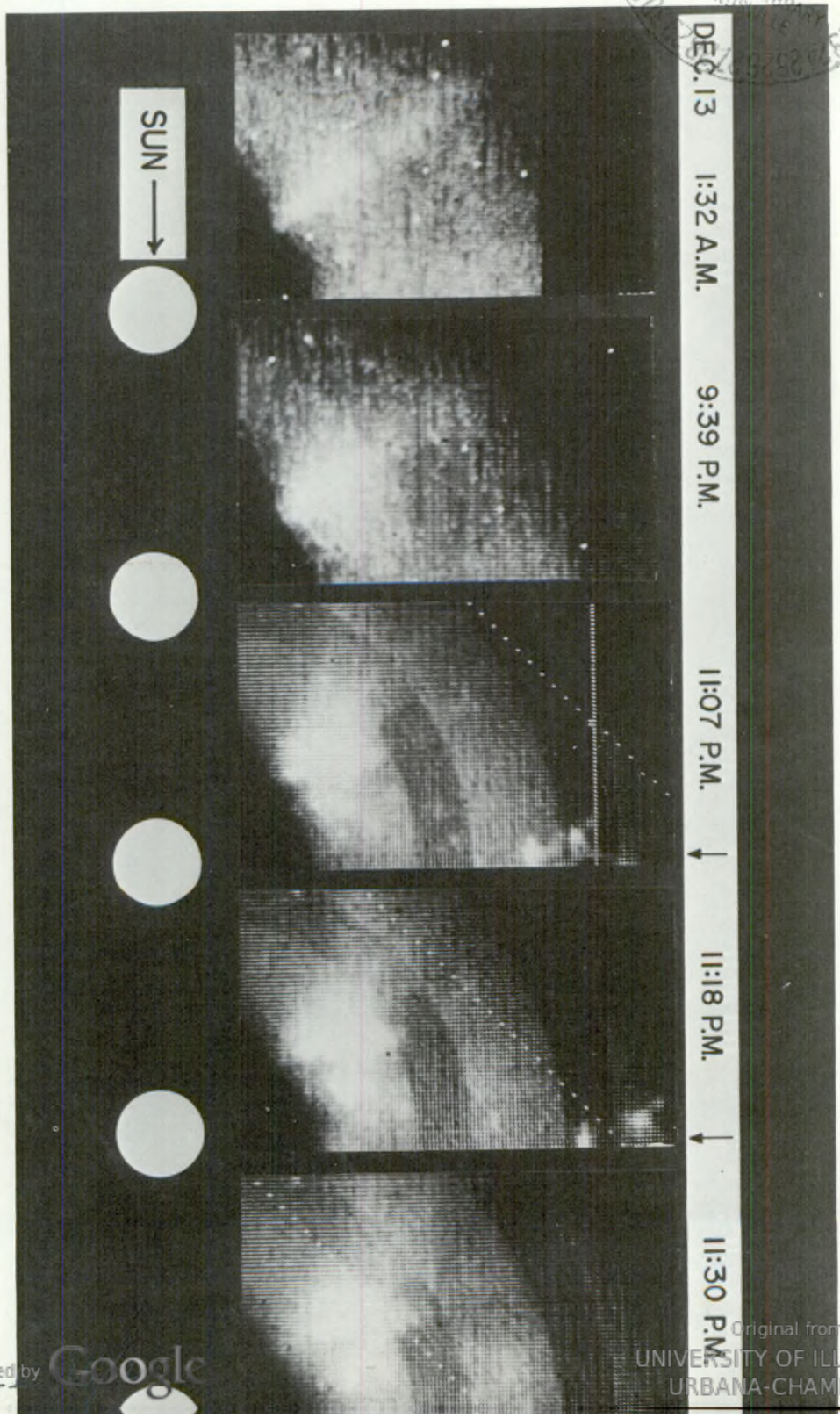
NAVAL RESEARCH

REVIEWS

JANUARY 1972



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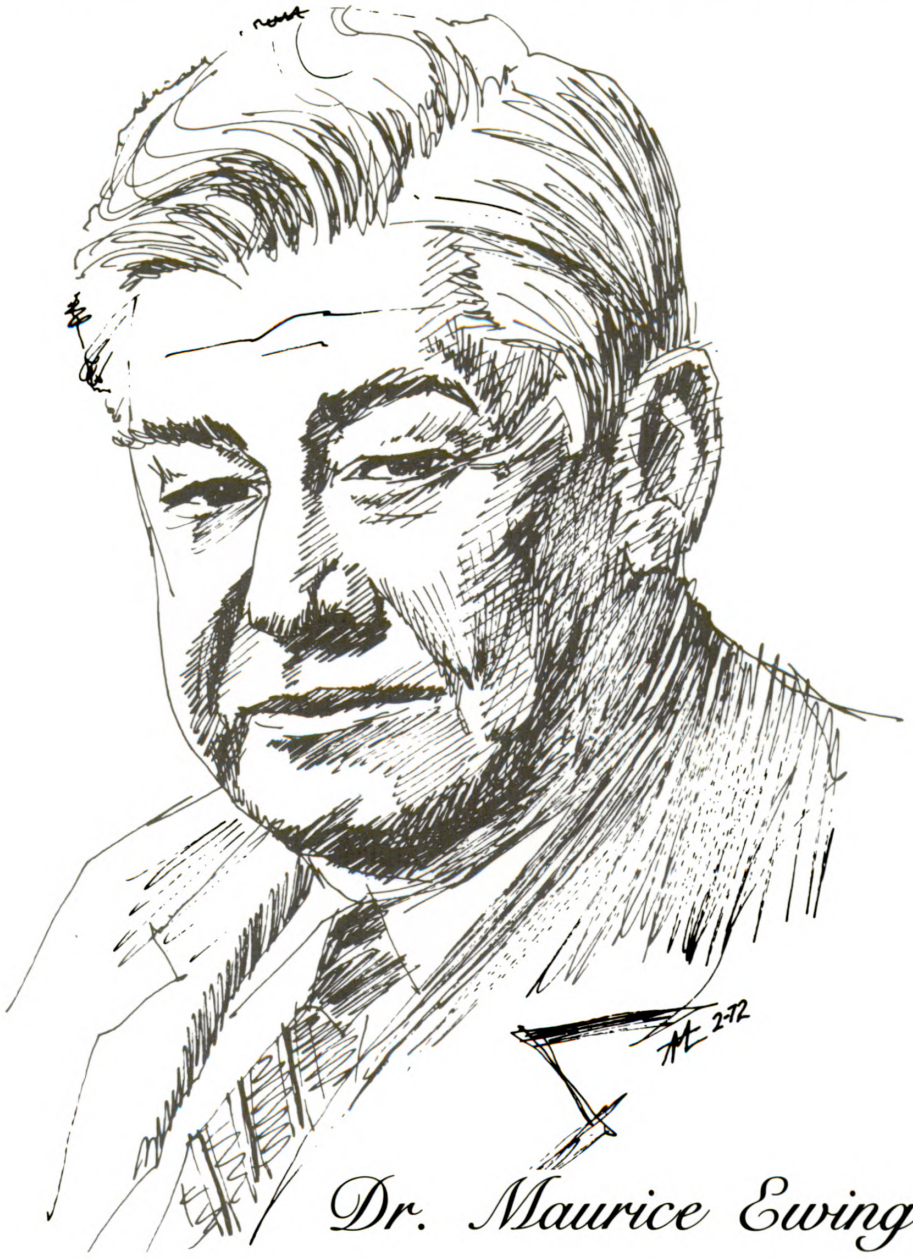
PROFILES IN SCIENCE



Dr. Maurice Ewing

Maurice Ewing is Higgins Professor of Geology at Columbia University and has served as Director of its Lamont-Doherty Geological Observatory during the 22 years of its existence. He has been one of the pioneers in marine geophysics. In 1935 he initiated exploration of the continental shelf by seismic refraction and reflection traverses, and in 1936 he began work on seismic measurements on the continental slope and in the ocean basins. His discovery that the earth's mantle lies only about 7 miles below the ocean floor, compared to about 30 miles below continents, is ranked as one of the most important in the history of geophysical research. The Office of Naval Research has supported Ewing's work for 25 years. Under ONR sponsorship he invented or developed many of the instruments and techniques now commonly used in the fields of seismic reflection and refraction, magnetism, gravity, heat flow, echo sounding, ocean bottom photography, piston coring of sediments, and nephelometry.

Infrared Detectors—Old and New

Robert G. Morris
Office of Naval Research

Nearly everything we look at we see by reflected light: the printed page, people, landscapes, even the moon. Important exceptions are stars and traffic lights, which are visible because of the light they emit. Yet many things can be perceived by their own radiation if we have the right equipment. This radiation is *infrared light,* given off by every object according to its temperature: the hotter the object, the more radiation.

Infrared Radiation

Infrared or "redder than red" radiation is not visible to the eye. Its wavelength is longer than the wavelength of red light. Visible light wavelengths extend from 0.4 micrometer (one millionth of a meter, the replacement term for micron) at the blue end of the spectrum to 0.7 micrometer at the red end. Radiation with wavelengths 0.7 micrometer to 1 millimeter is conventionally termed infrared. Longer wavelengths are generally called radio waves or microwaves. Yet the main distinguishing feature between visible, infrared and radio waves is their wavelength: they are all electromagnetic waves. Radio waves are generally coherent, however, while light and infrared waves are not since they are generated much differently. By coherence we mean that the shape of the wave is repeatedly and continuously produced over a distance large with respect to the wavelength. Because infrared radiation is invisible it was not discovered until 1800 when Sir William Herschel succeeded in focusing it with a glass prism on an ordinary mercury thermometer. He found the hottest part of the spectrum produced by the prism was beyond the red end, where there was no visible light.

Applications

Many Naval applications of infrared radiation have been suggested and tried: heat-seeking guidance systems in missiles such as the Sidewinder or Redeye, detection of missiles or jet engines in surveillance systems, intrusion alarms, gun flash detection, and for use with lasers in ranging and covert target illumination.

Infrared sensors in the applications just mentioned need be only yes-no indicators. Infrared *imaging* devices are also possible in which one small detector or an array of detectors scans a scene point by point and reproduces heat-emitting objects in picture form, usually in a TV-like

display. Such a scanning technique is called for since ordinary schemes used for visible light imaging do not work in the infrared. Photographic film is sensitive only to about 1.3 micrometers and glass lenses do not pass much long-wavelength light. Nor do TV cameras operate in the far infrared. Infrared scanner-viewers have found widespread use in night vision devices and aerial mappers. Forward-looking infrared (FLIR) systems provide aircraft pilots a picture of the terrain beneath them at night. Aerial maps have important civilian uses in agricultural crop evaluation and harvest prediction; thermal pollution in rivers and lakes is clearly visible from air photos since the extreme accuracy of the system shows up temperature differences of less than one degree. This same temperature sensitivity enables an infrared imaging device to detect diseased tissue in living creatures because of its higher temperature, to detect hot spots in electronic microcircuits and to locate overloaded transformers in distribution systems.

Detectors

Detectors of infrared radiation may be divided roughly into two categories, thermal and quantum. Thermal detectors depend on the variation of some physical property with temperature: the more radiation absorbed, the greater the temperature rise and the greater the change in the property. In bolometers the change is in resistance, in thermocouples or thermopiles it is voltage and in Golay cells it is the pressure of a confined gas. Thermal detectors as a class are slow to respond and relatively insensitive.

In a quantum detector the incoming light quantum or bundle of waves with energy $h\nu$ kicks loose an electron from an atom. This electron then can lead to a higher conductivity as in photoconducting detectors, or to a measurable voltage in photovoltaic detectors. Quantum detectors are quick to respond and may be made extremely sensitive. Imaging devices utilize quantum detectors almost exclusively.

Figure of Merit and Windows

Photodetectors are rated according to their minimum detectable signal. This signal is usually taken to be equal to the inherent noise of the detector or the noise-equivalent power (NEP). To make the figure of merit (detectivity D) go up with increasing temperature, one takes the reciprocal of the NEP: $D^* = 1/NEP$. The asterisk refers to a standard detector of area 1 cm^2 and a standard bandwidth of 1 cycle per second (1 Hertz). Detectors for most applications are useful only for radiation readily transmitted through the atmosphere. Water vapor and carbon

dioxide are responsible for strong infrared absorption over wide wavelength bands *except* 0.7-2.5, 3-5 and 8-14 micrometers. These transmission bands are referred to as atmospheric windows. The 8-14 micrometer window is important for two reasons: the CO_2 laser and room-temperature (300 K) radiators. The powerful, efficient gas laser utilizing CO_2 emits at 10.6 micrometers; radiators of infrared having temperature near 300K, which includes much natural terrain as well as the human body, emit maximum energy at about 10 micrometers, inside the 8-14-micrometer atmospheric window. For these reasons, infrared detectors for this band are of great interest.

Detector Problems

The copious radiation in the range 8-14 micrometers by natural objects constitutes a problem for the detection of warm objects with detectors sensitive in this range. Thermal radiation from different parts of the detector itself, the housing or the base causes error signals which are confused with the thermal target. Thus most detectors for this band are cooled by means by some cryogenic liquid like helium (temperature 4 K) or nitrogen (77 K), or by means of an attached refrigerator. This necessity for cooling adds to the complexity of the system, increases maintenance requirements, adds weight and generally makes such detectors hard to use in planes, or ships or in the field.

Detectors thus operate less well as the detector temperature is increased due to this thermal masking of the signal. Furthermore, detectors operate less well as the infrared wavelength is increased simply because longer wavelengths are less energetic. These two general features of detector behavior are shown in Figure 1, a plot of the figure of merit D* *vs* wavelength for several detector temperatures. Numerical values for some typical detector materials are given in Figure 2.

Any program of detector material improvement, therefore, will concentrate on raising performance at longer wavelengths and at higher detector temperatures.

New Effects for Infrared Detection

Several effects suggested for infrared detection are listed and shown schematically in Figure 3. Of the nine effects, six are included in investigations supported by the Office of Naval Research Physics Program and are denoted with an asterisk. All except superconductivity show promise for application in detection devices operated without cooling entirely, or with minimal cooling.

Detectivity D^* is reciprocal of noise equivalent power for detector of area 1 cm^2 and bandwidth 1 Hz.

1. D^* decreases with increasing wavelength
2. D^* decreases with increasing detector temperature

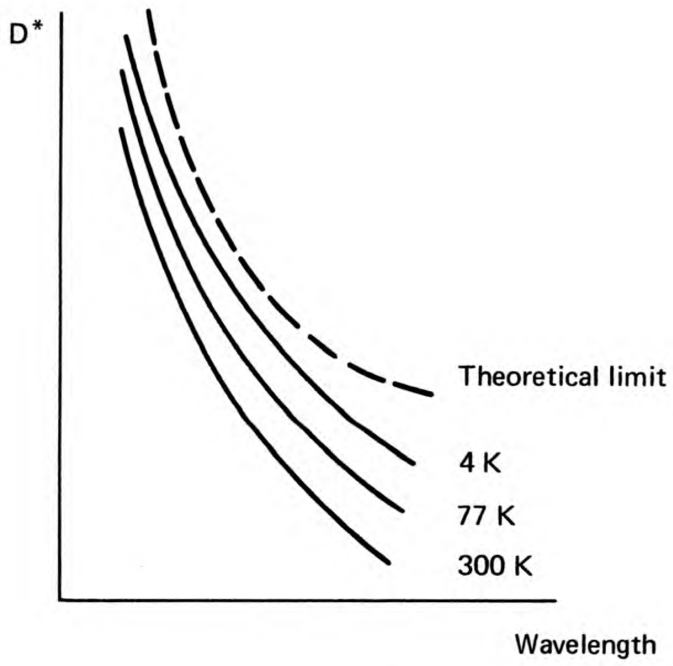


Figure 1

Band (μm)	Typical Material	Sensor Temperature (K)	D^*	Sensor Temperature (K)	D^*	Sensor Temperature (K)	D^*
0.7-2.5	Ge, PbS	300	10^{11}	77	$2(10)^{11}$	4	$4(10)^{11}$
3 - 5	InAs, InSb	300	10^{9}	77	$6(10)^{10}$	4	10^{11*}
8 - 14	HgCdTe,Ge	300	$3(10)^{7*}$	77	10^{10}	4	$2(10)^{10}$

*Extrapolated

D^* units: cm-$Hz^{1/2}$/watt

Figure 2

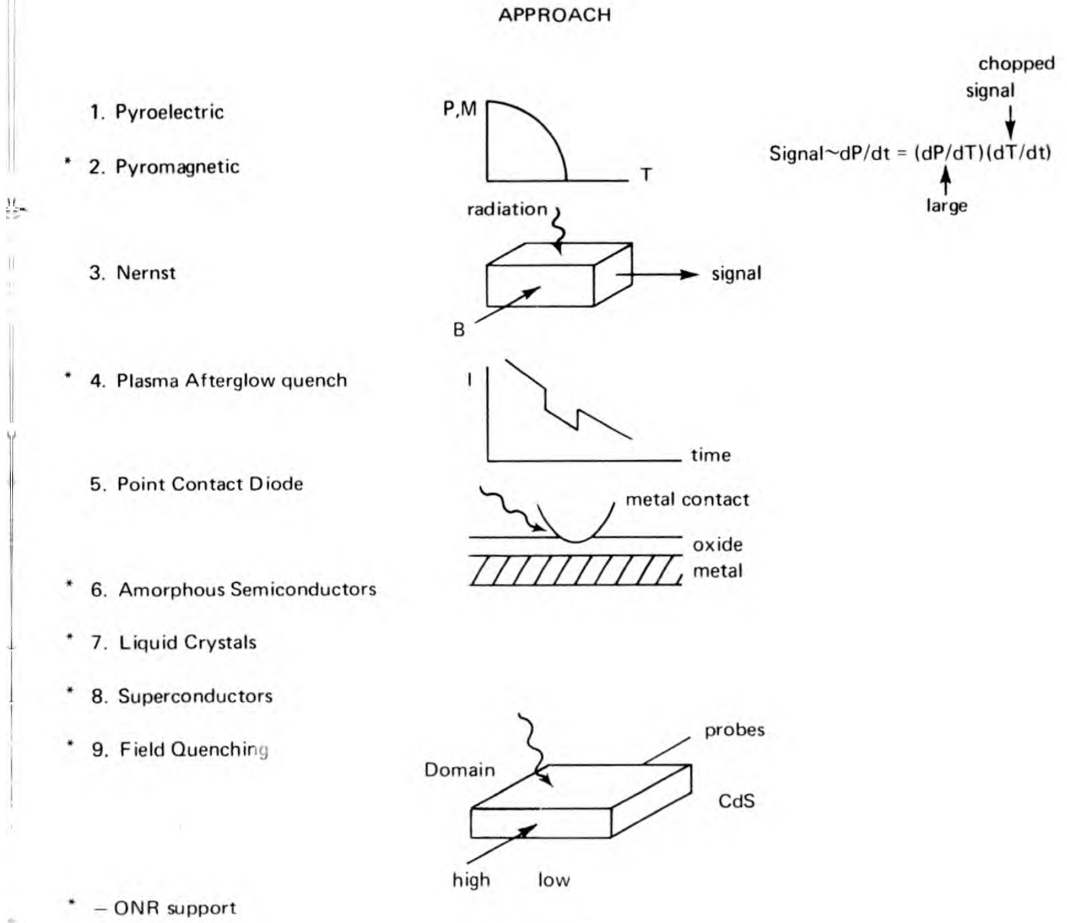


Figure 3

Descriptions

Pyroelectric and Pyromagnetic

Both the pyroelectric and the pyromagnetic effects make use of the large change in polarization P of a suitable material (ferroelectric or–magnetic) near its critical temperature T_c at which the polarization disappears. The induced signal voltage is proportional to the time rate of change of the polarization $dP/dt = (dP/dT)(dT/dt)$; t is the time and T the temperature. The slope of P plotted against T, dP/dT, is large near T_c and a large time-temperature dependence dT/dt is obtained by means of a chopper in the signal path. The pyroelectric detector is the most advanced of the unconventional detectors listed here. Even arrays and image tubes employing this effect have been made. Typical materials are triglycine sulfate, barium titanate, lithium titanate and lithium niobate. Pyromagnetic materials include gadolinium, FeRh, MnAs and Mn_5Ge_3. Extensive work on pyroelectrics has been carried out at Bell Telephone Laboratories. ONR-sponsored work on pyromagnetics is performed by R. W. Benè and R. M. Walser at the University of Texas.

Nernst

The Nernst detector utilizes the Nernst effect. This is the appearance of a signal voltage in a sample subjected to a magnetic field and a temperature gradient set up by the incident radiation. The voltage arises due to the bending of paths of electrons set into motion by the heat. A material in which this effect has been used for detection is bismuth alloyed with 3% antimony. One advantage is that detector response is not a function of thickness. Generally, thin photodetectors are faster to respond but give less signal; one sacrifices signal for response time. This is not the case for Nernst detectors. E. R. Washwell at Lockheed-Palo Alto has studied these detectors.

Plasma Quench

This effect was actually discovered in 1843 by Becquerel, and has been rediscovered. Light emitted by glowing rare gases (as in neon lights) may be reduced by shining infrared on the gas. The infrared apparently provides enough energy to ionize some of the electrically excited gas atoms, thus interrupting their normal light-emitting decay cascade. L. Goldstein and H. Merkelo at the University of Illinois investigated this effect for ONR using a CO_2 laser as an infrared source.

Point Contact Diodes

Point contacts on slightly oxidized semiconductor surfaces have been used to detect airborne signals. A thin wire making point contact with an oxidized metal plate acts as an infrared pickup antenna and rectifying diode, detecting the incident signal. R. L. Abrams at Bell Laboratories has detected in this way infrared with wavelengths as short as 5 micrometers.

Amorphous Semiconductors

Lead compounds such as lead sulfide have been widely used in crystalline photodetectors. Addition of germanium or tellurium is found to stabilize amorphous (noncrystalline) forms of these compounds preserving some of their photosensitive properties as well as increasing the electrical resistivity. P. Scharnhorst and H. R. Riedl are making and studying these amorphous compounds at Naval Ordnance Laboratory, White Oak, under an ONR contract.

Liquid Crystals

Cholesteric liquid crystals, or those in which a spiral ordering of the molecules occurs, exhibit striking color or transparency changes under

the action of electric and magnetic fields or temperature changes. The effect is due to a change in the pitch of the spiral brought about by the external stimulus. Although the sensitivity is high (large color changes for 10^{-8} joules/cm^2 incident light) the chemical stability is poor and response times are slow, in the millisecond range. James McColl and Richard Allen at Yale are receiving ONR support for their study of thermodynamic relationships and force models in liquid crystals.

Superconductors

The change in resistance of a superconductor at the transition temperature (where the resistance goes to zero) could be used in a thermal detector of infrared. However, most superconducting detectors in practice or in hypothesis make use of the AC Josephson effect, in which an incident infrared wave beats against the characteristic AC Josephson current. Constant-voltage steps occur in the current-voltage characteristic and enable measurement of signals as small as 10^{-15} watt with a response time of 10 nsec for wavelengths out to 100 micrometers. ONR supports several investigators doing work of this type. A representative of this group is Sidney Shapiro of the University of Rochester.

Field Quenching

Shining infrared light on certain photoconductors while they are being illuminated by visible light can cause a decrease in photocurrent. Electrons normally made available for conduction by the visible light fall into energy states emptied by the infrared and the conductivity decreases. In cadmium sulfide large electric fields can do the same thing. Fields in this crystal tend to be nonuniform, high in some regions, low in others. Infrared illumination can alter the conductivity and hence the field distribution. Since the fields are high, charges in voltage measured near a region of changing field can be high.

K. W. Boer at the University of Delaware has made a long study of field and infrared quenching with ONR financing. Together with R. C. Tyagi of NASA's Langley Research Center he has made a detector of one-micrometer infrared which gave a 900-volt signal when irradiated with 10^{15} photons/cm^2-sec.

Summary

The key element in Naval systems using infrared for guidance or surveillance is the infrared sensor. New applications of physical effects long studied for their intrinsic interest may improve existing sensors in some respects. One important improvement that could be made would be to reduce the necessity for sensor cooling which now greatly complicates sensor operation and system maintenance.

Major Solar Eruption Observed

R. Tousey, G. E. Brueckner, M. J. Koomen, and D. J. Michels
Naval Research Laboratory

A large region of the sun's outer atmosphere erupted on December 13, 1971 and energetic debris from this massive disturbance collided with the earth three and a half days later. For the first time in the history of science such an eruption was seen in action and recorded optically, in the rapid disintegration of a solar streamer (a bright extension of solar gas, millions of miles long) and subsequent ejection of masses of energized gas.

Dr. Richard Tousey and co-workers at the Naval Research Laboratory released a dramatic series of photographs produced by the NRL white light coronagraph aboard NASA's OSO-7 Orbiting Solar Observatory (Figures 1 and 2). The pictures, taken at 11-minute intervals during the night of December 13, show enormous gas clouds, spewed out of a flaring region on the back side of the sun (hidden from direct view on earth). The clouds, consisting of electrons and protons at million-degree temperatures and measuring 20 to 40 times the diameter of the earth, had

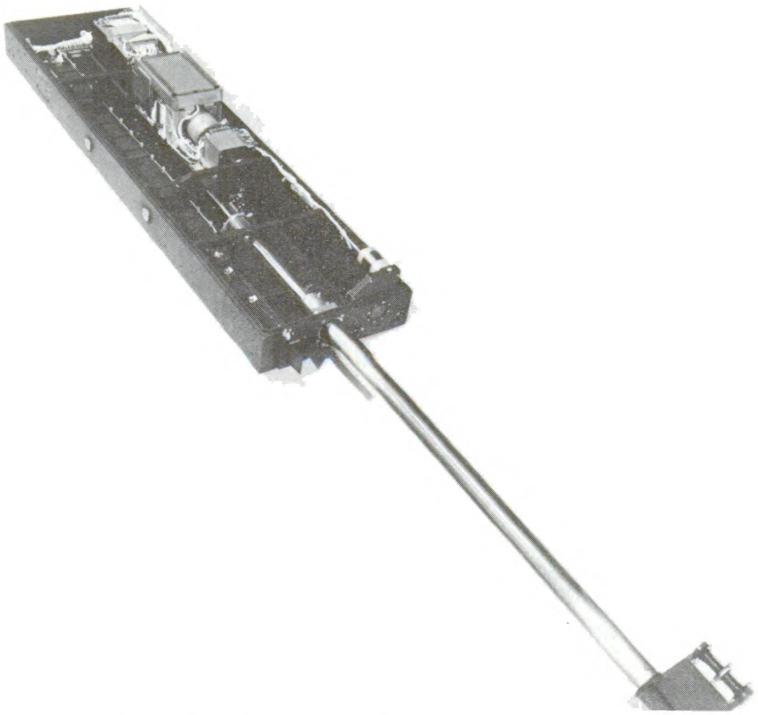


Figure 1 — NRL's white light coronagraph with occulter boom extended

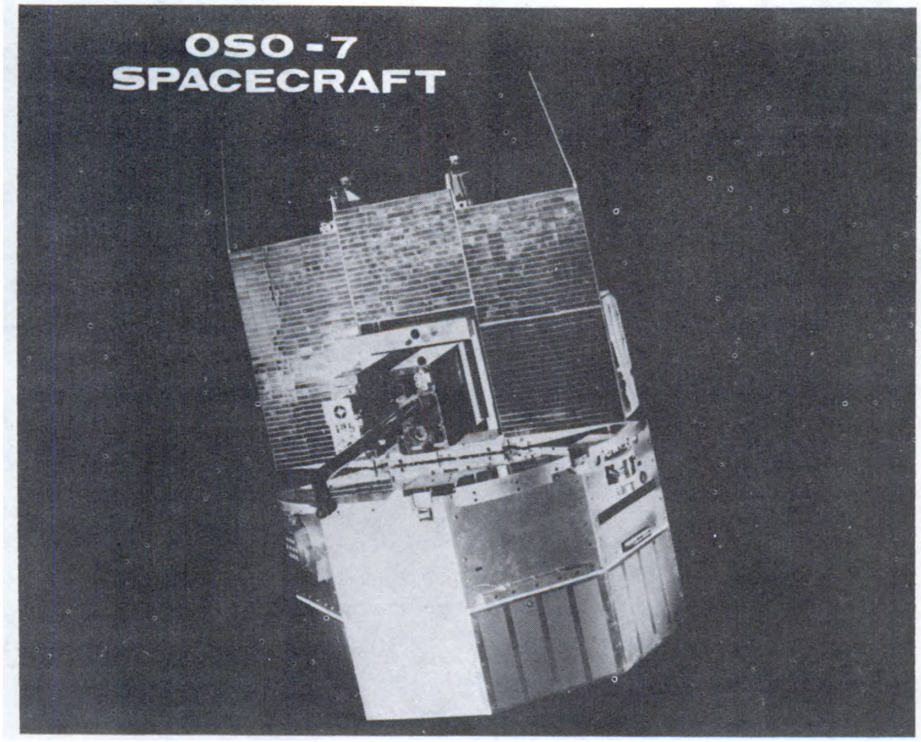


Figure 2 — OSO-7 spacecraft

shot some 2-1/2 million miles above the sun's horizon and were watched by the satellite coronagraph as they rushed through space at 600 miles per second.

The satellite observation was hailed as a completely new method for observing solar flares, explosive outbursts of the sun's atmosphere which cause such effects on earth as long distance radio communication blackouts, spectacular displays of the northern lights, and geomagnetic storms or disturbances of the earth's natural magnetic field. This new orbiting instrument method provides the potential of making earlier and better predictions of terrestrial effects caused by major solar activity.

In order to view the dim light of the sun's corona or outer atmosphere the NRL coronagraph produces an artificial eclipse of the sun within the instrument itself, making use of a small blackened disc held at an arm's length in front of the instrument to blot out the sun's direct light from entering the instrument. With the glare from the sun itself eliminated, and the bright sky no longer in the way at this high altitude, the sun's corona can be seen against the inky darkness of space an an immense halo of light, often streaked with bright rays called streamers (Figure 3). The T.V. "eye" behind the satellite telescope is a relatively new device called an SEC (Secondary Emission Conduction) vidicon. Built for NRL by Westinghouse, the SEC was integrated into a highly sophisticated digital electronic scanning system at the Electro-Mechanical Research Corporation's laboratories in Sarasota, Florida.

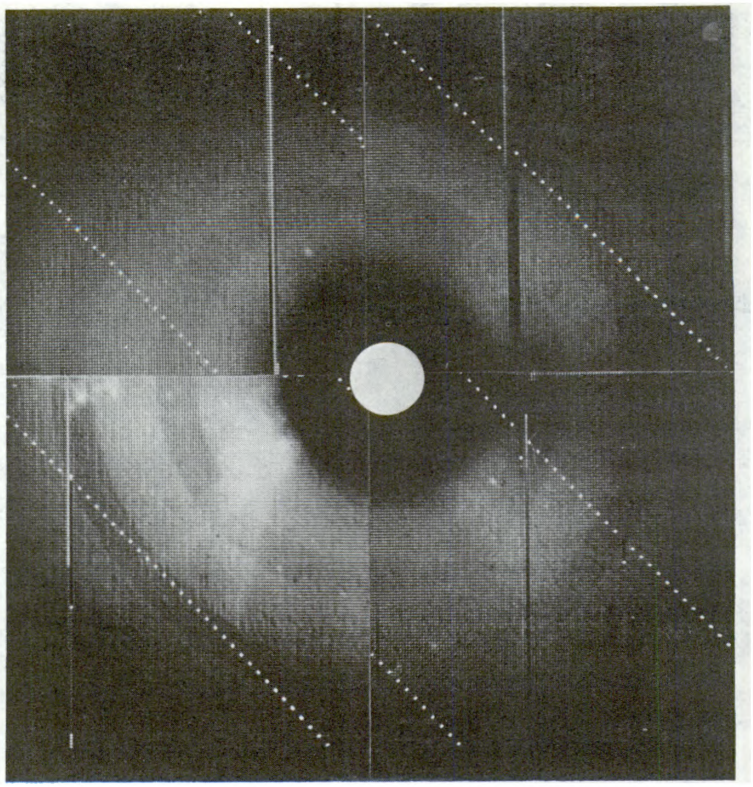


Figure 3 — The four quarters of a coronagram, telemetered to earth from NASA's Orbiting Solar Observatory (OSO-7) satellite on December 13, revealed the effects of a massive eruption behind the east limb of the sun (lower left).

The sequence of pictures recorded by NRL's coronagraph shows the development of the eruption over a period of about a day. On December 12, and at 1:32 AM (EST) on 13 December, an unusually bright streamer was present, which extended to at least 4 million miles, some 10 times the sun's radius. At 9:39 PM, the streamer was seen in a rapid state of expansion and intensification in the region one to three million miles above the surface of the sun, but collapsing beyond this point. Through the OSO Control Center at the Goddard Space Flight Center, NRL scientists commanded the instrument to scan, as rapidly as possible, the quadrant containing this streamer. An hour and half later three images were recorded at 11-minute intervals (Cover Picture). The picture taken at 9:39 PM (EST) shows the streamer apparently undergoing rapid disintegration. At 9:46 PM the observatory at Carnarvon, Australia, recorded a faint spray of incandescent gas (H-alpha surge) rising far above the solar horizon near the site of the streamer. Concurrently, bursts of radio waves were detected by observatories at Manila, in the USSR at Voroshilov, and at Calgoora, Australia. Material travelling at 600 miles per second, after having left the sun's surface at about this time, would have reached, shortly after 11:00 PM, the positions in which

two clouds are actually seen denoted by arrows in the picture for 11:07. The two following pictures (11:18 and 11:30 PM) show the clouds continuing outward from the sun at just this velocity. On the next day, December 14, only remnants of the original streamer could be seen.

These phenomena indicate that a major flare took place on the back side of the sun. Almost exactly two days later, rotation of the sun carried into view a new, bright, hot, active region having the proper location, probably the site of the flare.

The most spectacular of the many energized gas clouds that can be seen in the pictures are the two rising vertically, and marked with an arrow in the three images made 11 minutes apart. Each of these clouds was some 20 to 40 times larger than the earth. The kinetic energy is estimated to be of the order of magnitude of the total radiant energy released in a major solar flare. Converted to its electrical equivalent it would supply the electrical needs of the entire United States at the current rate of consumption for more than a million years. This energy could also be compared to the explosive effect of 100 million thermonuclear bombs.

For three days, the ejected gas clouds sped into interplanetary space, eventually reaching the earth's orbit, 93 million miles away. Had the flare occurred on the western edge (or limb) of the sun, almost certainly a great magnetic storm would have taken place on earth. As it happened, the flare was behind the east limb. The plasma clouds were not properly aimed to hit the earth full-on. Nevertheless, on December 17th large numbers of low-energy protons, ten thousand times the normal flux of solar particles, collided with the earth's magnetosphere. Although those striking in the vicinity of earth comprised only a minute fraction of the number released by the sun, the impinging particles dissipated more energy in the earth's upper atmosphere than a wind storm of hurricane proportions. During such times, when ejected solar gas encounters the earth's atmosphere, magnetic storms and bright auroral displays are common; even long distance telephonic communications may become impossible, and magnetic compasses can no longer be trusted for navigation. For flares of the greatest intensity, high energy protons may penetrate the earth's upper atmosphere, producing hazardous conditions for astronauts and possibly for people travelling at high altitudes in supersonic transports.

On December 19th the Pioneer VI spacecraft, nearly 27 days out from the earth, registered the passage of high-energy protons 180 times the background count, with energies greater than 190 million electron volts. The most energetic cloud of coronal material had missed the earth and was speeding toward the outer planets of the solar system.

The sun is not always so active as it was on December 14th, but it is always volatile in that its atmospheric gas is escaping continuously,

producing a "solar wind" of charged particles. The solar wind blows fragments of comets into long tails which point away from the sun, and it creates the Van Allen radiation belts of the earth and of Jupiter. In reality, then, the solar atmosphere extends outward, however tenuously, to the orbit of the earth and beyond.

It is realized nowadays that the sun is nature's plasma physics laboratory where reactions are taking place that we have not yet been able to duplicate on the earth. The new pictures show nature in the process of conducting a great experiment. By observing all the phenomena that occur during such a series of explosions, we can learn much about the physical processes taking place at these extremely high temperatures, and under conditions that have not yet been produced in man-made plasma machines. Therefore, in addition to helping man understand and predict solar-terrestrial relationships, these studies can also provide clues to the problem of providing pollution-free energy sources through controlled thermonulcear fusion reactions.

There are three important aspects of these direct observations of highly energetic plasma clouds, ejected from the sun:

(1) First of all, their origin is not very well understood. It seems to be certain that high energy plasma clouds are very closely correlated to solar flares. But flares manifest themselves in many other ways. They show up as heating of the lower solar atmosphere, they produce high energy x-rays, and they produce radio waves generated in the outer solar atmosphere, the corona. Large flares usually occur in very complex sun spot groups which are the location of strong magnetic fields in the solar atmosphere. Many of these aspects of flares have been studied by astronomers in great detail either with telescopes from the ground or using space probes. Despite all these studies, it is not possible at the present time, to explain all the observations by means of one theoretical model of ı solar flare. Some people believe all flare energy comes from the lower solar atmosphere where strong magnetic fields govern all movement of the ionized material. They believe that annihilation of magnetic energy can produce a major flare.

Another theory points out that a flare is a giant discharge of electrical currents in the solar atmosphere, most closely likened to a bolt of lightning. But the electrical currents in the flare reach 100 billion amperes.

Material condensing from the solar corona downward to lower, more dense regions causes the flare phenomenon in another flare theory, proposed recently.

This first synoptic observation of the outer corona during a flare will have an important impact on flare theories, because it has shown that the changes in the corona during a flare are much greater than expected. Also, for the first time we are able to give an actual observed timing of

the events occurring during a flare. Surprisingly the coronal disturbance starts prior to all other changes, which, if confirmed, seems to rule out many flare theories.

Solar flares produce ionized plasmas with the highest temperatures which we can now observe, either in our laboratories or in space. Their study is therefore very important for obtaining a better understanding of the behavior of high energy plasmas.

(2) Secondly the direct optical observations make possible for the first time measurements of the number of particles moving outward from the sun in the plasma clouds. Furthermore we can determine the density because we see directly the dimensions of the clouds. When these clouds move through the corona, they have in front of them a "shock wave," like a fast-moving bullet in the earth's atmosphere. These shock waves cause the corona to emit radio waves, or radio bursts. The bursts change in frequency when the shock waves move through coronal material of varying density. Because we now know precisely the properties of these clouds, for the first time we can calculate their influence on the corona and check the theory of radio burst generation in the corona. It is a routine procedure today to observe these radio bursts. Perhaps it will be possible to establish a much better quantitative correlation between radio bursts and material movements than exists today, which would clarify the interpretation of these radio events.

(3) Finally, the detailed study of this event should reveal much more about the relationship between events in the earth's magnetosphere and activity on the sun. As pointed out earlier, a proton enhancement was observed at the earth, but according to existing theories, a high energy clouds actually left the sun on quite different paths than those intersecting the earth's orbit around the sun. The relationship between solar flares and enhanced radiation around the earth has puzzled scientists very much. For the very large events, there is a clear-cut correlation. But for the numerous small events the relation to changes in the radiation belts is not so well established. A detailed study of this particular event should show that the disintegration of the streamer disperses enough plasma clouds in all directions, so that some of them will intersect the earth. This can almost be seen in the pictures. The plasma clouds hitting the earth can hardly be those ejected radially from the solar surface. But they could be coming from the streamer which appears to be exploding in many directions.

The new and unique character of the observations reported here, together with the fact that solar activity associated with very large events manifests itself in many different ways and at widely distant points on earth, have combined to make prompt announcement of the solar event of 13 December difficult. Even now, all correlative observations are not yet available, and a complete understanding of the pictures obtained will require long and intensive study.

Aircraft Crashworthiness

Lt. David Laananen
Office of Naval Research
Structural Mechanics Program

The ONR Structural Mechanics research program in aircraft crashworthiness is directed at providing a sound technological basis for design improvements in Navy and Marine Corps aircraft which will reduce the rate of fatalities and serious injuries resulting from aviation accidents.

In an initial phase of the program, a survey of the Navy/Marine Corps crash environment was conducted. Whereas the majority of studies of military and civilian aviation accidents have been directed at causes of the accident, this effort examined the causes of occupant injuries and deaths and identified areas for possible improvement in structural design. Information was obtained from a search of the available literature; examination of accident reports at the Naval Safety Center; and interviews with safety officers, rescue crews, and survivors at a number of Naval Air Stations. One of the areas which has been shown to merit further consideration is that of injury to body extremities caused by impact with cabin structure or objects within their dynamic research. In fact, approximately half the injuries which occur in serious but survivable accidents are of this type. Head injuries occurred in half the survivable accidents to one or more of the occupants. Surprisingly, and not evident from prior studies, an equal number of leg injuries occurred. Even though not all these injuries are serious in themselves, they may interfere with the occupant's ability to escape the stricken aircraft. The data show the primary importance of the ability to escape when it is considered that, of the deaths which occurred in the survivable Navy helicopter accidents surveyed, half were due to drowning (or recorded as lost at sea) and nearly another quarter were caused by burns. Therefore, the protection of an aircraft occupant's head and limbs consititutes an important part of this crashworthiness research program.

In order to determine exactly where design changes are needed and to quickly evaluate proposed modifications, a computer simulation model of an aircraft occupant would be a valuable aid. Such a model, if it accurately depicted the occupant's motion during a crash, would facilitate a greater number of design iterations and reduce the expense of model testing by reducing the number of tests and simplifying instrumentation decisions. Although a number of digital computer simulation models exist, nearly all have been developed for analysis of automobile passenger response during a collision, and all have their shortcomings in actual human body response. As part of this research program in crashworthiness, a simulation model of Naval aircraft occupants is being developed from the existing programs. These programs will be compared against each other and with experimental data from tests involving both live subjects and human cadavers. The model which best simulates the crash victim will be improved, if necessary, from the standpoint of numerical quality, documentation quality, and output display. The program will then be modified to better represent characteristics of selected Navy aircraft and to permit simulation of such new design features as crashworthy seats and airbags.

Work under another project will provide the human body response data required for evaluation and improvement of the simulation model. The effectiveness of human cadavers in providing accurate data will be evaluated by comparison with existing data on response of live human volunteers in the lower acceleration range. Tests of human cadavers in actual Navy seats subjected to more realistic crash pulses will then be used in development of the simulation model and in evaluation of protective devices suggested by other contractors.

Problem areas will be determined and possible solutions suggested from an examination of certain Navy and Marine Corps aircraft, selected on the basis of their numbers in service and the number of deaths and major injuries which have occurred in them. Information from accident and medical reports for these aircraft will be studied in depth to relate the injuries to strike zone objects and cabin or cockpit structure. Each of these injurious impact points will be studied, and based on estimated impact velocities, possible schemes for correction, such as changes in structural design or addition of padding, will be studied. As for protection against leg injury, an important problem area which could be made more serious through the incorporation of energy-absorbing seat systems, the effectiveness of minor modifications to the control pedals and the feasibility of using an airbag system, considering weight, space, and cost, will be examined. In addition to corrections at probable points of impact, the seat systems in the selected aircraft will be studied from the points of view of their tie-down strengths, energy-absorving capabilities, and restraint harnesses. Close coordination of this work with the projects on occupant simulation and human body response should yield the most useful model and sound retrofit recommendations.

Because head injuries occur frequently in aviation accidents, and because procedures for helmet design are relatively crude from an engineering point of view, more accurate information on head injury is needed for design of head protection devices. Research into the mechanisms of concussion and skull fracture and the development of predictive procedures for determining skull and/or brain damage as a function of loading conditions should provide such information. A linear elastic finite element analysis has been performed on a model of the skull. Results, consistent with experimental observations on fracture in cadaver skulls, have suggested that the human skull's resistance to frontal loads is approximately 2.5 times its resistance to side loads. Extension of the analysis to dynamic loading should provide a sound basis for design of helmets without unnecessary weight.

Results of the previously mentioned survey of the Navy crash environment has shown that very few accidents involving jet aircraft are of the type where improvements in structural design of the aircraft itself can result in increased crash survivability. The most significant reason for this conclusion is the use of ejection seats before impact. However, certain low altitude, low velocity situations may preclude ejection or bail-out. In such cases of hitting the water during a carrier takeoff or landing or a hard landing on an airfield, keeping the pilot conscious to allow him to escape immediately is critical. One possible solution to this problem is the use of an inflatable collar to prevent the forward "whiplash" which can easily cause blackout. The feasibility of using such a device, similar in concept to the airbags suggested for automobiles, in Naval aviation is being examined both at the Naval Air Development Center and by

an ONR contractor. Such a device could be activated manually, as part of the takeoff or landing routine, or automatically, on impact.

A study of Naval helicopter accidents has revealed the almost certain tendency of the aircraft to roll inverted after a water impact as soon as rotor RPM is lost. Such an inversion makes escape difficult by making exits inaccessible or by trapping passengers under shifting cargo. An investigation of the stability of helicopters is underway with the intent of examining the feasibility of various anti-roll flotation systems to alleviate this problem.

Another very important area for achieving improved crash survivability involves crashworthy design of the airframe structure itself. Principles for crashworthy design involve, chiefly, ensuring that a protective envelope surrounding the occupants is maintained during a crash and allowing the bottom structure to deform in a predictable, controlled manner to attenuate the impact loads experienced by the occupants. Efforts to improve the crashworthiness of basic airframe structure have been stifled by the belief that any significant improvement in airframe crashworthiness must be accompanied by increases in structural weight. Based on the state-of-the-art of plastic analysis and design, this belief is not necessarily true, and further research should indicate the extent of crashworthiness improvement possible with minimal or no weight penalty.

NRL Scientists Patent Method to Control Silicone Antifoam Agent

Paul R. Gustafson, a scientist with the Naval Research Laboratory's Chemistry Division and his co-worker Roman R. Miller, who retired from NRL recently, have been granted a patent on their development of "Foam-Inhibited CO_2 Regenerative Amine Absorbent Compositions."

In speaking of their success, the scientists related that the effective foam control life of silicone antifoam composition is extended by including aminoalkanesulfonic acids and their salts.

They added that even greater antifoam protection is provided with their method by further addition of a glycine compound or salt to the composition. Addition of the novel compositions of this invention to nonoethanolamine scrubber solutions appreciably increase the effective life of such solutions over that which is possible by using a silicone antifoam agent alone with respect to its foaming.

Mr. Gustafson said the invention could be important to the Navy, especially in submarine operations, where silicone compositions are used to cleanse the atmosphere in the subs by "scrubbing" or removing carbon dioxide. He added that, as a spinoff, this method could have valuable used in the food, brewery or other industry where additional foam control is desired.

The invention may be used for governmental purposes without the payment of royalties to the inventors. Patent number is 3,585,1500.

On the Naval Research Reserve

NRRC 12-2

Among the recent lectures at NRRC 12-2 was one on a new method of heading-off potentially fatal heart attacks presented by CDR Robert L. Chapman, USNR, who is a member and former Commanding Officer of NRRC 12-2. CDR Chapman is co-inventor of the Ventricular Impulse Detector and Alarm (VIDA). This is an electronic device for continuous monitoring of cardiac sufferers during their normal daily lives. It sounds a warning if certain changes occur in the heart's electrical activity of the type which can precede ventricular fibrillation. Virtually all suddent death attacks are of this type. CDR Chapman also described the normal cardiac function and how coronary artery disease and other high-risk factors can trigger heart attacks. He explained how early warning can allow time for preventative life-saving treatment. At their request, CDR Chapman later delivered the same talk to NRRC 12-5 in Berkeley.

By modulating an audio carrier wave, VIDA also provides for transmission of the user's electrocardiogram through an ordinary telephone circuit. Using a special receiving instrument called a Vidagraph, a physician can record the EKG and give immediate advice to his patient regardless of location. Last November an associate of CDR Chapman's, using a VIDA heart monitor, successfully transmitted his electrocardiogram from an office building in Frankfurt, Germany to the Anaheim Convention Center near Los Angeles, California, during the annual meeting of the American Heart Association, a distance of 9,000 miles.

NRRC 12-3 Contributes

On the community scene NRRC 12-3 has participated on such projects, as judges in the Science Fair Contest for Santa Clara County and as individuals in various community projects such as the restoration of the Billy Jones Wildcat Railroad in Los Gatos.

Contributions to the Active Forces has included ACDUTRA assignments by members of the unit to commands such as: Destroyer Development Group in Newport, Rhode Island; Naval Ammunition Production Engineering Center, Crane, Indiana; and U.S. Naval Ammunition Depot, Hawthorne, Nevada.

NRRC 12-3 is working with the Naval Post-graduat School in Monterey, California to support the research activities of several academic departments. Many electronic computer and management skills of Research Reservists can be applied in a research support role for

investigators at naval laboratories. In view of this fact NRRC 12-3 has pioneered a novel support role at Naval Post-graduate School in physics, computer science and electrical engineering. As experience in this support activity is gained, new contributory activities at other institutions will be undertaken.

Practical Support from NRRC 12-5

Like most other units, NRRC 12-5 on the Berkeley Campus of the University of California is composed of officers trained in many disciplines. These specialists are being tapped by various Naval activities in the area as consultants. As such, they are used to handle special projects which cannot be undertaken by the resident staffs. In this way the Navy Department is able to provide practical local billets for specialist officers who desire active duty for training but for whom funds are not available. Some of the projects continue throughout the year as appropriate duty.

The Unit has been divided into Biological and Physical Science Committees. The committees meet to discuss the technical problems involved in their support projects and gain the advantage of the experience of other members. At the same time Unit members gain by being kept abreast with what is new in naval research at these activities. The volunteer team approach not only assists the activities involved but helps engender interest of the junior officers in feeling a part of the active Duty Navy. With backgrounds ranging from opthalmology to natural gas distribution, the Unit is able to handle a wide variety of referrals.

NRRC 12-6 Provides Judges for California Central Valley Science Fair

CAPT A. H. Smith and LCDR F. T. Schlamp of NRRC 12-6, Davis, California served as judges for the Navy Science Cruiser Award division of the California Central Valley Science Fair in Sacramento. The criteria for selection of the winning award was established by Smith and Schlamp to include experimental and analytical aspects of the research results and the effort, creativity and method of presentation of the exhibit or model.

Although failing to get the nod as the most outstanding Research Company nationally, the Davis Unit ranked high and was recently given a "Well Done" along with other finalists by Admiral Holmquist. The Unit's current C.O., CDR David R. Storm, has vowed to wrest the award from this year's winner, San Diego, NRRC 11-5 and in so doing keep the award in California.

CDR Hartbower recently returned to Russia as the National Academy of Sciences exchange welding technologist to the USSR. Commander Hartbower observed that the USSR had advanced significantly in heavy plate welding since his earlier exchange visit in 1961. He also was aware of great cultural and social changes which have taken place in the same period.

Annual Saturday Symposium Trends in Naval Aviation

Once a year the Naval Postgraduate School (NPS), and two California Research Reserve companies—NRRC 12-8, Monterey and NRRC 12-3, Sunnyvale—sponsor a symposium at the NPS on a topic of current interest to Naval Reservists in the Twelfth Naval District. This year's symposium, which provided insight and information on Trends in Naval Aviation, was attended by 184 officers including one of flag rank. Most of the attendees to the classified symposium were USNR officers with a few USMCR, USAFR, USAR, and USN.

Topics and speakers were as follows:

Moderator: Professor Allen E. Fuhs* (CDR USNR)

Aircraft	
F-14	LCDR Ron Heisman*
S-3	Professor Howard Power
Harrier	Professor Max Platzer
Advanced Deck Launched Interceptor	Ensign Gus Hokenson
Missiles	
Phoenix	Professor Hal Titus
ARM	Mr. Charles May, NWC
Shrike	Mr. Richard Mello, NWC
Technology	
100 Knot Navy	Professor Donald Layton
ASW	Professor O. B. Wilson* (CDR USNR)
Composite Materials	Professor Robert Ball
High Power Lasers	Professor Dan Collins
Holographic Techniques	Professor Dan Collins

*Members of NRRC 12-8.

NRRC 8-3 Seminar

NRRC 8-3 of College Station, Texas hosted a weekend seminar on the topic of "Crime and National Security." The featured speaker and chairman of the program was Mr. W. D. Kutach, Assistant Director for Rehabilitation, Texas State Department of Corrections.

Mr. Kutach presented a most enlightening program based upon the methods he helped to pioneer in the State of Texas for transforming convicted criminals from liabilities into productive members of society. The program also included Dr. John Holbrook, Psychiatrist with the Texas Department of corrections, who discussed the Profile of a Criminal, and four inmates of the Texas prison system who are interned for narcotics crimes and who related their history and experiences which led in involvement with drugs. The program also featured CAPT George Sult, USN of the Department of Defense and CDR John Brennan of the Bureau of Naval Personnel, who made presentations concerning the state of the narcotics problem in the Navy and the other Armed Forces.

Lunar Soil Study

Scientists at the Naval Research Laboratory studying moon soil samples believe they have proved that lunar soils have been oxidized to some extent in the nearly-nonexistent lunar atmosphere.

All lunar soils returned by Apollo astronauts have displayed a "characteristic" resonance when examined by a technique called electron spin resonance spectrometry. Scientists had felt that the "characteristic" resonance could arise from either oxidized iron or from iron metal; and since metallic iron had been found in lunar soils with little evidence of high oxides, the "iron metal" hypothesis became the generally accepted one.

Now, by oxidizing a powder of simulated lunar glass, NRL moon scientists have produced for the first time in the laboratory a resonance resembling the "characteristic" resonance of lunar soils. And, when comparing their data with the chemical analyses of other investigators, they discovered a positive correlation between the spectral linewidth of the "characteristic" resonance and the amount of titanium dioxide (TiO_2) in the soil.

The NRL scientists are now convinced that their findings show conclusively that the "characteristic" resonance arises from chemical compounds involving TiO_2 and Fe_2O_3 (ferric oxide) produced by oxidation of fine soils in the lunar environment.

Detailed results of this work was submitted for publication in the Proceedings of the Third Lunar Science Conference held in mid-January.

Research Notes

Navy Study Isolates Organisms that Feed on Oil

A Navy study has isolated and identified a number of species of marine microogranisms that specifically biodegrade or feed on oil, bringing closer the possibility of accelerating the removal of oil through biodegradation.

A study at the Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California, under the direction of Dr. T. B. O'Neill, supported by the Office of Naval Research (ONR), has been able to identify 62 different species that thrive on oil by oxidizing it. In laboratory tests the presence of oil sharply increased the population of these species.

The Navy is seeking means of speeding up the dissipation of oil slicks by stimulating the biodegradation process. Although oil can be removed from the surface of the water by skimmers, much of it sinks to the bottom or is absorbed by beach sand and can only be removed by oil-oxidizing bacteria.

Species of oil-consuming organisms have been identified previously, but the NCEL study has resulted in the largest number by far to be isolated. Since it is a combination of species that achieves the most efficient biodegradation of the oil, it is now possible to conduct experiments to determine the most effective combination in dissipating oil, especially Navy fuels.

Further research will also seek to analyze the media and environmental conditions that increase the oxidizing ability of organisms as well as to identify more species of bacteria that degrade oil. Stimulating the ability of microorganisms to degrade oil will vastly increase the microbial population. Since this microbial population is the beginning of the food chain in the sea, a side benefit of the study would be to provide an increased food supply for higher levels of marine life.

European Undersea Biomedical Society

On 30 September in the Marcus Beck Library of the Royal Society of Medicine in London a group of scientists and physicians interested in diving research founded the European Undersea Biomedical Society. Prof. Carl M. Hesser of the Department of Physiology of the Karolinska Institute in Stockholm was made president by acclamation. Dennis Walder, Prof. of Surgical Science at the University of Newcastle upon Tyne was elected Vice-President and Surgeon Commander Peter Barnard of the Institute of Naval Medicine and the RN Physiological Laboratory in Alverstoke was made Secretary-Treasurer. Other officers are J. H. Corriol, Prof. of Physiology in the Medical School of Marseille, Dr. Xavier Fructus, Scientific Director of the COMEX Company in Marseille, Surgeon Captain Klaus Seemann of the German Naval Medical Institute in Kiel-Kronshagen, Dr. Paul Paulev of the Institute of Medical Physiology in Copenhagen, and Surgeon Captain John Rawlins, Director of Medical Research in the Royal Navy.

The European society was first seriously discussed at the second diving physiology conference in Marseille last July. It arose out of a desire to continue such meetings as a regular event in Europe. The new organization is very similar to the Undersea Medical Society in the United States to which it has a number of very close ties. For example, Dr. Peter Bennett of Alverstoke is a member of the Program Committee of the UMS for the Underwater Physiology Symposium in the Bahamas next August and is also Chairman of the Membership Committee for the European society. The founders and officers of the new group are not only individual leaders in diving research but together they represent all the major national groups working in this field in western Europe. A few continental members expressed a private hope that the new society could become a forum for a truly pan-European scientific communication in diving.

New Phosphazene Polymers

The Navy needs high performance polymers which are thermally stable and fire resistant. Polymer technology has produced a number of new "high performance" polymers in recent years, but few possess both thermal stability and fire resistance. The polymers which have these properties are usually costly and difficult to process on conventional equipment.

A new class of inorganic high molecular weight polymers having Phosphoros Nitrogen (PN) backbone has been synthesized. The successful synthesis of stable polyphosphazene polymers is one of the most important developments in the field of inorganic polymers since the development of silicones. Past research investigations, both in house and contract, have produced many new polymers, but none of the materials developed prior to phosphazene polymers have achieved the combination of low cost, chemical inertness, high temperature stability, fire resistance, and low temperature flexibility that researchers have sought.

The synthesis of polyphosphazenes is relatively straight forward. The starting material for synthesis is hexachlorocyclotriphosphazene which can be prepared by the interaction of phosphorus pentachloride and ammonium chloride. Polymerization of the cyclic trimer under controlled conditions brings about a high conversion to the linear high polymer. This material is soluble in benezine or tetrahydrofuran, and can be subjected to substitution reactions in solution. Organo substituted products can be prepared by reaction of the chloro polymer with alkoxides, aryloxides, and with primary or secondary amines.

The properties of the polymers formed by this synthesis are unique. When OR is phenoxy, trifluoroethoxy, methoxy or ethoxy, the polymers vary from transparent polyethylene-like plastics to white rubbery elastomers. The polymers have initial decomposition temperature of 300°C in air and some polymers are non-flammable even in an oxygen atmosphere. The polymers appear to be unaffected by immersion in boiling water, concentrated mineral acids and various bases such as potassium hydroxide. The solubility of the polymer in various solvents varies with the substituant side group.

It has been determined through the use of viscosity, osmometry and light scattering techniques that the phosphazene elastomers have exceptionally high weight average molecular weights, often values of Mw greater than 10^7. High molecular weights undoubtedly contribute to the strength of the elastomeric products. Tensile strengths, of the cured phosphazene elastomer, have been reported as high as 2300 psi with elongations above 300 percent. The polymers also have unusually broad molecular weight distributions—the ratio of weight to number average molecular weights (Mw/Mn) greater than 16 and sometimes as large as 100, meaning that each polymer sample is composed of molecules with widely varying sizes and properties. The broad polydispersity (Mw/Mn > 16) suggests that the polymerization mechanism is largely due to factors other than chain branching. Gel permeation chromatography is being used to better understand the polymerization mechanism.

Since contract work has demonstrated that large scale synthesis is feasible, it is anticipated that pilot plant quantities of this material will be available by mid FY 73.

The Navy has many critical applications for phosphazene polymers including hoses, O-rings, gaskets, electrical potting compounds, coatings, wire coverings, tires, thermal insulation, acoustic damping material *etc*.

Acknowledgment

The synthesis work outlined above is being conducted by Horizons Research Inc., Cleveland, Ohio. This program is under the joint sponsorship of the Army Materials and Mechanics Research Center (AMMRC) and the Naval Ship Systems Command (SHIPS 03421).

The polymer characterization described herein was performed at AMMRC by Dr. Gary L. Hagnauer and the work regarding the relation of synthesis to molecular structure is being performed also at AMMRC by Dr. Robert E. Singler (Capt. U.S. Army).

1971 Nobel Prize Winner Associated with ONR

Dr. Dennis Gabor has been awarded the 1971 Nobel Prize in physics for his discovery of holography in 1948. Although never an ONR principal investigator, he had had indirect association with the Office of Naval Research since 1968. He was involved with ONR studies in Acoustical Holography, which is perhaps an order of magnitude more difficult to realize than optical holography. The main reason is the difficulty inherent in the conversion of the acoustical signal to a visible display.

During 1968, a project entitled "Underwater Holographic Imaging" was supported by ONR at CBS Laboratories, Stamford, Conn. Dr. Gabor was a consultant to CBS four days a week for six months of the contract period. In fact, he performed a considerable share of the work, and designed an annular array of 360 hydrophones three meters in diameter for sensing the underwater acoustic signal. Such an array would have many properties of a single sensor

of the same diameter, and would have been used in a holographic system using acoustic waves rather than light waves for underwater viewing.

The fifth day of the week while he was in the United States that year Dr. Gabor served as visiting professor at the State University of New York at Stony Brook. There he worked with Professor G. W. Stroke, principal investigator for another ONR research contract entitled, "Synthetic Optical Methods."

The CBS contract terminated at the end of 1968. People from CBS, including Dr. Gabor, made a report on the contract to RADM T. B. Owen, then Chief of Naval Research, and other ONR personnel in December 1968.

Dr. Gabor still divides his time between England and Stamford, where he remains a consultant to CBS. His 1948 discovery had to await the invention of the laser in 1960 in order to find widespread use. A hologram, or whole picture, has the form of a complicated diffraction pattern. It contains information concerning both the amplitude and the phase of light from an object. This phase information is present because of the use of coherent (laser) light and gives the picture reconstructed from the hologram a three-dimensional quality.

NRL Develops Weld Material for Radiation-Resistant Steel Structures

Scientists at the Naval Research Laboratory have developed a radiation-resistant filler metal for submerged arc welding A533-B steel, which has been proved with a commercial-scale test weld.

The major alloy content is similar to that of the low-alloy welding composition now used for reactor vessel fabrication.

Extensive pre and postirradiation test exposures of the weld metal have revealed that all performance requirements set for the new composition have been satisfied.

It has already been demonstrated through Laboratory tests that tonnage quantities of radiation-resistant steel can be produced commercially. Now, with the development of the weld composition, NRL scientists feel that the full radiation-resistant potential in large welded structures soon will be realized.

Scientists Study Steel Stress Corrosion Inhibitors

Scientists at the Naval Research Laboratory (NRL) are studying the action of chemical inhibitors of stress corrosion cracking of AISI 4340 steel, and have found that such cracking in boiling KNO_3 solution is more efficiently prevented by a suitable combination of complementary or synergistic inhibitors than by either inhibitor alone.

Examples of the effect are inhibitor pairs consisting of $NaNO_2$ and a basic compound such as NaOH, Na_2CO_3, Na_3PO_4, or Na_2SiO_3.

Test results indicate that as inhibitor concentration was increased, the change from negligible protection to full protection occurred within a relatively narrow range of inhibitor concentration.

Although these inhibitors are presently being used to prevent surface corrosion in steel, NRL scientists are studying their possible application to the hydrostatic testing of high pressure steel vessels.

Alvin Returns to Service

In June 1971, *Alvin,* the Office of Naval Research's deep research submersible, was returned to service after an extensive overhaul. A total of 75 research dives were made in support of oceanographic and deep ocean technology research. Areas of investigation included the Gulf of Maine, the Straits of Florida, and the Tongue of the Ocean in the Bahamas.

Alvin, which is 23-feet long with an eight foot beam, is designed to operate at depths as great as 6,000 feet. Its deepest dive has been 6,242 feet. The submarine displaces 13 long tons and has a draft of eight and a half feet when riding on the ocean surface. It has a top speed of about eight knots and a cruising speed of 2.5 knots. Its range is 20-25 miles.

Alvin has a steel pressure sphere made of high strength steel which is 1.33 inches thick. It is slightly less than seven feet in diameter. There is room in the sphere for a pilot and one or two observers together with instrumentation and life support equipment. The sphere can be released from the hull and, being buoyant, will float the personnel in *Alvin* to the surface in an emergency. By 1973 the steel sphere will be replaced with a titanium pressure sphere that will give *Alvin* an operating depth of 12,000 feet. Although the titanium sphere will be 1.9 inches thick, it will be about one ton lighter than the steel sphere. *Alvin's* outer skin is made of reinforced fiber glass, which is not subject to pressure.

Alvin has four viewing ports to see ahead and beneath the vehicle. The only openings in the hull are the hatch and an emergency sphere release. All other connections between the inside and outside of the sphere are electrical, with the wires passing through specially designed fittings. The power for the vehicle comes from three conventional lead-acid batteries located in external packages that may be dropped in an emergency.

Alvin is driven by three propellers, which are controlled by a "joy stick" inside the sphere. The main propulsion is provided by a large four-foot shrouded propeller located at the stern, which can be turned from side-to-side to steer the vehicle just as an outboard motor is steered. On each side of the craft is a small "lift" propeller that is rotatable up or down, ahead or astern. The two 14-inch lift propellers are also separately reversible to provide increased maneuverability. For example, the vehicle can turn on its own axis by reversing one and going ahead on the other. To control fore and aft angles of the vehicle a mercury trim system has been installed with allows trim angles as large as 30 degrees to be applied.

Alvin is also equipped with a mechanical arm for collecting samples from the ocean bottom as well as planting and retrieving instruments on the ocean floor. This mechanical arm has a "wrist" that can turn 360 degrees and extend a maximum of six feet. At its outer end are parallel jaws that operate like a thumb and forefinger. Extended six feet, the arm can lift 25 pounds straight up and down. It can hang onto 200 pounds. A magnet can be substituted for the jaws to pick up metal.

As compensation for differences in the weight of personnel and instruments as well as to provide up and down maneuverability, an unusual variable ballast system is included in the vehicle. This system utilizes inter-connected pressure-proof titanium (originally aluminum) spheres and collapsible rubber bags which

are both partially filled with oil. As oil is pumped from the spheres into the rubber bags the amount of sea water actually displaced by the vehicle is increased, thus increasing the buoyancy while the weight remains the same. The effect is to make the vehicle lighter. When oil is pumped from the collapsible bags into the spheres, the vessel becomes heavier.

By the end of 1971, *Alvin* had made nearly 400 dives. Perhaps its most famous feat occurred in 1966 when two American planes collided in the air and dropped a hydrogen bomb into the Mediterranean Sea off the coast of Spain. *Alvin* located the bomb, which had tumbled down a deep slope, in 2,500 feet of water. On another occasion *Alvin* lost and then recovered its own mechanical arm at a depth of 4,000 feet.

The submarine has been used for many scientific studies. It made a geological study and sampled the Blake Plateau Surface beneath the Gulf Stream current does reach bottom on Blake Plateau. *Alvin* aided in studies of fish schools. Other dives by the submarine established basic geological facts about the east coast canyons.

The important work *Alvin* had been doing came to a standstill in late 1968. *Alvin* was being launched from its mother ship *Lulu* when two wire ropes that lift the cradle parted and plunged *Alvin* into the sea. The personnel inside were able to surface, but *Alvin* finally sank to a depth of 5,051 feet. *Alvin* lay on the ocean floor for ten months before she was recovered by the Navy and then rebuilt. Her pressure sphere was still sound and was reused, but much of her skin had to be refabricated because of damage during the accident. The equipment inside the personnel sphere was not designed to be exposed to salt water, and new designs for *Alvin's* instrumentation and control system were produced.

Alvin was returned to service in June 1971 and is conducting dives in the North Atlantic and Caribbean.

NRL Development Marks Milestone in Time/Time Frequency Transfer

In future ages of supersonic flight, aircraft collision avoidance will not be a matter of minutes or seconds, but of microseconds. This is but one of the many vital considerations that has led the Navy to pioneer in the establishment of a worldwide time standard system that will be accurate within (literally) fractions of a second.

Refinement of the system recently led the Naval Research Laboratory to develop a new technique for the global transfer of time and time frequency standards by microwave and satellite that will keep the system synchronized to within an accuracy of 1 microsecond.

Robert R. Stone, NRL's principal investigator of the system, said that commercial outlets could have the use of the microsecond time accuracy throughout the world, such as telephone companies and airlines. If the airlines were to be tied into the system it would be possible to obtain synchronization of time to submicrosecond. This information to pilots could very well make the difference in the avoidance of mid-air crashes.

In addition, Navy officials are saying that the new system is of vital significance in major time-ordered electronics such as communications, navigation, weapons and ships.

Time transfer links, using this development, were established from Brandywine, Maryland, to Helemano, Hawaii; Hawaii to Guam, and Fort Dix; New Jersey, to Landstahl, Germany. The time transfer system is presently preparing its function.

Multiple entry transfer also has been established to Fort Dix and Camp Roberts, California, on the regular time transfer from the Brandywine to Hawaii link. All DSCS earth terminals will soon be similarly equipped to receive time transfer either on point and point links or on multiple entry basis.

The technique of using this system for clock comparisons accurately over large distances by the way of Defense Satellite Communications System was a concentrated effort by the Naval Electronics Systems Command, the Naval Observatory and the Defense Communications Agency, with Naval Research Laboratory scientists performing the research.

Officials concerned with the development report that the service is of interest to all major nations involved in the precise transfer of time and it will be available to commercial outlets. Calibration of clocks can be accomplished to submicrosecond accuracy for those that may want to take advantage of this service.

How It Works

Clock comparisons are made through the use of a highspeed pseudo-random code generated by special communication modems that are presently used at many of the Defense Satellite Communications Systems earth terminals.

While communicating, the code generated by the transmitter of one modem is matched at the receiver of the other, and signals are available from both modems indicating the states of their code streams. The state indications can be treated as though they were very short pulses transmitted by one modem and received by the other. Since DSCS satellites are in nearly synchronous orbits, the length of the communications path changes slowly. If the time signals are sent at roughly the same time, therefore, the signals transmitted in both directions experience nearly equal delays. Officials said therefore, if clock comparisons are made in both directions over a reciprocal path, the path length may be compensated by using half the difference of the two measurements. Using this system modem signals are measured in time relative to cesium clock outputs at each SATCOM terminal. A numerical figure is obtained at each terminal, and the difference between the figures represents the difference between the cesium clocks.

Saves U.S. Money

Officials report that the system of time/time frequency transfer now employed to major world time standard stations *via* the microwave/satellite method was completed and put into use at a very reasonable cost because the DSCS satellites were already operational and the microwave equipment was surplus to the Naval Research Laboratory.

In addition, when additional links to the new system are implemented it will eliminate most of the costs involved in the old method of physically transporting portable cesium beam clocks from the U.S. Naval Observatory for clock calibration at all standard stations, including the very remote ones.

Geology and Geophysics Studies in the Caribbean

The research vessel KNORR has departed from the Woods Hole Oceanographic Institution to conduct studies in geology and geophysics in the Caribbean Sea. Dr. Charles Hollister will lead a scientific party of 22, including 15 students from the Oceanographic Institution, Worcester Polytech Institute, Dartmouth College, M.I.T., and the Scripps Institution of Oceanography. The cruise is supported by the Office of Naval Research.

The principal scientific program of this voyage will be to recover approximately 10 large-diameter cores from the Antilles Outer Ridge, which will be studied to determine the origin of sediment in the area. Between coring sites, hydrographic casts will be made and bottom photographs will be taken.

The cruise will also feature the first deep-water giant coring experiment and the first attempt at taking large diameter cores over 100 feet in length from depths of up to 15,000 feet. The same rig was used successfully last year on the KNORR Cruise 10 to take a giant core in the Gulf of Maine but only from a depth of 250 feet.

The large mass of sediment deposited north of the Puerto Rico trench is approximately 200 miles long, 60 miles wide, and one-third mile in thickness. Previous cruises and investigations have indicated that this sediment may owe its shape and origin to the circulation of bottom currents.

In addition to taking the series of giant cores, a new profiling system will be tested and mapping of the sediments will be attempted. The hydrographic work will be carried out by Dr. W. Redwood Wright of the Oceanographic Institution's Department of Physical Oceanography. Other programs on the cruise will consist of sea-floor photography, large volume water sampling, and bathymetric surveys.

The launch and recovery of the experimental giant coring rig will be under the direction of Captain Emerson Hiller, skipper of KNORR, Jerry Cotter, the ship's Bos'n, and Alan Driscoll of the Institution's Department of Geology and Geophysics. The same team was instrumental in obtaining the first giant core in the Gulf of Maine.

The 245-foot KNORR was built especially for oceanographic research and is the newest of the five ocean-going research vessels operated by the Woods Hole Oceanographic Institution. An unusual propulsion concept utilizing cycloidal propellers fore and aft gives the ship extreme maneuverability with finger-tip controls. KNORR is the fourth ship to leave Woods Hole since the first of the year. The catamaran LULU departed on January 12 with the underwater habitat Edalhab for a three-month scientific investigation off the Florida coast; ALTANTIS II left on January 20 for a five and one-half month geological and geophysical study off the west coast of Africa; and CHAIN departed on January 29 for a month's study of buoy technology in the deep water currents of the North Atlantic.

A resident staff of more than 650 scientists and support personnel work at the Woods Hole facilities on Cape Cod in a wide range of studies of the world's oceans conducted by the Departments of Biology, Chemistry, Geology and Geophysics, Ocean Engineering, and Physical Oceanography.

NRL Scientists Study Techniques for Improving Satellite Power Sources

Naval Research Laboratory (NRL) scientists are working on techniques which permit the cooling of solar cells for satellites, thereby increasing their power and efficiency.

Researchers at the Laboratory say the techniques may well result in extending the lifespan of satellite power supply systems as well.

One technique consists of replacing fiberglass insulators on solar cell panels with a much thinner anodized aluminum insulation layer. The panel portions surrounding the solar cells are then coated with metallized teflon.

Another promising NRL technique is the soldering of solar cells to beryllium oxide ceramic slabs which have been metallized with a thin film of chromium and copper, and copper plated to the required thickness. Thermal stress between the solar cell array and the copper plated aluminum solar panel is absorbed by the use of indium solder.

Ongoing research continues at NRL using these and other techniques for improving satellite power source performance.

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NAVSO P-510

IN THIS ISSUE

VOL. XXV, NO. 1

The sequence of pictures recorded by NRL's coronagraph shows the development of the solar eruption over a period of about a day. A bright streamer, which indicates the eruption, extended to at least 4 million miles. *See page 8.*

DEPARTMENT OF THE NAVY
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