understanding of the behavior of rarefied gases. Early work was directed to the development of wind tunnels or alternative devices for laboratory simulation of gas-dynamic phenomena encountered in high altitude flight, and to the search for useful theoretical approaches. The new field was attractive scientifically because it involved the reconciliation of two distinctive concepts of a gas; that of a continuous medium—which had sufficed for aerodynamic theory at "ordinary" altitudes, and that of an assemblage of discrete molecules, embodied in the kinetic theory of gases, and of proven usefulness in the design of high vacuum systems, molecular beams, etc. It was clear from the beginning that research rockets, re-entry vehicles, and satellites in low orbits would pass through flight regimes in which one concept or the other would prove more powerful and the question was: under what conditions does the transition from "continuum flow" to "free molecule flow" take place, and how are the characteristic phenomena of one regime transformed into those of the other?

ONR-sponsored work was particularly significant in the pioneering days of the field. The low-density wind tunnel and associated instrumentation developed at the University of California, Berkeley became a model from which similar tunnels have been developed all over the world. Cryogenic pumping of wind tunnels and space-simulation chambers was given a great boost by the ONR-OSR sponsored work of Dr. Chuan at the University of Southern California. Laboratory studies of the interaction of molecular beams with solid surfaces, essential to the prediction of aerodynamic behavior in the free-molecule regime, were pioneered at Berkeley and at the University of Virginia. Much of the early influential theoretical work has also ONR-sponsored.

The twenty-two years since first operation of low density wind tunnels at Berkeley and at the NACA Ames laboratory have seen a remarkable development and proliferation of such tunnels. For the most part, they have been used for the elucidation of basic flow phenomena rather than for model testing of actual flight vehicles, although models of components or of the entire vehicle have been tested in connection with the Aerobee research rockets, the X-15 rocket plane, various missiles, and the Apollo command module.

The "continuum" and "free-molecule" flow regimes mentioned above are two limiting cases of a spectrum of flow regimes which are characterized by different values of a parameter called the Knudsen number $Kn = \lambda/D$, which is the ratio of an appropriate mean free path λ in the gas to a representative length D which might, for example, be the diameter of a body immersed in the flow. The mean free path is inversely proportional to the gas density, and thus the Knudsen number of, say, a 1-foot diameter sphere moving through the atmosphere varies tremendously with altitude. At sea level its Knudsen number would be about 2×10^{-7}, whereas at an altitude 500,000 feet it would be about 160. Values of Kn much less than unity, such as the sea level one, characterize the "continuum flow" regime, where for the purposes of aerodynamics the molecule nature of air need not be considered except insofar as it determines such properties as viscosity and thermal conductivity. The opposite extreme, characterized by Knudsen number much larger than unity, is called the "free-molecule" regime. Here molecular nature of the gas is all-important. In the case of the sphere at 500,000-foot altitude, the mean free path is so much greater than the sphere diameter that gas molecules strike the sphere in a manner completely uninfluenced by the molecules rebounding from the sphere. The aerodynamic characteristics of a body, such as its lift, drag, and surface temperature, are calculated essentially by summing the momentum and energy transfers of all the individual molecular encounters with the body surface. Obviously, the nature of the molecule-surface interaction, that is, how much energy and momentum is transferred to the surface in an encounter, must be known in order to evaluate aerodynamic characteristics in the free-molecule flow regime.

A flow which is neither continuum or free-molecule is usually termed a transition flow; the terms "slip-flow" and "near-free-molecule flow" are commonly employed to signify flow regimes in which, respectively, the first departures from continuum and free-molecule behavior are observed.

The properties of the various flow regimes are very well exhibited in the series of photographs of Figures 1 and 2, taken from the film "Rarefied Gas Dynamics" by F. C. Hurlbut and F. S. Sherman, made under the auspices of the National Committee for Fluid Mechanics Films. In Figure 1 we see a model, in the form of a circular disc with a central hole, placed normal to a jet flow of argon, bearing a trace of sodium vapor, issuing from a sonic orifice. The flow is made luminous through the scattering of a thin sheet of light from a sodium vapor lamp, projected from above across the flow.

The first picture of the sequence for which the model Knudsen number is 68, shows some of the characteristics of a free-molecule flow. Because

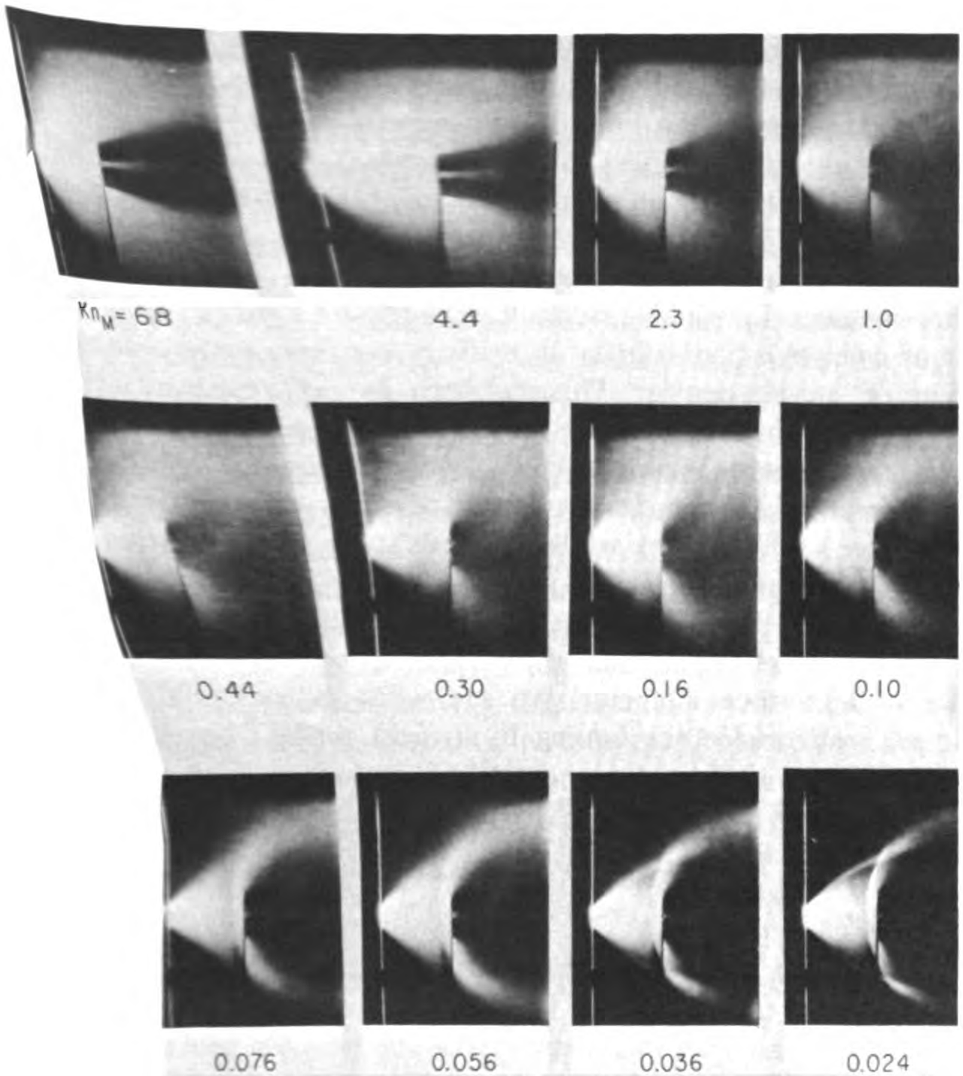


Figure 1 — Flow over a blunt model at a Mach number of 7. The Knudsen number $Kn_M = \lambda_M/D_M$ is the ratio of the mean free path ahead of the model to the model diameter.

their mean free paths are large, the molecules issuing from the ori travel in straight lines, without undergoing collisions with other m cules. Those that miss the disc continue in a straight line, which accou for the sharpness of the wake boundaries. Those that issue along the proceed without collisions through the hole, forming a well-collima molecular beam. (The dark line beneath the model is its optical shad produced because the illumination is from above.)

The remaining frames of Figure 1 show the changes in the flow as the Knudsen number is decreased and intermolecular collisi become important in the transition flow regime. One can see the w roaden and its edges become fuzzy while the molecular beam attenua A bow shock wave commences to become visible, and as the Knud umber approaches the continuum limit this shock wave beco progressively thinner, until finally at the lowest Knudsen number de tails of a familiar continuum hypersonic blunt body flow emerge.

This sequence depicts the kind of changes which occur in the flov field about a body as it re-enters the atmosphere. Much effort has bee expended in understanding in detail the nature of these changes, i order to be able to predict the aerodynamic characteristics of vehicle throughout their re-entry trajectories.

Another instance in which rarefraction effects are important is th behavior of a jet exhausting from an orifice or nozzle into an ambien atmosphere of varying density. This problem is of technical importanc in application to exhaust plumes of launch vehicles during their ascen through the atmosphere. Figure 2 shows a sequence of the flow pattern produced in such a situation. In this sequence, the pressure ratio acros the orifice was held constant while the pressure was varied betwee minimum and maximum limits.

In the first frame of the sequence, corresponding to the highest Knud sen number (here defined as the ratio of the stagnation chamber mea free path to the orifice diameter) we see what is essentially a free molecule jet, with molecules issuing in straight paths from the orific

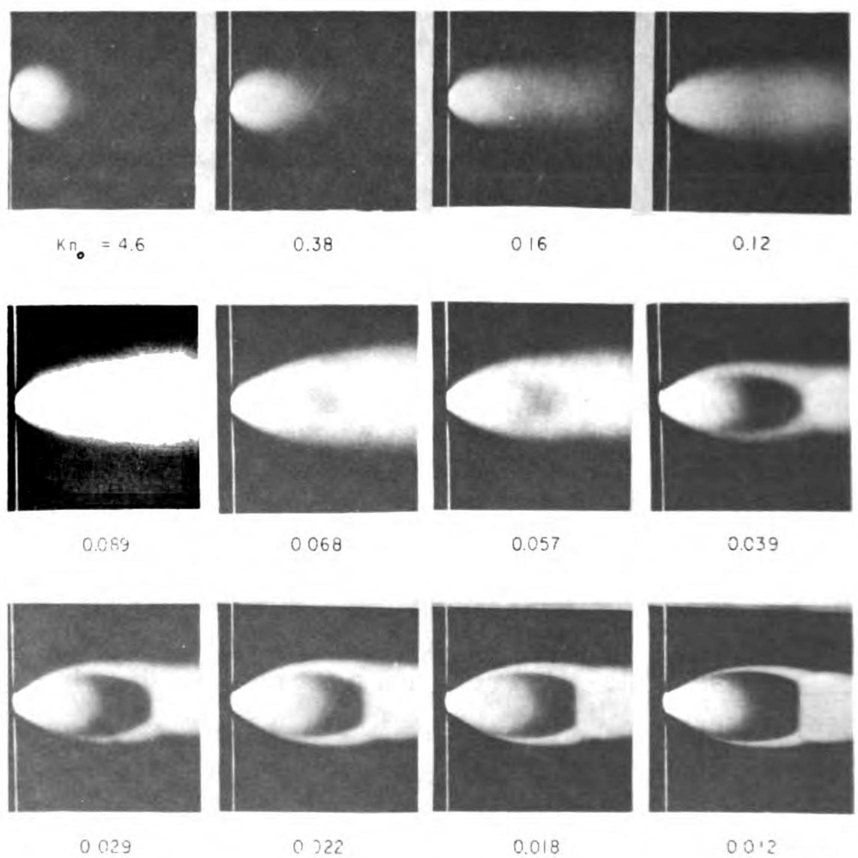


Figure 2 — Free jet flow from a sonic orifice. The Knudsen number $Kn = \lambda_0/D_0$ is the ratio of the mean free path in the source region to the diameter of the orifice.

in such a way that the number flux varies as the cosine of the angle from the flow axis. For such a distribution, the surface of constant density (and hence luminosity) are spheres tangent to the orifice plane, and this explains the spherical shape of the jet. As the Knudsen number is reduced one sees the gradual focusing of the jet due to collisions between the jet molecules, and the gradual buildup of the shock wave system, which starts as a result of collisions between the jet molecules and the background gas in the chamber. With decreasing Knudsen number the shock wave becomes progressively thinner and more sharply defined, until finally in the last frame one sees the continuum flow pattern, a flow which is familiar to anyone who has observed an Apollo launch.

The kinds of rarefied gas dynamics phenomena illustrated in Figures 1 and 2, as well as many others, have been the subject of intensive theoretical and experimental investigation over the last two decades. The theoretical work has involved many sophisticated analyses of the Boltzmann equation, which is the fundamental equation of the Kinetic Theory of Gases, and many extensive computations using different numerical schemes for solving this equation or for directly simulating the trajectories and collisions of molecules. These studies are beginning to bear fruit, and it is now possible to compute with reasonable accuracy such things as the drag coefficient of a simple body throughout the transition flow regime, the details of the structure of a shock wave, the rarefaction along the centerline of an expanding jet, and many other fundamental flows. These theoretical developments have, of course, been aided immeasurably by the availability of high speed computers. However, complicated as these analyses and numerical computations are, they are still in the main rather simplified and idealized versions of the technical problems of current application. Thus, a continuing program experimentation in this area is of prime importance.

EXPERIMENTAL METHODS

The flows depicted in Figures 1 and 2 were produced in a low-density wind tunnel. Although shock tubes and hot-shot wind tunnels have been used successfully for the study of rarefied flow phenomena, the low-density wind tunnel in the form developed by the early ONR-supported research has remained the most productive tool for laboratory studies of rarefied flows. In conception the low-density wind tunnel is not radically different from the conventional wind tunnel, except that the source pressure from which the test gas is expanded may be less than 1/1000 of atmospheric pressure. Conventional convergent-divergent supersonic nozzles or free jets are used to produce the required flow fields. However, instead of the fans and compressors used in normal-density wind tunnels, large vacuum pumps are employed to drive the flow, usually in a non-return circuit which exhausts to the atmosphere.

These vacuum pumps may be steam ejectors, oil diffusion pumps, or, for very low pressure, cryogenic pumps in which the pumping action is the freezing of the test gas on cryogenically cooled surfaces. The cryogenic pump is particularly desirable for the production of molecular streams in wind tunnels, by means similar to but more elaborate than the crude method used to produce the molecular beam shown in the first frame of Figure 1. Here the cryogenic pump has the advantageous feature that the stream and background molecules, once they have struck the cold surface, stick to it and are excluded from the possibility that on rebound they might collide with beam molecules and degrade the beam collimation.

Transition-flow aerodynamic studies, involving detailed measurements of force, temperature, and heat transfer characteristics of bodies immersed in a rarefied flow, are most conventiently carried out in nozzle- or jet-produced flows. On the other hand, measurements of molecule-surface interaction parameters, which are required for the aerodynamic characteristics of bodies under free-molecule flow conditions, require the use of molecular beams. In such studies a beam is directed at a surface of interest, and the angular distribution of energy and momenta of the reflected molecules is measured. Both transition-flow aerodynamics and molecule-surface-interaction studies can be carried out over a large range of gas temperatures and molecular energies, by heating the source supply of the test gas. One of the most interesting features of rarefied-gas-dynamics wind tunnels is the ease with which ionized flows may be produced through the use of electrical discharges in the source region. Such ionized flows provide laboratory simulation of many of the plasma sheath and wake phenomena which are characteristic of high speed flight. Studies of these sheath and wake phenomena have direct application in the area of vehicle-ground communications (the communications blackout problem) and in the area of radar discrimination.

In addition to providing an environment in which transition-flow aerodynamics can be investigated in the laboratory, low-density wind tunnels also serve as a sort of magnifying glass through which many conventional aerodynamics problems can be viewed on a scale not possible in "ordinary-density" wind tunnels. Under rarefied flow conditions, boundary layers, wakes and shock waves can become a centimeter thick, or greater, and measurements within them can be made on a scale equivalent to the sampling of an element of gas whose dimensions are of the order of one mean-free-path. Probes for the measurement of pressure, temperature and ion content of a flow can be fabricated whose dimensions are small compared to a mean-free-path, and whose presence produced negligible disturbance to the flow. Also, electron-beam techniques can be used for the production of local regions of self-emission of radiation within the flow. Through the use of various spectroscopic methods this emitted radiation can be interpreted to yield the local temperature, velocity, density, and chemical composition of the flow. This electron-beam technique, which has only recently been developed, is a remarkable advance in experimental rarefied gas dynamics, and has already yielded a wealth of information on local flow properties which has hitherto been inaccessible to the experimentalist.

In the two decades which have elapsed since rarefied-flow aerodynamics became the object of serious investigation, the subject area has been transformed from a frontier of science to a relatively mature discipline. Geometrically simple flows of physical simple gases have been quite thoroughly explored and many important design decisions can now be guided by a firm physical understanding of the flow phenomena involved. On the other hand, very little work has been done on geometrically complex flows, and the study of physically or chemically complex gases is just beginning to flourish. There is still a significant gap between what we can predict or simulate, and what we need to know to solve many specific practical problems of high altitude flight and exploration.

Radar System for Atmospheric Research

The University of Chicago has recently received a $405,000 grant from the National Science Foundation to develop an ultrasensitive transportable radar system for atmospheric research. This system will include a powerful and highly sensitive pulse Doppler radar capable of detecting echoes from both clouds and regions of clear air turbulence. It also will include sophisticated signal and data processing devices to permit the rapid measurement and display of the reflectivity of echoing regions and associated atmospheric motions. Such high speed data processing is required especially in tornado detection where the tornado funnel with its high rotational velocities must be located with the least possible delay. The system is being designed for ready transportation to permit its use in various weather situations anywhere in the country. At present, the radar is temporarily installed on the IIT campus.

A second powerful radar facility has also been made available to the University by the National Science Foundation. Located at Monee, Illinois, about 35 miles south of Chicago, this radar was previously operated by the U.S. Air Force Defense Command as part of its detection and warning network. It, too, has great sensitivity and Doppler capability to measure target motion.

Both radars will be used in research programs supported by the National Science Foundation. Professor David Atlas presently has an NSF research grant concerned with electromagnetic scatter from clear air phenomena and Doppler radar studies of thunderstorms and other precipitation. The program is also supported by a grant from United Air Lines and the Environmental Sciences Service Administration.

Paralleling the research is the academic program at the University of Chicago. The Department of Geophysical Sciences offers a three course graduate level sequence in radar meteorology and remote probing. The first two quarters are presented by Atlas; the third, dealing with advanced theory and techniques, is being presented by Jesse J. Stephens, a Visiting Associate Professor from Florida State University. It is also planned to initiate a parallel course of study at IIT. Arrangements are being made to facilitate the exchange of students between the two institutions.

Research Notes

RIMEX II-69

Five scientists from ONR Headquarters, three from the Naval Research Laboratory, and 17 from other organizations flew to San Juan, Puerto Rico, in April. They boarded USS Calcaterra (DER 390) for transportation to the site north of Puerto Rico for RIMEX II-69. This exercise was conducted under the direction of RADM I. C. Kidd, Jr., Commander of Cruiser-Destroyer Flotilla 12. The ships besides Calcaterra participating in the exercise were: USS Charles F. Adams (DDG-2), USS Sampson (DDG-10), USS Tattnall (DDG-19), USS Semmes (DDG-18), USS R. L. Page (DEG-5), and USS Goodrich (DDR-831).

RIMEX II-69 was primarily an exercise to test and evaluate surface-to-air missile capability. The exercise lasted about 72 hours. Each missile ship fired a number of missiles at drone targets such as AQM and BQM. Nonfiring exercises were also carried out. The ships' five-inch guns were exercised in bombardments of Culebra Island. Before returning to Puerto Rico the ships took on fuel from the oiler USS Chikaskia (AO 54).

For most of the ONR observers it was the first time at sea with the Navy. The general impression was that the weaponry and detection systems are extremely complex and sophisticated and the men who operate them very hard-working. Some of the crews were inexperienced in exercises of this kind; Sampson, R. L. Page and Calcaterra had not taken part in the earlier RIMEX. The manner in which the crews adapted and learned to cope with the problem in a short time spoke well for those engaged in the detailed operation as well as for the commanding officers.

The Navy has developed navigational aids recently such as TRANSIT (Navy Navigational Satellite) and OMEGA. Thought should be given to installing these systems aboard ships such as were in this exercise to assist in navigating when normal aids (such as LORAN) are not available and to increase initial accuracy in gunfire problems on shore targets.

Long-term benefits to those taking part seem assured since in the short time following the cruise several specific occasions have already arisen where the seagoing experience has been meaningful. Examples are in discussions with the Navy Postgraduate School about a model for an NTDS system for the SQS/26 sonar, in consideration of underway replenishment problems, and in exploration of an integrated logistical system for the SQS/26.

All the ONR representatives were grateful for the opportunity to observe RIMEX II-69 at sea and returned to Washington with both a deeper appreciation of the Navy's problems as well as a firmer commitment to their solution.

Naval Research Advisory Committee

Act of 1 August 1946, Public Law 588, 79th Congress, Codified by Title 10, U.S. Code 5153, authorized the Secretary of the Navy to establish a Naval Research Advisory Committee (NRAC) to advise the Chief of Naval Operations and the Chief of Naval Research in matters pertaining to research and development. By statute the Committee consists of fifteen persons preeminent in the fields of science and research, one of the members being selected from the field of medicine. Members are appointed by the Secretary of the Navy. Meetings are held regularly four times a year and at such other times as called by the Secretary of the Navy or the Chairman. The agenda, prepared by the Chairman and staff, includes presentations of interest to the Committee and items arising from requests for Committee advice. The bureau and system commands provide information and access to facilities as needed by the Committee for execution of its work.

The above picture was taken at the 80th meeting of the Committee which was held March 1969. At this meeting Mr. E. H. Heinemann became Chairman of NRAC and Dr. J. H. Wakelin Jr. became Vice Chairman. Left to right are RADM T. B. Owen, Dr. O. G. Villard, Jr., Dr. Joel S. Lawson, Jr., Dr. Ivan E. Sutherland, Dr. R. A. Kern, Dr. R. A. Frosch, Dr. Alexander Slafkosky, Dr. Peter King, Dr. W. D. Lewis, Dr. J. H. Wakelin, Jr., Mr. E. H. Heinemann, Dr. Roger Revelle, MGEN L. Metzger, Dr. C. C. Furnas, Dr. W. P. Raney, RADM E. A. Ruckner. Members not shown in the picture are Dr. Harvey Brooks, Dr. William A. Fowler, Dr. Augustus B. Kinzel, Dr. Carl Pfaffmann, Dr. Isidor I. Rabi, Dr. Frederick Seitz, Dr. E. A. Walker.

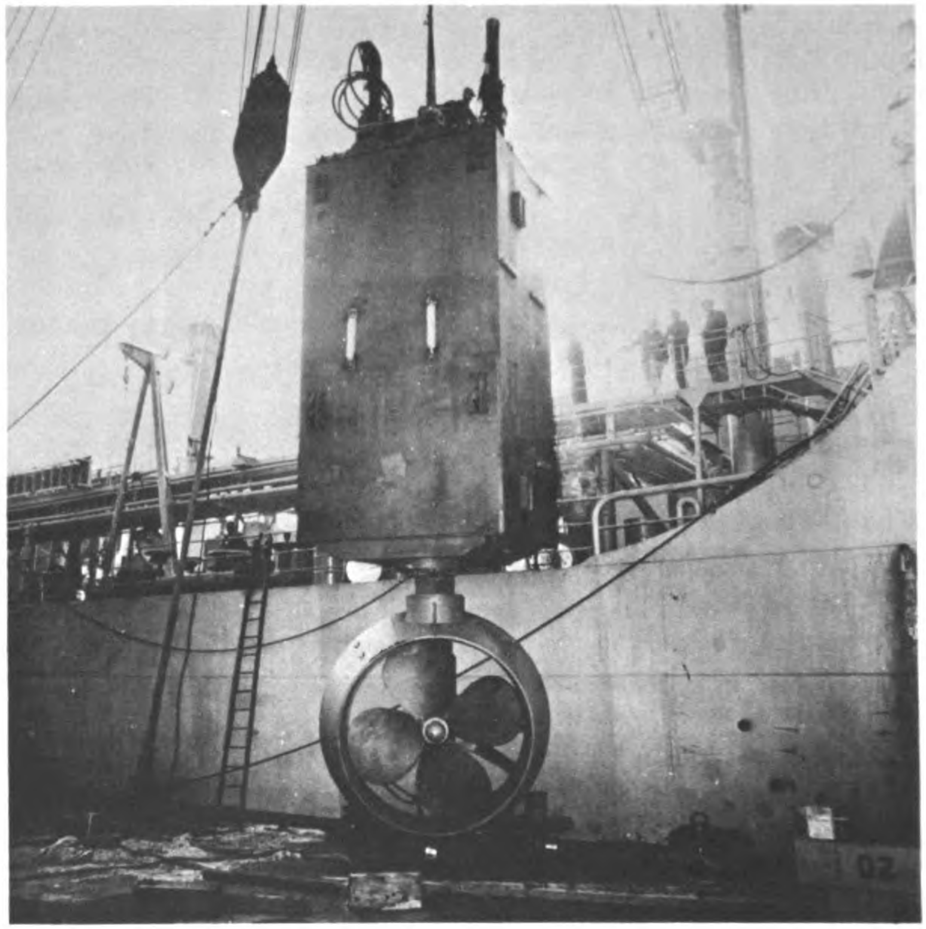
Subcommittees composed of members of the committee are established from time to time to conduct and report on specific studies as requested or directed by the Chairman. Assistance on special studies and surveys of either a permanent or transitory nature may be accomplished by appointment to the Committee of panels or ad hoc groups to act on behalf of the Committee. In late 1967 the Assistant Secretary of the Navy (Research and Development) asked NRAC to provide him with a meaningful method by which he might have a continuing independent overview of the Navy laboratories. In response to this request five Laboratory Advisory Boards were established under the aegis of NRAC and were assigned certain laboratories under their area of responsibility. The Boards are entitled: NRAC Laboratory Advisory Board for Research, Naval Ships, Cornance, Undersea Warfare, and Air Warfare. At least one member of NRAC serves on each of the Boards.

For administrative ease the Chief of Naval Research furnishes staff assistance and support to the Committee; he also serves as Executive Director of the Committee.

Automatic Position-Keeping System Tested on Navy Ship

The first automatic acoustic dynamic position-keeping system, which has been installed in the Navy's research ship MISSION CAPISTRANO, has successfully completed two years of testing. The system has permitted the ship to hold its position for an extended length of time in water depths of 13,000 feet, drifting only a few hundred feet during a period of strong gusty winds and high seas.

The 524-foot MISSION CAPISTRANO has been used for the past several years in experiments for Project Artemis, a long-range research program conducted by the Office of Naval Research. The program involving underwater acoustics research is aimed at studying the feasibility of ocean surveillance. The major piece of equipment on the ship



Auxiliary Propulsion pod being lifted aboard USNS MISSION CAPISTRANO

is a very large sound source, which is lowered into the water through a well in the ship and operated while the ship holds a precise position.

Previously the vessel maintained its position in deep water by means of anchors or by the use of tugs. A thruster, installed in the bow, was used to adjust the ship's heading. Unsatisfactory results plus the fact that tugs are limited by weather and are expensive led to a decision to develop a dynamic position-keeping system.

The requirement was a system that would hold the ship within a thousand-foot radius with concurrent beam winds of 25 knots and a current of one knot while operating in water with a depth of 20,000 feet. The position-keeping system devised to meet this need utilizes two 1250-horsepower electric propulsion units which are fed commands by a computer to correct both the ship's position and heading. The units may be rotated 360 degrees and are equipped with seven-foot diameter four-bladed propellers.

The system was designed by AC Electronics Defense Research Laboratories of General Motors, Goleat, Calif., and the propulsion equipment provided by Murray and Tregurths Inc., Quincy, Mass. The Military Sea Transportation Service, which operates the ship, installed the system.

The basic automatic mode of operation employs an acoustic beacon on the ocean bottom. Signals from the beacon are picked up by three hydrophones mounted on the bottom of the MISSION CAPISTRANO. The difference in the arrival time of the signals at each of the hydrophones indicates the displacement of the vessel from the beacon. This information together with the ship's actual heading is fed into a computer which controls the two propulsion units. Instead of a beacon the system can utilize Loran C signals processed through a device developed by Hudson Laboratories of Columbia University.

A semi-automatic mode of operation can also be used. In this case the control computer holds a selected heading automatically while an operator corrects the position using visual displays of acoustic, Loran C or radar information. With a "joy stick" he commands combinations of fore-aft and broadside forces, enabling him to move the ship in any direction while maintaining constant heading.

In a manual mode of operation, the computer is cut out and the operator dials in thrust and direction commands to each of the propulsion units.

In the typical test in 13,000 feet of water the standard deviation of the ship from the desired location was 142 feet with a peak deviation of 241 feet. This occurred with winds averaging 28 knots and gusting up to 35 knots, a sea height of five feet and a swell height of 11 feet.

Each propulsion unit is self-contained in a watertight housing or pod which is retractable into the hull. In effect, the units are plug-in "engine rooms" which ride up and down on rails in elevator trunks and can be readily removed from the vessel.

Although the system was specifically designed for the MISSION CAPISTRANO to service Project Artemis, the ability to hold a ship on station in the deep sea has given the Navy a new stable, precision tool for oceanographic research.

Scientists Discover Salt Domes

NAVOCEANO scientists have discovered salt domes—geologic structures known to accumulate oil—in deep ocean sediments of the eastern Atlantic. These structures had been previously found only on continental shelf areas where the petroleum industry is now concentrating all offshore drilling operations.

Lt. Eric Schneider, a research geologist who heads the Global Ocean Floor Analysis and Research (GOFAR) project for NAVOCEANO, recently announced the discovery in a scientific paper presented at the convention of the American Association of Petroleum Geologists in Dallas, Texas.

"The finding of domes along with organic-rich sediments (known to contain oil) may thrust the search for oil into the deep ocean areas," Lt. Schneider predicted. "Our data shows the domes to be located 400 miles west of Senegal and 180 miles north of the Cape Verde Islands (Africa)."

The scientists working on GOFAR, believe the cone-shaped structures they found are salt domes because they have no magnetic signature—a test geologists use to identify sedimentary and igneous rock beneath the sea floor.

Th structures, which appear to be pushing their way up out of the sediments underneath the sea floor, are also located near documented salt deposits on the Senegal continental shelf.

The data, leading the GOFAR scientists to identify the structures as salt domes, were collected last summer when the USNS KANE—the most modern research ship operated by the Oceanographic Office—traveled 20,000 miles across the Atlantic from Bermuda to Liberia.

The GOFAR project, sponsored by the Navy, is designed to further man's understanding of the geological processes that formed and are continuing to mold the ocean floor.

On the Naval Research Reserve

NRRC 5-8 and 5-10 Hold Joint Meeting

In March members of NRRC 5-8 of Washington, D.C. and NRRC 5-10 of Bethesda, Maryland, along with their wives held a joint dinner meeting. CDR Julian C. Nall, the Commanding Officer of 5-8 and CDR Sherman Ross, the Commanding Officer of 5-10 welcomed the guests. CAPT James R. Patton, Jr. of 5-8, who is an original officer in the research reserve program, reviewed the Naval Reserve Research Program. He also discussed the history of 5-8, being the occasion of its twentieth anniversary.

The principal address was given by Colonel Robert C. Goerder USAF, who is Director of the Seminar School at the Industrial College of the Armed Forces, Washington, D.C. His subject was "Political Implications of the Military Posture."

NRRC 12-3 Sponsors Seminar

Eighty-five reserve officers from states west of the Mississippi River met at Treasure Island in San Francisco Bay for the 16th Annual West Coast Research Reserve Seminar. This year's presentation was conducted by NRRC 12-3, Stanford, California, commanded by LCDR Hugh Satterlee USNR, and examined the theme "The Earth's Ocean: Hydrosphere, Atmosphere, Magnetosphere."

Following opening addresses by RADM Thomas B. Owen USN, Chief of Naval Research, and Seminar General Chairman LCDR Bill Jones, USNR, a series of speakers discussed the phenomonology of each "Ocean" and explained the Navy's mission and operating problems in these environments.

An innovation tried in this seminar was guided group and panel discussions among the attendees as a formal part of the seminar program. The purpose was to involve more fully the audience with the material presented and to obtain their opinions and suggestions on the research being conducted.

Field trips were conducted to Lockheed's Ocean Systems Center in Sunnyvale; Fleet Air Wing Pacific at NAS Moffett to visit the P3 Orion Aircraft System; the San Francisco Bay Model operated by the US Army Corps of Engineers in Sausalito; and to the Richmond Field Station of the University of California where facilities have been constructed to study wind-wave interaction, closed ecology systems for space travel, and fog effects on aircraft landings.

Active Duty for Training (ACDUTRA) Project

CAPT Nello Pace, USNR, NRRC 12-5 (left), and CAPT Arthur H. Smith, USNR, NRRC 12-6 (right), performed ACDUTRA with the Aircrew Equipment Branch, Naval Missile Center, Point Mugu, California. CAPT Pace is Professor of Physiology at the University of California, Berkeley, and CAPT Smith is Professor of Physiology at the University of California, Davis. The ACDUTRA permitted CAPT Pace and CAPT Smith to test a short-range biotelemetry device developed for continuous monitoring of heart rate in CAPT Pace's laboratory. The device was placed on LT T. S. Treanor, USN, and his heart rate was recorded while he piloted a supersonic F-4B during a simulated attack mission. The record permitted assessment of the pilot's physiological status throughout the mission. The Aircrew Equipment Branch is continuing the monitoring program initiated by CAPTs Pace and Smith.

NRRC 13-1 Winter Program

Two prominent speakers and a field trip highlighted the winter season for NRRC 13-1, Seattle, Washington. The Honorable Henry M. Jackson, member of the Senate Armed Services Committee and Chairman of The Subcommittee on National Security and Internal Operations, spoke to the group on world affairs in relation to the expanding influence of U.S. technology with emphasis on the proposed Advanced Manned Aircraft Systems, Satellite Communications and Fleet Ballistic Submarines.

Later in the season CAPT Robert Barton USNR-R, past National President of the Naval Reserve Association, spoke. CAPT Barto participated in Operation Deepfreeze as well as flights to retrace the land routes of the Byrd and Scott expeditions. CAPT Barto toured installations for the New Zealand expedition station to the South Pole observing the work of the scientific teams in their geological and meterological studies. He discussed the influence these studies are producing economically and strategically.

On the field trip NRRC 13-1 visited the Air Route Traffic Control Center in Auburn, Washington. The Center monitors 180,000 square miles of the Pacific Northwest and control about 7500 aircraft per day.

Training Officer Among First Waves Selected For Captain

For the first time in Naval Reserve history Waves were selected for Captain rank by the 1969 Reserve Line Selection Board. Captain Eleanor F. Kehoe, USNR, Training Officer for the Research Reserve was one of the three Waves selected.

Miss Kehoe joined the staff of the Research Reserve in 1956 as an Education Specialist. In addition to her present position as Training Officer, she also serves the the Research Reserve Assistant for the Fifth and Sixth Naval Districts.

Captain Kehoe became a member of Naval Research Company 5-8, Washington, D.C. after completion of active duty from February 1943 to August 1955. She commenced her active Naval service by attending the U.S. Naval Midshipmen's School at Northhampton, Massachusetts, and was commissioned an Ensign on 4 May 1943. From 1943 to 1955 she served in communication and administrative duties on the staff of Commander, Western Sea Frontier; Commandant, Twelfth Naval District; Commander, Naval Station, Treasure Island; Commanding Officer, Naval Supply Center, Oakland, California and Chief of Naval Personnel as the Military Personnel Officer. Miss Kehoe has been awarded the Naval Reserve Medal, American Area Compaign Medal, Victory Medal World War II, National Defense Service Medal, Armed Forces Research Medal and Navy Expert Pistol Medal.

CAPT Eleanor Kehoe, USNR receiving her commission from RADM Thomas B. Owen, Chief of Naval Research

A native of Alexandria, Minnesota, Miss Kehoe attended St. Cloud Teachers College, the University of Minnesota, and the University of Wisconsin. She received a Bachelor of Science degree in Education from the University of Maryland and a Master of Arts degree from The George Washington University in Personnel Administration.

Dr. Furnas is Dead

Dr. Clifford C. Furnas, President Emeritus of the State University of Buffalo and a nationally recognized leader in the field of defense planning, died suddenly on April 27 at the age of 68. Dr. Furnas retired in 1966 after 12 years as the chief administrator of the University of Buffalo, but maintained close contact with the University as head of its Nuclear Research Center.

Dr. Furnas did a great deal of research in process metallurgy specializing in fluid flow, heat transfer, combustion, and aviation research. In 1954 Dr. Furnas took a leave of absence from the University of Buffalo to become Assistant Secretary of Defense for Research and Development. Later he occupied a series of other government posts under Presidents Eisenhower and Kennedy. He was cited many times for his contributions to national defense and engineering.

Dr. Furnas was a member of the Committee on Aircraft Construction of the national Advisory Committee for Aeronautics; the Army Ordance Advisory Committee, and Chairman of the Technical Advisory Panel of Aeronautics for the Assistant Secretary of Defense. He was instrumental in organizing the Defense Science Board formed in 1956, serving both as a member and its chairman. He also was Chairman of the Army Scientific Advisory Panel and a trustee of the Naval Research Advisory Commission. In all his activities, Dr. Furnas stressed the importance of basic as well as developmental research.

Selected Contract Research Reports

The contract research reports listed below have been extracted from U.S. Government Research & Development Report 69, No. 3 of 10 February 1969. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in USGRDR 69, No. 3.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 21151.

ASTRONOMY AND ASTROPHYSICS

Relativistic, Spherically Symmetric Star Clusters. Stability Theory for Radial Perturbations; CalTech; Ipser and Thorne; AD-678 662

Neutron Tunneling in 3He (3He,2p)4He; CalTech; May and Clayton; AD-678 663

Resource Letter OE-1 on Origin of the Elements; CalTech; Fowler and Stephens; AD-678 664

Rotating Neutron Stars, Pulsars and Supernova Remnants; Cornell U.; Pacini; AD-678 668

Moving Pairs Among the A-type Stars within 20 Parsecs; Chicago U.; Vandervoort; AD-678 875

A Formal Third Integral of Motion in a Nearly Spherical Stellar System; Chicago U.; Saaf; AD-678 876

Optical Studies of Flare Stars in Conjunction with Simultaneous Radio-Frequency Observations of the Same Stars; Smithsonian Astrophysical Observatory; Martin; AD-679 178

Infrared Excesses in T Tauri Stars and Related Objects; Arizona U.; Mendoza; AD-679 258

ATMOSPHERIC SCIENCES

Airborne Observations of Cloud Particles and Infrared Flux Density (8-14 Microns) in the Artic; Wash. U.; Witte; AD-679 241

BEHAVIORAL AND SOCIAL SCIENCES

Richard T. Ely Lecture: Economics of Inquiring, Communicating, Deciding; Calif. U.; Marschak; AD-678 680

India, China and the Afro-Asian Bloc; Calif. U.; Rose; AD-678 665

Location of an Ancient Roman Shipwreck by Modern Acoustic Techniques; Scripps; McGehee *et al*; AD-678 811

Some Factors in the Design of Systems for Computer-Assisted Instruction; Harvard Computing Center; Stolurow; AD-678 740

The Use of Computers in High Schools; Harvard; Crick and Stolurow; AD-678 741

Auditory Training for Perception of Time-Shortened Consonant-Vowel Syllables; Ohio St. U.; Black and Grimm; AD-678 761

Individual Behavior in a Simulated Panic Situation; N. Carolina U.; Schultz; AD-678 742

Defensive Communication; National Training Labs; AD-678 845

Risk Taking in Military and Economic Decision Making: An Analysis via an Experimental Simulation; Purdue; Streufert and Streufert; AD-678 951

The Effects of Persuasive Communications on Attitudes; Hunter College; Weiss; AD-678 952

BIOLOGICAL AND MEDICAL SCIENCES

Immunochemistry of Sperm Whale Myoglobin. The Specific Interaction of Some Tryptic Peptides and of Peptides Containing all the Reactive Regions of the Antigen; St. U. of N.Y.; Atassi and Saplin; AD-679 127

Immunochemistry of Sperm Whale Myoglobin. Modification of the two Tryptophan Residues and Their Role in the Conformation and Antigen-Antibody Reaction; St. U. of N.Y.; Atassi and Caruso; AD-679 128

Immunochemistry of Sperm Whale Myoglobin. Modification of the Three Tyrosine Residues and Their Role in the Conformation and Differentiation of Their Roles in the Antigenic Reactivity; St. U. of N.Y.; Atassi; AD-679 129

Pulse Modulated UHF Energy Illumination of the Heart Associated with Change in Heart Rate; Institute for Research; Frey and Seifert; AD-678 942

Inhibition of Embryonic Deoxyribonucleic Acid Synthesis by Colcemid; Texas U.; Williams; AD-679 361

Hyperbaric Effects of High Pressure Exposures on Endocrine Physiology; Vermont U.; Howe; AD-678 655

An Apparatus for Psychophysical Investigations of Visual Processes in Semi-Restrained Cats. Dark Adaptation in the Cat; Kansas St. U.; LaMotte and Brown; AD-678 750

Dark Adaption in the Cat: Study of Visual Perception in Humans and Animals; Kansas St. U.; LaMotte and Brown; AD-678 752

Brain Stem Evoked Responsed Associated with Low-Intensity Pulsed UHF Energy; Inst. for Research; Frey; AD-678 943

CHEMISTRY

Piperazinobisdiborane and its Polymeric Consequences; U. of S. Calif.; Burg and Iachia; AD-678 660

Cryatallization During Polymerization; Rensselaer Polytechnic Inst.; Wunderlich; AD-67[illegible] 585

Conformational Isomerization of Hexahydro 1,3,5-Trimethyl-1,3,5-Trizine; Ill. U.; Gutowsk[illegible] and Temussi; AD-679 244

Vibrational Relaxation of Anharmonic Oscillator Molecules: Relaxation Under Isothermal Conditions; M.I.T.; Bray; AD-678 674

Competitive Unimolecular Decomposition in Chemically Activated Radical Systems. Isopropyl Radical Rupture; Washington U.; Rabinovitch and Larson; AD-678 745

Vibrational Relaxation in the Tetrachlorides of C, Si, Ge, Sn, and Ti; Scripps; Rasmussen; AD-678 806

An Integrated Gas Chromatograph-mass Spectromenter System with Carrier Gas Separator; Woods Hole; Blumer; AD-678 844

Viscosity of Dispersed and Aggregated Suspensions of Spheres; Monsanto Research Corp.; Lewis and Nielsen; AD-679 115

Thermodynamics of Ion Association. Copper Complexes of Diglycine and Triglycine; St. U. of N.Y.; Brunetti *et al*; AD-679 157

Light Scattering Studies of Orientation Correlations in Cholesteryl Esthers; Mass. U.; Rhodes *et al;* AD-679 186

An Isotope Effect on 6P (1/2)-6P (3/2) Mixing in Cesium, Induced in Collisions with CH4 and CD4; Windsor U. (Canada); McGillis and Krause; AD-679 188

Spin-Echo NMR Studies of Internal Rotation in 1,1-Difluoro-1,2-Dibromodichloroethane; Ill. U.; Vold and Gutowsky; AD-679 242

Dipole - Dipole Interactions of a Spin-1/2 Nucleus with a Quadrupole-Coupled Nucleus; Ill. U.; VanderHart *et al;* AD-679 243

Internal Field and the Additivity of Bond Polarizabilities; Mass. U.; Rowell and Stein; AD-679 260

Optical Potential for a Chemically Reactive System; M.I.T.; Eu and Ross; AD-679 285

Antiferromagnetic and Crystal Structures of Alpha-Oxygen; Chicago U.; Meyer *et al*; AD-679 343

Spin-Labeled Protein Crystals; Stanford; McConnell; AD-679 428

The Trapping and Quenching of Potassium Resonance Radiation; Windsor U.; Copley and Krause; AD-679 184

Recent Studies on Triplet-Singlet Transitions in Aromatic Molecules; Calif. U.; El-Sayed; AD-679 191

Spin Polarization and Spin-Lattice Relaxation in the Lowest Triplet State of Pyrazine at 1.6 Degrees K; Calif. U.; El-Sayed *et al*; AD-679 192

The Intersystem Crossing to and the Phosphorescence from the Individual Sublevels of the Lowest Triplet State in Pyrazine at 1.6K; Calif. U.; El-Sayed; AD-679 238

Radiationless Loss Mechanism and Intermolecular Interactions; Calif. U.; El-Sayed; AD-679 239

Photocurrents at a Metal-Electrolyte Interface; N.Y.U.; Delahay *et al*; AD-679 334

The Intersystem Crossing to and the Phosphorescence from the Individual Sublevels of the Lowest Triplet State in Pyrazine at 1.6K; Calif. U.; El-Sayed; AD-679 352

EARTH SCIENCES AND OCEANOGRAPHY

The Distribution of Certain Trace Elements in Tropical Sea Water and Their Biological Significance; Miami U.; Corcoran and Alexander; AD-678 695

Investigations of Oceanic Stratification, Currents and Surface Waves; Westinghouse Research Labs; Gaul; AD-678 654

Determination of Current Velocity Profile Using an Inclinometer Line; Miami U.; McNary; AD-678 915

A Falling-Particle Current Meter; Columbia U.; Pochapsky; AD-679 195

Tectonic Erosion in the Roberts Mountains, Nevada; Scripps; Winterer; AD-678 681

Palaeomagnetism of Deep-Sea Sediments; Scripps; Harrison; AD-678 812

Mathematical Model and Fortran IV Program for Computer Simulation of Deltaic Sedimentation: Stanford; Bonham-Carter and Sutherland; AD-678 909

Continental Shelf Sediment, Northwestern United States; Wash. U.; Gross *et al;* AD-678 676

Gulf of California: A Result of Ocean-Floor Spreading and Transform Faulting; Scripps; Larson *et al;* AD-678 679

Holocene Sedimentation in Tanner Basin, California Continental Borderland; U. of S. Calif.; Gorsline *et al;* AD-678 685

Geology of the North Slope of the Puerto Rico Trench; Woods Hole; Chase and Hersey; AD-678 691

Block Faulting on the Gorda Rise; Scripps; Atwater and Mudie; AD-678 809

Sea-Floor Spreading-Another Rift; Scripps; Raff; AD-678 810

Non-Explosive Profilers: Methods (Arcers, Sparkers, Boomers, Gas-Guns, Air-Guns, and Similar Devices); Scripps; Shor, Jr., AD-678 813

The Crust-Mantle Transition in the Bering Sea; Scripps; Helmberger; AD-678 818

Electron Microscopy Investigation of the Microstructure in Sediment Samples from the Gulf of Mexico; Texas A & M; Bowles; AD-678 984

A Mathematical Model for the Description of the Optical Properties of Turbid Water in Terms of Suspended Particle Size and Concentration; Johns Hopkins U.; Williams; AD-679 168

Determination of Particle Size and Concentrations from Photometer and Secchi Disc Measurements; Johns Hopkins U.; Williams; AD-679 169

Problems of Ambiguity Involved with the Utilization of the Mie Theory in Particle Size Determination; Johns Hopkins U.; Williams; AD-679 170

The Leeward Reefs of St. Vincent, West Indies; La. St. U.; Adams; AD-679 346

Richards, A. 1968 Discussion to Session 1. Shear Strength of Soft Clay; Ill. U.; AD-679 348

Seismic Refraction Studies off Oregon and Northern California; Scripps; Shor, Jr. *et al;* AD-678 816

Spatial Coherence of Geomagnetic Rapid Variations; Lamont Geological Observatory; Davidson and Heirtzler; AD-679 432

ELECTRONICS AND ELECTRICAL ENGINEERING

Electron Beam Noise Reduction Through Operation Near Limiting Perveance; Colorado U.; Twombly and Valent; AD-679 193

The Matrix Algebra Program a Conversational Language for Numerical Matrix Operations.

Reference Manual; Harvard U.; Newbold; AD-678 517

Graph Models of Computations in Computer Systems; Calif. U.; Baer; AD-678 753

Automatic Reprogramming with the Piler System; Probe Consultants, Inc,; Barbe; AD-679 237

The Decision Module Compiler; G. W. U.; Caves and Tomlinson; AD-679 240

Detection of a Potentially Shifting Signal Parameter; Columbia U.; Farley and Hinich; AD-678 910

MATERIALS

Role of the Interface in Glass-Epoxy Composites; Monsanto Research Corp.; Kenyon; AD-679 116

Fracture Properties of Glass Filled Polyphenylene Oxide Composites; Monsanto Research Corp.; Wambach *et al;* AD-679 118

Diffusion of Cadmium in Lead; Harvard U.; Miller; AD-679 205

Rubber Elasticity; Princeton U.; Tobolsky; AD-679 235

MATHEMATICAL SCIENCES

Reconstruction of Tournaments; Ill. U.; Parker; AD-678 647

Small Sample Power of the Bivariate Sign Tests of Blumen and Hodges; Harvard; Klotz; AD-678 697

Connectivity in Products of Graphs; Ill. U.; Reid; AD-678 751

Disproof of a Conjecture of Erdos and Moser on Tournaments; Ill. U.; Reid and Parker; AD-678 783

Extended Uses of Linearized Non-Linear Regression for Random-Nature Simulations; S. Methodist U.; Walsh and Kelleher; AD-678 784

On Estimating the Parameter of a Truncated Geometric Distribution; S. Methodist U.; Thomasson and Kapadia; AD-678 785

Exact Existence of Every Possible Distribution for any Sample Order Statistic; S. Methodist U.; Walsh; AD-678 786

Sample Sizes for Approximate Independence Between Sample Median and Largest (or Smallest) Order Statistic; S. Methodist U.; Walsh; AD-678 787

On Sets of Arcs Containing no Cycles in a Tournament; Ill. U.; Reid; AD-679 209

A Transformation Technique 'for Optical Control Problems with a State Variable Inequality Constraint; Harvard U.; Jacobson and Lele; AD-679 231

Duality in Discrete Programming: Applications; Carnegie-Mellon U.; Balas; AD-678 733

Formal Solutions for a Class of Stochastic Pursuit-Evasion Games; Harvard; Willman; AD-679 232

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

Experiments on the Resistance of a Family of Boxlike Hull Forms for Amphibious Vehicles; Mich. U.; Nowacki *et al;* AD-678 652

Oceanographic and Experimental Platforms; Scripps; Spiess; AD-678 832

Additional Deep Sea Anchoring of the USNS J. W. GIBBS, T-AGOR-1; Columbia U.; Beck and Ess; AD-679 196

NAVIGATION, DETECTION, COMMUNICATIONS, AND COUNTERMEASURES

Lineations of Magnetic Anomalies in th Northeast Pacific Observed Near the Ocea Floor; Scripps; Loyendyk *et al;* AD-678 830

Millimeter/Microwave Radomes - Susceptance Theory for a Metallic Circular Hole Lattice, Resources Development Inst.; McMillan; AD-678 950

ORDNANCE

The Feasibility of Using the Pressure-Time Data from a Solid-Gas Reaction as a Measure o the Reactivity of a Pyrotechnic Material; Denve Research Inst.; Fay; AD-679 160

PHYSICS

Microwave Research; Stanford U.; Quat *et al;* AD-678 731

Mode Response of a Sinusoidally Excited Circular Bimorph; Houston U.; Mitchell an Muster; AD-678 744

The Hudson Laboratories Ray Tracing Program; Columbia U.; Davis *et al;* AD.678 759

Underwater Acoustic Positioning: Applications Scripps; Spiess; AD-678 804

Quick Characterization of the Direction Response of Point Array; Scripps; Lowenstei and Anderson; AD-678 817

Pulse Shape of Totally Reflected Plane Wave as a Limiting Case of the Cagniard Solution f spherical Waves; Woods Hole; Towne; AD-67 843

Lateral Displacement of an Ultrasonic Bea Upon Reflection From a Solid Immersed in Liquid; Tennessee U.; Smith; AD-678 913

Experimental Study of Rarefied Argon Co tained Between Concentric Cylinders; M.I.T Sheldon and Springer; AD-678 673

A Steady-State Simulation of Small Amplitu Wind-Generated Waves; Stanford; Ott *et* AD-678 739

Research of Aerodynamic Physics Institu for Project Strategic Technology; Polytech Inst. of Brooklyn; Bloom; AD-678 762

Lee Waves in a Stratified Flow. Semi-Circu Obstacle; Calif. U.; Miles and Huppert; A 678 946

Peristaltic Pumping with Long Wave Lengt at Low Reynolds Number; M.I.T.; Shapiro *et* AD-679 180

A Study of the Hypersonic Leading Edge Fi in the Merged Layer and Strong Interact Regimes; General Electric Co.; Garvine; A 679 185

The Intermittently Turbulent Region of Boundary Layer; U. of S. Calif.; Kaplan a Laufer; AD-679 234

U. S. GOVERNMENT PRINTING OFFICE : 1969 O - 352-4

Zero-Field Splitting of S-State Ions. Corrections to Parts I and II and Application to Distorted Cubic Crystals; Calif. U.; Sharma *et al;* AD-678 702

Optimization of the Frequency Response of a Fabry-Perot Interferometer; M.I.T.; Katyl; AD-678 675

Interaction of Light and Microwave Sound; Stanford; Quate *et al;* AD-678 833

The Meaningful Use of the Secchi Disc; Johns Hopkins U.; Williams; AD-679 166

The Design of an Optimum Beam Transmittance Meter; Johns Hopkins U.; Williams; AD-679 167

RF Amplitude and Phase Stabilization for a Superconducting Linear Accelerator by Feedback Stabilization Techniques; Stanford; Suelzle; AD-678 717

Particle Motion in a Standing Wave Linear Accelerator; Stanford; Chambers; AD-678 718

The Development of Low Temperature Technology at Stanford and its Relevance to High Energy Physics; Stanford; Schwettman; AD-678 721

Measurement of the CP-Violation Parameter the Absolute Value of ETA sub oo in K (sub L) Meson Decays to 2 Neutral Pions Decay; Princeton; Liu; AD-679 189

Experiemtnal Study of Some Radiative Decay Modes of the K (L) and K (S) Mesons; Princeton; Pilcher; AD-679 190

Electric Arc Stabilization in Crossed Convective and Magnetic Fields; M.I.T.; Winograd and Klein; AD-678 737

Plasma Diagnostic Techniques for Nonequilibrium Plasmas; Fla. U.; Bloss *et al;* AD-679 177

On the Numerical Determination of Shrinkage Stresses; N.Y.U.; Bauer and Reiss; AD-678 588

Stress Strain and Velocity Fields in a Suddenly Loaded Semi-Infinite Rod of Material Described by Nonlinear Viscoelastic Models; St. U. of N.Y.; Cozzarelli and Shaw; AD-678 650

Nonlinear Viscoelastic Stress Analysis with Small Dilatational Changes; Stanford; Ting; AD-679 070

A Mixed Boundary Value Problem in Viscoelasticity with Time-Dependent Boundary Regions; Stanford; Ting; AD-679 071

Ultrasonic Attenuation by Interaction with the Soft Optic Mode in KTa03; Harvard; Barrett; AD-678 911

Spin Wave Instabilities and Relaxation in Single Crystal Permalloy; Harvard; Milton; AD-678 914

Applications of the Fountain Effect in Superfluid Helium; Stanford; Lyneis *et al;* AD-678 719

Micropolar Viscoelastic Waves; Princeton; McCarthy and Eringen; AD-678 648

On the Transmission of Place Waves Through Layered Linear Viscoelastic Media; St. U. of N.Y.; Shaw and Bugl; AD-678 653

27th U.S. Navy Symposium on Underwater Acoustics to be held at the U.S. Naval Undersea Warfare Center, San Diego, California, 28-30 October. Additional information may be obtained from Mr. John B. Hough, Office of Naval Research (Code 466), Washington, D.C. 20360. Phone: Area Code 202, 696-2693. Sponsored by the Office of Naval Research.

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IN THIS ISSUE

VOL. XXII, NO. 6

Semiautomatic Signaling in Tactical Voice Communications .... CDR R. C. HANDFORD 1

Such a system would greatly reduce the time needed for sending signals and messages.

Critical Properties .... ROBERT G. MORRIS 7

Magnetism is an example of a critical phenomenon because temperature is critical to its existence.

Gamma Radiation Kills Snails, Carriers of Schistosomiasis 12

Gamma rays may control snail fever, one of the worst parasitic diseases.

Rarefied Gas Dynamics .... L. TALBOT, F. S. SHERMAN, AND F. C. HURLBUT 15

ONR was a pioneer in this field which is vital to the design of various missiles and the Apollo command module.

Research Notes 22

On the Naval Research Reserve 26

Selected Contract Research Reports 30

Radio Communications Satellite: The Naval Research Laboratory (NRL) developed the moon relay communications system, and in 1954 sent the first voice message by the earth-moon-earth path. Later messages were sent to Hawaii and a moving ship at sea. NRL also developed a radio communication satellite designed to measure very-low-frequency (VLF) signal levels in and above the ionosphere. The orbital flight of this satellite provided new information on the role played by the ionosphere in radio transmission.

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