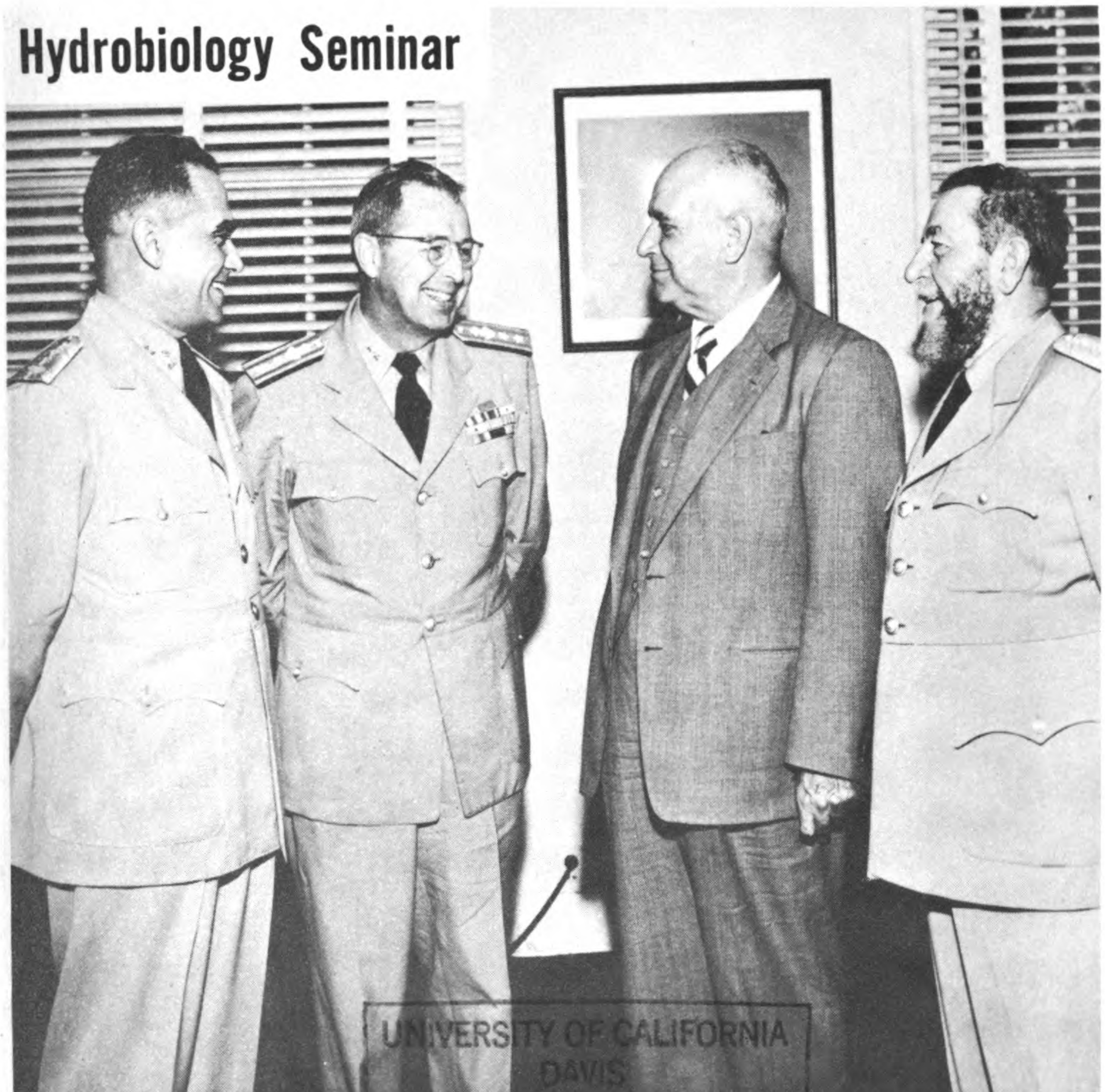
OFFICE OF NAVAL RESEARCH NOVEMBER 1954

RESEARCH REVIEWS

Hydrobiology Seminar

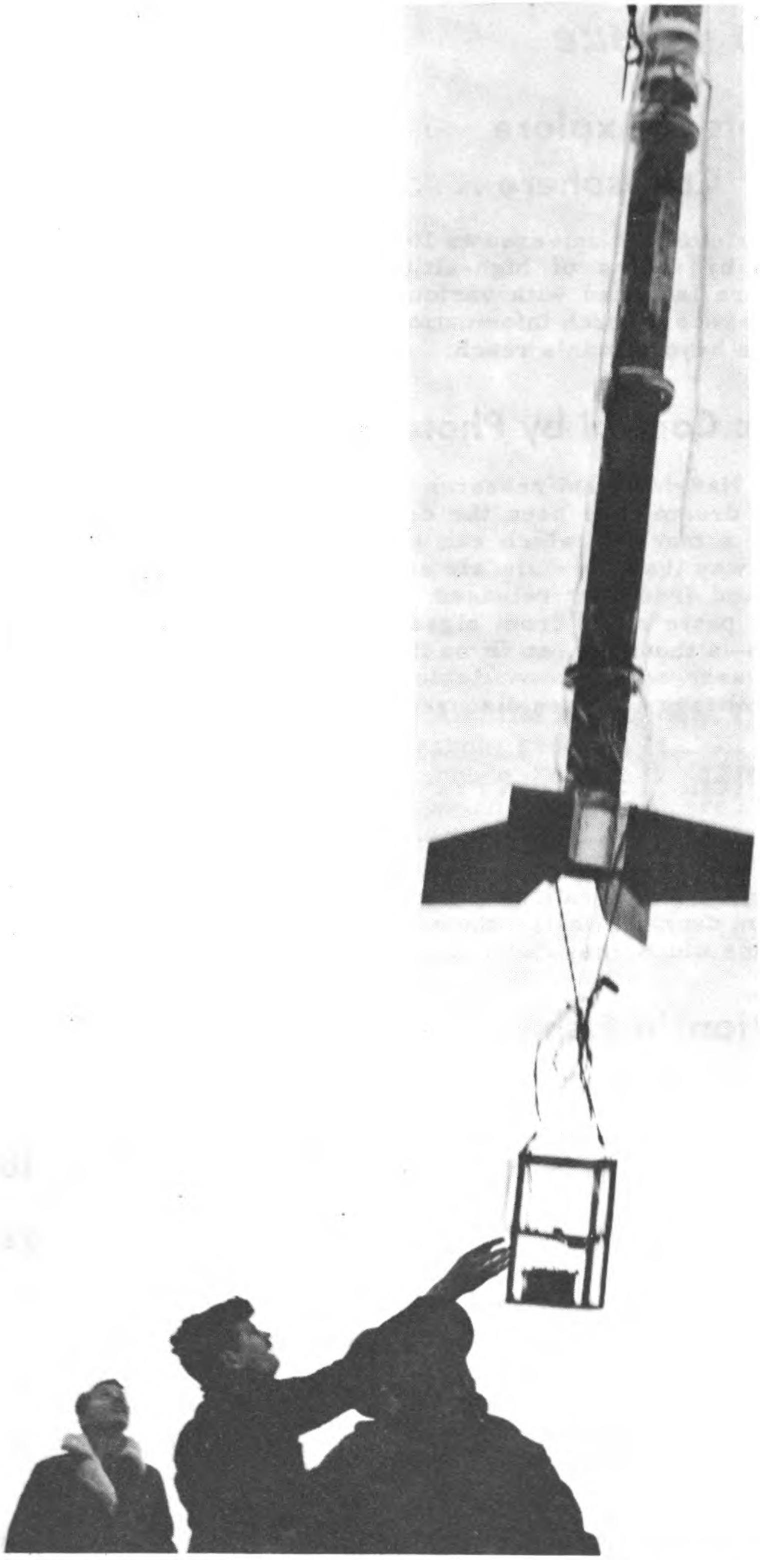


NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: REAR ADM Frederick R. Furth, Chief of Naval Research, greeting MAJOR GEN Rodolfo Sanchez Taboada, Secretary of Marine of the Republic of Mexico. Looking on are REAR ADM Antonio J. Aznar Zetina, Deputy Chief of Staff (left) and ADM Mario Rodriguez Malpica (right). GEN Sanchez and his staff attended a presentation of ONR's Hydrobiology Program.

In This Issue



Launching balloon-borne rockets to obtain atmospheric data.

Using Rockets to Explore the Upper Atmosphere

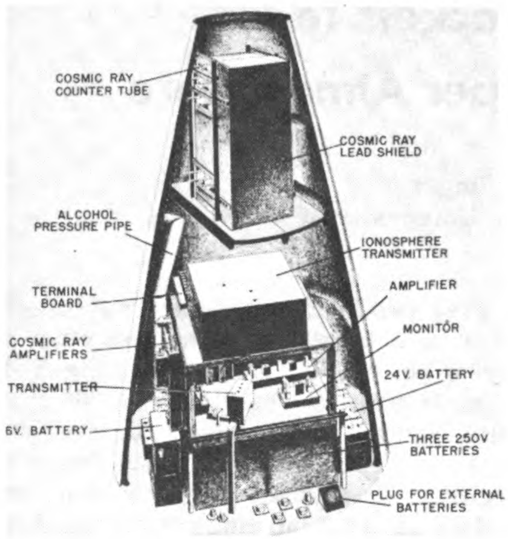
S. F. Singer
Department of Physics, University of Maryland

During the past eight years, over two hundred rockets have been sent into the upper atmosphere with scientific instruments to study a variety of phenomena there. They have ranged from the huge V-2 weighing 40,000 lbs, down to very small rockets weighing only 200 lbs. Launching sites included the White Sands Proving Grounds in New Mexico, ships at various positions in the Pacific and Atlantic Oceans, and even balloons in the arctic regions. One small rocket which was launched from the nose of a V-2 at the end of its burning period reached the peak altitude of 250 miles above sea level, the highest ever attained by a man-made object.

Many questions naturally arise concerning these rocket experiments. What is their purpose? How are they performed? What sort of results are obtained? The answer to the first of these questions lies in the fact that the atmosphere is transparent only to visible radiation despite the fact that we can see through it. The atmosphere is not transparent, for example, to the ultraviolet radiation coming from the sun. It is also well known that the ionospheric layers in the upper atmosphere will not transmit radiowaves but will bounce them back. Therefore, in order to study the radiations which are not transmitted through the atmosphere, one has to go above it and carry out measurements at very high altitudes.

Such studies have been done in a variety of ways and we know quite a bit by now about the emission of ultraviolet radiation and even X rays from the sun. This knowledge is very important; it not only reveals a lot about the various mechanisms which operate on the sun's surface and in the solar corona, but also the very profound influence exerted on our own atmosphere by these radiations. For example, they produce the ionospheric layers already referred to, which are so important for radio communication. Although most of the heat which we receive from the sun arrives in the visible range of the spectrum, the ultraviolet is important because it produces gases such as ozone in the upper atmosphere which tend to trap this heat near the earth, somewhat in the same fashion as the greenhouse traps heat by means of glass. We suspect, further, that the ultraviolet emission from the sun may have considerable influence on weather as we know it on the earth.

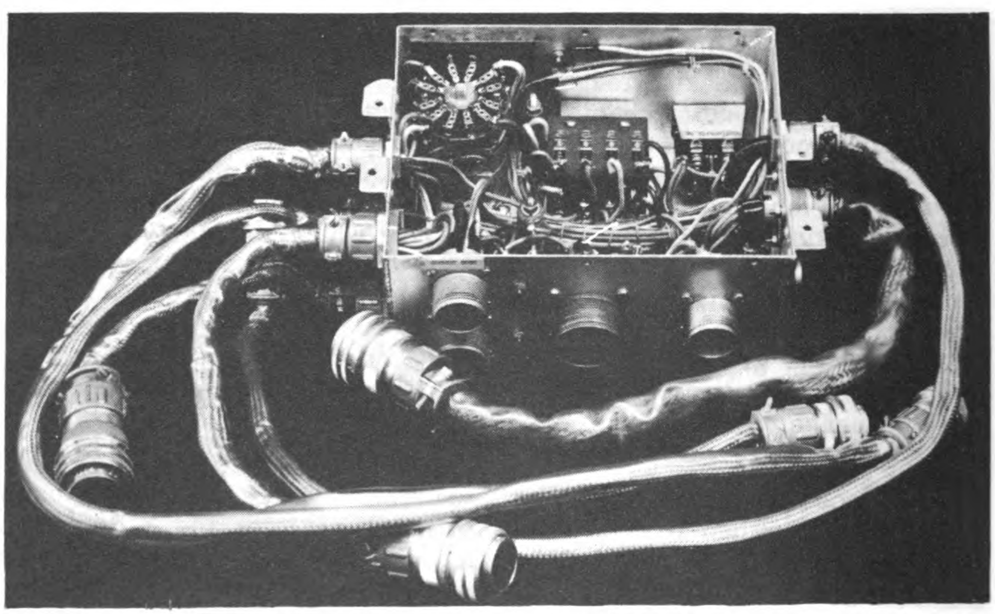
Although the sun appears to be a stable type of star, it is actually quite variable when it comes to emitting ultraviolet and X radiation. We believe that its output of ultraviolet radiation may change by factors on the order of 1,000 when the sun's atmosphere really becomes disturbed. Naturally, we would like to know more about these disturbing



Warhead instrumentation.

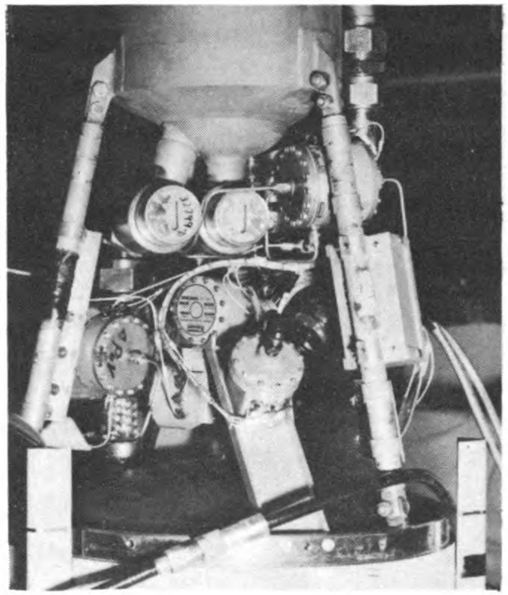
conditions. Here, however, appears the most important handicap of present-day rockets. It is true they can go to very high altitudes and therefore look at the sun directly and measure all of its radiations. However, they cannot stay up much longer than perhaps 3 to 6 minutes. And one would like to observe the sun for a period of perhaps several weeks in order to learn something about these solar disturbances. It is for this reason that astrophysicists, particularly those interested in solar physics, have become very much concerned with the possibility of building a rocket vehicle which will stay above the atmosphere for long periods of time. In other words, a rocket which would become an artificial satellite of the earth traveling around it in an orbit at an altitude of perhaps only 300 miles or so.

Another investigation which has been carried on with rockets is the study of cosmic radiation, particularly the primary rays, i.e., before they strike the atmosphere. These primary rays were investigated by placing observing instruments above the atmosphere. They have now been analyzed and are known to consist mainly of protons (hydrogen nuclei), helium nuclei, and nuclei of heavier elements, although the last form only one percent of the total number of incoming particles. These atomic nuclei travel at nearly the speed of light and carry tremendous



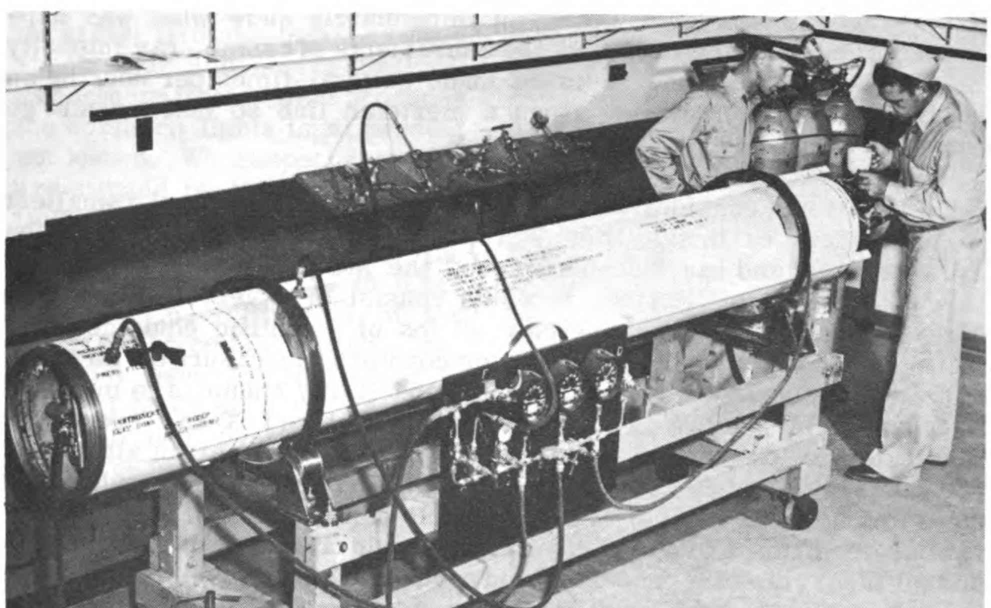
Distribution box-focal point of all electrical distribution and telemetering.

energies—on the order of thousands of millions of electron volts. How and where cosmic rays are produced is at present not known, although it seems fairly certain that the sun has a very profound effect on their intensity and may even produce a substantial amount of them.

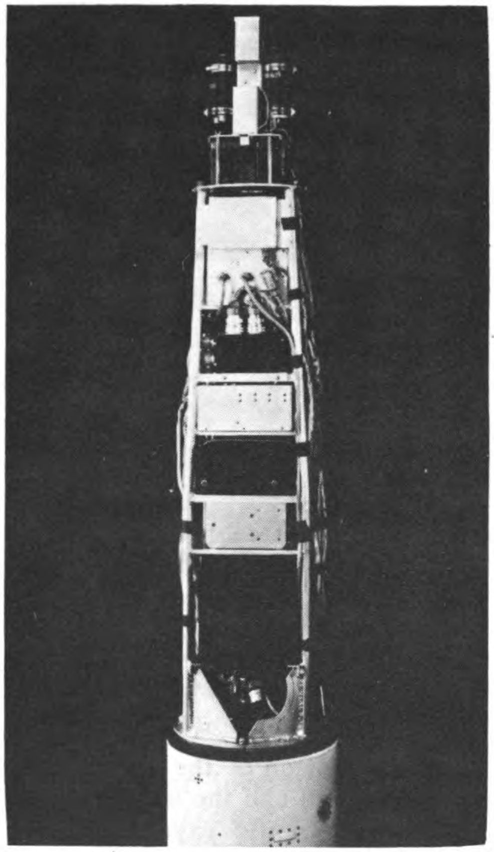


Rocket motor instrumentation—showing electric gauges which measure pressure and flow rate of propellants.

Being charged particles, cosmic rays are deflected when they come into the earth's magnetic field. At the equator only the very high energy particles can reach the earth's atmosphere and hence be detected. As one goes to higher and higher latitudes, however, more and more of the lower-energy particles will come into the atmosphere instead of being deflected away. Finally, at the poles all of the cosmic radiation comes in along vertical magnetic lines of force. By studying the variation of the cosmic-ray intensity as a function of latitude, it is possible to use the earth's magnetic field as an analyzer of the energies of cosmic rays. By doing rocket experiments at various latitudes in the manner just described, the energy spectrum for the primary cosmic radiation has been determined.



Part of checking-out procedure on a missile. Tanks are inspected to see if they will withstand pressures encountered in flight.



Rocket with outer cover removed to show arrangement of equipment.

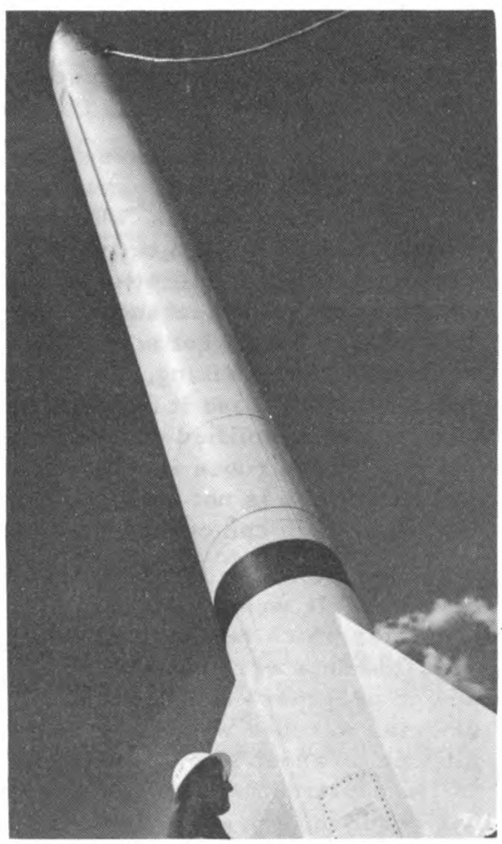
Here again we are handicapped by the short times which the rockets spend above the atmosphere. We know that the intensity of cosmic rays fluctuates. Sometimes we observe large increases in cosmic-ray intensity accompanying outbursts of ultraviolet on the sun; occasionally also we see large decreases accompanying so-called magnetic storms, disturbances of the earth's magnetic field produced by a beam of low-energy particles shot out from the sun. We should like to know what causes these fluctuations. We want to know whether the sun produces cosmic rays when it is in its disturbed phase or whether it merely accelerates those which already exist. In order to decide between a variety of theories which have been put forth to explain such changes in cosmic rays and to explain indeed the whole problem of their production, it would be most desirable if we could measure their energy spectrum on a continuous basis so that, as the cosmic-ray intensity changed at sea level, we would immediately know what was happening to the primary radiation. Measurements of cosmic-ray intensity as a function of latitude could be made several times per hour by an artificial satellite traveling along a meridian line so that it would go across both poles.

Let us now consider what would be involved in building the smallest possible useful earth satellite. A proposal for such a satellite has been made recently and has been christened the MOUSE (Minimum Orbital Unmanned Satellite, Earth). It would consist of a very small rocket carrying a payload of perhaps only 40 lbs of scientific equipment. In fact we would instrument it with Geiger counters to measure the intensity of the cosmic radiation and with photon and X-ray counters to measure the number of photons in the solar ultraviolet and X-ray spectrum. This satellite, circling the earth once every two hours at an altitude of 300 miles, would keep us in touch with events on the sun and would allow us to link up these ordinarily inaccessible solar data with solar observations from the ground. This in turn would allow us to form a consistent theory of solar processes and perhaps make it possible to predict the solar effects which have such tremendous practical importance for radio communication and meteorology. It seems worthwhile, therefore, to tackle the difficult technical problems which will lead us to the final achievement of this research satellite rocket.

Rockets have, of course, also been used to study the properties of the upper atmosphere itself. We now have very good information on how the density of molecules falls off as a function of altitude. Indeed, we find that at an altitude of 110 miles the air is so rarefied that one could travel many yards without hitting a single air molecule. This is the region of the ionosphere where many of the air molecules are ionized by solar radiation and form the radio-reflecting layers which are so important for long-distance communications. Rocket experiments have also been carried out to measure the temperature of the upper atmosphere and its composition. We have found that the temperature first decreases, then increases, reaches a maximum at about 30 miles, then decreases again to a minimum at about 50 miles and finally starts to increase very rapidly to higher and higher values. It reaches a temperature of $400^{\circ}K$ at an altitude of 100 miles. This, of course, doesn't mean that if you were at this altitude you would burn up. The atmosphere there is so rarefied that it would take a long time for the temperature of a large body to reach that of the surrounding atmosphere.

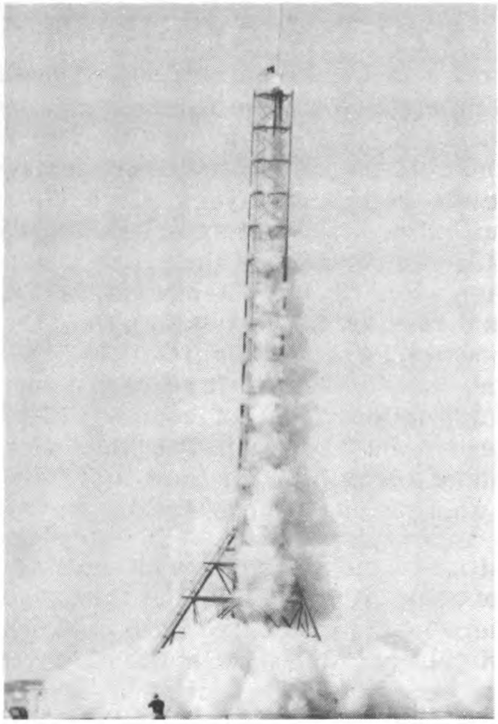
We also find that the composition of the atmosphere changes as a function of height. In the region of about 70 miles most of the oxygen which exists in the lower atmosphere in the molecular form is broken up by a portion of the solar ultraviolet radiation into its atomic form. At higher altitudes the nitrogen molecule also is broken up or dissociated into its atomic form.

Special studies are being carried out with rockets to investigate the very faint emission of light which takes place in the highest layers of the atmosphere. This light emission is rather difficult to see with the naked eye but at high latitudes becomes quite spectacular and manifests itself as northern lights. What produces the northern lights is at present not known. We suspect that they are caused by low-energy particles which come, somehow, from the sun, probably in the beam which gives rise to magnetic storms. Pictures of the earth's surface taken from rockets have been of great value to weather studies. It is often possible to see over very large distances in this way, and to study the distribution of clouds over wide regions.



Close-up view of rocket.

It is tempting to look ahead in rocket research to predict what is in store for us during the coming years. Thanks to the active rocket program, we now



Launching of the Aerobee.

know a great deal more about the upper atmosphere and about the incoming solar radiation. From now on most of the rocket work will be dedicated to making periodic studies of atmospheric conditions at high altitudes. This requires cheap and small rockets and we may expect in the next few years to see more of these small rockets being launched from balloons and perhaps aircraft. In the not too distant future, however, it is possible that an artificial satellite orbiting around the earth may monitor the radiations which our atmosphere hides from us.

EDITORS NOTE: News has just reached us of a highly successful test flight of an Aerobee rocket at White Sands on October 5. It was predicted that an altitude of 100 miles would be reached; the actual altitude was 100.6. All equipment was recovered intact by means of a parachute, the first time this has been accomplished from such an altitude.

The Aerobee has many advantages over the Viking as a research vehicle. First of all, it is only one-tenth as expensive. Secondly, the number of experiments which can be conducted simultaneously in a Viking is often limited because it has been found that major upper-air experiments are frequently not compatible due to their different requirements on rocket aspect and roll rate, and due to competition for desirable locations in the rocket nose cone. Furthermore, the most serious disadvantage of the Viking, the problem of rocket gas, does not exist with the Aerobee because it is completely pressure-sealed. Field operations are greatly simplified with the Aerobee since fewer personnel are required. The Aerobee is a more reliable rocket because of its simplicity and because it is not vulnerable to the many electrical and mechanical troubles which can occur in a controlled missile.

The Aerobee flown in this test was 22 feet long and 15 inches in diameter. It was fired from a launchinig tower and started by igniting a booster which remained attached for the first 2-1/2 seconds of flight. Valuable data were obtained which are necessary for the development—now in progress—of a new type of Aerobee known as Aerobee-Hi. The original Aerobee was designed to carry a 150-lb instrument load to an altitude of about 70 miles. Substitution of a new type of stainless steel in its construction and the incorporation of a chemical gas generator has resulted in predicted altitude performances for the planned vehicle of 202, 184 and 168 miles with payloads of 120, 150 and 180 lbs, respectively. The Aerobee-Hi will weigh 1100 lbs less payload and will be ready for testing at White Sands next May.

Atmospheric Control by Photosynthesis

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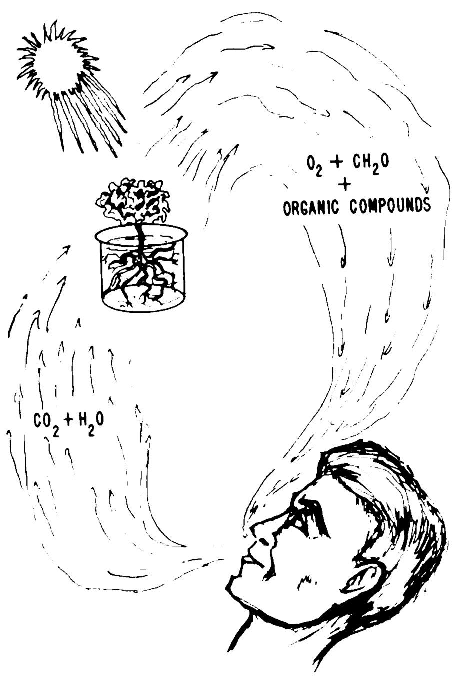
University of California, Radiation Laboratory

The maintenance of livable oxygen and carbon dioxide pressures in closed spaces in which men must live, as aboard submarines, is a serious problem to the Navy. Accordingly, efforts have been made to reproduce the natural balance which exists between these gases in the earth's atmosphere. This balance is the product of two simple reactions—one is the photosynthesis of green plants, by which carbon dioxide is absorbed and oxygen liberated and the other is the reverse process and consists of the respiration of all living systems, plants included, by which oxygen is absorbed and carbon dioxide liberated. If one looks at the chemical reactions which represent these two processes,



$$CO_2 + H_2O \; \underset{\text{respiration}}{\overset{\text{photosynthesis}}{\rightleftharpoons}} \; O_2 + CH_2O$$

(organic compounds)

it is apparent that there is a balance not only of the gases, CO_2 and O_2, but also of reduced organic matter, including food and water. Therefore, in a closed, artificial system, we would be concerned not only with the immediate problem of gas exchange but also at longer times, with the conservation of organic matter. Such a system would find practical application on an extended space journey of several years where it might not be possible to carry enough food and it would become necessary to process plants to make food. We will discuss here principally the gas-exchange problem involved in such a transformation.

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The reaction above by no means tells the whole story on the photosynthesis process. There is, in addition to the gaseous exchange, an uptake of nitrogen (in the form of ammonium or nitrate ions), phosphate, and the ions of numerous metals, including iron, magnesium, sodium, potassium, etc. In any photosynthesizing system these elements must be supplied, just as fertilizers are required in agriculture.

In selecting a suitable plant for gas exchange, one is led to a consideration of various types of green algae by their many favorable characteristics. Ranging from single cells to treelike colonies, these primitive plants support a variety of marine life and also contribute directly to needs of man. When a manufacturer wishes to test performance of new production methods without spending too much, he sets up a pilot plant. Nature seems to have availed herself of the same device in the form of algae, a simple plant most commonly known as seaweed. Most diverse and flexible of all classes of organisms, they vary in size from microscopic single cells to the giant kelp, which is as big as a large tree. They can adjust to extremes of environmental conditions on land and sea.

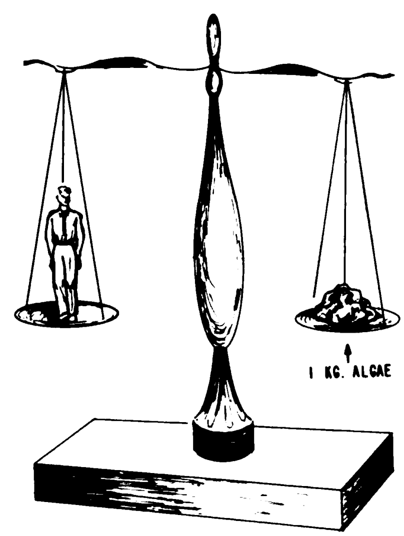
Their most important function is conversion of inorganic matter into organic substance. Like all green plants, they transform CO_2 and water into living material by photosynthesis. It was the invention of photosynthesis by some simple algae billions of years ago that made evolution of life on this planet possible. They still account for most of the photosynthetic activity on the earth. There is about 10 times as much photosynthesis going on in oceans as on land and this is almost entirely due to life processes of algae. What makes these small green plants so hardy is that they are equipped with the most complete and self-sufficient chemical apparatus one can imagine. From the tiniest to the largest species, they possess all the equipment necessary for good production and other life processes. They contain chlorophyll and other pigments for absorption of radiation and conversion of CO_2 and water into carbohydrates. They possess the full array of minerals, trace minerals, enzymes, coenzymes, vitamins and other not yet fully explored substances which play an important part in photosynthesis, respiration, nitrogen fixation, protein formation, etc. They produce growth hormones and all the complicated organic compounds associated with reproduction, inheritance and survival under extreme conditions.

Among the practical uses, they are excellent fertilizers for depleted soils. In fact the alginic acid of brown algae resembles the recently synthesized soil conditioner Krilium used as animal feed and human food by millions of Asiatics. They are rich in minerals and certain vitamins and supply bulk lacking in modern refined foods.

Suspensions of algae in nutrient solutions can be kept in tanks, which can be rather easily adapted in shape to fill available space. The suspension can be pumped, and "harvesting" of the plant yield can probably be made continuous and automatic. "Planting" consists merely of inoculation of a vessel of liquid nutrient solution with a suspension of live algae. Some unicellular algae are capable of a very high rate of photosynthesis which results in a large amount of gas exchange per unit volume of space as compared with higher plants. Absorption of light energy can be made nearly complete.

The biggest disadvantage of algae appears to be their susceptibility to contamination by bacteria. In addition there is a tendency on the part of some species of algae to form spores, causing a temporary large decrease in the rate of pnotosynthesis. Other species have complex nutrient requirements which have not been fully determined.

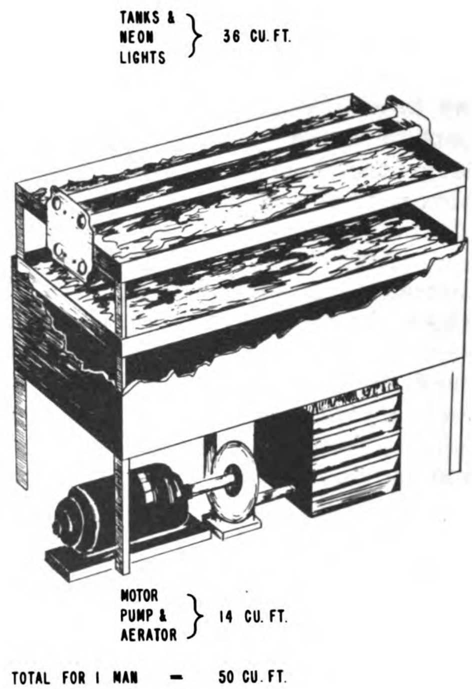
Apparently all of these problems can be solved. In regard to contamination it should be noted that in some sewage-disposal research, algae have been grown very successfully in the presence of a great variety of bacteria. In this case the algae liberate oxygen which is then used by the bacteria to decompose the organic matter, supplying in turn a rich source of CO_2, minerals, and organic compounds for the algae. There are a number of algae species which do not sporulate, and nutrition requirements can be determined by patient investigation.



The space requirements of a photosynthetic gas-exchange apparatus can be calculated from the known photosynthetic rate of one of the more active algae, Chlorella, equated against the respiration rate of man. A man weighing 154 lbs (70 kg) and doing light labor would, over a 24-hour period of working, resting and sleeping, require about 600 liters of oxygen or 25 liters per hr. The very efficient unicellular green alga, Chlorella, is easily capable of rates of photosynthesis which cause the evolution of 30 liters of oxygen per hr per kg of fresh weight of algae, and rates as high as 45 liters per hr have been measured under laboratory conditions, though not under conditions of steady-state growth. It seems reasonable that a steady-state rate of 25 liters per hr per kg might be achieved. It we make this assumption, then it is seen that the respiration of each man could be balanced by the photosynthesis of 1 kilogram wet weight of algae.

However, algae must be suspended in nutrient solution in order to receive adequate light and nutrient for photosynthesis. A concentration of 1-percent algae (wet weight) in nutrient solution is practical for maintaining growth. Therefore, 100 liters of algal suspension are required for each man.

The light requirement for maintaining the necessary rate of photosynthesis can be calculated from the known light-absorption data for



Chlorella. Such a calculation* shows that for a 1-percent suspension of algae 0.4 cm thick, a light intensity of about 600 foot-candles from each side would be required to supply enough light to maintain the desired rate of photosynthesis, if the light were all of the 6800 Å wavelength. Since one kilogram of algae in 1-percent suspension occupies 100 liters, this thickness would result in a layer of algae with an area of 10^5 cm^3/0.4 cm, which is 2.5 x 10^5 cm^2 or 270 sq. ft. One might imagine an arrangement of tanks made of transparent plastic sheets 1/4 in. thick, about 4 ft on a side and spaced 0.4 cm apart, with separators to maintain the desired width. A unit layer would consist of one such tank with a depth of about 3/4 in, and a bank of neon or fluorescent lights of perhaps 1/2 in. thickness with spaces between for air cooling. The total height of this unit would then be about 1-1/2 in, and since each layer would have an area of 16 sq ft, some 17 layers would be required, making a total height of about 27 inches. This volume would then be 4 ft sq and 2-1/4 ft high, or 36 cu ft per man. If another 14 cu ft were allowed for pumping, aerating, harvesting and control mechanisms, about 50 cu ft would be required per man. Good engineering design should result in a more compact unit. For example, the many thicknesses of plastic walls might be eliminated and the light placed directly in the algae tank, with only the terminals coming out. Cool-running lights and a good mechanism for removing heat from the rapidly circulating algae suspension would then be required.

In addition to space requirements, the power requirement of an algae gas-exchange system should be considered. Since respiration and photosynthesis are approximately reverse processes in energy as well as materials, we can consider the power expended by a man at 120 kcal per hr as equal to that which must be supplied to the photosynthesizing Chlorella to maintain the necessary gas exchange, and this amounts to about 0.2 hp. The maximum efficiency with which Chlorella uses light energy under laboratory conditions is still a subject of controversy; efficiencies reported to date range between 35 and 100 percent. In any event, the conversion of red light energy to chemical energy by Chlorella growing on a large scale could probably not be

*We are indebted to Dr. Jack Myers, University of Texas, for a private communication concerning this and certain other calculations presented here.

better than about 25 percent, even if most of the light supplied to them were of wavelengths of 6300 Å to 6800 Å. The wavelength of the light is important in this connection since the pigment systems of the algae apparently degrade light energy of shorter wavelengths to energies equivalent to red light before converting this energy to chemical energy. Thus if blue light were used, about half the energy would be lost as heat before any conversion to chemical energy would take place.

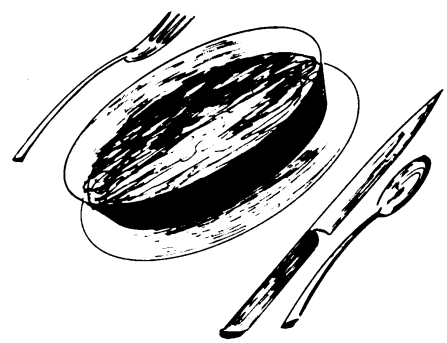
The efficiency of conversion of electrical energy to visible-light energy is about 20 percent in a standard fluorescent lamp, but some further studies may be required in order to find a lamp which would produce red light with this efficiency. If we combine these efficiencies with the power requirement of 0.2 hp for one man, we obtain 0.2/(.2 x .25) = 4 hp. If our "ship" were powered by a reactor this would require the consumption of about 10 grams of atomic fuel per year per man, if an efficiency of conversion of fuel to electrical energy of 0.02 percent were obtained.

The ratio of CO_2 to O_2 in the gas exchange of a respiring man is not 1.0 as would be expected if man consumed only carbohydrate but is actually about 0.8 due to the metabolic consumption of proteins and fats. Since photosynthesizing algae produce proteins and fats as well as carbohydrates, the photosynthetic gas-exchange ratio or CO_2/O_2 also differs from 1.0 and can vary from 0.7 to 0.9 in the case of <u>Chlorella</u>, depending on whether nitrate of ammonium is used as a nitrogen source. The gas exchange ratio of <u>Chlorella</u> can thus be made to just compensate that of man by controlling the ratio of nitrate to ammonium in the nutrient supplied to the algae.

The nitrogen requirements of algae can be calculated as follows: one kilogram of algae producing 25 liters of O_2 per hour at a gas exchange ratio of 0.82 would take up 20.5 liters of carbon dioxide or 0.915 moles of carbon. According to Myers, the cells produced by growth are about 50 percent carbon and 10 percent nitrogen so that 0.16 moles of nitrogen per hr would be required. This nitrogen could be supplied by the addition of 13.6 g of sodium nitrate, 4.8 g of urea or 2.7 g of ammonium per hour. Lesser amounts of phosphate and a number of other elements would also have to be added.

Such considerations naturally lead to a desire to reclaim the nitrogen and other minerals from the harvested algae. However, processes which burn the algae harvest to inorganic minerals will consume as much oxygen and liberate as much CO_2 as was required for the algae growth. Consequently if we are to burn the algae we can afford to do so only by feeding it to the crew and so we come back to the problem of converting algae to palatable food. Such conversion will probably be accomplished in the not too distant future, perhaps long before we have interplanetary travel. Algae are a potentially good food, some species containing as much as 50 percent protein, 7 percent fat, and sizeable amounts of digestible carbohydrates. Professor Tamiya and co-workers at the Tokugawa Institute in Japan have made palatable bread, cookies and imitation "soy sauce" from algae.

If the algae harvest can be consumed as food then the human excreta would have to be processed, probably by the action of bacteria, to provide the nutrient for the algae. This processing would require some further oxygen uptake and CO_2 evolution which would in turn bring about an increase in the volume and energy requirements of the algae cultures.



Thus there appear to be several alternate methods of using photosynthesis of algae to balance respiration of man, involving different degrees of conservation of material. We can carry along all the food required by the crew and all the nutrients required by the algae for the duration of the trip and throw away all the human excreta and the algae harvest. The other extreme is to consume all the algae harvest for food and to process all excreta and waste for feeding to the algae. Between these two extremes lie a variety of choices, such as carrying all necessary food but processing excreta for algae nutrients, etc. The method chosen will doubtless depend on the limitations of time and space imposed by the size of the space ship and the duration of the voyage.

The problems to be worked out in designing a satisfactory system are many and involve problems in microbiology, engineering, medicine, chemistry and physics. Nonetheless, there are no theoretical reasons for believing such a system will not work. It is, after all, simply a miniature model of the biological system in which we live.

NRL Scientist Awarded Harry Diamond Memorial Award

Dr. Bernard Salzberg, Associate Superintendent, Electronics Division, has been notified by the Institute of Radio Engineers that he has been awarded the 1955 Harry Diamond Memorial Award. This award, established in 1949, is given annually to a person or persons in the government service for outstanding contributions in the field of radio and electronics as evidenced by publication in professional society journals. Dr. Salzberg, who is an IRE Fellow, was cited "for his contributions in the fields of electron tubes, circuits, and military electronics." Since the award was established, it has been given three times to Navy employees, all of whom were at NRL. Dr. Haeff was the first award winner in 1950; Dr. R. M. Page, Associate Director of Research for Electronics, received the 1953 award.

Swimmer's Itch

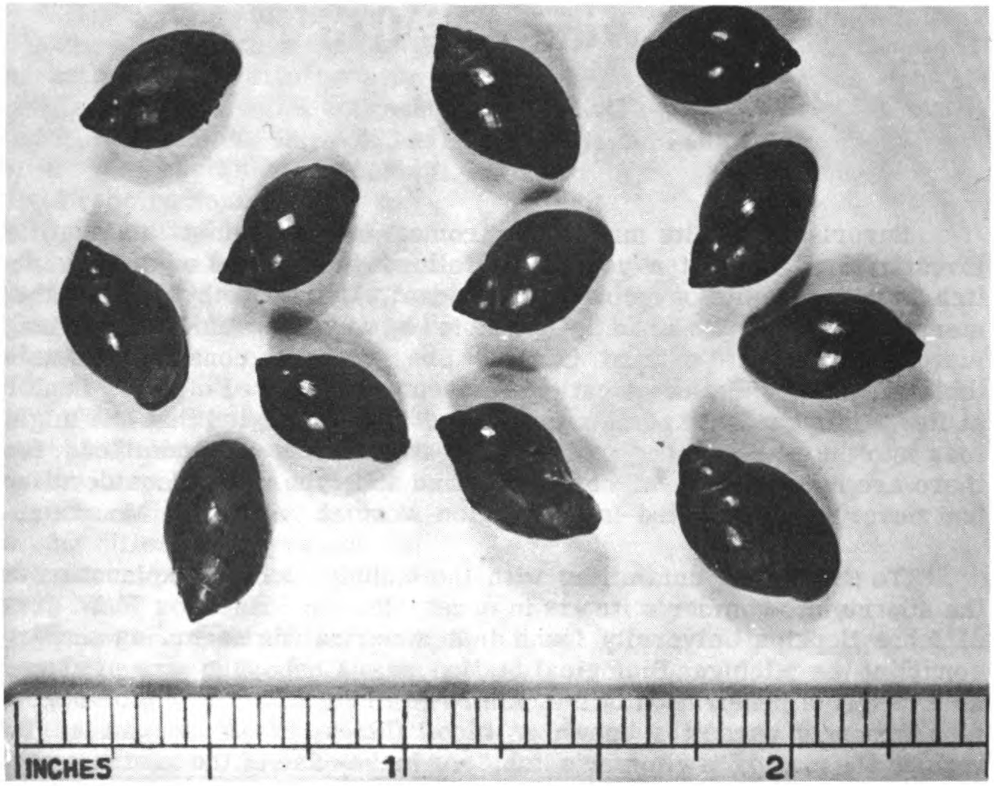
Dr. Ralph W. Macy
Reed College, Portland, Oregon

Surprising results may come from small beginnings in scientific investigation. About ten years ago, following a lecture on swimmer's itch in my parasitology course, a student, Mrs. Dorothy Macfarlane, mentioned that a friend had been troubled by a skin rash after swimming in a nearby lake in Portland, Oregon. She wished to consider this as a topic for her thesis, an educational adventure required of every senior at Reed College. With some misgivings it was suggested that she might look into the matter. The symptom mentioned was a slender lead, for there are many causes of dermatitis and the type under consideration had never been reported in the region west of the Rocky Mountains.

To the reader unfamiliar with the subject, a brief explanation of the source of swimmer's itch is in order. In 1928 Professor W. W. Cort of Johns Hopkins University found that a dermatitis occurring on personnel at the Michigan Biological Station, near Cheboygan, was produced as a result of penetration of the skin by a minute larval worm belonging to a group of parasites known as blood flukes, or schistosomes. He termed the malady "swimmer's itch." As in the case of the vast majority of flukes, or trematodes, these were found to utilize a snail as intermediate host. It was discovered that these larvae died soon after penetration and set up an allergy-type reaction as a result of the presence of the foreign protein.

Actually, schistosome flukes as a group had been known for many years before Dr. Cort's discovery, but study had centered principally around three species, existing mainly in warm climates, which mature within the blood vessels of man causing serious systemic disease. With the realization that animal schistosomes in North America, Europe, and elsewhere, could adversely affect the health of man a number of investigators became interested in studying the biology of these intriguing parasites. Today about twenty species of such flukes are known to be capable of causing schistosome dermatitis in man, and the life cycles of at least half of them are known. Natural hosts of the adult worms include ducks, blackbirds, starlings, sparrows, muskrats, mice, and cattle. The larval stages develop in certain kinds of snails in many countries.

To return to the events which led to the discovery of dermatitis-producing schistosomes in the Pacific Northwest, snails were collected in the suspected lake but the few that were found were small and proved to be uninfected with schistosomes. Infections of forked-tail cercariae which matched the description of the group known to be capable of causing dermatitis were finally found in some Physa snails from a large pond on the Reed College campus. Six students volunteered to serve as experimental recipients of the larvae and two of them developed the malady. As the water containing the cercariae evaporated on their wrists, a prickling sensation was felt, followed by extreme itching.



Physa snails, intermediate hosts for swimmer's itch parasites.

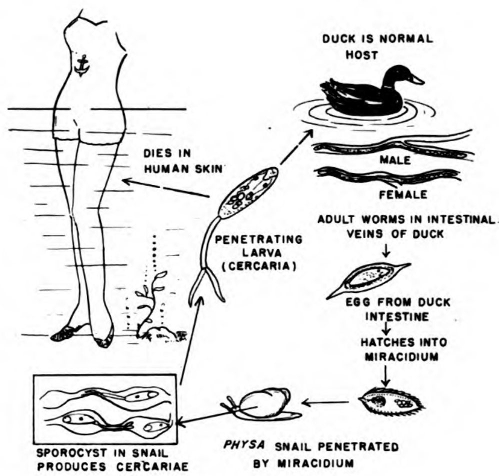
During the next two days papules developed. In one case the dermatitis disappeared in a week; in another it persisted for a month.

A study of the cercariae found seemed to indicate that an undescribed species was being dealt with, since there were slight differences in measurements of the parts and behavior was somewhat peculiar. Accordingly, the species was given the name Cercaria oregonensis.

Sometime later another student, Robert Carson, undertook further investigations on the subject as his thesis project and was successful in rearing some of the adult worms in a duck, but lack of sufficient material and time during the school year prevented the acquisition of more than a general knowledge of the biology of the parasite.

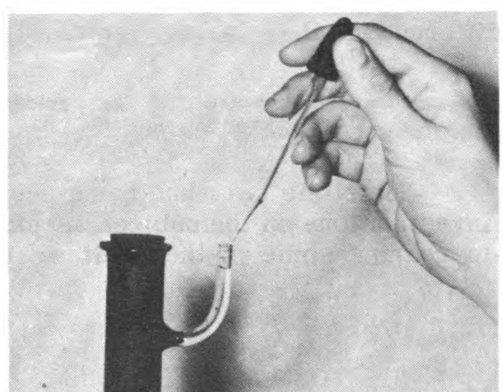
When ONR agreed to support investigations on this and related matters, new possibilities were opened to us. There were many questions to be answered. The structure of the adults and their relationships to other species were largely unknown; the nature of the egg and the miracidium or first-stage larva, time required for development in the snail, seasonal occurrence in the snails, and geographical distribution of this and other species on the West Coast had not been determined.

Our first attempts to obtain adults were not very successful for several reasons. The minute, adult worms live inside the smallest veins of the intestinal wall and are difficult to detect. There were also other technical difficulties, but eventually these were overcome and rather complete details of the life cycles were learned. In this work I had the assistance of two capable students, who could devote full time to the investigations during the summer months. As work progressed a motion picture of the results was made. The diagram above depicts the cycle of the Oregon swimmer's itch fluke, as proved by our research.



Life cycle of the organism responsible for swimmer's itch.

In order to obtain the miracidium, the ciliated, protozoan-like larva which hatches from the egg, a quantity of droppings were weighed out and placed in a McMullen-Beaver flask which is black and opaque except for a small side arm. Water was then added until it was well up in the side arm and neck, which was corked to exclude light. When the water was lukewarm, hatching occurred in a matter of minutes and the miracidia, attracted to the light, soon appeared in small numbers in the side arm from which they could be removed by a pipette. Experiments had previously demonstrated that recovery of miracidia in this manner is nearly 100 per cent efficient. Optimum dilution of feces was found to be about six grams in 540 milliliters of water in the flask, and each sample from a heavily infected duck produced only about 18 miracidia. Making use of the positive attraction of the miracidia to light, as just described, was a milestone in research on this group of schistosome flukes because it resulted in much greater efficiency in detecting infections in experimental hosts.



McMullen-Beaver flask for recovering the minute, ciliated miracidium of the swimmer's itch organism.

Next, we wanted to find out as much as possible about the reaction of the miracidia to snails, details of penetration and length of time of development within the snail until cercariae were shed. In order to be sure that snails were free from natural infections we reared our own stock by introducing Physa eggs into aquaria and feeding them. In subsequent investigations it was learned that it required about three weeks to obtain infections in snails at room temperature, and that a snail exposed to miracidia in September, and then kept at 10°C. began to shed cercariae first in March, five months later, when it was placed in a vial at room temperature.

After dealing with the life cycles of three eastern species of dermatitis-producing schistosomes, McMullen and Beaver, in 1945, concluded that the shape of the eggs was the most helpful single criterion to use in distinguishing species. We wanted to obtain eggs and adult worms of our species so that we could compare them critically with others.

Ducklings exposed to cercariae, through both foot and mouth portals, developed infections of adult worms in about two weeks, as shown by the appearance of miracidia in the McMullen-Beaver flasks, with maximum production on the twenty-sixth day in one instance and thereafter remaining nearly constant until the fiftieth day. The maximum egg-producing life of the adults was about 43 days.

In order to find adults it was necessary to take pieces of opened intestine, place them under pressure between two glass slides, and examine exhaustively under the binocular-dissecting microscope. When at length one was detected in a small vein, it had to be laboriously dissected out with honed insect pins used as microscalpels, so small were the worms. In spite of patient hours of work only occasionally could an entire worm be extracted. A method of flushing the hepatic portal vein was devised which enabled recovery of a number of complete worms. At last we had both adults and eggs, the latter embedded in the intestinal wall, and the species could now be assigned with confidence to the genus Trichobilharzia.

Meanwhile I found schistosome dermatitis to be prevalent in certain lakes in the state of Washington, but the source was from a different snail, a large species—Lymnea stagnalis—not usually found

Collecting snails and other hosts of parasites.

in Oregon. I collected infected snails of this species at Cascade Lake, on Orcas Island, Puget Sound, and brought them more than 300 miles to our laboratory where ducklings were exposed to cercariae. Adults and eggs from the Washington species of schistosome appeared to be Trichobilharzia elvae, as reported recently from Green Lake, Seattle, by Hunter and associates. This species is common east of the Rocky Mountains.

When adults and eggs of both species reared side by side were compared, the differences were striking. For example, the eggs of the Oregon species were straight, whereas those of Trichobilharzia elvae were sickle-shaped. At last we had definite proof that these were distinct entities. Ducks migrate across both regions and must expose snails everywhere to the several species of swimmer's itch organisms. Geographical differences in the distribution of species are, therefore, most likely due to the peculiarities of snail distribution.

Since our observations first began about ten years ago, schistosome dermatitis has come to be recognized as a commonly occurring malady in the vast region west of the Rocky Mountains and extending from southern California to the Arctic Circle. Additional biologists and public health officials have become concerned with the problem, and we may expect much further progress in this field.

In scientific research it is well recognized that work on one problem generally leads to many other possibilities, and our investigation of schistosome dermatitis was no exception. Snails and other hosts are infected with many kinds of parasites and it was possible to observe and experiment with some of these at the same time. As a result, parts of many other fluke cycles have been discovered and some have been completed. One of the most interesting of these proved to be not only a new species, but also a new genus which we named Cephalophallus obscurus, because of the small size of the adult.

Other studies have included work on the parasites of fish, frogs, salamanders, snakes, birds and mammals, some of which may prove to be of economic as well as biological interest.

Animals used in work on parasitic organisms.

Communication in Fish

C. M. Breder
Dept. of Fishes and Aquatic Biology
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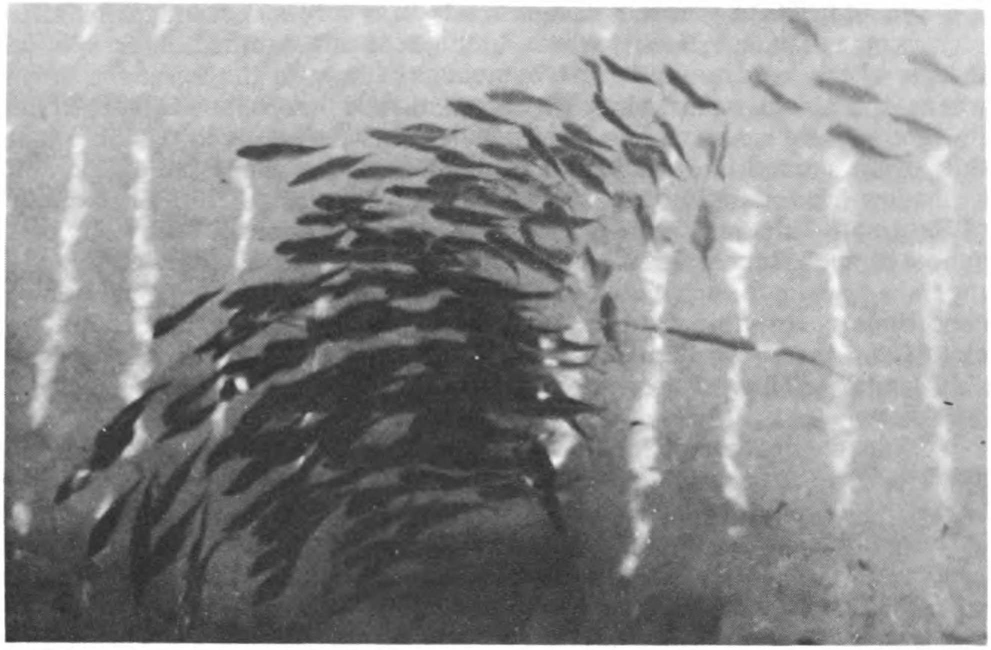
Relatively little is known about communications beneath the sea's surface and this relatively new field of research received its real impetus with the development of SONAR and other underwater scanning devices. A better understanding of the more subtle aspects of such communication is highly important to national security in view of the increasing military interest in subsurface activities. Oddly enough, most of what we know in this field has been learned from the study of one of nature's most elementary species, the fish.

Communication between fishes is just as essential to their well-being and propagation as it is to land animals including man. The form which such communication takes is, of course, quite different since we are dealing with water instead of air and there are important physical differences between the two. There are also differences in the type of equipment and in behavioral patterns within the species.

The latter variable is perhaps the most interesting since the habits of our piscian population are far more complex than is generally realized. Some prefer the solitary life and are even actively hostile to others of their own kind. Others exhibit various degrees of sociability, ranging from forms which are normally found in loose aggregations to that most consolidated of all fish groups, the fish school. Here the individuals are all substantially oriented the same way even using the same maneuvers. The picture opposite shows a small, tag end, of a larger school of jacks circling under the shadow of a dock, the outer ones moving in to close ranks in the manner of those in closer formation. Surely this would be impossible without a neatly integrated sensory pickup and as appropriate responsiveness from fish to fish.

Before discussing what we know and don't know about the operation of such closely organized assemblages of fishes, it is necessary to clarify the nature of the sensory systems of fishes in general so that their capabilities and limitations can be appreciated. Basically, fish have their own version of the sensory systems common to all vertebrates. The fish eye, for example, forms its image on a retina not vastly different from that of man, but because of the difference in the refractive index of water from that of air, the lens system in man is appropriately modified so that sharp focus is possible with the eye in contact with air.

Fish do not have external ears because they are completely unnecessary in water. This is partly due to the almost negligible sound perspective in water as compared with air. Furthermore, the greater density of water in contact with the head of the fish causes less loss by reflection and, therefore, better penetration to the inner ear. Associated with the innervation of the ear in most fishes is a series of pores or canals just under the skin, the so-called lateral line, which is completely



A small portion of a school of jacks (Trachurops crumenopthalma) swirling in the shadow of a dock. These fishes average about a foot in length. (Lerner Marine Laboratory, Bimini, B. W. I.).

absent in land animals. It is evidently very sensitive to low frequency sounds and general water movements as well as chemical stimuli. Since we—or animals living in the medium to which we are confined—have no such equipment, it is difficult to visualize the nature of the cues which this organ supplies and what they mean to the fish. How such information is integrated into the general sensory pattern is not clear.

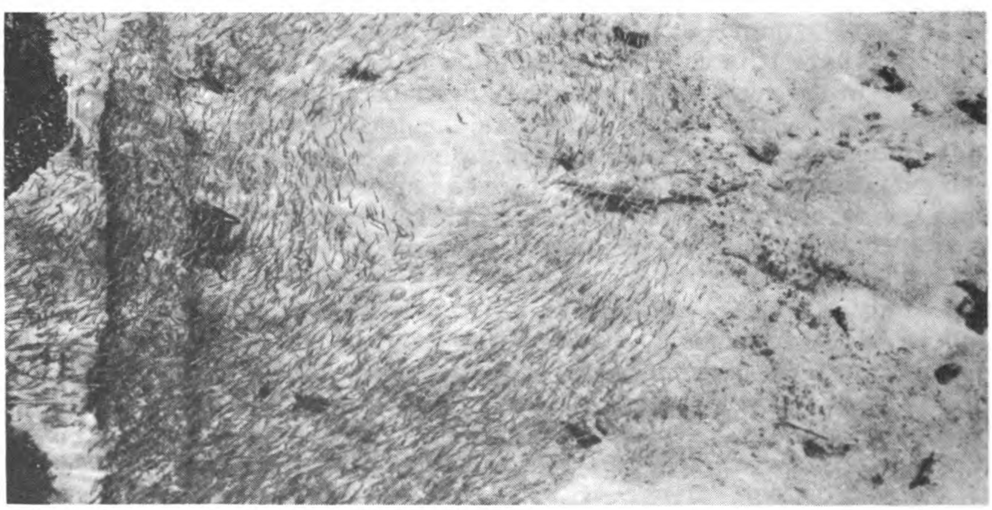
Taste is more widely distributed in the bodies of fish than in land animals where it is usually confined to the mouth. Fish have taste buds not only in the mouth, but variously distributed over the surface of the head and sometimes as far back as the tail fin. Since taste buds are able to operate only when wet, land animals lost the possibility of their use except in places where they can be kept moist, as in the mouth. In both terrestrial and aquatic animals the taste buds are contact organs, thus differing from the preceding sensory equipment which are all distance receptors. In fish, however, the taste buds sometimes falsely appear to be distance receptors. This is the case when some dissolved substance in heavy concentration wafts over a fish and cues it to follow up this solution to its source and thus find food. Olfaction is also present in fish and distinct from taste as in man. The olfactory receptor is located in the nasal capsule only, which is accessible through a small nostril. This nasal opening is found somewhat before the eye on the snouts of most fishes.

Tactile sense is present and evidently similar to that of other vertebrates. There is also present the kinesthetic sense, common to most if not all animals, but which would seem to have nothing to do directly with normal communication between individuals.

In addition to these, the pineal body has a pronounced light sensitivity in many fishes. Such forms which possess a decided clear spot on the top of the head, permitting free access of light to the top of the brain where the pineal rests, show the most marked responses to variations in light. While no work has been done on this as yet, it is possible that this organ comes into operation in dense schools where the passage of a shadow over the pineal area causes a sharp change in the behaviour of the fish. This may well affect the shape and general behaviour of a school of such fishes. It should be noted here that many types of schooling fishes possess such a clear spot on their skull and under experimental conditions react violently to the passage of such a shadow. It should be clear from the above that fishes are generally equipped with a considerably larger variety of sensory devices than land animals.

These creatures also have equipment that is probably useful for signalling. For example, in fish which have elaborate reproductive behaviour, including parental care of the young, the males are often quite differently marked or colored from the females and appropriate response is made by others in accordance with these markings. Young fish can be shown to respond appropriately to marks on the parents. These marks are often only present during the breeding season. The markings displayed by one male threatening another differ widely from those of a defeated fish. If this sounds confusing, it should be remembered that many fishes can change their colors, or patterns more or less rapidly, in some cases practically instantaneously.

Sound production is a marked characteristic of many marine animals, including many fishes. This is generally known because of the large amount of activity in recent years on subsurface "background noise." The croakers are a group of fishes noted for its sound production. In this group, which includes weakfish and drum, only the males have voices. At the outset of the reproductive season, the males produce great choruses much as frogs do in a pond. The females lack the

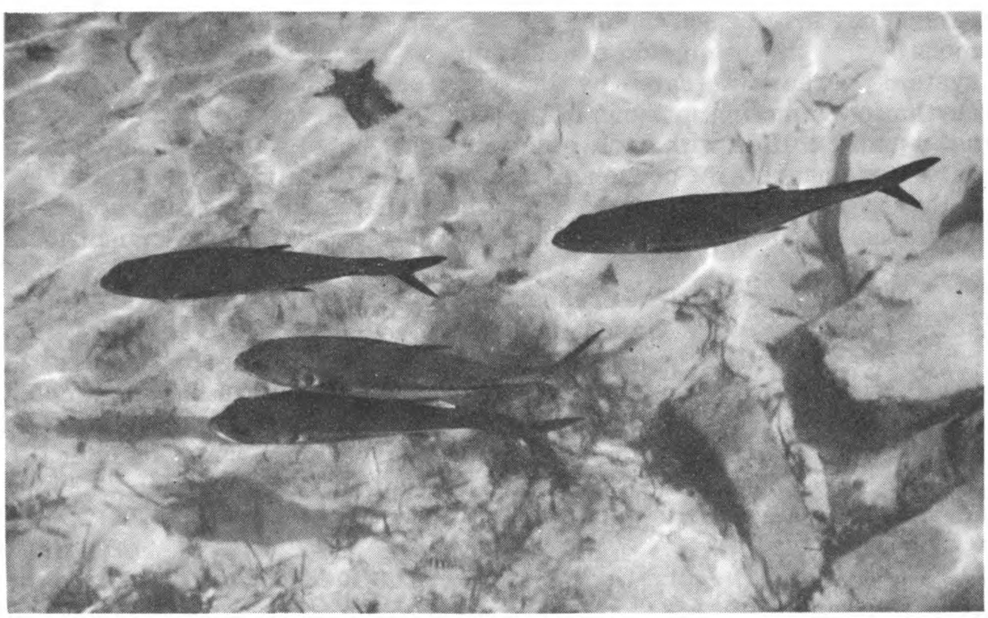


A portion of a school of dwarf herring (Jenkinsia stolifera) advancing rapidly in shallow water. These fishes are about two and one-half inches in length. (Lerner Marine Laboratory, Bimini, B. W. I.).

muscles which are responsible for such sound production. In other types of fishes, such sounds are evidently warnings, similar to the bark of a dog. While most fish do not as a rule touch one another, many forms engage in various strokings and contacts during the mating seasons. These seem to be in the nature of tactile stimuli and, therefore, must be considered as a special kind of communication. While it has been shown that both taste and smell give various fishes useful cues, such as warning and data on their own location, it has not been established that individual communication from fish to fish is ever mediated through these senses.

Having reviewed the nature of the sensory mechanisms of fishes and the structures which they can invoke to produce signals of social or other significance, we can now consider the integration and maintenance of fish schools. The first step was taken in 1927 when Dr. A. E. Parr temporarily blinded mackerel by rubbing lampblack in vaseline on their eyes. Fish so treated could not school with their fellows. As the vaseline washed off after a time and vision returned, the fish rejoined their group and behaved as before, moving just so close to their fellows and no closer, maintaining their closely ordered ranks. Such a compact school, not of mackerel, but of a small kind of herring is shown below. Here we can see the regularity of a group on the move, as compared with fish idling under a dock as shown on pg. 2.

Since Dr. Parr made his demonstration, various workers, using other species of schooling fish, have confirmed that this type of social structure is dependent on vision. This is not the end of the story nor does it tell us all we would like to know about fish schools. Without light, schools must break up by loss of visual contact. It can be shown



A "school" of four jacks (Caranx sexfasciatus). Arbitrary reduction in numbers does not inhibit the schooling reaction. These fishes are about two feet in length. (Lerner Marine Laboratory, Bimini, B. W. I.).

experimentally in a biological dark room that this is just what does happen. However, we also know that schooling fish are often taken commercially on very dark nights. Actually many of these "dark nights" are not really devoid of all light and schools can retain their integrity in very low light values thanks to the high sensitivity of the fish eye. Some preliminary rough experiments indicate that the loss of ability to school disappears just about at the light intensity where the fish are no longer visible to human observers. That the fish have really separated at this point can be checked by snapping on a light. The fish are first seen widely spaced but rush together immediately as soon as visual contact is reestablished.

There are several questions in this connection which should be further studied. These may involve other sense organs. When the schools break up owing to darkness, not in the confines of a small laboratory tank, but in the open sea, do the fishes in fact "lose" contact completely or only the ability to keep the "squadron" in perfect formation? If they do maintain some contact, what is its nature? It would seem, from the limitations of the fishes' sensory equipment, that such contact would most probably be mediated through the ear-lateral-line system. The success of commercial fishermen on truly "inky" nights might be based on some such situation, if their own lights do not suffice to account for a school forming near them.

Considering the opposite situation (a school in proper form in light), how do the fishes maintain such a uniform distance apart? This distance, is usually just large enough to provide the necessary swimming room between them. Is it because the retinal image of nearby companions is held at a certain size by adjusting the distance between fishes appropriately or may more than vision be involved? It is entirely conceivable that, while the fish can be demonstrated to be drawn together on a visual basis, they may be, on the other hand, kept from contact by some other modality. This, too, could conceivably be through the ear-lateral-line system, perhaps actuated by the pressure inequalities set up by the rhythmic swimming motions of the fishes. The fact that most fishes do not usually collide with each other or inert objects under conditions of darkness suggests the presence of some form of "micro-echo-ranging." If this is so, it should not be surprising that swimming fish so neatly avoid collision when darting about under very crowded conditions.

The numbers of fish present do not change the basic nature of the school, although very large schools are more prone to breaking into two than are smaller ones. At the other end of a numerical series, as few as two fish will form a "school." The picture opposite shows a school of four jacks. Thus, evidently, the phenomenon is not one induced by some influence based on the presence of large numbers of individuals, but is primarily an individual, fish-to-fish, matter, the school being merely the sum of these.

Under certain conditions a variety of influences may so deflect the leading members of a school that they see the trailing members of the same group. They turn to join them and the school quickly takes a circular form, the so-called "mill," in which the group makes no forward progress but each fish follows the other in a circular path endlessly or until some disruptive influence intervenes. So far as is known this is without biological value to the species and is seemingly a potentially dangerous trap for a school to fall into. Such a "mill" would appear to be analogous to a feedback mechanism so trapped in its own circuits as to repeat over and over some simple program without reference to the apparatus it was designed to serve. It should be obvious from this and the earlier comments that fish schools do not have any "leader," as is sometimes supposed, and that the individuals composing it are, as nearly as can be determined, equipotential so far as their influence on their fellows is concerned.

Aside from the interest in the general problem of fish communication and especially its application to the fish school, it is possible that a whole series of practical points of vantage may be attained by developing a clearer understanding of some of these questions.

Scientists and the Common Touch

The editorial staff of this magazine has been repeatedly enjoined to report on the ONR scientific program "in language the average Navy man can understand." Does this injunction prevent Research Reviews from printing articles on basic investigations in the more esoteric fields? Must plain English be a foreign tongue that learned scientists are too proud to speak?

One spokesman for scientists, the Editor of the Bulletin of the National Society for Medical Research, apparently thinks not. We quote, in part, from a recent editorial:

"Professional vanity can be amusing—that is, when it isn't downright annoying. Each professional group believes that its talents are pivotal. The salesman says that everything everyone does is salesmanship. The engineer says that everything done by man is essentially a piece of engineering. And we are told by the scientist that science, being precise knowledge, is the foundation of human activity.

"We are inclined to believe that all of these egocentric points of view are substantially correct, except insofar as they carry with them contempt for differently orientated talents. That is, the scientist should appreciate that the hard-headed business man is really quite a scientist, and so are most of the advanced musicians, painters, and believe it or not, politicians.

"Scientists complain that they are not understood by the 'lay public.' At least a part of the barrier to understanding is the conceit of scientists who believe that their work is much too profound for the 'lay public' to understand.

"Actually, everybody is at least part scientist, just as we all are salesmen, engineers, artists, politicians, etc. So it is not at all difficult to build understanding of science as long as one talks in terms of this universal experience. The only way to prevent understanding of science is to interpret it as though it were a secret ritual practiced only by ordained scientists."

Research Notes

ONR Host to Mexican Secretary of Marine

The Office of Naval Research was host to His Excellency, Major General Rodolfo SANCHEZ Taboada, Secretary of Marine of the Republic during his recent trip to this country as the guest of the Secretary of the U. S. Navy. In addition to his naval duties, General Sanchez is responsible for the Mexican merchant marine, fisheries and other maritime matters and is interested in all phases of hydrobiology.

Because of this interest, Dr. S. R. Galler, Head of ONR's Biology Branch, presented the ONR hydrobiological program and discussed the Navy's basic research interests in marine, estuarine and fresh water biology. Present also at the meeting representing other Federal agencies with hydrobiological interests were M. Le Bosquet of the Dept. of Health, Education and Welfare, Dr. Carbine of the Fish and Wildlife Service, Dr. W. R. Boss of the Atomic Energy Commission, Mr. Robert Randall, Bureau of the Budget, Dr. Leonard P. Schultz and Mr. Frederick H. Bayer of the Smithsonian Institution.

Dr. Galler's presentation included a discussion of some of the objectives of ONR's hydrobiological program and a review of some of the steps taken to improve coordination in this area. These include: reduction or elimination of marine biological handicaps which prevent efficient naval operations; discovery, through fundamental research, of methods by which the Navy can reduce marine deterioration; protection of survivors at sea from marine organisms; and instruction of naval personnel in the use of marine life for survival during emergencies.

ONR has taken the initiative in numerous activities in this field; these include organization of a Hydrobiology Advisory Committee in the American Institute of Biological Sciences; sponsorship of a recent biological orientation conference, and a hydrobiology symposium at the AAAS convention next December, as well as a marine biological deterioration research conference early next year. In addition ONR sponsored a research inventory "Directory of Hydrobiological Laboratories and Laboratories and Personnel in North America," which has become a standard reference since its completion last April. ONR is presently sponsoring compilation of a comprehensive bibliography of all references to research, development and engineering activities in the field of marine biological deterioration.

General Sanchez was accompanied by Vice ADM Antonio Vasquez del Mercado, Mexican Naval Attache in Washington, ADM Mario Rodriguez, Malpica, Director General of the Mexican Navy and other members of his staff.

NRL Develops Radiation Measuring Device

Navy scientists have come up with another peacetime application of military research and of atomic energy in the form of a special kind of glass which changes color when exposed to atomic radiation. In "dog-tag" locket dosimeter form, it has already been adopted for monitoring personnel against an overdose of radiation from nuclear weapons. On the basis of experiments to date, it now appears also to be an answer to the Atomic Energy Commission's search for a low-cost, easy-to-use, rugged device for measuring the amount of high-intensity radiation needed to pasteurize or sterilize food and drugs.

The new development is an outgrowth of basic research begun in 1947 at the Naval Research Laboratory on the effects of radiation of luminescent crystalline materials. Dr. James H. Schulman of the Solid State Division discovered that glass containing a small amount of silver, and normally colorless under ultraviolet light, turned orange, or fluoresced under such light after it had been exposed to X-ray or gamma radiations. The intensity of this fluorescence was a measure of the intensity of radiation, which could then be read off separate meters.

This silver-activated phosphate glass is now being bought by the Navy's Bureau of Ships and by the Air Force in "dog-tag" locket form for military personnel. The Federal Civil Defense Administration has also followed the development with a great deal of interest.

As developed for personnel use, the dosimeter operates over a radiation range of 10 to 600 roentgens. Radiation intensities from a few thousand to a few million roentgens, however, are used in experiments dealing with the pasteurization and sterilization of food and drugs. A dosimeter for this work should measure such high intensities simply and rapidly enough to lend itself to production-line irradiation of foods and drugs.

Since existing dosimeters would not satisfy these exacting requirements, work was begun at NRL, in cooperation with the AEC, to determine whether the silver-activated phosphate glass, already in production by three major glass companies in this country, could be adapted to this new application. Extensive experiments at NRL, confirmed by work at the Brookhaven National Laboratory and M.I.T., have demonstrated that the material will do the job. The change in color of the glass after exposure to radiation can be measured with commercially available densitometers, another important point in favor of the glass. Satisfactory results have been obtained from exposure to radiation from radioactive isotopes, such as Cobalt-60, from waste fission products, and from high-voltage electron beams produced by particle accelerators.

Work is continuing at NRL on the problem, with the dual objectives of improving the present glass and of providing an even lower-cost dosimeter for the purpose. Plastic materials are also being investigated as a possible additional material. The development is expected to prove an important contribution to the five-year study of food preservation by radiation announced this year by the Army Quartermaster Corps, which combines the efforts of other Government agencies, as well as educational and industrial laboratories.

Velocity of Sounds in Liquids

Sound velocities in liquids have generally been reported to claimed accuracies of .1% to .01%. Despite this fact discrepancies as large as 5% appear in the literature. Even in so common a liquid as pure water the values reported at 30°C range from 1476 to 1546 meters per second.

Because of these discrepancies and in order to ascertain the limit of accuracy of sound-velocity measurements, the Naval Research Laboratory undertook a particularly exhaustive theoretical and experimental investigation, using the NRL ultrasonic interferometer.

Among the possible sources of error considered were design and technique, diffraction at the source, excitation of Rayleigh modes, choice of imposed characteristic, wall effects, screw error, acoustic streaming, change of waveform, cavitation, and purity of sample (distilled water).

The results indicate that all sources of error other than diffraction are smaller than the claimed accuracy of 1 part in 30,000. The experimental data, as well as a theoretical wave field obtained by following (and correcting) King's expression for velocity potential, indicate that the total error considering diffraction is not above that claimed, provided no measurements are made within 15 half-wavelengths of the 1-inch 1-Mc source.

On the basis of this investigation, the velocity of sound in distilled water at 30.000°C is reported as 1509.85 ± 0.05 meters per second (4953.56 ± .16 ft per sec).

New Method of Bonding Fiberglass

The Bureau of Ordnance has announced the development of a new structural material for bonding fiberglass, which will produce laminates and tubular products of superior strength. Instead of the conventional method of bonding fiberglass with resins and organic materials, the new methods combine metals and inorganic substances, or combinations of both. Fiberglass filaments are formed in the usual way by the use of appropriate refractory furnaces and bushings. As the filaments emerge from the furnace at high speeds, they are individually coated with metallic and other inorganic substances. Metal coatings, such as iron, nickel, molybdenum, aluminum, zinc, lead, tin, and copper have been applied. The coated fibers are then bonded and compacted to form tubular products and laminates in a subsequent stage of the process which involves the application of suitable conditions of heat and pressure with or without the use of the more common flux materials. The new process, on the basis of work accomplished to date, indicates that the following important advantages may be obtained: (1) A fiberglass-reinforced structural material which is suitable for higher temperatures than presently available materials, (2) improved strength-weight ratio, (3) high resistance to the usual corrosion agents, and (4) raw materials available in this country. When available, the new material should have important commercial applications. BuOrd is seeking industrial participation in its further development.

New Tool for Probing Ocean Bottom

A new instrument for studying the bottom sediments under water has been designed, built and tested by two scientists at the University of Rhode Island, Prof. Clarence E. Miller, Head of the Geology Department, and John D. Nixon, former Assistant Professor of Physical Oceanography. The Narragansett penetrometer, which is the result of three years of work,provides scientists for the first time with a method of measuring the compactness of underwater sediments without disturbing them. Its construction was sponsored by ONR and the Navy Hydrographic Office.

The penetrometer consists of a steel tube with a probe on the end which is driven through a hollow shaft into the bottom by a motor, and a mechanism which measures and makes a permanent record of resistance at depths up to 200 feet. The working mechanism is mounted on a five-foot frame resembling a bell buoy and weighs 415 pounds without the lead weights which hold it in position underwater. The motor which drives the probe is equipped with a watertight cover which can be pressurized.

The penetrometer is designed for use in marine geological and biological research where it is important to know just how tightly packed are the silts and sands in a given area of the sea's bottom. It will be employed by the Navy in solving some of the problems involved in its broad oceanographic program.

The instrument may also replace the more expensive and time-consuming mechanical analysis in many cases where it is important to know how the bottom will act under certain loads. The penetrometer may also be used on land as a soil-mechanics instrument for such practical purposes as highway planning and foundations.

Underwater tests of the penetrometer, which was built to specifications by a machine shop, have been made at depths from 30 to 110 feet from the Narragansett Marine Laboratory's boats, "Virginia" and "Seahorse." More than 330 indoor tests have also been made using large containers of silt, sand and gravels, wet and dry, and packed in various degrees of compactness.

Electronic Strafing Recorder

An electronic strafing recorder was recently developed by a team from the Office of Naval Research who undertook to erase discrepancies inherent in conventional targets. It consists of six sheets of rubber, each sheet four by six feet in size. When assembled, the sheets of rubber are divided by a piece of plywood of equal dimensions in order to stabilize the resilient sheets. These rubber sheets are impregnated with minute particles of carbon. When energized with electric current, a steady reading is reflected on a recorder. Any variation of this constant, such as the impact of a bullet or even a sharp blow of a hammer creates a disruption of the circuit and registers a hit.

On the Naval Research Reserve

Oak Ridge Seminar Scheduled

The Sixth Annual Nuclear Science Seminar convenes at Oak Ridge, Tennessee on 28 November. During a period of two weeks a group of 50 Naval Reserve Officers with scientific and technical backgrounds will be brought up to date on developments in this important field. A new development this year is the fact that a group of Army Reserve Officers representing the Army Research and Development Reserve Program will be ordered to the seminar. There will be 30 to 40 officers in this group.

The seminar is sponsored by ONR in cooperation with AEC and the Oak Ridge National Laboratory. As in the past, the seminar will be conducted by members of NRRC C-3, Oak Ridge, Tennessee, who are being ordered to active duty for this purpose. CDR G. B. King, USNR, is Commanding Officer of this unit. The seminar chairman is CDR Richard B. Martin, USNR.

This year the program will feature nuclear reactions. The group will be composed of research scientists and military authorities in this field. Speakers will include representatives from AEC, Oak Ridge National Laboratory, Oak Ridge Institute of Nuclear Studies, as well as military authorities for the Navy Department and the Sixth Naval District. CAPT L. D. Coates, USN, Deputy and Assistant CNR, will address the group at the opening symposium on 29 November. CAPT Theodore Blanchard, USNR, Special Assistant to the CNR (Research Reserve), will appear on the program on 3 December. Mr. F. C. Wiesner, Head, Power Branch, ONR, will discuss the ONR Propulsion Program.

Reorganization Within

Administrative Group, ONR Washington

ONR Notice 5430, effective 8 October 1954, directed the following reassignment of functions, responsibilities, and personnel in the Research Reserve. Captain Theodore Blanchard, formerly Head, Research Reserve Branch, is now designated Special Assistant for Research Reserve, Code 120, and will report directly to the Deputy and Assistant Chief of Naval Research. All functions, responsibilities, and personnel currently in the Research Reserve Branch are assigned to the Special Assistant for Research Reserve. This means that the code number of Research Reserve now becomes Code 120. Titles and codes will be as follows: Training Officer, Code 121; RPO, S.E. Area, 122; Civilian Assistant to Captain Blanchard, Code 120-A. It is requested that the new title and code numbers be used upon receipt of this notice.

LCDR Burr New Training Officer

The billet of Training Officer, Research Reserve, vacant since the detachment of LCDR E. S. Churchill, USNR, on 15 July 1954 was filled 18 October 1954. LCDR H. F. Burr, USNR, who has been Reserve Program Officer at ONR, Boston for the past year is reporting for duty on that date as Training Officer, Research Reserve. LCDR Burr's performance as a program officer has been outstanding and he is well qualified to assume the duties of training officer.

LCDR Burr's naval career began after his graduation from Colby College (Waterville, Maine) in 1940. From 1944 to 1945 he was on active duty, seeing service aboard the USS INDIANA as Assistant Navigator and CIC Officer. He also served aboard the USS LAKE CHAMPLAIN. Then for five years he was employed at the Scovill Manufacturing Company in Waterbury, Connecticut. He returned to the Navy in 1950 reporting to Washington, D. C. as Operations Officer in the Potomac River Naval Command. He next spent a year as Executive Officer on the NORRIS (DDE 859). With this background LCDR Burr should be a valuable addition to the Research Reserves.

Pass Us the Word

The "Research Reserve" section of this magazine is intended as an informal information-exchange for all Naval Reserve Research Companies. If it fails to cover the program, it is because we do not hear about the more important happenings. The "word" has to go up as well as down.

If you, in your training program, have done something unusual or outstanding, we would like to report it. Perhaps your company has undertaken a research project as a team; maybe it has distinguished itself and the Reserve Program by participating in an exhibit or scientific expedition; maybe a VIP has visited you and said something significant and quotable; perhaps one of your members has merited an unusual distinction or award or has completed a neat bit of research. Let us know.

Reporting is easy. Just send the item to the Chief of Naval Research, Office of Naval Research, Washington 25, D. C., Attention: Special Assistant for Research Reserve (Code 120).

Pictured here are the participants in last month's Training Conference attended by Commanding Officers of Naval Reserve Research Companies and subunits, Ninth Naval District, at NTC, Great Lakes, Illinois.

Front row, left to right: CAPT Joseph B. Berkley, USN, Commanding Officer, ONR-Branch Office, Chicago; LTJG Donald A. Pitt, USNR, NRR Co. 9-6, Minneapolis; LCDR Gerald Spawn, USNR, Subunit 9-6, Brookings, So. Dak.; LCDR John Maloney, USNR, NRR Co. 9-13, Des Moines, Iowa; CDR William Smith, USNR, NRR Co. 9-20, Lawrence, Kans.; LCDR Robert Shaw, USNR, NRR Co. 9-5, Ames, Iowa; CAPT Chauncey M. Louttit, USNR, Conference Leader, Detroit, Mich.; CAPT Theodore Blanchard, USN, Director of Naval Research Reserve.

Second row, left to right: LCDR Frank Sills, USNR, NRR Co. 9-19, Iowa City, Iowa; LCDR Audra E. Bell, USNR, NRR Co. 9-7, Lafayette, Ind.; CDR Glen Hawks, USNR, NRR Co. 9-23, Chicago; LCDR Willard Martin, USNR, Subunit 9-13, Rapid City, So. Dak.; CDR Emmett O'Neil, USN, representing the Chief of Naval Personnel; CAPT Peter Lackner, USN, Director of Training, Ninth Naval District; LCDR Herbert Wordell, USN, Program Officer, 8th and 9th Naval Districts.

Third row, left to right: LCDR Fred Briggson, USNR, NRR Co. 9-3, Ann Arbor, Mich.; LCDR John Blakeslee, USNR, NRR Co. 9-16, Lansing, Mich.; LT John Duffie, USNR, NRR Co. 9-14, Madison, Wis.; CDR John Chellevold, USNR, Subunit 9-19, Waterloo, Iowa; LCDR Robert Elgin, USNR, NRR Co. 9-9, Rolla, Mo.; LT Walter Thomas, USNR, NRR Co. 9-12, Fort Collins, Colo.

Top row, left to right: LCDR Edward Rietz, USNR, NRR Co. 9-1, Chicago; LT Robert Lommasson, USNR, NRR Co. 9-22, Lincoln, Nebr.; LT Robert Dworschack, USNR, Subunit 9-2, Peoria, Ill.; CDR Charles Bowman, USNR, NRR Co. 9-2, Urbana, Ill.; CDR John Carter, USNR, NRR Co. 9-8, St. Louis, Mo.; and CAPT Jackson Champlin, USN, Reserve Coordinator, Ninth Naval District.

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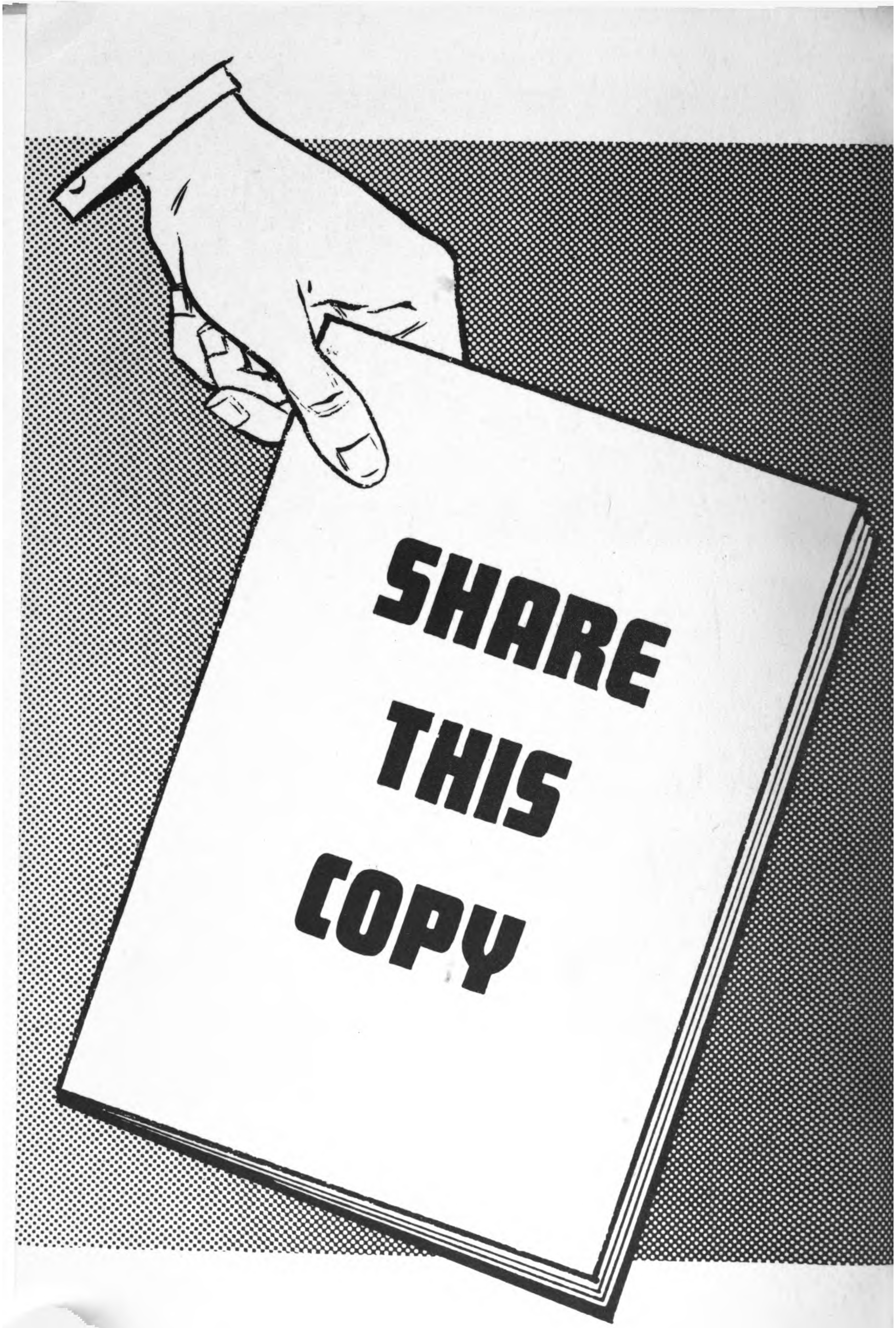
Probing the Ocean Bottom (See pg. 27)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